Heterotrophic nutrition

Heterotrophic organisms are organisms that feed on complex ready-made organic food. They use it as source of: -

(i) energy for their vital activities,
(ii) building materials, that is specific atoms and molecules for cell maintenance and repair and growth,
(iii) vitamins (co-enzymes) that cannot be synthesised in organism but which are vital specific cellular processes.

The main forms of heterotrophic nutrition include
(i) holozoic,
(ii) saprotrophic (or saprophytic) e.g. mould, mushroom
(iii) mutualistic
(iv) parasitic, although some overlap between groups may occur.

Holozoic nutrition

It is a type of heterotrophic nutrition involves the following processes

(i) **Ingestion:** is taking in of complex organic food(solid or liquid).
(ii) **Digestion:** is the breakdown of large complex insoluble organic molecules into small, simple soluble diffusible molecules. This is achieved by mechanical break down and enzymatic hydrolysis. Digestion may be either extra or intra cellular.
(iii)**Absorption:** is the uptake of the soluble molecules from the digestion region, across a membrane and into the body tissue proper. The food may pass into the blood stream to be transported to appropriate regions within the body of the organism.
(iv) **Assimilation** is the utilisation of the absorbed molecules by the body to provide either energy or materials to be incorporated into the body.
(v) **Egestion** is the elimination from the body of undigested waste food materials.

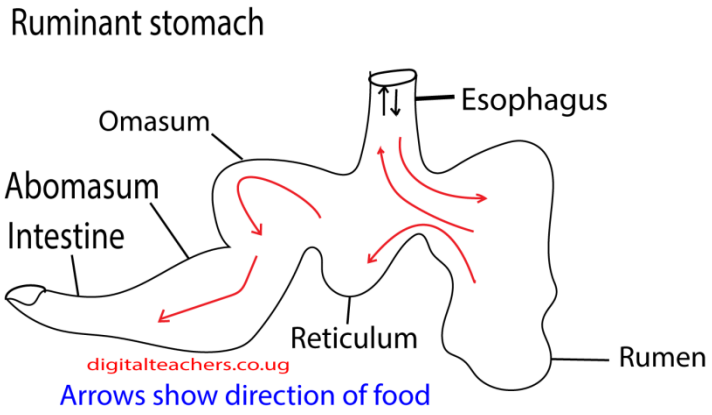
Animals which feed one plants are called **herbivores,** those that feed on other animals **carnivores,** and those that eat a mixed diet of animal and vegetable matter are termed **omnivores.**

If they take in food in form of small particles the animals are **microphagous** feeders, for example earthworms, whereas if the food is ingested in liquid form they are, classed as **fluid feeders,** such as aphids and mosquitoes. Animals which take in food in the form of large pieces are termed as **macrophagous.**

Herbivores

Challenges of herbivores while feeding on plant

(i) Indigestible cellulose
This is overcome in two ways
(a) Ruminant e.g. cow and goat; developed a porch at anterior end of the stomach called rumen that provides space for bacterial fermentation of ingested leaves.



(b) Other herbivores such as horse, zebra, rabbit, have well developed cecum inside which bacteria digest cellulose. Unfortunately, the cecum is ta the end of the intestine that absorption of digested materials may not be efficient. Actually, rabbit feed on their faeces to obtain enough nutrients from their food.

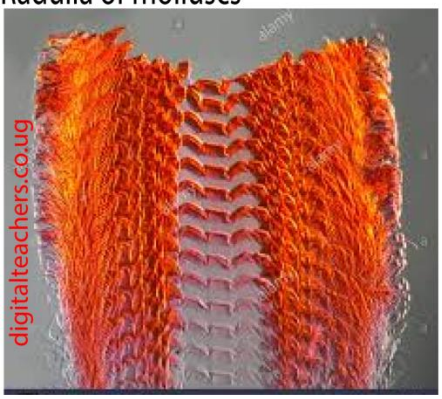
(ii) Low nutrient value in plant materials: this is overcome by eating large volume of food.

