
بسم الله الرحمن الرحيم


رب اشرح لي صدري ويسر لي أمري

Nutrition and Digestion

PROF DR /

Amr Shalaby

Nutrition and Digestion

PROF DR / AMR SHALABY

Minerals

- inorganic elements Are needed in all parts of the body, especially bones and teeth.
- Affect all body functions, including heartbeat and blood oxygen level!
- Are ESSENTIAL for body functions

Minerals

Inorganic elements

-are not changed in the body

-minerals in = minerals out (compare to all other nutrient classes discussed thus far)

-can not be destroyed by heat, light, acid or mixing

-can only be lost by leeching

Class exercise

1) Why are minerals essential?

2) Why do minerals have different roles?

3) Why are minerals unable to be transformed by the body?

4) What does inorganic mean?

Definition of major minerals

-present in body in amounts of greater than 5 grams

Inorganic elements-

Sodium ----muscle cramps

Potassium--weakness

Calcium– bones ,growth

Phosphorous--weakness

Magnesium-

N.S Sulphur

Major minerals

Body's handling of minerals

potassium easily absorbed into the blood, transported freely, and readily excreted by the kidneys-like water soluble vitamins

calcium needs carriers to be absorbed and transported- like fat soluble vitamins

Nutrient Interactions

-sodium intake high- leads to high sodium and calcium excretion

-phosphorous binds with magnesium in the small intestine so magnesium absorption limited when phosphorous intakes are high

Varied roles -calcium-bone building
-sodium- water balance

Major minerals

Sodium

Sources- table salt, processed foods

-Metabolism- water balance

-acid base balance

(excretion of hydrogen ions in exchange for sodium ions in kidney)

Major minerals

Chloride-sources table salt, processed foods

-metabolism- water balance

-hydrochloric acid

Major minerals

Potassium-

-sources-all whole foods, meats, milk, fruits, grains

-metabolism- water balance

-supports cell integrity

-promotes steady heartbeat

Major minerals

Calcium

-sources-milk and milk products,
small fish with bones,
tofu, broccoli, chard

-metabolism- bone and teeth
formation
-cell signalling

Major minerals
Phosphorous

-Sources-all animal tissues

-Metabolism- buffers
-part of DNA/RNA
-phosphorylation of many enzymes and B vitamins to make them biochemically active
-ATP
-phospholipids-cell signalling

Magnesium

-Sources-nuts, legumes, whole grains, dark green vegetables, seafood, chocolate

-Metabolism- enzyme co-factor (glucose use in body plus synthesis of protein, lipids and nucleic acids)
-part of enzyme that transforms ADP to ATP

Major minerals

Sulphur

-Sources-all protein containing

-Metabolism- protein structure
-part of thiamine

Found in what foods

Roles in metabolism including regulation of metabolism

-degree of presence regulates function

Class exercise

What is the relation between source and metabolism for the major minerals? Give 5 examples

Minor minerals

Definition of minor minerals

-present in body in amounts less than 5 grams

Minor minerals

Inorganic elements

Iron ---- anemia

Zinc--reproduction

Iodine-goiter (Thyroird

Selenium—muscle pain

Copper—anemia ,bone

Manganese—abnorma bone and cartelage

Fluoride- tooth

Chromium– impaired glucose metabolism

Molybdenum – disordes in excreation

Minor minerals

Body's handling of minerals

-iron uses carriers for absorption, transport and proteins for storage- no free iron- oxidation issue

-example of minor mineral requiring no carriers or storage proteins

iodine

Variable Bioavailability

Minor minerals

Nutrient Interactions

-slight manganese overload may exacerbate iron deficiency

-combined iodine and selenium deficiency reduces thyroid hormone function more than just iodine deficiency alone

