# *Why are hens' teeth hard to find?*

## Ingesting food

### *Birds*

Have you ever heard the saying, 'as rare as hens' teeth'? Hens' teeth are not rare – they do not exist, because birds do not have teeth. A bird's **beak** and **tongue** carry out many of the feeding activities of teeth. The beak has very sharp edges and **ingests** (takes in) food. The shape and size of the opening, called the **gape**, of a bird's beak is related to the type of food the bird eats. For example, the kereru or wood pigeon can open its beak 14 mm, wide enough to eat the fruits of the miro tree, each about 14 mm in diameter.

### *Kiwi*

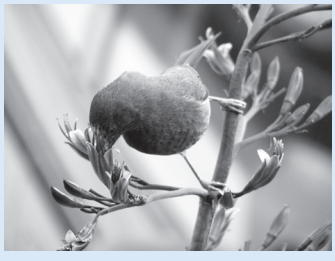
The kiwi has a very long, thin beak. The beak has whiskers for feeling at the head end and nostrils for smelling at the tip end.

Kiwi feed at night. With their nostrils and the tips of their beaks, they smell and sense movements of prey, such as worms and insects, up to 3 cm under the soil. Kiwi push their long beaks through the leaf litter and soil to catch the prey. Then they pull gently until the prey is pulled out and can be ingested.


The New Zealand kiwi is the only bird in the world with its nostrils at the tip of the beak.

### *Bellbird*

The bellbird has a short, slightly curved beak with a gape of 6 mm, which enables it to ingest **invertebrates** (insects, worms, spiders), nectar and fruit. The bellbird's diet changes with the seasons, so the beak must be able to ingest many different types of food.



The following table shows the different percentages of various food types eaten by bellbirds throughout the year, in autumn, winter and summer.

| Type of food | Percentage eaten | | |
|---|---|---|---|
| | Autumn | Winter | Summer |
| Invertebrates | 37 | 86 | 38 |
| Honeydew | 3 | 14 | 6 |
| Fruit | 60 | 0 | 0 |
| Nectar | 0 | 0 | 56 |

### *Tui*

The tui's curved beak is exactly the right shape to collect nectar from the bottom of flax flowers. The tip of a tui's tongue is split into many thin strips. The tongue dips into the nectar and is then drawn back into the beak, full of nectar.

### *Kea*

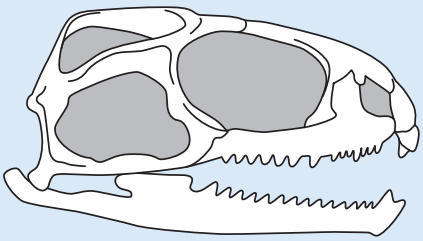
Kea are members of the parrot family. They have a long curved top beak and a very short lower beak. This sort of beak is extremely strong. Its shape lets kea ingest a wide range of foods. Kea feed on more than 40 different plant species, often eating the entire plant – leaves, buds, roots, flowers, fruits and seeds. Kea also eat invertebrates such as beetle larvae, as well as birds' eggs and chicks, rabbits, and even sheep.

Kea that live in wildlife parks eat nuts, carrots, bread, meat and pasta. Kea are known as cheeky birds that take and damage objects. Their beaks are so strong that they can rip apart campers' boots, car parts and books.

## Reptiles

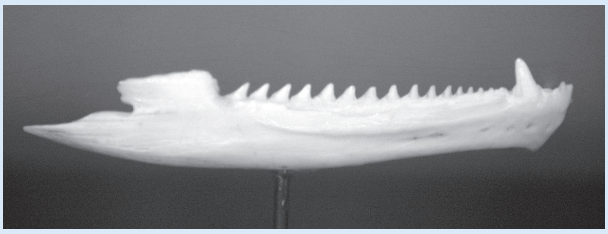
### *Tuatara*

Tuatara have three sets of teeth. When the tuatara closes its mouth, the lower teeth fit perfectly between the two rows of teeth on the upper jaw. Tuatara are the only living animal with this arrangement of teeth.



Tuatara skull

Tuatara teeth are made of bone. The teeth do not sit in the jawbone as human teeth do. Instead, the teeth sit on the jawbone in the same way as snakes' teeth. The teeth cannot grow, so they wear away as the tuatara gets older. Then the tuatara has to chew food on its smooth jawbone. Old tuatara have to eat soft food, such as worms and slugs.



