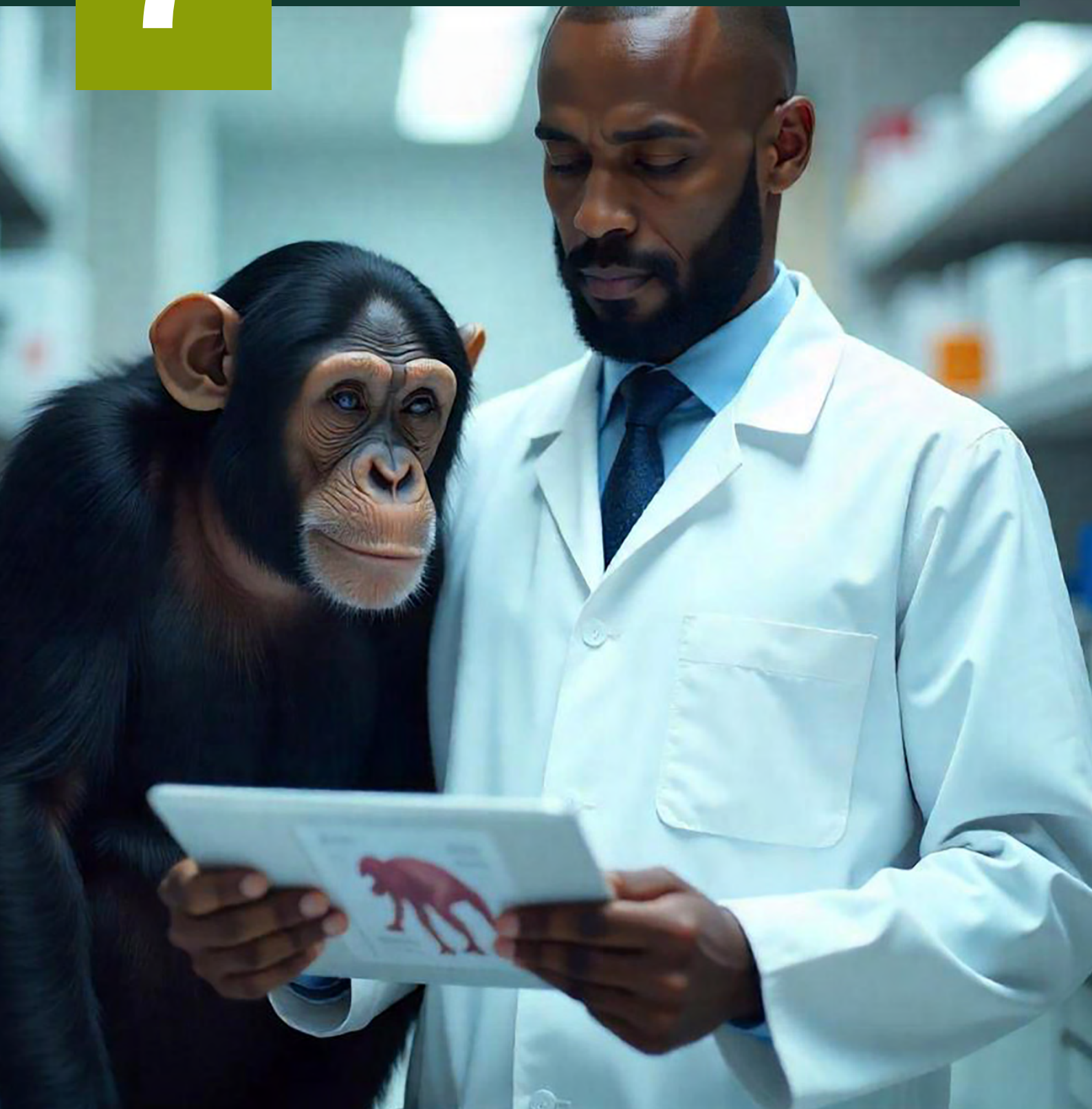
Biology

Year 1

SECTION

7

# MAMMALIAN SYSTEMS



# SYSTEMS OF LIFE

## Mammalian Systems

## INTRODUCTION

Mammalian systems are made up of several organs and tissues which work together to support life functions in mammals. At the core of these systems of organs is the vertebrate body plan, which has features such as bilateral symmetry, a segmented vertebral column with the spinal cord, and many specialised internal organs that play specific roles. The various systems in mammals includes the musculoskeletal system, digestive system, excretory system, nervous system, reproductive system, endocrine and exocrine systems, and cardiovascular system. Mammals also possess an immune system that defends them against pathogens and invaders of the body. Mammals exhibit thermoregulatory mechanisms to maintain internal body temperature and ensure successful metabolic processes. Mammalian systems have evolved over time to adapt to diverse environments, which allow them to thrive in various habitats within the earth's biosphere.

**At the end of this section, you will be able to:**

- Relate the external and internal features of Mammals to their functions.
- Compare the digestive systems and associated organs of different groups of mammals.

**Key Ideas:**

- Some external organs or features of mammals include fur/hair, Mammary Glands, Limbs and Appendages and Teeth and Jaws.
- Some internal organs of mammals include: Mouth, Stomach, Small Intestine, Large Intestine which form the digestive system, Lungs, Heart, and Kidney.
- Mammalian sensory organs include Ears for the sense of hearing, Eyes for the sense of sight, Nose for the sense of smell, Tongue for taste and Skin for the sense of touch which gather information about their surroundings.

- Herbivores feed mainly on plant material and have relatively long digestive tract with large caecum or rumen that contain symbiotic microorganisms that help to digest especially cellulose in plant material.
- Carnivores feed mainly on flesh of other animal and have relatively short digestive system with high acidic content to digest flesh and bones and also to kill micro-organisms likely to be present in the meat.
- Omnivores feed on wide range of plant and animal material. They have intermediate length of digestive tract.
- Mammals are capable of adapting to feeding choices in their environment they are not original to their feeding mode.

## RELATE SOME EXTERNAL ORGANS/FEATURES OF MAMMALS TO THEIR FUNCTIONS

Some external organs or features of mammals include fur/hair, Mammary Glands, Limbs and Appendages and Teeth and Jaws. The external organs and their functions are discussed below.

**Fur/Hair**

*Function:* Insulation and protection. Fur functions to regulate body temperature of mammals by trapping warm air close to the skin. It also serves as a protective layer against harsh environmental factors such as rain or snow. In some mammals it serves as camouflage of predators or their prey. In some cases, the colour and density/length of hair gives out signals of gender or status. E.g. the lion's mane.

**Mammary Glands (Mammary Papillae/Nipples)**

*Function:* Lactation. Mammary glands produce milk, a rich source of nutrition for young mammals. Nipples allow offspring to nurse, promoting maternal care and increasing survival chances.

**Limbs and Appendages**

*Function:* The structure of limbs and appendages varies among mammals based on their mode of action. For instance, terrestrial mammals have limbs optimised for walking, running, swimming, fighting, obtaining food, climbing, gliding or flying, while marine mammals have evolved flippers for swimming.