(iii) Cellulose in plant cell walls makes materials tough and difficult to digest, herbivores like cow and elephants have strong premolar and/or molar with ridges and large surface area to grind food. These molar and premolar grow throughout life.

Molar of cow

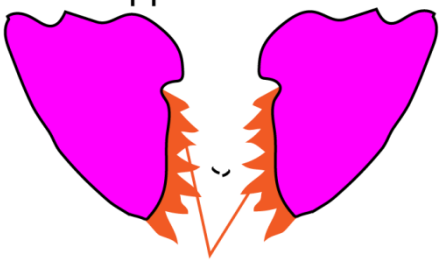
Herbivorous molluscs such as the snail possess a rasping organ, the **radula.** The radula is like a serrated conveyor belt, which by rubbing backwards and forwards against the hardened roof of the mouth can tear plant food

Radulla of molluscs



Herbivorous insects like the locust have a pair of mandibles with a gagged edge for cutting through leaves of grass and other plants

Grasshopper mandibles



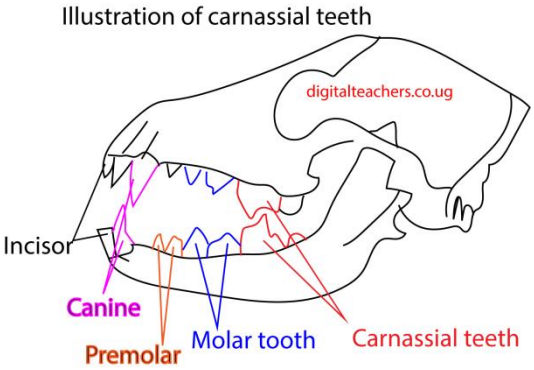
Sharp cutting edges

Carnivores

The challenge is not so much digesting the food as obtaining it.

Adaptation of carnivores to obtaining food

1. high speed locomotion,
2. sharp claws and dagger like **canine** teeth in the great cats,
3. sucker **- bearing tentacles** in octopus and squids
4. tentacles armed **with stinging cells** in sea anemones and jelly fishes.
5. teeth for tearing flesh for instance dog has strong canine and carnassial teeth for tearing meat.



Insectivorous plants.

These insectivorous plants live in nitrogen - deficient soils. All have green leaves and obtain their carbonhydrates by photosynthesis; they obtain nitrogen from trapping and digestion of small animals, particularly insects