Tuatara jaw

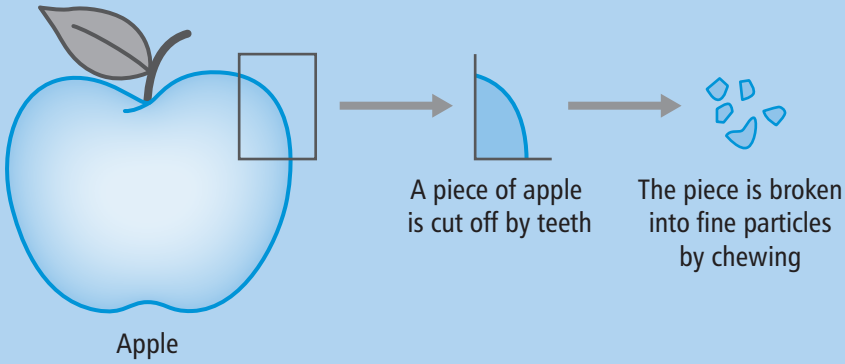
At night tuatara sit outside their burrows and use their sticky fat tongues to catch small animals that come close. These are usually weta, millipedes, spiders, lizards, beetles, grasshoppers, beetle larvae and slugs. Tuatara also eat birds' eggs and chicks.

The tuatara's bite is so powerful that it can cut through bone, and the hard material in the skeleton of an insect.

Biting cuts food into pieces small enough to be ingested. Food is chewed slowly, with the jaw moving backwards and forwards. Chewing is **physical digestion**, in which lumps of food are broken into smaller lumps so the food can be swallowed.

**Example: Physical digestion**

Taking bites of an apple breaks the apple into smaller pieces. Chewing turns the pieces into many smaller particles. This makes the apple easier to swallow and increases its total surface area ready for chemical digestion. The chemical composition of the apple has not yet been changed, so this process is called 'physical' digestion.




Physical digestion – an apple

## *Why are hens' teeth hard to find?*

Answers p. 73

**1.** What is special about the beaks of the following birds?

**a.** Kiwi

**b.** Tui

**c.** Kea

**d.** Explain how the position of its nostrils is helpful to a kiwi.

**2. a.** What does the word 'ingest' mean?

**b.** Describe how kiwi catch and ingest food.

**c.** In the following spaces, name six foods ingested by kea.

| | | |
|---|---|---|
| | | |

**3.** Describe how the shape of a tui's tongue is related to the tui's diet.

**4.** **a.** What is special about the arrangement of teeth in tuatara?

**b.** Why must old tuatara eat a different diet from young tuatara?

**c.** From what material are tuatara teeth made?

**d.** The photo shows human teeth. Describe how the attachment of tuatara teeth is different from the attachment of human teeth.

**5.** **a.** What is 'physical digestion'?

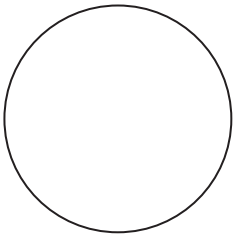
**b.** Explain why physical digestion is important.

**6.** **a.** Draw three pie charts to show the changes in a bellbird's diet over a year. (Remember 10% = 36°). First, complete the key to show a colour to represent each type of food.

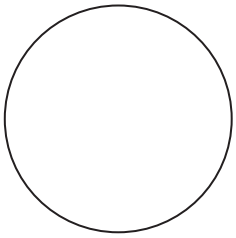
Key:

| | |
|---|---|
| | Invertebrates |
| | Honeydew |
| | Fruit |
| | Nectar |

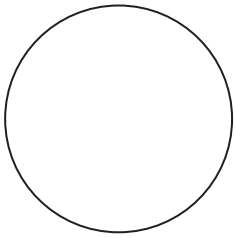
Autumn



Winter



Summer



**b.** Explain why the bellbird's diet is different in different months of the year.

**7. a.** Use examples to explain how the structures of the beaks of two different birds are related to how those birds find and ingest their food. Name the birds.