### Teeth and Jaws

*Function:* Feeding. Different mammalian teeth types (incisors, canines, premolars, molars) are specialised for various diets. Herbivores have teeth adapted for grinding plant material, while carnivores have sharp teeth for holding and killing prey and crushing bones.

**Activity 7.1**

Search from textbooks and available sources (audio and video documentaries, articles, online resources) and relate the external organs/features of the mammal below to their functions

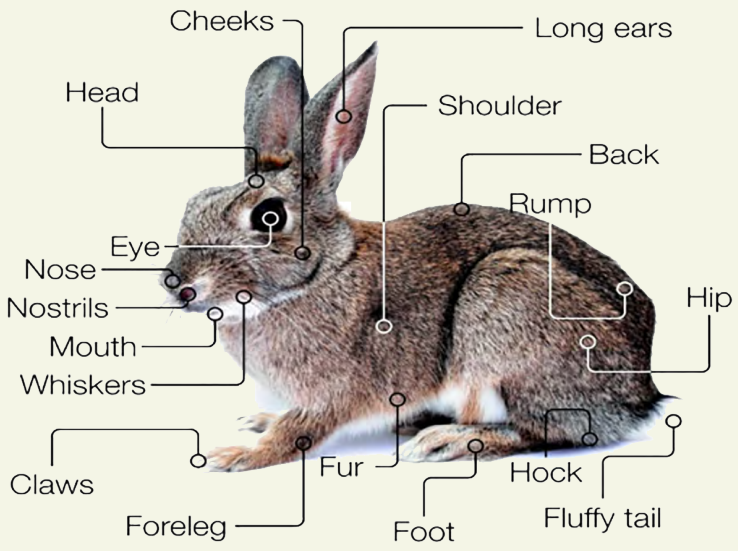



**Fig. 7.1:** Parts of a rabbit

## Some Internal Organs/Features of Mammals to their Functions

Some internal organs in mammals and their functions include the following:

### Four-chambered heart

*Function:* Efficient circulation.

The four-chambered heart keeps oxygenated and deoxygenated blood separate, allowing mammals (and birds) to have a more efficient circulation system which supports their high metabolic demands.

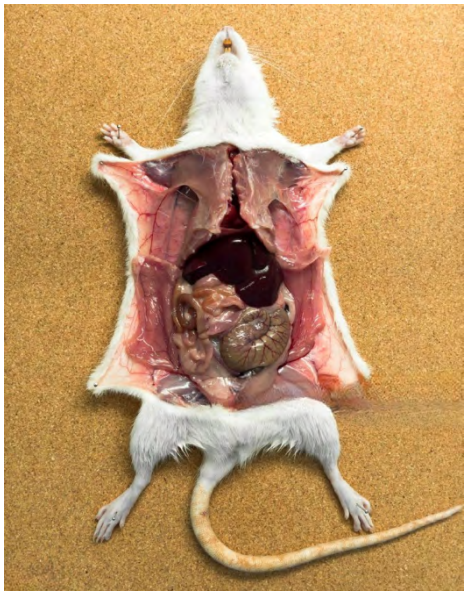


**Fig. 7.2:** Diagram of a dissected albino rat showing some internal organs

## Diaphragm

*Function:* Breathing.

The diaphragm is a muscle that aids in the process of breathing by contracting and relaxing. This changes the pressure in the thorax, bringing about the expansion and contraction of the lungs, thus facilitating the exchange of oxygen and carbon dioxide for respiration.

## Complex digestive system

*Function:* Efficient nutrient extraction.

Mammals have a specialised digestive system with different chambers (e.g., stomach, small intestine, large intestine) that allow for efficient breakdown and absorption of nutrients from their diverse diets.

## Reproductive system

*Function:* Reproduction and maternal care.

Mammals have evolved diverse reproductive strategies, including internal fertilisation and viviparous (live) birth. Mammalian reproductive organs include the testes, scrotum and penis in males, and structures such as the uterus or womb, fallopian tubes, the vagina and the vulvas among females. The reproductive system plays a crucial role in ensuring the survival and development of offspring.

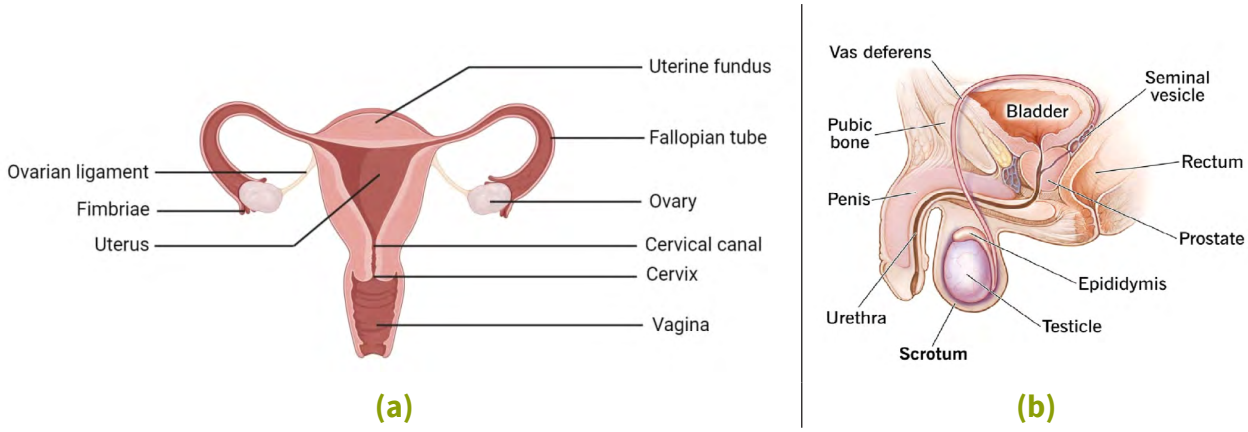



**Fig. 7.3:** Diagrams of female (a) and male (b) reproductive systems

## Well-developed brain

*Function:* Cognitive abilities and complex behaviours. Mammals generally have a larger and more complex brain compared to other animal groups, which supports advanced cognitive functions, problem-solving, and sophisticated social behaviour.

