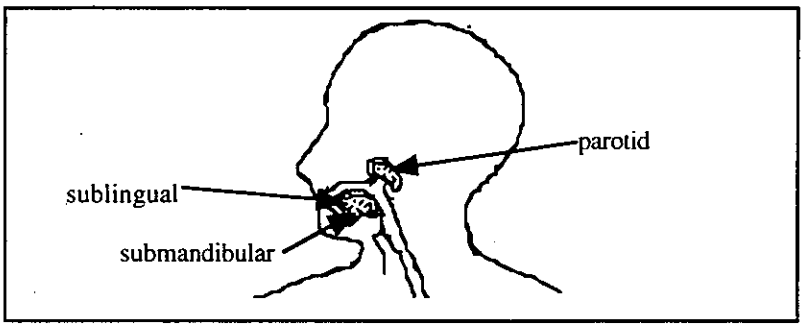
CHEMICAL DIGESTION NOTES

Chemical digestion is the breakdown of food by digestive enzymes and other chemicals.

A. MOUTH
- salivary glands secrete saliva
- there are three pairs of salivary glands:
  - *parotid* glands lie at the sides of the face immediately below and in front of the ears; each gland has a duct that opens on the inner surface of the cheek at the location of the second upper molar
  - *sublingual* glands lie beneath the tongue
  - *submandibular* glands lie beneath the lower jaw

ducts from these glands open into the mouth under the tongue



- saliva contains mostly water, mucus and the digestive enzyme *salivary amylase*
- salivary amylase is a hydrolytic enzyme (water must be present to break down the substrate)
- the reaction:

$$\text{starch} + H_2O \xrightarrow{\text{salivary amylase}} \text{maltose}$$

- maltose is a disaccharide which is broken down to *glucose* further along the digestive tract

B. STOMACH
- the stomach contains millions of microscopic digestive glands called gastric glands
- glands produce *gastric juice* (pepsinogen and hydrochloric acid)
- pepsinogen and HCl become the digestive enzyme *pepsin*
- pepsin is a *protease* (digests protein)

$$\text{protein} + H_2O \xrightarrow{\text{pepsin}} \text{peptides}$$

- peptides are short chains of amino acids and further broken down into single amino acids in the small intestine

C. SMALL INTESTINE
- the liver produces *bile* which is stored in the gall bladder
  - the bile is sent to the *duodenum* via the bile duct when needed
  - bile contains bile salts which emulsify fats (break it up into small droplets which can then mix with water and undergo chemical digestion

$$\text{fat} \xrightarrow{\text{bile salts}} \text{fat droplets}$$

- the pancreas sends pancreatic juice into the duodenum via the pancreatic duct
  - makes digestive enzymes and sodium bicarbonate ($NaHCO_3$) which neutralizes the HCl from the stomach (increases the pH from 3.0 to 8.5)
  - enzymes secreted in the pancreas include:
    1. *pancreatic amylase* - acts on starch

$$\text{starch} + H_2O \xrightarrow{\text{pancreatic amylase}} \text{maltose}$$

2. *trypsin* - a protease that acts on protein

$$\text{protein} + H_2O \xrightarrow{\text{trypsin}} \text{peptides}$$

3. *lipase* - acts on fat droplets in water

$$\text{fat droplets} + H_2O \xrightarrow{\text{lipase}} \text{glycerol} + \text{fatty acids}$$

- digestion of fat is now complete and molecules of glycerol and fatty acid are absorbed by the lining of the small intestine

- the wall of the small intestine contains millions of intestinal glands that produce intestinal juice
  - enzymes in juice complete digestion of proteins and carbohydrates

$$\text{peptides} + H_2O \xrightarrow{\text{peptidase}} \text{amino acids}$$

$$\text{maltose} + H_2O \xrightarrow{\text{maltase}} \text{glucose}$$

  - other disaccharides have a specific enzyme used to break it down into monosaccharides
  - all nutrients are absorbed by villi and microvilli found in the intestinal walls of the jejunum and ileum

QUESTIONS:

