Activity 5A: Nutrition in animals

1. Define the following terms:
   a. ingestion **b.** digestion **c.** absorption **d.** egestion.
2. Distinguish between mechanical and chemical digestion.
3. Explain the differences between the teeth of mammalian herbivores, carnivores and omnivores.
4. Explain how the surface area of ingested food is increased, and how this aids digestion.
5. Discuss the role of enzymes in the digestion of food.
6. Following are differences between the *carnivore digestive system* and the *omnivore digestive system* of humans. Give reasons for these differences.
   a. Saliva does not contain amylase.
   b. The stomach has relatively large amounts of HCl (pH of about 1).
   c. Both pepsin and lipase are present in the gastric juices (in some animals, lipase is present in the gastric juices as well as the pancreatic juices).
   d. Food spends a longer time in the stomach (e.g. can be as long as 4–8 hours in dogs and as short as 30–60 minutes in humans).
   e. Food spends a shorter time in the small intestine (in humans, food can spend 12–60 hours before moving into the colon).
   f. Small intestine is shorter than in humans.
7. Following are differences between the hindgut herbivore system and the omnivore digestive system of humans. Give reasons for these differences.
   a. Food is stored in the stomach for a few hours.
   b. The small intestine is longer.
   c. The large intestine is longer.
   d. There is a large well-developed caecum.
8. Discuss the differences in the digestive systems of humans, dogs and rabbits.
9. Explain how the digestive system and the transport system work together in mammals to provide for a successful way of life.
10. Discuss diversity in nutrition in three named groups of animals. In your answer:
    - describe the structure of the digestive system in each group
    - explain the ways in which the structures carry out the process of digestion
    - discuss why the systems in these three groups are different.

Activity 5A answers: Nutrition in animals

1. **a.** Ingestion is the taking in of food into the (first part) of the digestive system.
   b. Digestion is the breaking down of food by mechanical and chemical processes into its small soluble constituent molecules (e.g. glucose, amino acids).
   c. Absorption is the process in which the products of digestion (e.g. glucose, amino acids) leave the gut and enter the transport system/body cells.
   d. Egestion is the process of removing materials that cannot be digested (e.g. cellulose products) from the body (as faeces).
2. Mechanical digestion is the *physical* breakdown of food (e.g. by teeth, gizzard); chemical digestion is the *chemical* breakdown of food (e.g. by enzymes, acids).

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3. The differences in the teeth of mammals *reflect their diet*, with herbivores having large incisors and molars, carnivores having sharp incisors and molars and pointed canines, omnivores having all three teeth types very similar in shape and size. Herbivores have large incisors to bite off (often hard) vegetation and large ridged molars to grind up the vegetation; canines are absent (as they are the piercing, stabbing teeth needed to kill and tear meat). Carnivores have canine teeth to kill prey and tear meat; their incisors and molars are very sharp and/or pointed to eat meat and crunch up/gnaw hard bones. Omnivores eat both vegetation and meat, so have all three types of teeth, but these teeth are more uniform in size and shape, which reflects the unspecialised diet.
4. Mechanical digestion (by e.g. teeth) is important in breaking food into smaller pieces, *increasing its surface area* for the process of chemical digestion by enzymes and acids. The larger the surface area of the food, the faster enzymes are able to act/catalyse its breakdown. Therefore, the greater the surface area of the food, the faster the process of digestion.
5. Enzymes are the agents of *chemical digestion* of food, as they are *catalysts/catalyse the breakdown* of the food. As catalysts, enzymes *speed up* the process of digestion, allowing it to *occur fast enough* to meet an animal's nutritional needs. Many *different enzymes* are needed, because digestion is a step-by-step breakdown of food, with chemical digestion occurring in the mouth, stomach, small intestine (in mammals), and each enzyme is *specific* in its action (i.e. catalyses only one reaction – e.g. amylase digests starch in the mouth, pepsin digests proteins in the stomach, lipase digests lipids in the small intestine). This is because the *active site* of the enzyme fits the shape of the specific food chemical (e.g. protein), so only that chemical can be catalysed. The end point of chemical digestion is the production of the small soluble constituent molecules from the large chemicals that are ingested as food.
6. **a.** The food of carnivores contains no starch (starch is found only in plants). As (salivary) amylase digests starch, carnivores have no need for amylase.
   b. HCl kills (potentially dangerous or pathogenic) micro-organisms; animal material consumed by carnivores while killing, eating or scavenging prey is likely to have large amounts of such pathogenic bacteria. Animal material ingested will have bones, hair/fur, nails/claws – HCl will chemically attack these and begin to break them down, especially bones (breakdown of bones helps to release the nutrients from marrow). HCl is essential in protein digestion; pepsin needs an acidic environment to break down proteins.
   c. Pepsin digests protein, lipase digests fat – the meat diet of carnivores is rich in both protein and fat.
   d. Food spends a longer time in the stomach to allow the digestion of the larger amounts of protein (by pepsin) and HCl and for bones, etc. to be broken down to release nutrients.
   e. Food spends only a short time in the small intestine/duodenum, as most protein digestion occurs in the stomach and most of the digestion in the duodenum is that of fats (by lipase); no need for carbohydrate digestion.
   f. No carbohydrate digestion occurs in the duodenum (unlike omnivores and herbivores), and complex carbohydrates take longer to digest than either fats or proteins. Therefore, there is no absorption of the large amounts of glucose resulting from complex carbohydrates' digestion. As a result, the small intestine is shorter in carnivores (shorter intestine saves on materials and energy that would otherwise be needed in making and maintaining the intestine; also saves space in the abdominal cavity).