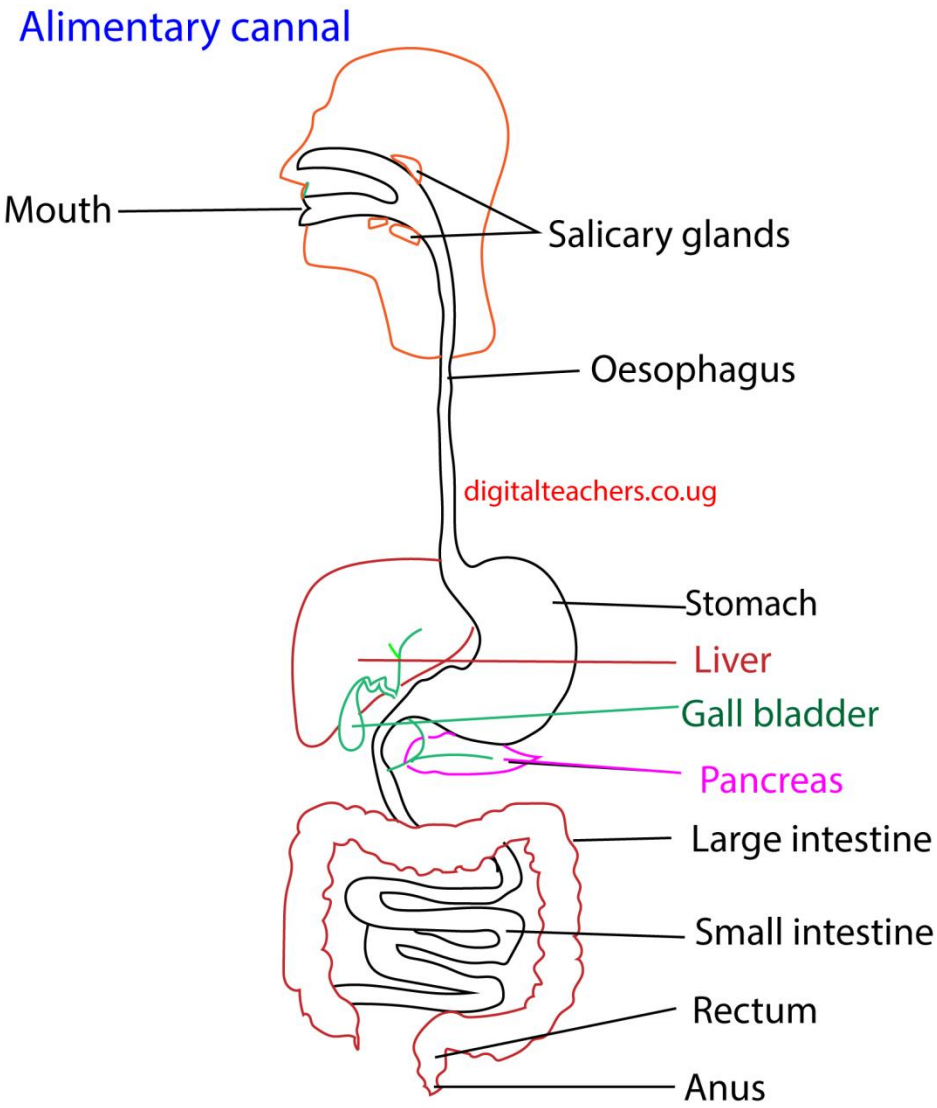
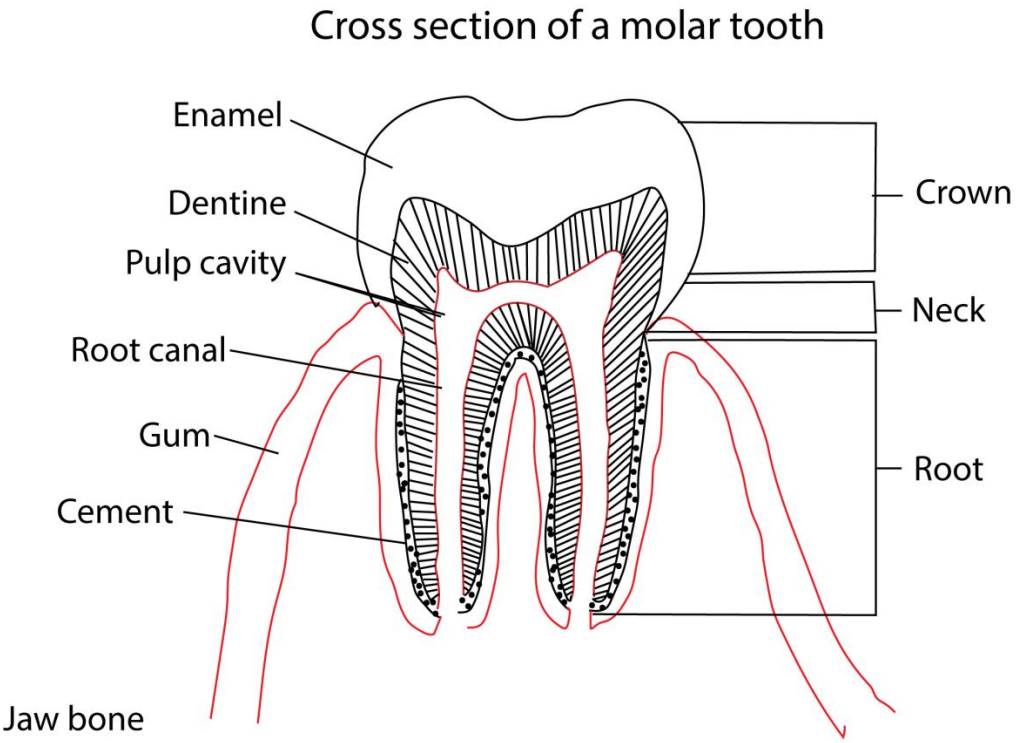


Table 1.: Summary of the functions of the different parts of the human digestive system.