1. What organs produce the same set of enzymes?
2. State two tubes where digestion does not occur.
3. If you dissected an alien worm and found a structure that had a lot of projections, what would its function be - elimination, secretion, absorption, or digestion.
4. Why do you think there are two sets of organs producing the same enzyme?
5. Why is water not digested?
6. What other nutrients are not digested? Which of these are also not absorbed?
7. Why aren't there villi all the way down the digestive tract?
8. Why do you think protein and carbohydrates have to be broken down in stages?
9. Discuss the action of enzymes in intestinal digestion.
10. Use the following terms to fill in the table on the next page which summarizes chemical digestion. NOTE: Some of the terms can be used more than once.

alkaline; glucose and fructose; sucrase; protein; peptides; lactose; intestinal glands; fat; pancreas; pancreatic amylase; maltase; pepsin; glycerol and fatty acids; mouth; gastric glands; trypsin; acid; amino acids; glucose and galactose; neutral; stomach; fat droplets; lactase; bile salts; salivary glands; liver; starch; lipase; small intestine; salivary amylase; peptidases; gastric glands; peptides; maltose; sucrose; glucose

CHEMICAL DIGESTION SUMMARY CHART

ENZYME OR CHEMICAL INVOLVED	ENZYME-PRODUCING ORGAN	NUTRIENT ACTED ON	LOCATION OF CHEMICAL DIGESTION	OPTIMUM pH	PRODUCT

DIGESTION

ORGAN OR SECTION	PROCESSES OCCURRING	ASSOCIATED GLANDS, ORGANS, AND DIGESTIVE FLUIDS
Oral cavity	Mechanical breakup of food, mix with saliva, begin breakdown of starch, lubricate with mucin	Salivary glands secrete salivary amylase, mucin, buffers, antibacterial agents
Pharynx	Swallowing of bolus, epiglottis closes trachea	
Esophagus	Bolus through esophageal sphincter, peristalsis moves bolus to stomach through cardiac sphincter	
Stomach	Food tissues broken down by low pH, protein denatured and hydrolysis begun, churning mixes acid chyme, exits through pyloric sphincter	Epithelial glands secrete gastric juice with pepsin and HCl; hormone gastrin regulates gastric juice release
Small intestine	Complete digestion of starch and proteins, fats emulsified and hydrolyzed, absorption of nutrients across epithelial lining into capillaries and lacteals, large surface area due to villi and microvilli	Pancreatic release of bicarbonate neutralizes acid chyme; pancreatic enzymes: amylase, trypsin, and other protein-hydrolyzing enzymes; liver produces bile salts, stored in gall bladder, emulsify fats; lipase hydrolyzes fats; brush border of epithelium contains disaccharides and dipeptidases; nucleases hydrolyze DNA and RNA. Hormones: secretin, CCK, enterogastrone control secretions and peristalsis
Large intestine	Reabsorption of water, feces stored in rectum; microorganisms may produce vitamin K	

DIGESTIVE HORMONES

STIMULUS THAT CAUSES RELEASE	HORMONE	EFFECTS OF THE HORMONE
Presence of food in stomach, stomach distension, previous gastrin secretion	Gastrin	Stimulates secretion of gastric juices; too low pH in stomach inhibits gastrin release
Acidic pH of chyme entering duodenum	Secretin	Stimulates release of bicarbonate from pancreas
Amino acids or fatty acids in duodenum	Cholecystokinin (CCK)	Stimulates release of digestive enzymes from pancreas and bile from gall bladder
Chyme rich in fats in duodenum	Enterogastrone	Inhibits stomach peristalsis and acid secretion

DIGESTION VOCABULARY

SWALLOWING

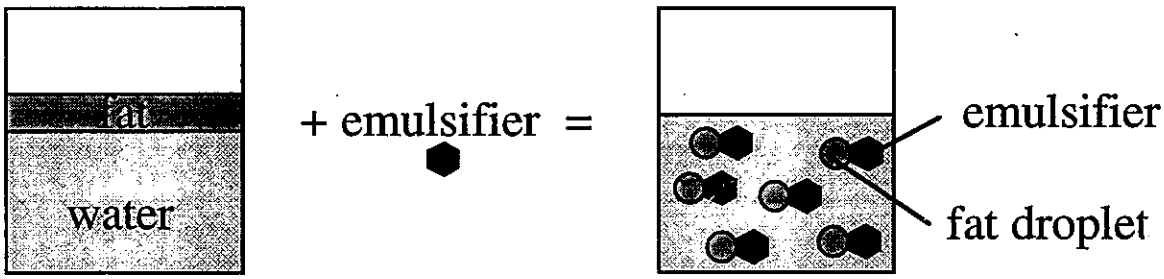
- a reflex action (uvula)
- occurs in the pharynx
- food is pushed by the tongue and pharynx muscles into the esophagus
- epiglottis closes to prevent food from entering the trachea