Bird 1: _____

Bird 2: _____

**b.** Explain why birds do not need teeth.

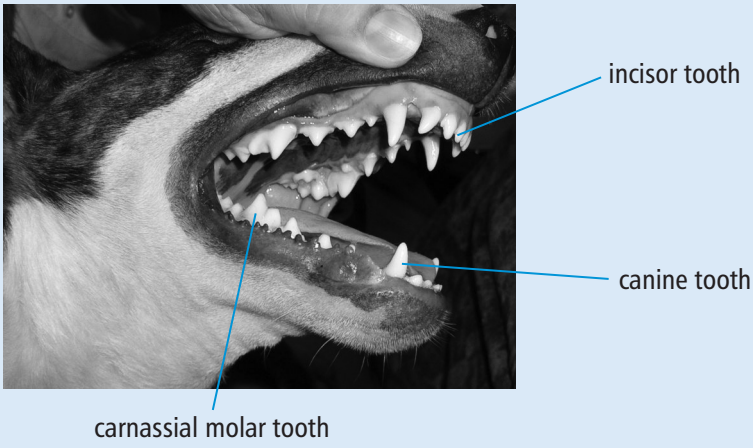
**c.** How is a bird's diet related to the size of the opening of the beak?

## YOUR INVESTIGATION

# *Why do dogs 'wolf down' their food?*

Physical digestion by chewing breaks large lumps of food into smaller lumps. However, even though dogs have many teeth, they do not spend much time chewing their food. Instead, they 'wolf' their food down quickly. Sometimes dogs have to throw up big lumps of food, cutting them into smaller pieces before swallowing again.

All animals have features, called **adaptations**, to help with the ingestion and digestion of food. The feeding adaptations of wild dogs help the dogs hunt and kill prey. Dogs have a powerful up-and-down bite and use their large pointed **canine** teeth to hold the prey. Large chunks of meat are ripped apart and swallowed whole. With their small incisor teeth, dogs nibble meat from bones, while the strong sharp **carnassial** teeth crack bones to get to the bone marrow inside.




## Chemical digestion

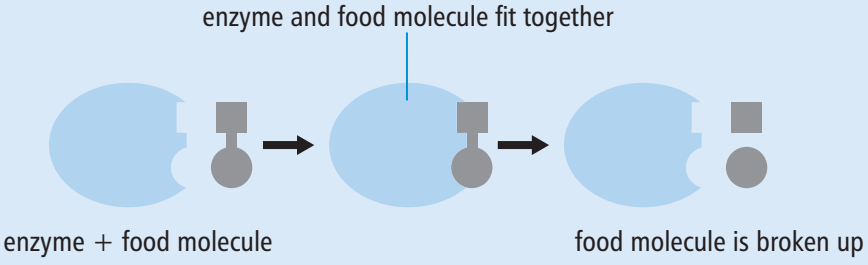
Dogs do not need to chew meat because **chemical digestion** is more important for carnivores (meat eaters) such as dogs than is physical digestion, by chewing.

Chemical digestion:

- breaks down large food molecules into small molecules
- produces food molecules small enough to be **absorbed** from the gut into the blood and transported around the body
- requires chemicals called **enzymes**.

### Enzymes

Enzymes are small **protein** molecules that have an area that is the **active site**. Different types of enzymes have differently shaped active sites. The shape of the active site matches the shape of one type of food molecule so the enzyme and food molecule can fit together. This is the only type of food that particular enzyme can break down.




Enzymes make digestion take place much more quickly than would be possible without enzymes. Without enzymes, digestion of food would take days rather than hours.

## *Adaptations for diet*

The diet of every animal must supply nutrients that:

- can release the energy needed to run life processes
- can be made into other materials, e.g. hair, feathers, muscles, enzymes, DNA
- cannot be made by the animal itself, e.g. vitamins, minerals, some fatty acids.

Most food chemicals (carbohydrates, proteins and fats) are used in **cell respiration** to produce an energy-carrying chemical called **ATP**. All cells need some energy just to stay alive, i.e. for **resting metabolism**. The energy in ATP maintains resting metabolism, as well as providing for activity, replacement of cells and temperature control. When an animal takes in more food chemicals than it needs for ATP production, the excess glucose, amino acids and fatty acids go towards growth or reproduction, or can be stored in the body.