Varied roles

-iron-oxygen carrying

-zinc- part of enzymes

Minor minerals

Iron

-Sources-red meats, fish, poultry, shellfish, eggs, legumes, dried fruits

-Metabolism- oxygen carrier

-part of electron carriers in electron transport chain

Minor minerals

Zinc

-Sources-protein containing foods:meats fish, poultry, whole grains,

-Metabolism part of many enzymes
-synthesis of DNA/RNA
-heme synthesis
-fatty acid metabolism
-release hepatic stores of vitamin A
-carbohydrate metabolism
-synthesis of proteins
-dispose of damaging free radicals
-oxygen carrying

Minor minerals

Iodine

-Sources-iodised salt, seafood, bread,dairy products, plants grown on iodine rich soil and animals that eat such plants

-Metabolism- thyroid hormones-metabolic rate(rate of oxygen use), body temperature

Minor minerals

Selenium

-Sources-seafood, meat, whole grains, and depending on soil selenium content-vegetables

-metabolism anti-oxidation (via enzyme)
- regulates thyroid hormone

Minor minerals

Copper

-Sources-seafood, nuts, whole grains, seeds, legumes

-Metabolism part of many enzymes all of which have common feature of consuming oxygen or oxygen radicals

-eg -hemoglobin synthesis
-collagen synthesis
-free radical control
-electron transport chain

Minor minerals

Manganese

-sources-nuts, whole grains, leafy vegetables

-Metabolism- essential for iron absorption and use in formation of hemoglobin

-part of several enzymes

Minor minerals

Fluoride

-Sources-fluoridated drinking water, tea, seafood

-Metabolism- formation of bones and teeth, resistance to tooth decay

Minor minerals

Chromium

-Sources meat, unrefined foods, fats, vegetable oils

-Metabolism - enhancing insulin activity

Minor minerals

Molybdenum

-Sources -legumes, cereals, organ meats

-Metabolism - co-factor for several enzymes

Found in what foods

Roles in metabolism including regulation of metabolism

-degree of presence regulates function

Class exercise

What is the relation between source and metabolism for the minor minerals? Give 5 examples.

Minerals

- Simple inorganic nutrients
- Usually required in small amounts
- Ex: Ca^{+2} and PO_4^{-3} required for bones
- Ex: Iron needed for hemoglobin, cytochrome complex (ETC)
- Na^+, K^+ and Cl^- needed for osmotic balance and transport