SPECIALISED PART	FUNCTION
Buccal cavity	Ingestion, mastication.
Pharynx	Swallowing.
Oesophagus	Links pharynx to stomach
Stomach	Food storage and digestion of proteins.
Duodenum	Digestion and absorption.
Liver (bile)	Emulsification of fats.
Pancreas (pancreatic juice)	Digestion of starch, proteins and fats.
Iteum	Completion of digestion & absorption of food
Colon	Absorption of water.
Rectum	Formation and storage of faeces.
Anus	Egestion

In the buccal cavity.
The food is broken up into smaller pieces by the chewing action of the teeth (**mastication)** and moistened by **saliva** from the salivary glands.



Dental formulae
It is written as an expression of the number of each type of **tooth** in one side of the upper jaw over the number of **teeth** in one side of the lower jaw. The letters correspond to the type of **teeth** (I = Incisor, C = Canine, P = Premolar, M = Molar).

Dental formula of human deciduous = $I\frac{2}{2}, C\frac{1}{1}, P\frac{2}{2}$, total 20

Dental formula of human permanent = $I\frac{2}{2}, C\frac{1}{1}, P\frac{2}{2}, M\frac{3}{3}$, total 32

Dental formula of sheep, goat, cow = $I\frac{o}{3}, C\frac{0}{1}, P\frac{3}{3}, M\frac{3}{3}$, total 32

In the stomach
The stomach is a dilated part of the gut where the food remains for two or more hours

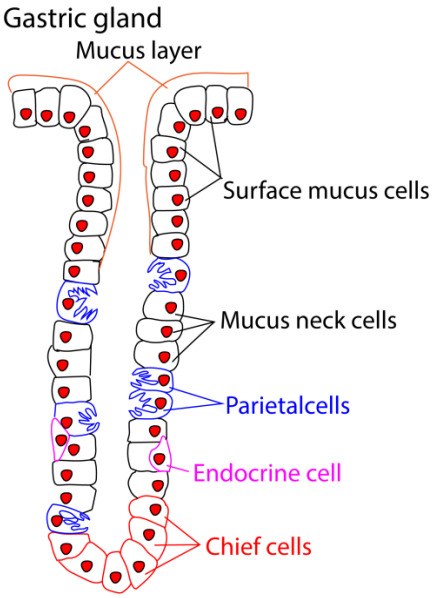
Once in the stomach the food gastric gland in gastric wall secrete **gastric juice**

Gastric juice contains
(i) **Hydrochloric acid** that kills germs and provide pH for the action of pepsin

(ii) Enzyme **pepsin** which breaks down proteins into short polypeptide chains. Pepsin is secreted as an inactive precursor **pepsinogen** to prevent the gastric gland being destroyed by its own enzyme (auto-digestion).

(iii) Enzyme **renin** coagulates casein, the soluble protein of milk, forming insoluble card which is then attacked by pepsin.

These enzymes are secreted by the **chief (or peptic) cells** in the walls of the gastric glands.



Parts of gastric gland

(i) Mucus cell secrete mucus that protects stomach wall for pepsin,

(ii) Parietal cells (**oxyntic** cells) are the epithelial cells that secrete hydrochloric acid (HCl) and **intrinsic** factor.

(iii) The **gastric chief** cell (also known as a zymogenic cell or peptic cell) is a cell in the stomach that releases pepsinogen and chymosin. Pepsinogen is activated into the digestive enzyme pepsin when it comes in contact with acid produced by gastric parietal cells.

Duodenum

Receives secretion from pancreas and gall bladder

(a) Gall bladder produces bile that emulsifies fats.