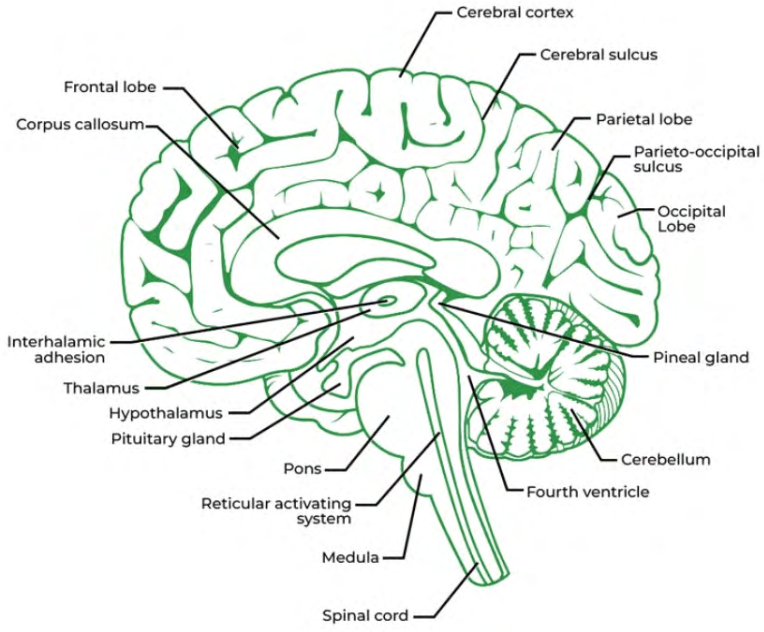



**Fig. 7.4:** Diagram of the mammalian brain

## Kidneys

*Function:* Filtration of blood and elimination of waste materials. Mammalian kidneys are well-equipped to filter blood and regulate water balance, allowing efficient excretion of waste products and maintenance of internal homeostasis.

## Activity 7.2

Search from textbooks and available resources (audio and video documentaries, articles, online resources), conduct actual dissection of the mammal(pig) below, identify and relate the internal organs/features to their functions using the human anatomy model as a guide.

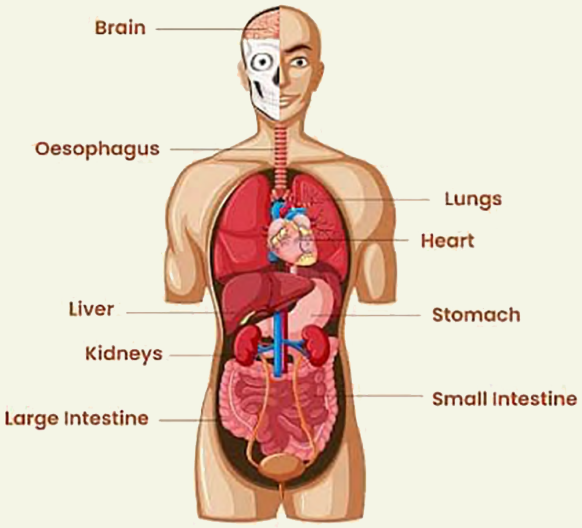



**Fig. 7.5a:** Human anatomy model

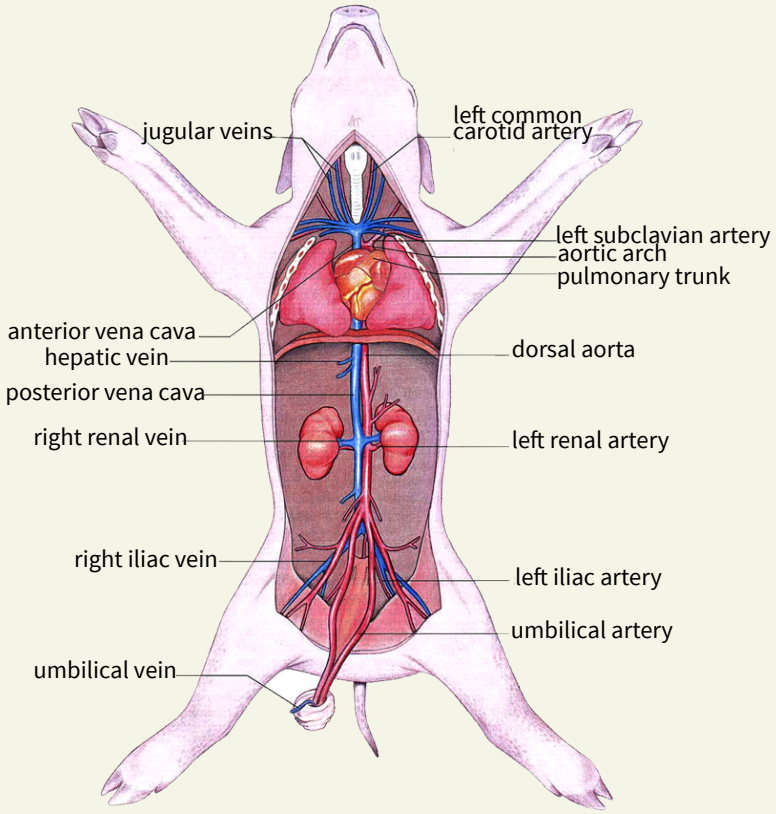



**Fig. 7.5b:** Diagram of a mammal(pig)

## Here's a step-by-step guide for a Dissection Exploration activity

### Materials

- Specimens (rabbit or rat)
- Dissection trays
- Scalpels
- Forceps
- Scissors
- Magnifying glasses
- Gloves
- Lab coats
- Diagrams and guides

### Instructions

1. Place the specimen on the dissection tray.
2. Make a midline incision using scissors or a scalpel.
3. Open the cavity and observe the organs.
4. Identify and label major organs (heart, lungs, liver, stomach, intestines, kidneys).
5. Use forceps and scissors to carefully expose and examine each organ.
6. Note observations and draw diagrams
   a. Focus on specific organs, such as:
      - Heart: observe chambers, valves, and blood vessels.
      - Lungs: note lobes, bronchi, and blood vessels.
      - Liver: identify lobes, bile ducts, and blood vessels.
   b. Use magnifying glasses to examine organ structure.
   c. Discuss organ functions and relationships.

# RELATE THE SENSORY ORGANS (EARS, EYES, NOSE, TONGUE AND SKIN) OF MAMMALS TO THEIR FUNCTIONS

Mammals have well-developed sensory organs to gather information about their surroundings.

*Function:* Perception of the environment.

**Eyes** are adapted for vision; **ears** for hearing, and for balance; the **nose** for detecting scents; the **tongue** for detecting taste, and the **skin** for detecting touch, temperature and pain.

**Activity 7.3**

Search from textbooks and available resources (audio and video documentaries, articles, online resources) identify and relate the sensory organs of mammals to their functions and how the sense organs coordinate to protect the body of the mammal.

# DESCRIBE THE DIGESTIVE SYSTEMS AND ASSOCIATED ORGANS OF HERBIVORES, CARNIVORES AND OMNIVORES

## Teeth

The digestive system start at the mouth, where the teeth grind the food. The teeth have adapted through evolution based on the food that is being eaten. For example: as a result of a plant-based diet, herbivores have large flat molars that help grind fibre-rich material. In comparison, the teeth of carnivores have well-developed incisors and canines; which are used for catching prey and tearing meat. Omnivores have mixed teeth compared to herbivores and carnivores, which can be used for both grinding as well as tearing. In this way, each animal has teeth that are specialised for their specific natural diet (see image). As a result, it is often possible to identify an animal just by looking at the skull and the placement of the teeth.