Minerals

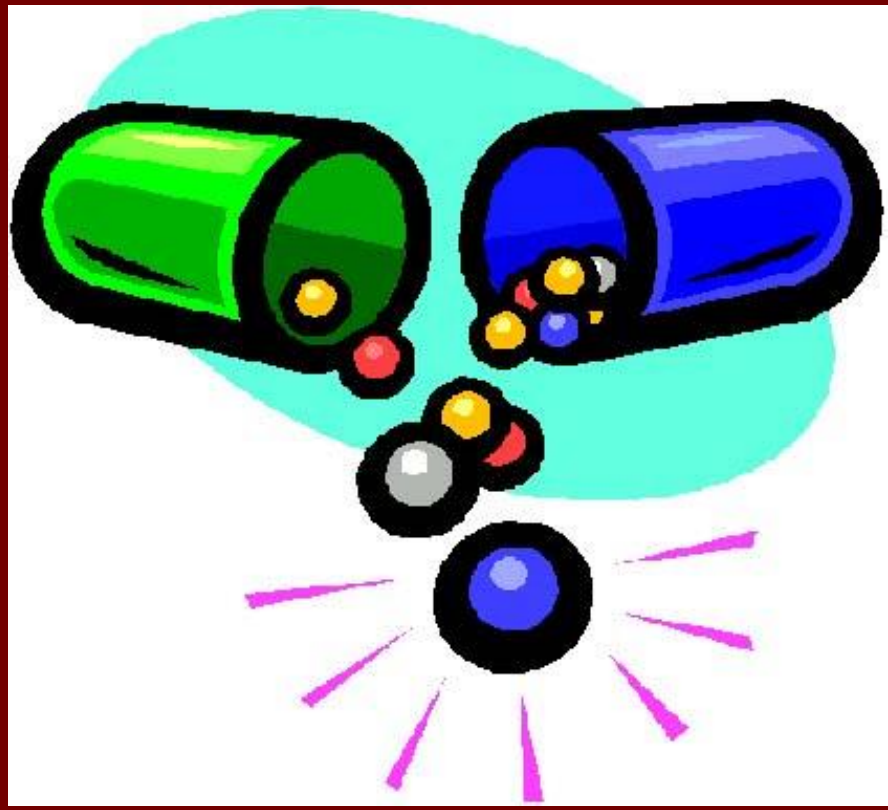
Mineral Requirements of Humans

	Major Dietary Sources	Some Major Functions in the Body	Possible Symptoms of Deficiency*
)	Dairy products, dark green vegetables, legumes	Bone and tooth formation, blood clotting, nerve and muscle function	Retarded growth, poss bone mass
(P)	Dairy products, meats, grains	Bone and tooth formation, acid-base balance, nucleotide synthesis	Weakness, loss of min bone, calcium loss
	Proteins from many sources	Component of certain amino acids	Symptoms of protein
C)	Meats, dairy products, many fruits and vegetables, grains	Acid-base balance, water balance, nerve function	Muscular weakness, p nausea, heart failure
)	Table salt	Acid-base balance, formation of gastric juice, nerve function, osmotic balance	Muscle cramps, reduc
	Table salt	Acid-base balance, water balance, nerve function	Muscle cramps, reduc
(Mg)	Whole grains, green leafy vegetables	Cofactor; ATP bioenergetics	Nervous system distur
	Meats, eggs, legumes, whole grains, green leafy vegetables	Component of hemoglobin and of electron-carriers in energy metabolism; enzyme cofactor	Iron-deficiency anemi impaired immunity
	Drinking water, tea, seafood	Maintenance of tooth (and probably bone) structure	Higher frequency of t
	Meats, seafood, grains	Component of certain digestive enzymes and other proteins	Growth failure, scaly s reproductive failure, i
	Seafood, nuts, legumes, organ meats	Enzyme cofactor in iron metabolism, melanin synthesis, electron transport	Anemia, bone and car changes
Mn)	Nuts, grains, vegetables, fruits, tea	Enzyme cofactor	Abnormal bone and c
	Seafood, dairy products, iodized salt	Component of thyroid hormones	Goiter (enlarged thyro
	Meats and dairy products	Component of vitamin B_{12}	None, except as B_{12} de
)	Seafood, meats, whole grains	Enzyme cofactor; antioxidant functioning in close association with vitamin E	Muscle pain, possibly deterioration
Cr)	Brewer's yeast, liver, seafood, meats, some vegetables	Involved in glucose and energy metabolism	Impaired glucose met
n (Mo)	Legumes, grains, some vegetables	Enzyme cofactor	Disorder in excretion containing compound

nerals are also harmful when consumed in excess.

Vitamins

- Vitamins are only needed in small amounts, but they are essential.
- Protect against disease, promote growth, and contribute to overall balanced health.



- The two different types of vitamins are classified by
- the fluid in which they can be dissolved: water-soluble vitamins (all the B vitamins and vitamin C)
- and fat-soluble vitamins (vitamins A, D, and K).

Vitamins

- Required in relatively trace (minimal) amounts
- However, deficiencies can have drastic effects
- 13 vitamins essential to humans
  - –water-soluble vitamins
  - –fat-soluble vitamins

Vitamin A (Retinol)

- Beta-carotene is converted into vitamin A

- Vitamin A:
  - Promotes good vision
  - Promotes healthy skin
  - Helps with growth and maintenance of bones, teeth, and cell structure

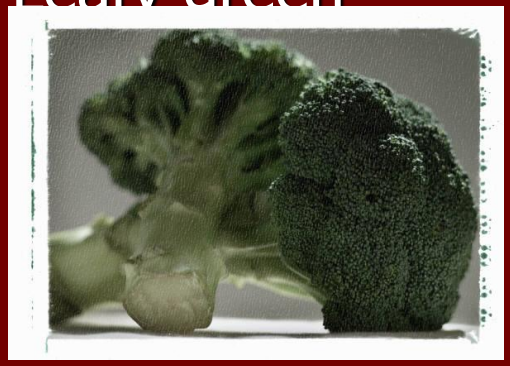
Too much vitamin A

- May turn your skin orange
- May cause fatigue, weakness, severe headache, blurred vision, hair loss and joint pain.