(b) Pancreas produces pancreatic juice that contains.

(i) Pancreatic amylase: breaks down starch to disaccharide maltose.

(ii) Pancreatic lipase**:** breaks down tri-glycerides in the emulsified fat into mono-glyceride and fatty acids.

(iii) Protease**:** (Protein - splitting enzymes) which include **trypsin, chymotripsin, carboxy-**peptidare and **elastase**)**.**

The four proteases are secreted as inactive precursors; **trypsinogen, chymotrypsinogen, pro-carboxypeptidase** and **pro-elaslase to** prevents auto-digestion. Trypsinogen is converted into trypsin by the action of the enzymes **enterokinase,** secreted by the wall of the small intestine. The trypsin then activates the other three proteases. These pancreatic protease breaks down proteins and polypeptides into **tripeptides** and **dipeptides.**

Pancreatic juice also contains **nucleases** which break down nucleic acids into nucleotides and a variety of **peptidases** which release some free amino acids from polypeptide chains.

(iv) **Bicarbonate** neutralise acidic chime from the stomach

Intestinal enzymes

Various enzymes, associated with the epithelial lining of small intestine complete the digestion of carbohydrate by breaking down disaccharides into mono-saccharides.

These enzymes include: -

- **Maltase:** hydrolyses maltose to glucose, thus completing digestion of starch.
- **Sucrase** hydrolyses sucrose (Sugar cane) to glucose & fructose.
- **Lactase** hydrolyses lactose (Milk sugar) to glucose & galactose.

The end products of carbohydrate digestion are all mono-saccharides. The final stage of carbohydrate digestion is **intra-cellular**, as disaccharides are absorbed by the plasma membrane of the epithelial cell before broken down into monosaccharides.

The epithelial cells also absorb tripeptides and dipeptides which are then broken down into **amino acids** by various peptidases. Thus, the final stages of protein digestion are also intra-cellular.

Nucleotidases: are also present in the epithelial cells of the small intestine. They split nucleosides into constituent submits.

Brunner's gland

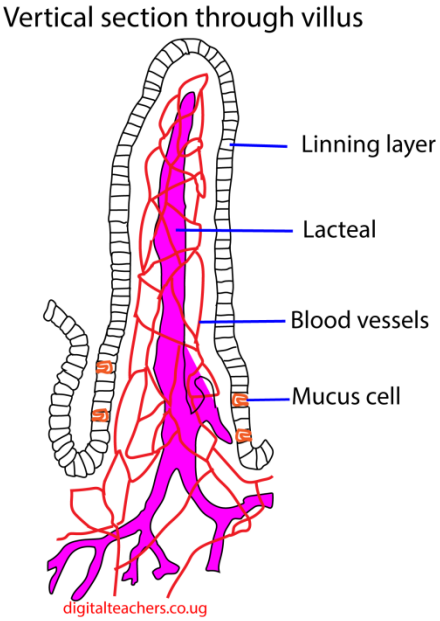
Found in the walls of duodenum, secrete alkaline mucus which:

- protect the duodenum from the acidic content of **chyme** (which is introduced into the duodenum from the stomach);
- provide an alkaline condition for the intestinal enzymes to be active, thus enabling absorption to take place;
- lubricates the intestinal walls.

At the bottom of Brunner's gland are cells called Crypts of **lieberkutin** that secrete enzyme for final digestion.

Adaptation of small intestine for absorption of food

1. Long to allow food enough time for absorption
2. Villi and microvilli increase surface area for absorption
3. Well supplied by blood to carry away absorbed food so as to maintain diffusion gradient
4. The villi have thin membrane to reduce diffusion gradient
5. Villi have high concentration of mitochondria to provide energy for active transport.
6. **circular fold** increase surface area for absorption
7. Villi contain lacteal for absorption of fats