7. **a.** Herbivores tend to have a bulky diet / consume large quantities of plant food. This bulk material is stored in the stomach and then released at intervals into the duodenum so that the capacity of the duodenum is not exceeded.

b. Longer small intestine is needed for the digestion of large quantities of starch / complex carbohydrates and then for the absorption of large quantities of glucose.

c. Longer large intestine is needed as there is large amounts of undigested material from their plant diet which requires more 'packaging' into wastes/faeces, together with the removal (and reabsorption) of large amounts of water.

d. The caecum is located between the small and large intestines. The caecum is large and well-developed as it houses the cellulose-digesting micro-organisms needed to digest the cellulose found in plant material. The released contents of the plant cells are then exposed to the action of digestive enzymes in the duodenum.

8. Answer needs to *compare* and *relate to differences in diet*, such structures and processes as the following.

- Ingestion / types of teeth present (could give dental formulae) and development.
- Chemical digestion – where it occurs / how / end products.
- Structures in digestive system – which present and why; comparative sizes; what processes occur in them.
- Absorption – where it occurs / how / why.
- Egestion – where / how / why.

9. Food is digested into small soluble molecules, e.g. glucose, for absorption through cell membranes of the small intestine and into blood capillaries for transport. Because mammals are large, multi-cellular organisms with complex systems, a transport system is essential to take substances from (cells of) one system to (cells of) another system. Digestive products need to be transported to (cells of) all parts of the body where needed, and to where they are processed and stored – give an example of these parts and processes, especially the liver. The transport system is very closely linked to the digestive system – describe the villi – and many blood vessels are associated with the small intestine, so the transport of digestive products is rapid. (Without a transport system, the digestive products would not be able to reach all parts of the body; mammals could not be large or complex as they would not get the nutrients needed to function, e.g. to respire, grow, repair, reproduce.) The transport system itself needs large amounts of nutrients to function (e.g. to supply the energy needs of a muscular pumping heart) so is dependent on the action of the digestive system. The transport system in return supplies the digestive system with the nutrients it needs to function, e.g. glucose for cellular respiration to provide the large amount of energy needed for e.g. ingestion, and for enzyme production and release. It is therefore essential that the two systems work together for mammals to be successful in their way of life.

10. Three clearly different taxonomic (e.g. birds, insects, mammals) or functional groups (e.g. parasitic insects, herbivorous insects, carnivorous insects *or* herbivorous mammals, carnivorous mammals, omnivorous mammals) need to be selected.
For *each* group, the *structures* associated with the processes ingestion, digestion, absorption, egestion, need to be *described fully and carefully using correct terms* such as the following.

- The mouthparts (e.g. teeth, mandibles, piercing stylets, sucking tubes) and their structure.
- The parts (e.g. stomach, crop, gizzard, small intestine, colon) of the digestive system and their structures.

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For *each* group, *how* these structures perform their particular function needs to be *explained*, including:

- how the mouthparts ingest food
- how the parts of the digestive system mechanically and chemically digest food
- the occurrence and function of enzymes
- the location of absorption, and how it occurs
- mechanisms to increase SA for digestion and/or absorption
- how digested nutrients are transported
- removal of water and packaging of wastes for egestion.

For *each* group, reasons for *differences* between the groups need to be *explained*, including:

- differences in diet (e.g. types of mouthpart, presence/absence of cellulose-digesting bacteria, length of intestines, types of enzymes, presence of anti-coagulents in saliva or crop)
- differences in size of the animals (e.g. the need for a transport system for digested nutrients)
- habitat – e.g. aquatic or terrestrial (filter feeding only in aquatic medium, terrestrial animals need to conserve water in wastes, fluid feeders need less complex digestive system)
- life cycle (e.g. different diets at different stages of life cycle – larvae/adults in insects with complete metamorphosis such as butterflies, amphibians such as tadpoles/frogs). These differences also reflect differences in the ecological niche of an animal at different stages in its life cycle.

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