Foods rich in vitamin A

- Foods
  - Only animal products
    - Liver
    - Eggs
    - Milk, butter and cheese

- Carotenoids
  - Orange/Yellow fruits and vegetables
    - Cantaloupes, carrots, sweet potatoes, winter squash
  - Leafy green



Vitamin D – "The Sunshine Vitamin"

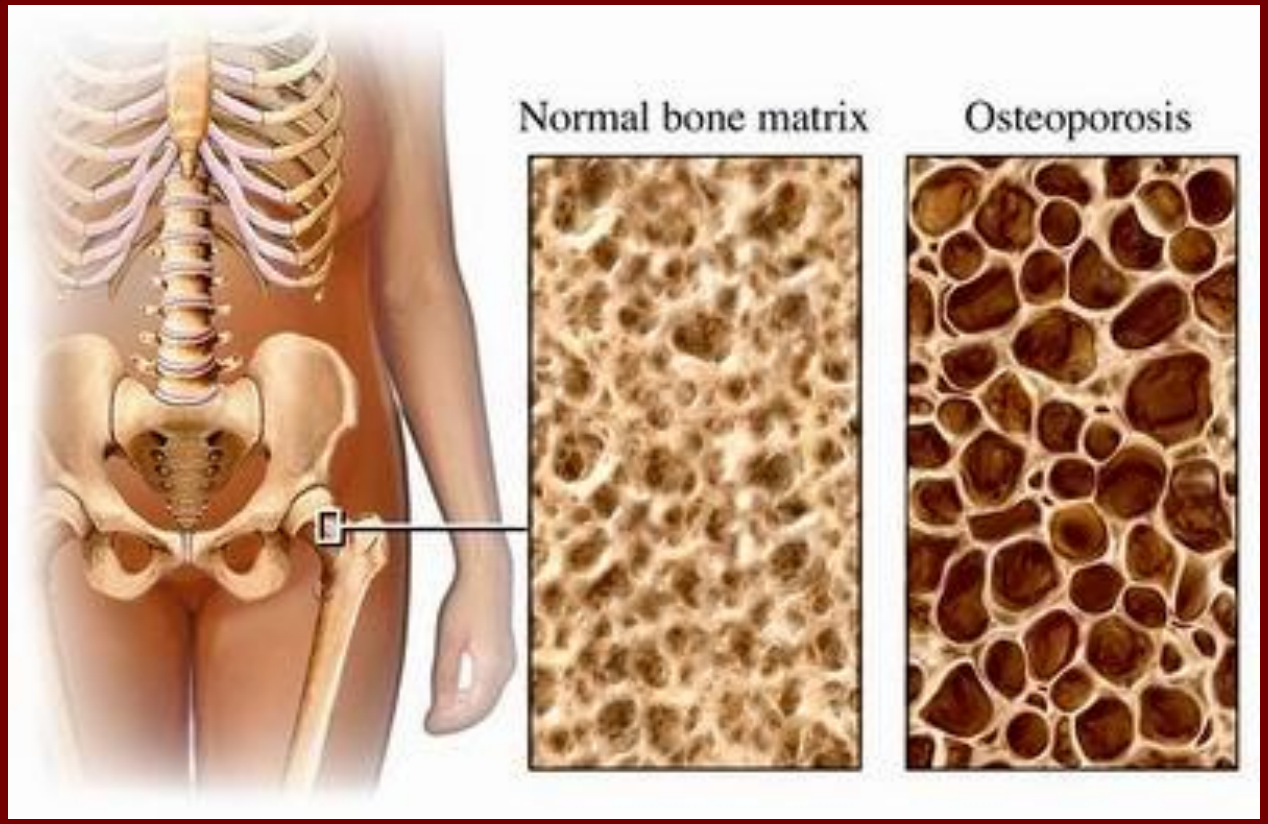
- Essential for building and maintaining bones and teeth
- Responsible for absorption and utilization of calcium
- Other health benefits:
  - May boost immune system
  - May also help decrease certain cancers
- RDA: 5 micrograms until age 50
  - 10 micrograms / day until 70; 15 mcg 70+