## Comparative Dentition

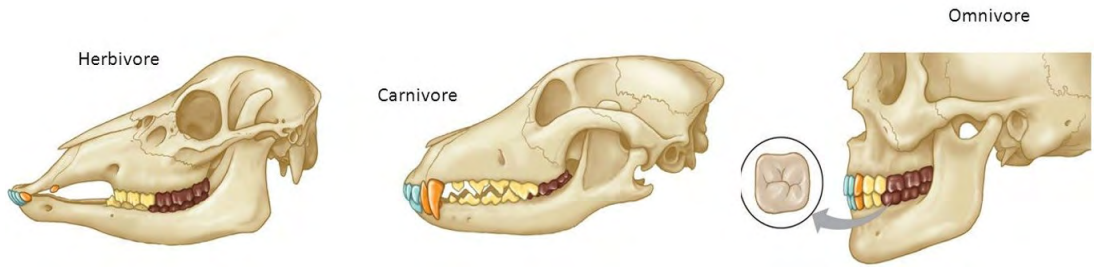



**Fig. 7.6:** Comparative Dentition
Source adjusted from: https://drbillspetnutrition.com/carnivores-omnivores-herbivores/

The digestive system and associated organs of some mammals based on their feeding habit include Herbivores, Carnivores and Omnivores.

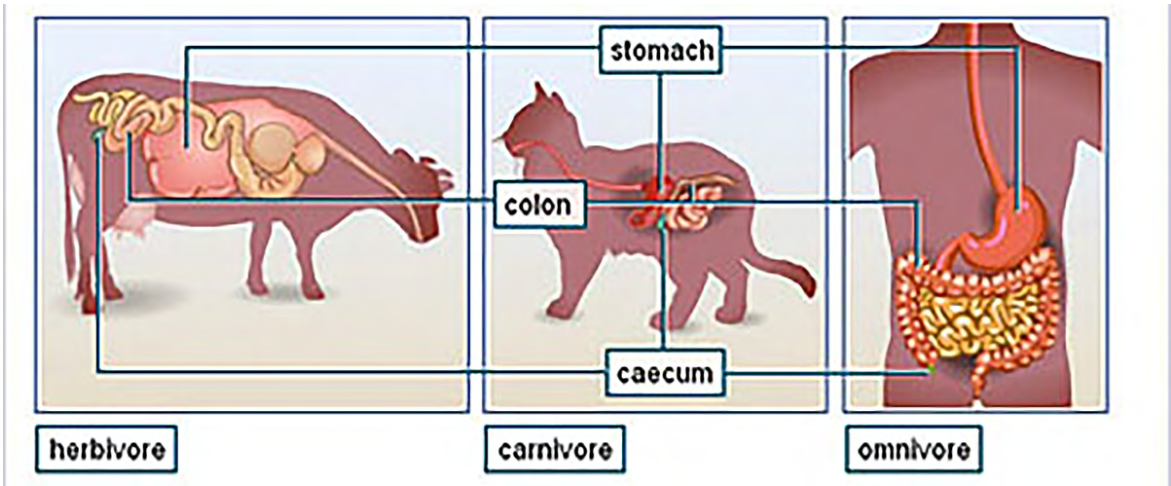



**Fig. 7.7:** Diagram of the herbivore, carnivore and omnivore alimentary canal

# Herbivores

*Diet:* Herbivores primarily consume plant material, such as leaves, grasses, and fruits.

## Digestive System Adaptations

*Long Digestive Tracts:* Herbivores typically have longer digestive tracts to allow more time for the breakdown of complex plant fibres and the extraction of nutrients.

*Large Caecum or Rumen:* Many herbivores have a specialised fermentation chamber, such as the caecum (in rabbits) or the rumen (in ruminant mammals like cows and sheep). These chambers contain symbiotic micro-organisms that help digest cellulose and other complex carbohydrates found in plant material.

## Associated Organs

*Large and Complex Stomach:* Herbivores often have a large stomach with multiple compartments to aid in the fermentation and breakdown of plant material.

*Well-Developed Colon:* The colon (large intestine) in herbivores plays a crucial role in absorbing water and nutrients from the digested material before excretion.

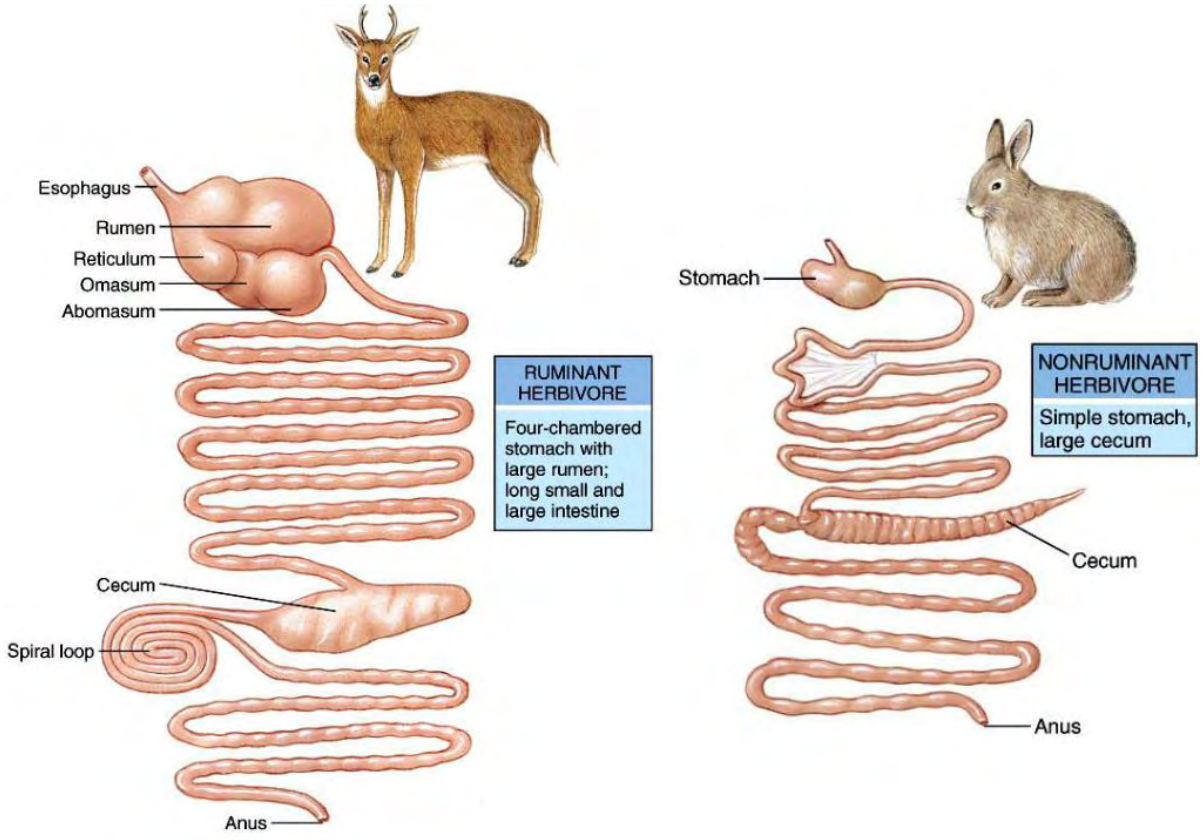



**Fig. 7.8:** Herbivore Digestive Tracts

# Carnivores

*Diet:* Carnivorous mammals are animals that primarily consume flesh of other animals.