Exercise

1. Which one of the following is set of nutrients which are final product of digestion in humans?
   A. Fats and maltose
   B. Amino acid and fatty acids
   C. Lactose and glycerol
   D. Sucrose and oils
2. The total number of teeth in an animal having a dental formula $I\frac{2}{1}\ C\frac{0}{0}\ Pm\frac{3}{2}\ m\frac{3}{3}$ is
   A. 24 B. 28 C. 30 D. 32
3. Digestion of proteins in mammals start in the
   A. Stomach
   B. Mouth
   C. Duodenum
   D. Ileum
4. Which of the following pairs of enzymes is contained in the juices secreted in the pancreas?
   A. Amylase and pepsin
   B. Trypsin and amylase
   C. Maltase and sucrose
   D. Peptidase and lactase

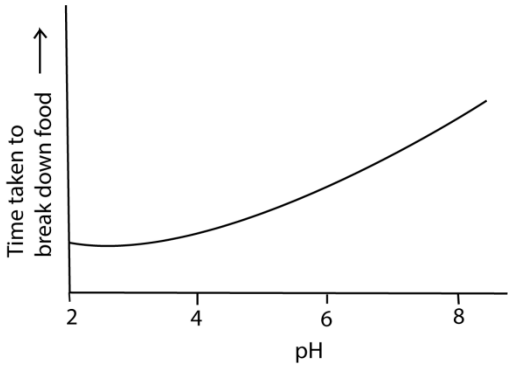
5. Termite are able to eat wood because
   A. They produce cellulose enzyme
   B. They possess strong mandible
   C. Microscopic fungi live in their guts
   D. They ingest only small pieces
6. Which one of the following is a role of bile in food digestion?
   A. Providing suitable medium for action of enzymes in duodenum
   B. Breaking down fats
   C. Activating enzymes
   D. Catalysing action of enzymes
7. Four test tubes, each with contents as indicated in the following table were incubated at a temperature of 37^0C for sometime

Test tube	Content
1	Albumen + pepsin
2	Albumen + dilute hydrochloric acid
3	Albumen + pepsin + dilute hydrochloric acid
4	Albumen + boiled pepsin + dilute hydrochloric acid

   In which test tube did the contents become clear?
   A. 1
   B. 2
   C. 3
   D. 4

8. Bile salts help in digestion of fats by
    A. Neutralising excess stomach acids
    B. Converting fats into simpler substances
    C. Breaking fats into simpler particles
    D. Separating fatty acids from glycerol
9. Which of the following digestive processes is catalysed by amylase enzyme?
    A. Maltose to glucose
    B. Sucrose to glucose and fructose
    C. Starch to maltose
    D. Lactose to glucose and galactose
10. Which one of the following is the mode of feeding of a mould?
    A. Holozoic
    B. Saprophytic
    C. Autotrophic
    D. Parasitic
11. Which one of the following enzymes act best at low pH?
    A. Pepsin
    B. Peptidase
    C. Trypsin
    D. Lipase
12. Which one of the following secretions does not play a digestive role in alimentary canal?
    A. Pepsin
    B. Renin
    C. Trypsin
    D. Lipase
13. Which one of the following enzymes acts in duodenum and ileum?
    A. Lipase
    B. Maltase
    C. Peptidase
    D. Secrase
14. Which one of the following is correct about nutrition in a Rhizopus?
    A. Digestion of food occurs outside the organism
    B. It makes its own food
    C. Digestion of food is intracellular
    D. It does not produce enzymes
15. Lack of iodine in human diety causes
    A. Anaemia
    B. Scurvy
    C. Goitre
    D. Rickets
16. Which one of the following parts of tooth contains living tissue
    A. Cement
    B. Pulp cavity
    C. Enamel
    D. Dentine

17. The graph below shows the effect of varying pH on the time taken for an enzyme to break down food.



Which one of the following enzymes below could have given the response?