## Feeding groups

Animals can be put into groups according to the type of food they eat. The main groups are **herbivores**, which eat plants, **carnivores**, which eat other animals, and **omnivores,** which eat both plants and animals. The digestive systems of animals in these groups have different features, related to their different diets. For example, gut lengths are different.

### Gut lengths

Scientists studied tropical fish to find out about the relationship between food type and gut length. The following table shows their results.

| Food type | Average length of gut compared with length of fish body |
|---|---|
| Carnivore | Gut length *less than* the length of the body |
| Omnivore | Gut length up to *twice as long* as the body |
| Herbivore | Gut length between *5* and *30 times longer* than the body. |

The difference in gut length is related to the **digestibility** of the different foods in the diet.

#### *Carnivores*

The diet of a carnivore is mostly meat, which is made of protein. Food containing a large amount of protein does not need much physical digestion. Protein is easily broken down into amino acids, by strong hydrochloric acid (pH = 1) and protease enzymes. Because protein is digested and absorbed quickly, a carnivore's gut is short.

#### *Omnivores*

The gut of an omnivore is longer than a carnivore's gut because of the different digestibility of the many types of foods an omnivore eats. Protein in the diet is quick and easy to digest, but some carbohydrates take longer, so the gut is longer. Omnivores do not eat the large volumes of plant material that herbivores eat, so omnivore guts are shorter than herbivore guts.

#### *Herbivores*

Herbivores have the longest guts. Herbivore species also have the widest range of gut lengths, because of the range of digestibility of plant materials. For example, nectar, containing simple sugars, is easy to digest compared with grass, which contains mostly cellulose.

Herbivores have a wide range of strategies for dealing with hard-to-digest cellulose and lignin, the two main carbohydrates in plant material. For example, snails can produce the enzyme cellulase, so snails have a short gut (for a herbivore), because cellulose is digested quickly by cellulase. However, most herbivores cannot produce cellulase, so cellulose is digested slowly, by micro-organisms in the gut.

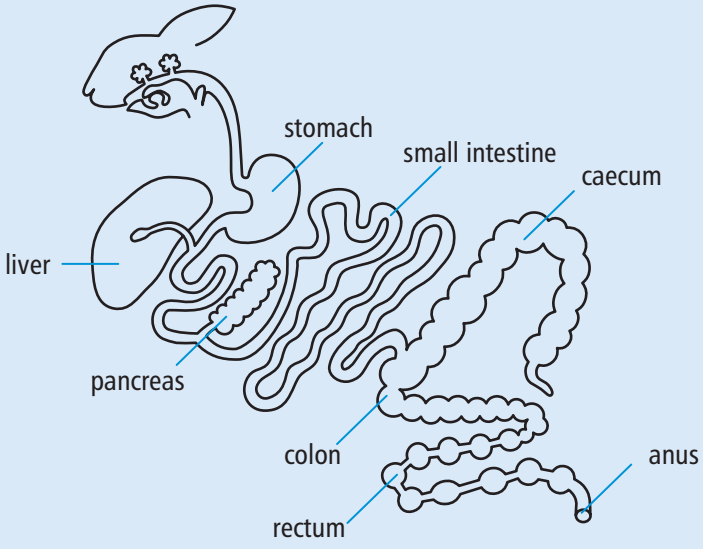
Different herbivores have the micro-organisms in different parts of their gut. The parts containing the micro-organisms make up a much higher percentage of the gut volume than the other parts. The following table gives the percentage volume of the different parts of the gut in two herbivores and two omnivores.

| Volume of organs in the digestive system | | | | |
|---|---|---|---|---|
| | Herbivore | | Omnivore | |
| | Horse | Cow | Hen | Pig |
| Total volume | 170 L | 300 L | 1 L | 26 L |
| Stomach<br>Rumen<br>Reticulum<br>Omasum<br>Abomasum<br>Crop<br>Proventriculus<br>Gizzard | 8% | 68%<br>(54%)<br>(3%)<br>(5%)<br>(6%) | 58%<br><br><br><br><br>(43%)<br>(1%)<br>(14%) | 30% |
| Small intestine | 25% | 20% | 26% | 34% |
| Caecum | 19% | 3% | 6% | 4% |
| Large intestine | 48% | 9% | 10% | 32% |

In a horse, the micro-organisms are in the caecum and large intestine – 67% of their digestive system. In cows, the micro-organisms are in the rumen – 54% of their digestive system. Pigs, which are omnivores, have a similar volume in the three main areas of the gut: stomach, small intestine and large intestine. The crop, which is for storage, is the largest organ by volume in a hen's digestive system.