## Digestive System Adaptations

*Shorter Digestive Tracts:* Carnivores have relatively shorter digestive tracts compared to herbivores because animal protein is easier to digest.

*Simple Stomach:* Carnivores generally have a simpler stomach structure compared to herbivores, as their diet consists of more easily digestible nutrients.

## Associated Organs

*Increased Stomach Acid Production:* Carnivores have a higher concentration of stomach acid, which aids in the breakdown of proteins and bone, and destroys harmful bacteria commonly present in meat.

*Reduced Caecum:* Many carnivores have a smaller or less developed caecum since their diet does not rely heavily on fermentation.

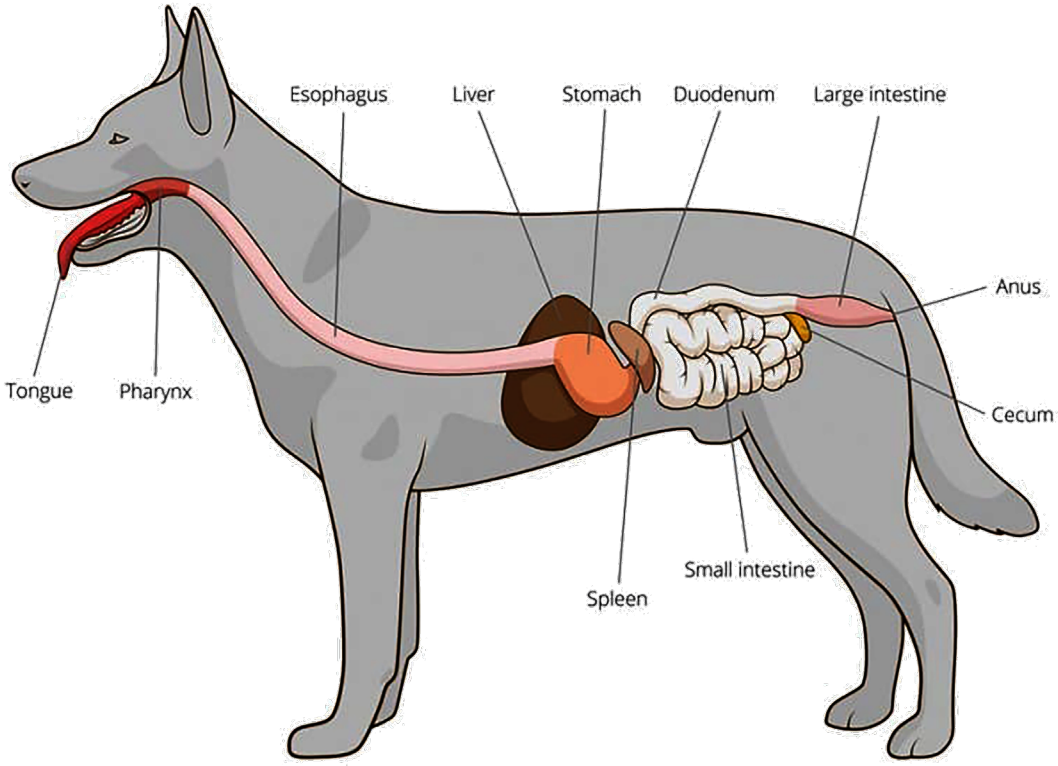



**Fig. 7.9:** Digestive System of a Dog

# Omnivores

*Diet:* Omnivores consume both plant and animal material, combining aspects of both herbivores and carnivores.

## Digestive System

Moderately Long Digestive Tracts: Omnivores often have intermediate length digestive tracts, reflecting their diverse diet.

*Flexible Diet Adaptations:* Omnivores have evolved to be more flexible in their feeding habits, allowing them to adapt to a broader range of food sources.

## Associated Organs

*Generalist Stomach:* Omnivores usually have a stomach capable of handling both plant-based and animal-based diets.

*Variable Caecum Size:* The caecum size in omnivores can vary depending on the species and their dietary preferences.

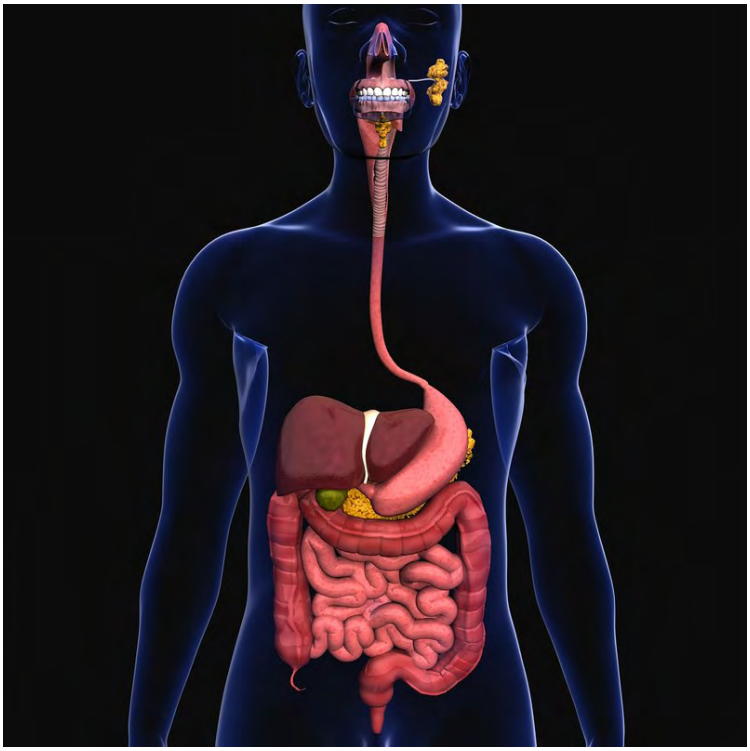


**Fig. 7.10:** Omnivores Digestive System

# Comparison of the Length of Digestive tract of Herbivores, Carnivores and Omnivores

The length of the digestive tracts in herbivores, carnivores, and omnivores is closely related to their dietary preferences. The comparison is as follows:

## Herbivores

- Digestive Tract Length: Herbivores have the longest digestive tracts, typically 10-12 times their body length.
- Reason: Their diet consists mainly of fibrous plant material, which is difficult to digest. The extended length allows more time for the breakdown of cellulose and absorption of nutrients. Additionally, many herbivores have specialized stomachs or fermentation chambers that house symbiotic bacteria to aid in digesting plant fibres.