Too little vitamin D

- Vitamin D deficiency has been in the news a lot lately.
- Deficiency may occur from:
  - Inadequate diet
    - Vegetarianism, lactose intolerance, milk allergy
  - Body unable to absorb needed vitamin D
  - Limited exposure to sunlight

Vitamin D Deficiency

- May lead to osteomalacia and/or osteoporosis



Getting vitamin D

- Sun exposure for 10 minutes a day
- Foods:
  - Fortified milk
  - Tuna
  - Salmon
  - May need a supplement
    - Check with doctor first though

Vitamin E

- Important to red blood cells, muscles and other tissues
- Deficiency is rare
- Toxicity is rare
  - But Vitamin E acts as a blood thinner
- Foods:
  - Vegetable oils, salad dressings, whole grain cereals, green leafy vegetables, nuts, seeds, peanut butter and wheat germ.

Vitamin K

- Important for blood clotting
  - Also has a role for bone health
- Mostly made in the intestines
- Foods:
  - Turnip greens, cauliflower, spinach, liver, broccoli, kale and cabbage

Water-Soluble Vitamins

- Vitamins Bs and C
- Eight B vitamins:
  - Thiamin (B-1)
  - Riboflavin (B-2)
  - Niacin (B-3)
  - Pyridoxine (B-4)
  - Cobalamin (B-12)
  - Folic acid
  - Pantothenic acid
  - Biotin

Thiamin or B-1

- Helps to convert carbohydrates to energy
- Deficiency:
  - Fatigue, nausea, depression, nerve damage
- Foods:
  - Pork, beef, liver, peas, seeds, legumes, whole-grain products, and oatmeal

Riboflavin or B-2

- Key to metabolism and red blood cells
- Deficiency:
  - Dry, scaly skin
- Foods:
  - Milk, yogurt, cheese, whole-grain breads, green leafy vegetables, meat, and eggs

Niacin or B-3

- Also involved with energy production
- Also helps with skin, nerves and digestive system
- Deficiency:
  - Rare but causes: diarrhea, dermatitis, dementia and death
- Foods:
  - Meat, poultry, liver, eggs, brown rice, baked potatoes, fish, milk, and whole-grain foods

Pyridoxine or B-6

- Involved in chemical reactions of proteins and amino acids
- Deficiency:
  - Skin changes, dementia, nervous system disorders and anemia
- Foods:
  - Lean meats, fish, legumes, green leafy vegetables, raisins, corn, bananas, mangos

Cobalamin or B-12

- Helps with nervous system, red blood cells and DNA synthesis
- Deficiency:
  - Nervous system disorders and pernicious anemia
- Foods:
  - Only found in animal products
    - Meat, fish, poultry, eggs, milk products and clams

Folic acid (Folacin, Folate)

- Key role in red blood cell formation and cell division
- Deficiency:
  - Anemia, digestive disorders
- Foods:
  - Leafy, dark green vegetables
  - Also found in liver, beans, peas, asparagus, oranges, avocados

Pantothenic Acid and Biotin

- Help with metabolism and formation of some hormones
- Deficiencies are rare
- Foods:
  - Almost any food, plant-based or animal-based

Vitamin C

- Important to bone health, blood vessel health, cell structure and absorption of iron
- Deficiency:
  - Rare
- Too much vitamin C
- Foods:
  - Melons, berries, tomatoes, potatoes, broccoli, fortified juices, kiwi, mangos, yellow peppers and citrus fruits