### *Herbivore example: the rabbit*

Rabbits are herbivores that exist on a diet of grass, which is digested largely by micro-organisms living in the rabbit's caecum.



Most of the nutrients released by the micro-organisms cannot be absorbed by the caecum or large intestine. However, the nutrients are not wasted, because rabbits have a **behavioural adaptation**, called **cecotrophy**, in which they eat their own faeces. During the day, rabbits egest dry faecal pellets containing indigestible material, but at night, they produce and egest a soft moist faecal pellet that contains material from the caecum. The pellets contain large amounts of VFAs, protein, vitamin B, sodium, potassium and water. The rabbit ingests the pellets (often directly from the anus) and the pellets go through the digestive system again. Proteins from the micro-organisms are digested and the amino acids and other nutrients are absorbed through the villi in the small intestine. Gaining the extra nutrients from the micro-organisms enables rabbits to survive well on a low-quality diet of grass.

Panda bears are herbivores, but with a short 'carnivore' gut. Their gut contains 13 species of bacteria to help digest bamboo, but pandas can digest only 20% of the food they eat. A slow-moving lifestyle helps pandas conserve energy, reducing the amounts of nutrients they need.

## *Adaptations for diet*

Answers p. 76

**1. a.** Complete the sentence:

An animal's diet must supply chemicals that are used to release _____ .

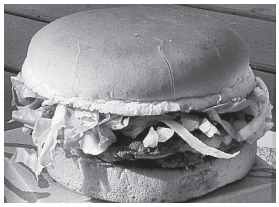
**b.** Each of the letters in 'MRS GREN' begins the first word in a life process carried out by living things. Name two life processes that require energy.

_____

**c.** Name three materials that food chemicals are changed into after being absorbed into an animal's body.

**i.** _____ **ii.** _____ **iii.** _____

**2. a.** Name the three most common groups of food chemicals.



**i.** _____

**ii.** _____

**iii.** _____

**b.** What is ATP's function in the cell?

_____

**c.** What two words are used to describe 'energy that cells use just to stay alive'?

_____

**d.** Complete the paragraph using words from the following word list.

amino ATP growth replacement stored temperature

The energy in ATP maintains resting metabolism, as well as providing for activity, _____ of cells and _____ control. When an animal takes in more food chemicals than it needs for _____ production, the excess glucose, _____ acids and fatty acids are used for _____ or reproduction, or can be _____ in the body.

**3. a.** Complete the following table. Describe the type of food eaten by each of the feeding groups. Give an example of an animal belonging to each feeding group, and an example of a food the animal eats.

| Group | Type of food eaten | Example animal from feeding group | Example of food |
|---|---|---|---|
| Carnivores | | | |
| Herbivores | | | |
| Omnivores | | | |

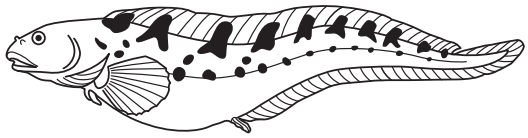
**b.** Write the following three groups of animals in order from those with the shortest gut to those with the longest gut: omnivores, herbivores, carnivores.

**c.** Gut length was measured in different species of fish. Use the information about gut length compared with body length of the six fish to work out if each fish is a herbivore, a carnivore or an omnivore. Colour the herbivores, carnivores and omnivores a different colour. Complete the key.

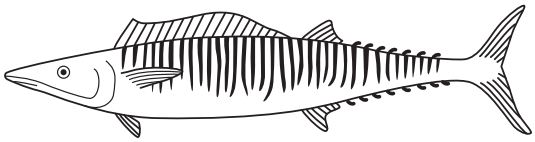
**Key**

| | |
|---|---|
| | Herbivore |
| | Carnivore |
| | Omnivore |

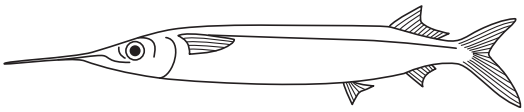
Fish 1: Gut length just under twice the body length