A. Pepsin
B. Lipase
C. Salivary amylase
D. Trypsin

18. What mode of nutrition is used by Rhizopus?

A. Heterotrophic
B. Autotrophic
C. Parasitism
D. Saprophytic

19. The mode of feeding displayed by a mucor is described as

A. Holozoic
B. Filter feeding
C. Parasitic
D. Saprophytic

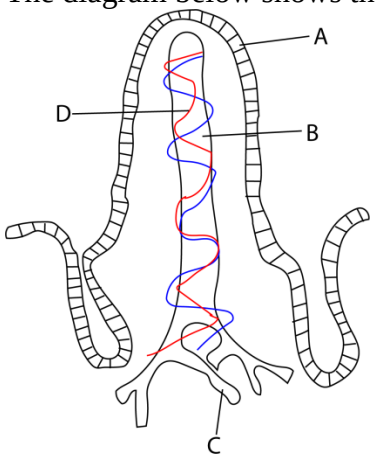
20. Which one of the following organisms carries out intracellular digestion?

A. Fungi
B. Algae
C. Amoeba
D. Hookworm

21. Milk teeth consist of

A. Incisor only
B. Incisor, canine, premolar
C. Incisor, canine
D. Incisor, premolar

22. The diagram below shows the structure of the villus



(a) Label parts marked A, B, C and D.
(b) What food substance enter
    (i) A
    (ii) B
(c) State two factors which make a villus an effective absorption structure.
(d) How does the absorbed food in B reach the general circulation?
(e) State two nutrients which are absorbed before reaching the villi.

23. (a) Describe the activities of digestion which occur in each of the following parts of alimentary canal
    (i) Stomach (04 marks)
    (ii) Ileum (06 marks)
    (b) How is the ileus adapted to food absorption (05marks)
24. (a) what is a balanced diet? (01)
    (b) in which ways is the ileum adapted to its function? (08marks)
    (c) Outline the fate of the food after absorption. (06marks)
25. (a) Describe the digestion of proteins in a mammal. (06marks)
    (b) Explain how the ileum is suited for its functions. (09maks)

Proposed answers

1	B	6	B	11	A	16	B	21	B
2	B	7	C	12	D	17	A		
3	A	8	C	13	C	18	D		
4	C	9	C	14	A	19	D		
5	B	10	B	15	C	20	C		

22 (a) A- lining layer
B – lacteal
C – lymphatic vessel
D –blood vessel

(b) A – glucose, amino acid, water, vitamins
B – fat droplets

(c) - thin lining facilitate diffusion
- rich blood supply transport absorbed food
- lacteal absorbs fat

(d) through internal jugular vein

(e) water and vitamins, glucose

23. (a) (i) digestion in stomach
- food is pound into small particles
- proteins are digested to poplypeptides
- sucrose is hydrolysed to fructose and glucose
- Amylase in bolus continues digestion of starch

(ii) digestion in small intestines
- Maltase digests maltose to glucose
- Lactase digest lactose to galactose and glucose
- Sucrose digests sucrose to fructose and glucose
- Peptidase digest polypeptides to amino acid.
- Nucleotidase digest nucleosides to nucleotides

(b) Adaptation of ileum

(i) Long to allow food enough time for absorption
(ii) Villi and microvilli increase surface area for absorption
(iii) Well supplied by blood to carry away absorbed food so as to maintain diffusion gradient
(iv) The villi have thin membrane to reduce diffusion gradient
(v) Villi have high concentration of mitochondria to provide energy for active transport.
(vi) **circular fold** increase surface area for absorption
(vii) Villi contain lacteal for absorption of fats

24 (a) A balanced diet is a diet consisting of a variety of different types of food and providing adequate amounts of the nutrients necessary for good health.

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(c) Fate of absorbed foods
- Proteins are used to make hormone, enzymes, tissues, antibodies and excess are deaminated to carbohydrates
- Carbohydrates provide energy
- Vitamins prevent deficient diseases

25. (a) digestion of proteins
- in mouth proteins are broken down into small particles
- in stomach proteins are digest to polypeptides by pepsin
- in duodenum proteins are digested by **trypsin, chymotripsin, carboxy**-peptidase and **elastase to polypeptides**
- In ileum polypeptides are digested by peptidase to amino acids