Water Soluble Vitamins

Table 41.1 Vitamin Requirements of Humans: Water-Soluble Vitamins

Vitamin	Major Dietary Sources	Some Major Functions in the Body	Possible Symptoms of Deficiency or Extreme Excess
Water-Soluble Vitamins			
Vitamin B_1 (thiamine)	Pork, legumes, peanuts, whole grains	Coenzyme used in removing CO_2 from organic compounds	Beriberi (nerve disorders, emaciation, anemia)
Vitamin B_2 (riboflavin)	Dairy products, meats, enriched grains, vegetables	Component of coenzymes FAD and FMN	Skin lesions such as cracks at corners of mouth
Niacin	Nuts, meats, grains	Component of coenzymes NAD^+ and $NADP^+$	Skin and gastrointestinal lesions, nervous disorders Flushing of face and hands, liver damage
Vitamin B_6 (pyridoxine)	Meats, vegetables, whole grains	Coenzyme used in amino acid metabolism	Irritability, convulsions, muscular twitching, anemia Unstable gait, numb feet, poor coordination
Pantothenic acid	Most foods: meats, dairy products, whole grains, etc.	Component of coenzyme A	Fatigue, numbness, tingling of hands and feet
Folic acid (folacin)	Green vegetables, oranges, nuts, legumes, whole grains (also made by colon bacteria)	Coenzyme in nucleic acid and amino acid metabolism	Anemia, gastrointestinal problems May mask deficiency of vitamin B_{12}
Vitamin B_{12}	Meats, eggs, dairy products	Coenzyme in nucleic acid metabolism; needed for maturation of red blood cells	Anemia, nervous system disorders
Biotin	Legumes, other vegetables, meats	Coenzyme in synthesis of fat, glycogen, and amino acids	Scaly skin inflammation, neuromuscular disorders
Vitamin C (ascorbic acid)	Fruits and vegetables, especially citrus fruits, broccoli, cabbage, tomatoes, green peppers	Used in collagen synthesis (e.g., for bone, cartilage, gums); antioxidant; aids in detoxification; improves	Scurvy (degeneration of skin, teeth, blood vessels), weakness, delayed wound healing, impaired immunity Gastrointestinal upset

Fat Soluble Vitamins

Table 41.1 Vitamin Requirements of Humans: Fat-Soluble Vitamins

Vitamin	Major Dietary Sources	Some Major Functions in the Body	Possible Symptoms of Deficiency or Extreme Excess
Fat-Soluble Vitamins			
Vitamin A (retinol)	Provitamin A (beta-carotene) in deep green and orange vegetables and fruits; retinol in dairy products	Component of visual pigments; needed for maintenance of epithelial tissues; antioxidant; helps prevent damage to lipids of cell membranes	Vision problems; dry, scaling skin Headache, irritability, vomiting, hair loss, blurred vision, liver and bone damage
Vitamin D	Dairy products, egg yolk (also made in human skin in presence of sunlight)	Aids in absorption and use of calcium and phosphorus; promotes bone growth	Rickets (bone deformities) in children, bone softening in adults Brain, cardiovascular, and kidney damage
Vitamin E (tocopherol)	Vegetable oils, nuts, seeds	Antioxidant; helps prevent damage to lipids of cell membranes	None well documented in humans; possibly anemia
Vitamin K (phylloquinone)	Green vegetables, tea (also	Important in blood clotting	Defective blood clotting

Water

- Essential for life
  - It is possible to live without food than without water.
- Water makes up about 45-75% of your body weight

Functions

- Controls body temp.
- Helps shape body
- Transports nutrients
- Aids digestion
- Carries out waste
- Lubricates joints
- Majority of body mass

- Water balance
- Regulation of food intake
- Hunger contractions
- Feeding center ---- satiety center

Why is water important?

- Aids with transport
- Mechanical functions
- Helps to break substances down
- Helps to maintain body temperature/pH

How much water do you need?