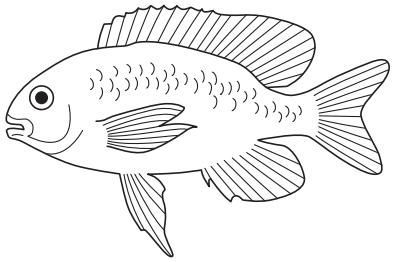
Fish 2: Gut length almost the same as body length



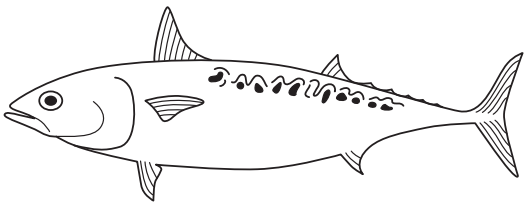
Fish 3: Gut length seven times the length of the body



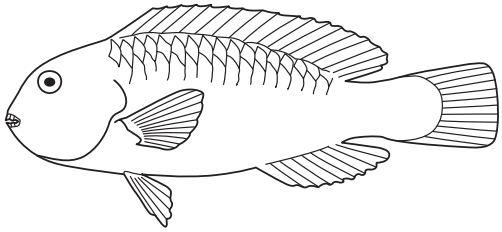
Fish 4: Gut length just over twice the length of the body



Fish 5: Gut length slightly longer than body length



Fish 6: Gut length five times the length of its body



# Answers

## Why are hens' teeth hard to find? (page 3)

**1. a.** Kiwi – long and thin with nostrils at tip

**b.** Tui – curves to fit the flax flower

**c.** Kea – long curved top and short lower beak so it can feed on many different foods

**d.** Having nostrils at the tip of the beak helps kiwi smell food animals in the soil under the leaf litter.

**2. a.** Take in food.

**b.** Kiwi push their long beaks through the leaf litter and soil to catch the prey. Then they pull gently until the prey is pulled out and can be ingested.

**c.** Six from: entire plant, leaves, buds, roots, flowers, fruits, seeds, invertebrates, beetle larvae, eggs, chicks, rabbits, sheep, nuts, carrots, bread, meat, pasta.

**3.** Tui feed on nectar. The end of the tongue is divided into thin strips that are dipped into the nectar and then drawn into the mouth.

**4. a.** Tuatara have three sets of teeth. When the mouth is closed, the lower teeth fit perfectly between the two rows of teeth on the upper jaw.

**b.** When their teeth wear away, old tuatara have to eat soft food such as worms.

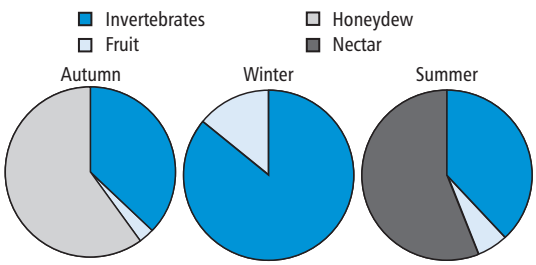
**c.** Bone

**d.** Human teeth are set *in* the jawbone; tuatara teeth are *on* the jawbone.

**5. a.** Physical digestion, such as chewing, breaks down large lumps of food into smaller lumps.

**b.** With smaller lumps, the food is easier to swallow, and has a greater surface area for enzyme action.

**6. a.** Percentages of food types eaten by bellbirds at different times of the year, shown as pie charts:




**b.** Different foods are available in different seasons, so the bellbirds have different diets in different seasons, e.g. mostly nectar from flowers in January (summer) and mostly fruit in March (autumn).

**7. a.** *Two of the following (or other suitable) examples:*

- kereru (wood pigeon) – has a gape of 14 mm, so can ingest large fruit
- kiwi – beak is long and thin so it can be pushed into the ground to obtain food such as worms
- bellbird – has a small gape so eats small fruits, nectar and small invertebrates
- tui – beak is curved in exactly the right shape to collect nectar from the bottom of flax flowers / tongue is split into many very thin strips so nectar can be drawn back into the beak
- kea – the long curved top beak and very short lower beak enable the beak to rip and tear tough foods.

**b.** Birds do not need teeth because their beaks carry out some of the functions of teeth. (The gizzard is also important for physical digestion.)