## Carnivores

- Digestive Tract Length: Carnivores have the shortest digestive tracts, usually 3-6 times their body length.
- **Reason**: Their diet is primarily composed of meat, which is easier to digest compared to plant material. A shorter digestive tract is sufficient for the rapid digestion and absorption of proteins and fats. Carnivores also have highly acidic stomachs to break down meat and kill potential pathogens.

## Omnivores

- Digestive Tract Length: Omnivores have digestive tracts that are intermediate in length, generally around 6-8 times their body length.
- Reason: Omnivores consume both plant and animal matter, so their digestive systems need to be versatile. The intermediate length allows them to efficiently process a variety of foods, extracting nutrients from both plant fibres and animal proteins.

*Summary*

- **Herbivores**: Long digestive tracts for breaking down fibrous plant material.
- **Carnivores**: Short digestive tracts for rapid digestion of meat.
- **Omnivores**: Intermediate digestive tracts for a mixed diet of plants and animals.

This adaptation ensures that each group can efficiently process their specific diets, maximising nutrient absorption and energy extraction.

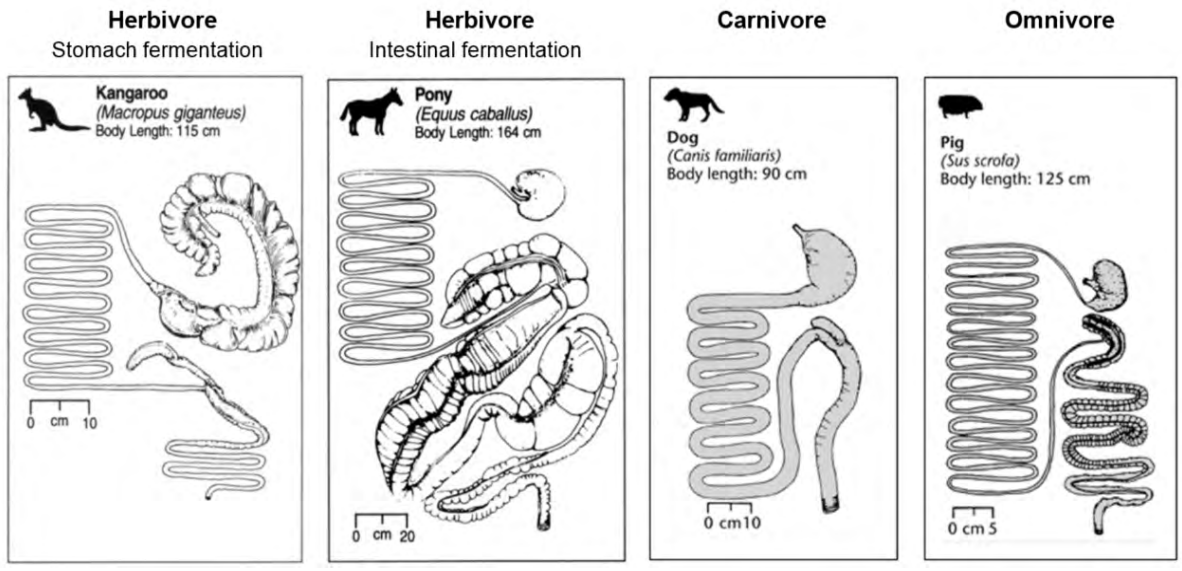



**Fig. 7.11:** Source adjusted from: https://www.sciencedirect.com/science/article/pii/S1095643308009914

**Note:** It is important to note that within each group, there can be significant variations in digestive systems based on specific adaptations and ecological niches. These adaptations highlight the remarkable diversity and adaptability of mammals to their respective environments and dietary choices.

In a rapidly changing habitat with decreasing animal diversity, omnivores are prone to face several nutritional challenges such as:

## Nutritional Challenges

- **Reduced Food Variety**: With fewer animal species, omnivores may struggle to find a balanced diet, leading to potential deficiencies in essential nutrients like proteins, fats, and certain vitamins.
- **Increased Competition**: As food sources become scarce, omnivores may face increased competition from other species, including herbivores and carnivores, for the remaining plant and animal resources.
- **Seasonal Availability**: Changes in climate can affect the seasonal availability of both plant and animal food sources, making it harder for omnivores to maintain a consistent diet throughout the year.

## Digestive System Adaptations

- **Enhanced Digestive Efficiency**: Over time, omnivores may develop more efficient digestive systems that can extract maximum nutrients from a wider variety of food sources. This could include improved enzyme production to break down complex carbohydrates and proteins.
- **Flexible Diet**: Omnivores might evolve to have even more flexible diets, allowing them to switch between available food sources more easily. This could involve changes in their taste preferences and foraging behaviours to better exploit whatever food is available.
- **Microbiome Adaptation**: The gut microbiome, which plays a crucial role in digestion, may adapt to help omnivores digest a broader range of foods. This could involve an increase in beneficial bacteria that aid in breaking down plant fibres and animal proteins.

*Example: Bears*

*Bears are a good example of omnivores that have adapted to changing environments. They have a versatile diet that includes fruits, nuts, insects, and small mammals.* Their digestive systems are capable of processing both plant and animal matter efficiently, allowing them to survive in diverse habitats.

Overall, while omnivores face significant challenges in a rapidly changing habitat, their inherent dietary flexibility and potential for digestive adaptation provide them with a better chance of survival compared to more specialised feeders.

## Impact of Climate Change

Climate change has profound effects on the feeding habits and survival of various groups of mammals, including herbivores, carnivores, and omnivores.

### Herbivores

Herbivores, which rely on plants for their diet, are significantly impacted by climate change. Rising temperatures and altered precipitation patterns can affect plant growth and distribution. For instance:

- **Plant Availability**: Changes in climate can lead to shifts in plant species composition and distribution, potentially reducing the availability of preferred food sources for herbivores.
- **Nutritional Quality**: Elevated CO2 levels can decrease the nutritional quality of plants, leading herbivores to consume more to meet their dietary needs.
- **Habitat Loss**: Climate change can lead to habitat loss and fragmentation, making it harder for herbivores to find sufficient food and increasing competition among species.

### Carnivores

Carnivores, which feed on other animals, are also affected by climate change, though in different ways:

- **Prey Availability**: Changes in the populations and distributions of prey species due to climate change can directly impact carnivores. For example, a decline in herbivore populations can lead to food shortages for carnivores.
- **Habitat Shifts**: As habitats change, carnivores may need to migrate to new areas to find food, which can lead to increased human-wildlife conflicts and competition with other predators.
- **Reproductive Success**: Climate change can affect the reproductive success of prey species, leading to fewer offspring and thus less food for carnivores.