PERISTALSIS

- waves of muscular contractions which push food down the esophagus
- also occurs in the stomach and small intestine

EMULSIFICATION

- the breaking of food into small particles (to increase surface area) for enzymes to help digestion
- example, bile emulsifies fat



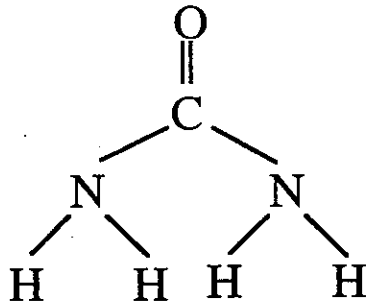
FUNCTIONS OF THE LIVER

1. Removes poisonous substances (i.e., alcohol) from the blood and breaks them down.

2. Keeps blood in homeostasis.
   i.e., maintains glucose level at 0.1% by storing excess glucose as glycogen and converting glycogen to glucose as needed.

3. Converts amino acids to glucose if needed.

4. Urea is produced from amino groups:



   Urea is transported to the kidneys for excretion.

5. Makes blood proteins from amino acids.

6. Destroys worn out blood cells; converts hemoglobin to bilirubin and biliverdin (components of bile)

7. Produces bile which is stored in the gall bladder. It then enters the small intestine where it is used to emulsify fat.

"FRIENDLY" BACTERIA IN THE LARGE INTESTINE

(Escherichia) E. coli

- a non-infectious bacterium that normally lives in the human large intestine
- capable of digesting material that our body cannot i.e., vitamins, some amino acids that are essential to us, and growth factors are released by bacteria and absorbed by the large intestinal wall
- many are continually passed out with the feces
- Choliform level readings as public beaches indicates a high level of *E. coli*