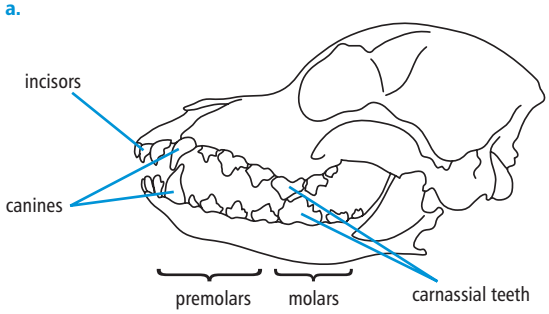
**c.** The size of the food a bird can ingest (e.g. seed or fruit) often depends on the extent to which the bird can open its beak.

## Why do dogs 'wolf down' their food? (page 8)

**1. a.** Physical digestion is the chewing or mixing of food to break lumps of food into smaller pieces.

**b.** and **c.** Mouth, has teeth with different functions to chew, rip and tear food. Stomach, has strong muscles in the wall to mix and churn food.

**2. a.**




**b.**

| Tooth type | Size | Shape |
|---|---|---|
| incisor | medium | pointed |
| canine | large | long sharp point |
| premolar | small to medium | sharp ridge |
| carnassial | large | sharp ridge |
| molar | medium | sharp ridge |

**3. a.** Chemical digestion is the breaking down of large food molecules into small molecules that can be absorbed from the gut into the blood.

**b.** **i.** amino acids **ii.** fatty acids / glycerol **iii.** fatty acids / glycerol **iv.** glucose

**c.**

| List A | List B |
|---|---|
| fat | lactase |
| sucrose | sucrase |
| protein | lipase |
| lactose | amylase |
| starch | protease |

**d.** Stomach

**e.** Has gastric pits that make protease enzymes; produces hydrochloric acid.

**4.**

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J | L | M | G | B | L | E | L | S | L | D | M | P | E | C |
| F | Z | P | S | J | F | M | K | T | X | G | Y | R | O | H |
| P | H | Y | S | I | C | A | L | O | V | O | V | E | J | E |
| X | C | A | N | I | N | E | B | M | E | I | E | M | J | W |
| D | E | C | H | E | M | I | C | A | L | R | Q | O | Z | I |
| C | C | A | P | J | G | W | Q | C | Q | C | Q | L | F | N |
| A | U | S | C | Y | T | K | G | H | H | Z | K | A | C | G |
| R | T | C | H | Y | D | R | O | C | H | L | O | R | I | C |
| N | A | C | T | I | V | E | S | I | T | E | L | F | E | I |
| A | U | H | A | O | F | D | I | G | E | S | T | I | O | N |
| S | A | G | A | S | T | R | I | C | T | S | L | Q | Y | M |
| S | E | N | Z | Y | M | E | Q | D | L | Q | Q | R | Q | R |
| I | E | L | P | R | O | T | E | I | N | Z | G | A | K | Z |
| A | E | K | U | B | I | N | C | I | S | O | R | O | A | O |
| L | C | N | L | I | F | M | O | L | A | R | C | O | Z | W |

**5.** **a.** The active site has a special shape that fits the shape of a particular food molecule. The active site is where the food molecule and enzyme join so the food molecule can be broken down.

**b.** Enzymes break down food molecules much more quickly than would be possible without them. Without enzymes, digestion would take too long.

**c.** **i.** Stage 2 **ii.** A **iii.** C and D

**6.** **a.** To feed dogs in a natural way they should be fed one large meal of raw meat three to four times a week. The meal must be large enough to fill the dog's stomach completely.

**b.** *A range of possible answers, such as:* difficulty in buying and storing raw meat, cost, inconvenience, availability of dry concentrated food, smell of 'off' meat, dog burying food not eaten immediately, bones left on the lawn.

**7.** **a.**

| Label | Name | Features (size, shape) | Function |
|---|---|---|---|
| A | molar | medium size, sharp ridge | cutting lumps of meat |
| B | carnassial | large size, sharp ridge | cracking bone |
| C | premolar | small to medium size, sharp ridge | cutting lumps of meat |
| D | canine | large, long sharp point | hold and kill prey |
| E | incisor | medium, pointed | nibble meat off bone |

**b.** The canine teeth in the upper jaw are so long that they fit on the outside of the lower jaw. This stops the jaw from moving sideways.