## Omnivores

Omnivores, which consume both plant and animal matter, may have a slight advantage due to their flexible diets, but they are not immune to the impacts of climate change:

- **Dietary Shifts**: Omnivores may need to adjust their diets based on the availability of food sources. For example, if plant availability decreases, they may rely more on animal prey, and vice versa.
- **Habitat Changes**: Like herbivores and carnivores, omnivores are affected by habitat changes They may need to migrate to find suitable habitats that provide both plant and animal food sources.
- Competition: Increased competition for food resources can occur as species' ranges shift and overlap due to climate change.

Overall, climate change poses significant challenges to the feeding habits and survival of herbivores, carnivores, and omnivores. Adaptation strategies and conservation efforts are crucial to mitigate these impacts and ensure the survival of these mammal groups.

### Activity 7.4

Observe the picture below


**Fig. 7.12:** Images of Mammals

1. Group the Mammals above as either herbivore, carnivore or omnivore.
2. Give reasons for your grouping.

## Activity 7.5: Dissecting a Small Mammals

### Materials

- Dissecting set
- Dissecting board
- Dissecting pins
- Chloroform
- Glass bowl / plastic container
- Cotton wool
- Nose mask
- Disposable hand gloves
- Small mammal (rat, guinea pig, rabbit, mouse, piglet)

**Fig. 7.13:** Dissecting Set

**Fig. 7.14:** Dissecting Pins

### Procedure

1. Wear your nose mask and hand gloves
2. Soak the cotton wool in chloroform and place in air-tight glass bowl or plastic container.
3. Place your small mammal (specimen) in the container and wait for it to be unconscious.
4. Place the specimen on the Dissecting board and hold in place with the dissecting pins.
5. Carefully cut open the specimen to expose the internal organs

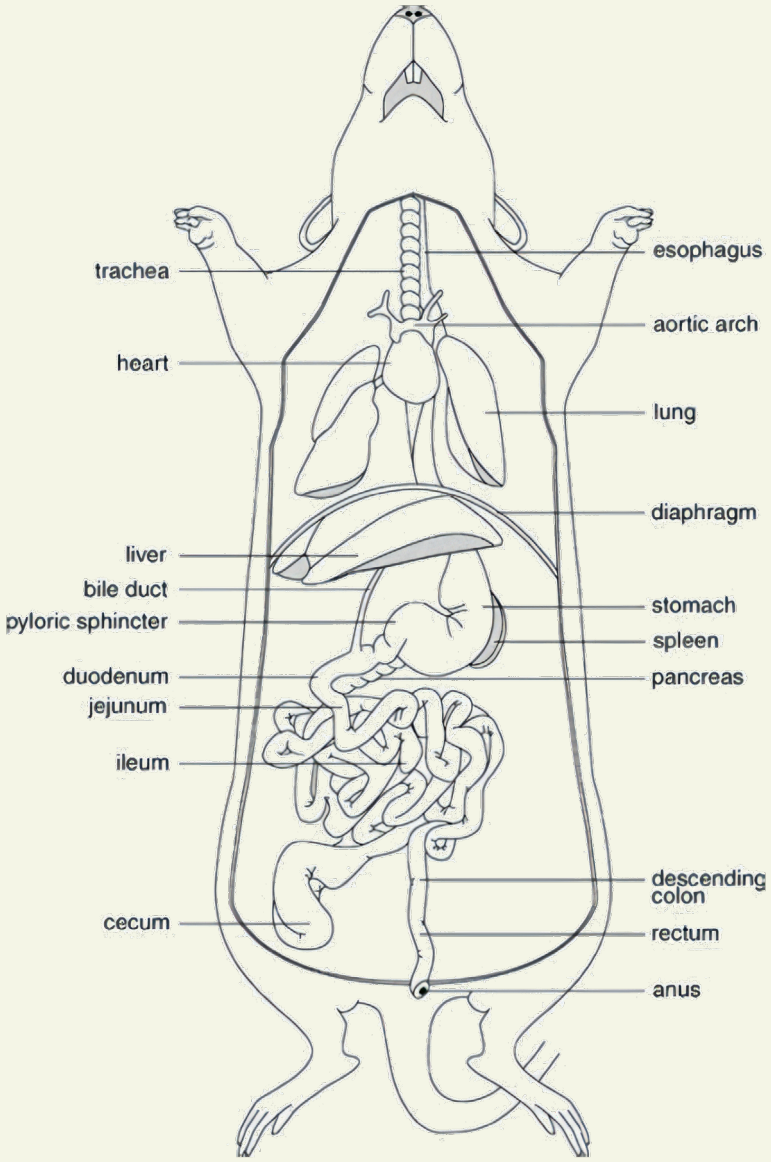



**Fig. 7.14:** Small mammal Specimen

6. Carefully examine the organs responsible for digestion and show how their structures adapt them for their function.
7. Compare the digestive tract of your specimen with that of your friends' specimens.
8. Compare the caecum of your specimen with that of your friends' specimens.
9. Record your observations.

**NB: Be sure to observe all laboratory safety protocols during dissections.**

## Activity 7.6

1. Carefully study the **Table 7.1** below
2. For the set of statements, indicate in their corresponding space whether herbivores, carnivores or omnivores.

**Table 7.1**

| | |
|---|---|
| 1. _____ | A. reduced caecum |
| 2. _____ | B. eat both plant and animal material |
| 3. _____ | C. symbiotic micro-organisms |
| 4. _____ | D. eat mainly plant material |
| 5. _____ | E. well-developed colon |
| 6. _____ | F. long digestive tract |
| 7. _____ | G. short digestive tract |
| 8. _____ | H. flexible diet adaptation |
| 9. _____ | I. have fermentation chamber |
| 10. _____ | J. eats mainly flesh |
| 11. _____ | K. variable caecum length |
| 12. _____ | L. diet of easily digestible nutrients |
| 13. _____ | M. Digestive tract with high acidic content |
| 14. _____ | N. moderately long digestive tract |
| 15. _____ | O. large caecum |

## Activity 7.7

1. In groups (preferably mixed), examine the diversity and adaptability levels of mammals in their specific habitat and their nutritional adaptability. (videos, texts, internet resources etc. may be consulted)

2. List these mammals so examined as either herbivores, carnivores or omnivores.
3. Link your list in 2 above to the adaptive features of their digestive systems to their choice of diet.
4. Write out your findings.
5. Do group presentations on your findings.

## EXTENDED READING

- https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/General_Biology_%28Boundless%29/34%3A_Animal_Nutrition_and_the_Digestive_System/34.02%3A_Digestive_Systems_-_Herbivores_Omnivores_and_Carnivores
- https://www.kiezebrink.eu/en/knowledge-base-zoos/differences-in-digestive-system-between-herbivores-carnivores-and-omnivores
- https://nutritionstudies.org/are-humans-herbivores-or-omnivores/

# REVIEW QUESTIONS

## Review Questions 7.1

1. Compare the limb structure of a named terrestrial mammal and a named marine mammal and explain how each is suited to their mode of movement.
2. Devise a plan for a conservation program aimed at protecting a specific endangered mammal species by considering its unique external and internal features, habitat, and diet requirements.