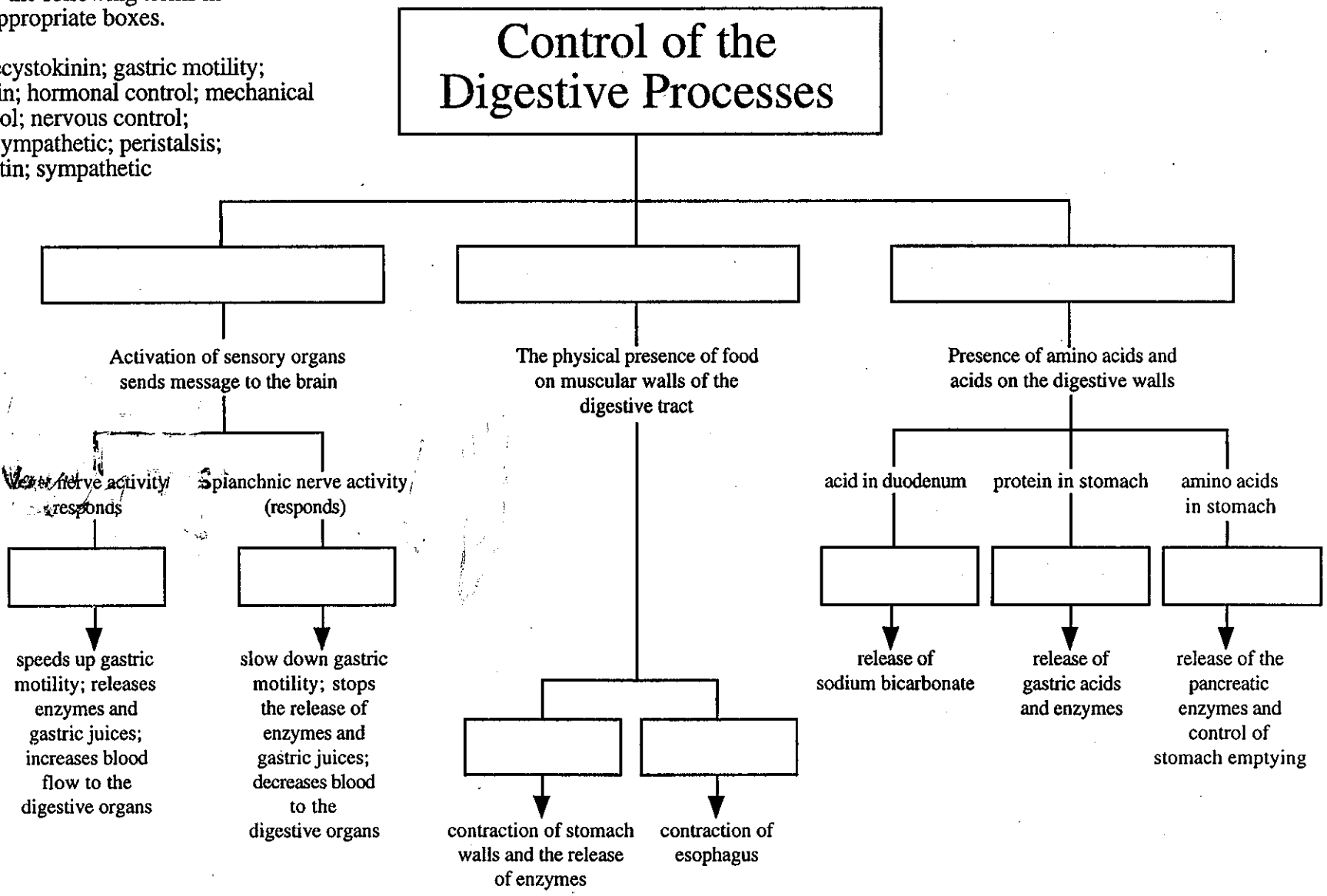
FUNCTION OF THE LARGE INTESTINE

- Some fibre low in cellulose is broken down (digested) by bacteria (when they feed on it) and is changed chemically to produce odorous molecules
- Bacteria produce amino acids and vitamins from this food. These are absorbed into the walls of the intestine and eventually reach the blood stream.
- We don't digest the fibre, bacteria do it for us.

DIGESTION FLOW CHART

Place the following terms in the appropriate boxes.

cholecystokinin; gastric motility; gastrin; hormonal control; mechanical control; nervous control; parasympathetic; peristalsis; secretin; sympathetic



DIGESTIVE HORMONES

INSTRUCTIONS: Cut and past the following terms in the proper place in the digestive hormone grid, then answer the following questions.

1 GIP (gastric inhibitory peptide)	8 lower part of stomach produces and releases	inhibits stomach secretion of gastric acid to slow down chyme, permitting increased 15 time for digestion
2 duodenal wall produces and releases hormone into the blood (protection)	arrival of protein- 9 rich chyme	causes gastric glands in upper part of stomach 16 to secrete pepsinogen
3 presence of acid chyme acting on duodenum	10 GASTRIN	signals pancreas to release enzymes to digest protein 17
4 signals pancreas to secrete highly alkaline bicarbonate-rich juices to help neutralize acids	11 presence of small peptides (partially digested proteins) and caffeine	hormone goes into blood and enters upper part of 18 stomach (digestion)
5 SECRETIN	distension of stomach 12 by food	signals gall bladder to release bile which neutralizes acid and 19 emulsifies chyme
6 arrival of fat or acid-rich chyme	duodenal wall produces and releases hormone into 13 the blood (protection and digestion)	20 CCK (choleocystokinin)
high fat content 7 in chyme	14 duodenal wall produces and releases hormone into the blood (conservation)	

QUESTIONS:

1. Which hormone has the same source and target tissue?
2. What two hormones serve to neutralize acid?
3. Can one digestive hormone affect more than one target organ? If so, name the hormone and target tissues.
4. Gastric juice secretion is inhibited by GIP. Why is it not also secretin or CCK inhibited?
5. GIP works opposite to which other hormone?
6. A hormone is a substance that is produced by one set of cell but affects a different set of cells. How are hormones transported to the target cells?
7. Explain what happens to the hormone gastrin after a person eats a protein-rich meal.
8. Explain the words in brackets. Why are they there? What do they mean?
9. Name the two main hormone glands.
10. (a) Name three main chemical factors that stimulate hormonal release.
    (b) Which of these are nutrients?