**8.** **a.** Physical digestion breaks lumps of food into smaller lumps, whereas in chemical digestion enzymes break down the molecules in food into smaller molecules. Physical digestion, such as chewing and stomach churning, is needed to give plenty of food surface for enzymes to attach to. Without chemical digestion, food molecules would be too large to be absorbed into the blood.

**b.** Protein is easy to digest with enzymes and acid, so dogs wolf their food down without chewing and let the stomach do all the digesting.

## Sheep, cows and greenhouse gases (page 16)

**1.** **a.** Burping by sheep and cows releases methane and carbon dioxide gases into the air. These gases are greenhouses gases that cause global warming.

**b.** fermentation

**c.** The rumen continues to expand as gases build up until the rumen pushes on the lungs, which kills the animal.

**d.** Calves and lambs feed on milk that is digested in the abomasum, not in the rumen / the reticulorumen does not contain any micro-organisms to produce the gases.

**2.** **a.** cellulose

**b.** cellulase

**c.** slugs, snails, some micro-organisms, bacteria, protozoa, fungi *(any three)*

**d.** sheep, cows, humans *(any two)*

**e.** Micro-organisms in their gut digest the cellulose.

**f.** Cellulose is made up of many glucose molecules joined in layers.

**3.** 1. oesophagus → 2. rumen → 3. reticulum → 4. omasum → 5. abomasum → 6. small intestine

**4.** **a.** bacteria, protozoa, fungi

**b.** temperature of 38 °C; slightly acid, anaerobic, plenty of food, plenty of water, constantly mixed

**c.** Three-quarters

**d.** The numbers of some types of micro-organism increase and numbers of other types decrease when the diet of a cow is changed.

**e.** Sudden changes in diet are harmful because the numbers of the correct type of micro-organism to digest the new type of food take time to increase before there are enough to digest the new food.

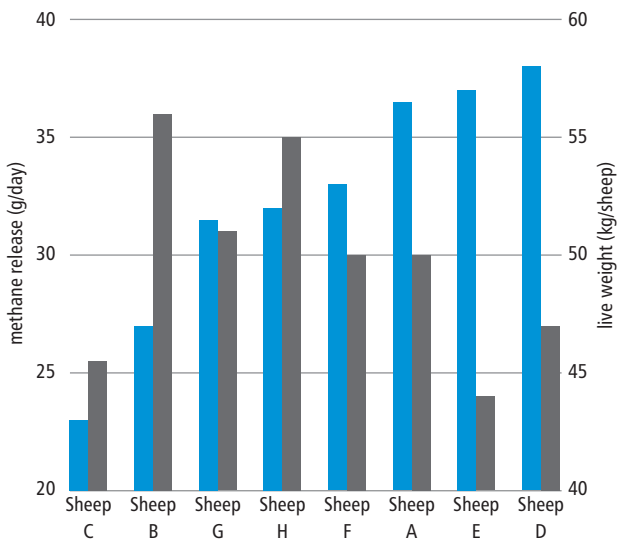
**5.** **a.**

| ← Lowest methane release (g/day) | | | | | | Highest methane release (g/day) → | |
|---|---|---|---|---|---|---|---|
| Sheep | Sheep | Sheep | Sheep | Sheep | Sheep | Sheep | Sheep |
| C | B | G | H | F | A | E | D |

**b.**

| | Four lowest methane-producing sheep (g/day) | Four highest methane-producing sheep (g/day) |
|---|---|---|
| Average methane release (g/day) | 28.4 | 36.1 |
| Average live weight (kg/sheep) | 51.9 | 47.8 |

**c.** Methane release (g/day) and live weight (kg/head) for eight sheep from lowest methane release to highest




**d.** No. The sheep producing the most methane have lower live weights OR lower average live weight.

**e.** To make sure the investigation was a fair test by checking that other factors that could not be controlled were staying reasonably steady and not causing differences in the results.

**6.** **Across:** 2. papillae; 3. cellulose; 6. abomasum; 8. methane; 9. rumen

**Down:** 1. cellulase; 4. VFA; 5. rumination; 7. omasum; 9. reticulum