## Review Questions 7.2

1. Name some internal organs that are found in mammals and give the function(s) of each.
2. Describe the features of the mammalian heart which allow it to perform its functions effectively.
3. Discuss ways in which mammals have adapted successfully to life on earth, by comparing them with other vertebrate groups.

## Review Questions 7.3

1. List the five sense organs in mammals and give the role(s) of each.
2. Explain why the functions of the sense organs are crucial to the survival of a named mammal.
3. Discuss some processes and activities that may impair the sense organs in mammals and disrupt their proper functions.
4. With a specific example, describe how information is channelled through a specific sense organ to the brain.

## Review Questions 7.4

1. Name the three major groups of mammals based on their dietary preferences and briefly define each of them with examples.

2. Compare the length of the digestive tracts in herbivores, carnivores, and omnivores. How do the lengths relate to their dietary preferences?
3. Propose potential challenges in nutrition likely to be faced by omnivores in a rapidly changing habitat where animal diversity keeps decreasing. How might their digestive system adapt over a period of time to overcome these challenges?
4. Discuss the potential impact of climate change and its effect on the feeding habit and survival of any of the following groups of mammals: a) herbivores b) carnivores c) omnivores.

# ANSWERS TO REVIEW QUESTIONS

## Answers to Review Questions 7.1

1. This response will be based on the mammals the learner choses. Fo example a comparison and explanation of limbs of land-based mammals (e.g. sheep) with the flippers of aquatic mammals such as dolphins and whales.
2. Answers should discuss conservation methods and practices such as avoiding hunting/poaching, criminalising the commercialisation and trading of endangered mammals and providing a healthy and safe habitat for endangered mammals.

## Answers to Review Questions 7.2

1. Some internal organs to consider are Mouth, Stomach, Small Intestine, Large Intestine which form the digestive system, Lungs, Heart, and Kidney. Look on Pages 4-6 for information on functions of some of these organs.
2. Describe the various adaptive features of the heart, such as being four chambered, the presence of a septum, muscular ventricles and the presence of valves, and the functions of these features.
3. Ways mammals have adapted successfully to life on Earth, distinguishing them from other vertebrate groups:
    a. Thermoregulation: Mammals can regulate their body temperature, unlike reptiles, which rely on external sources. This allows mammals to thrive in various environments.
    b. Hair and fur: Mammals have hair or fur, providing insulation, protection, and aiding in thermoregulation. This is unique compared to birds (feathers), reptiles (scales), and amphibians (smooth skin).
    c. Mammary glands: Mammals have mammary glands, which produce milk to nourish their young. This is a distinctive characteristic compared to other vertebrates.
    d. Dental structure: Mammals have a specific dental structure, including incisors, canines, and molars, adapted for various diets.

This differs from other vertebrates, such as birds (beaks) and reptiles (homogeneous teeth).

e. Brain development: Mammals have a larger brain-to-body mass ratio compared to other vertebrates, indicating advanced cognitive abilities.

f. Skeletal system: Mammals have a specific skeletal system, including a diaphragm, ribcage, and sternum, which supports their unique respiratory and circulatory systems.

g. Reproductive strategies: Mammals have adapted various reproductive strategies, such as viviparity (giving birth to live young) and placental development, distinguishing them from other vertebrates.

h. Specialised senses: Mammals have developed specialised senses, like echolocation in bats and dolphins, and electroreception in some mammals.

i. Social behaviour: Mammals exhibit complex social behaviours, such as cooperation, communication, and altruism, which are less prevalent in other vertebrates.

j. Adaptability: Mammals have adapted to diverse environments, from aquatic to terrestrial and arboreal habitats, showcasing their remarkable flexibility.

## Answers to Review Questions 7.3

1.
   - Ears for the sense of hearing
   - Eyes for the sense of sight
   - Nose for the sense of smell
   - Tongue for taste
   - Skin for the sense of touch

2. For example, Wolves rely heavily on their exceptional vision to:
   a. Hunt prey in low light conditions.
   b. Detect potential threats or competitors.
   c. Navigate through their territory.

3. Here are some processes that can impair the proper functioning of each sense organ:
    - Eyes (Sight) - Cataracts: Clouding of the lens in the eye, leading to blurry vision and impaired sight.
    - Ears (Hearing) - Otitis media: Middle ear infection, causing inflammation and fluid build-up, leading to hearing loss and impaired sound conduction.
    - Nose (Smell) - Sinusitis: Inflammation of the sinuses, causing swelling and congestion, leading to impaired olfactory receptors and reduced sense of smell.
    - Tongue (Taste) - Glossitis: Inflammation of the tongue, causing damage to taste buds, leading to impaired taste perception.
    - Skin (Touch) - Neuropathy: Damage to sensory nerves, causing numbness, tingling, or reduced sensitivity to touch and other sensations.
4. Let's take the example of the eye (sense organ) and how visual information is channelled to the brain:
    - Step 1: Light enters the eye - Light from an object enters the eye through the cornea (transparent outer layer) and passes through the pupil (opening).
    - Step 2: Light is focused - The light is then focused by the lens onto the retina (innermost layer) at the back of the eye.
    - Step 3: Photoreceptors convert light to signals - The focused light hits photoreceptors (rods and cones) in the retina, which convert the light into electrical signals.
    - Step 4: Signals transmitted to bipolar cells - The electrical signals from photoreceptors are transmitted to bipolar cells, which amplify and process the signals.
    - Step 5: Signals transmitted to ganglion cells - The processed signals from bipolar cells are then transmitted to ganglion cells, which collect and bundle the signals.
    - Step 6: Signals transmitted to the optic nerve - The bundled signals from ganglion cells are transmitted to the optic nerve, a cable-like structure that carries visual information.

- Step 7: Optic nerve transmits signals to the brain - The optic nerve transmits the visual signals to the brain, specifically to the lateral geniculate nucleus (LGN) in the thalamus.
- Step 8: Brain processes visual information - The LGN processes and relays the visual information to the primary visual cortex (V1) and other higher-level visual areas for further processing, interpretation, and understanding.

## Answers to Review Questions 7.4

1. Herbivores, Carnivores and Omnivores with their general definitions, and at least one example. Herbivores feed mainly on plant material. Example: goat. Carnivores feed mainly on flesh of other animals. Example tiger. Omnivores feed on both plant and animals. Example man.
2. Refer to pages 10-14 on comparison of the length of digestive tract of herbivores, carnivores and omnivores.
3. As animal diversity keep decreasing, Omnivores will be faced with reduced animal protein, reduced access to balanced diet, changes in gut microbe composition and increased competition for limited resources. The digestive system might adapt to these changes by increasing efficiency in plant digestion and adjustment of microbe composition and populations in the gut.
4. Refer to pages 16-17 on impact of climate change.

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