- Adequate intake:
  - For men: 125 oz / day
  - For women: 91 oz / day
  - Ideally 80% of water should coming from drinking fluids.
    - 20% of water intake should come from food

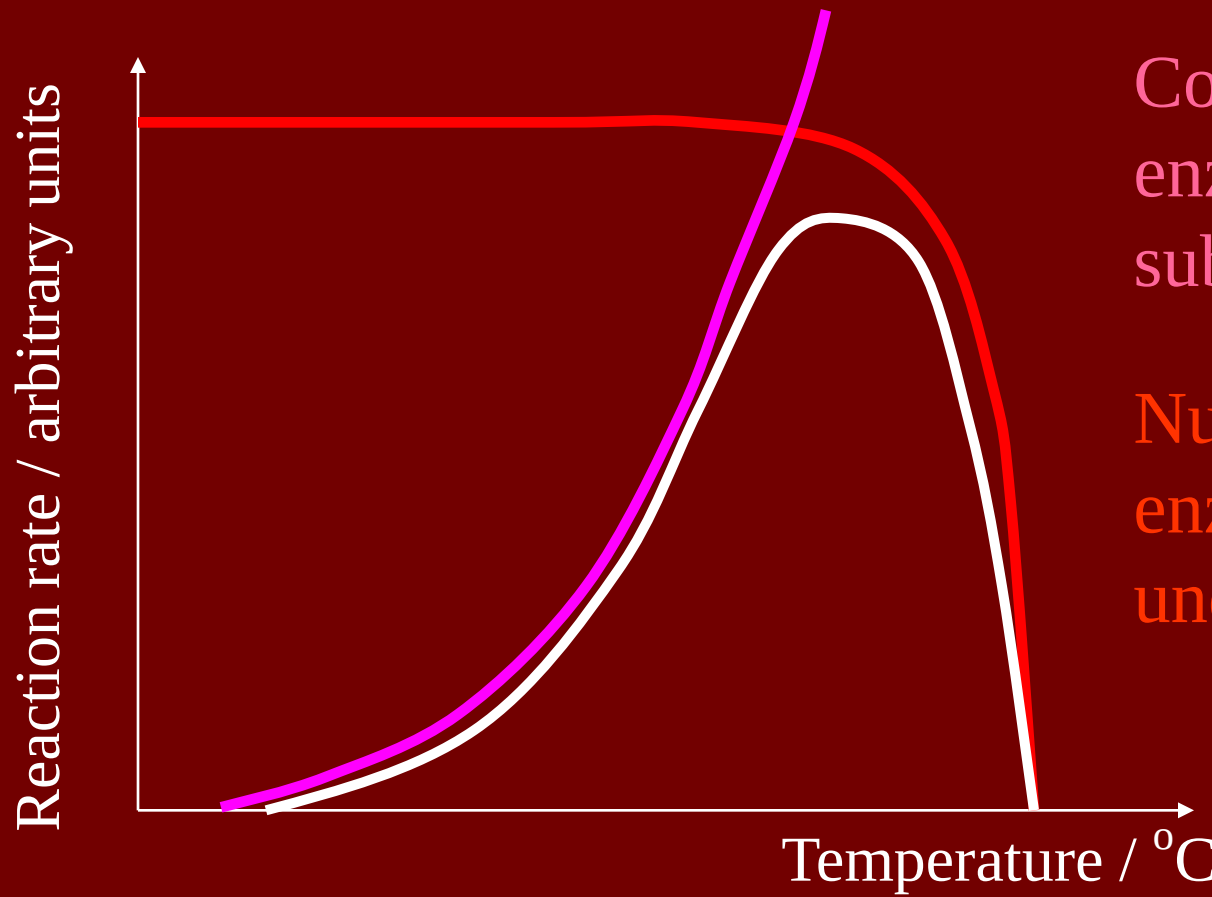
Enzymes

- All enzymes are complex proteins and remain unchanged during the reaction. They
- can be used repeatedly. Since they speed up the rate of chemical reactions in the body
- The process of digestion requires a number of enzymes for the conversion of
- complex molecules into simpler ones.

Factors of Enzymes

- 1- specificity of Enzymes
- Enzymes are specific in thir reation
- Carbohydrates----------amylase
- Lipids ----------lipase
- Protein --------pepsin ---acid
- ---------trypsine ----alkaline

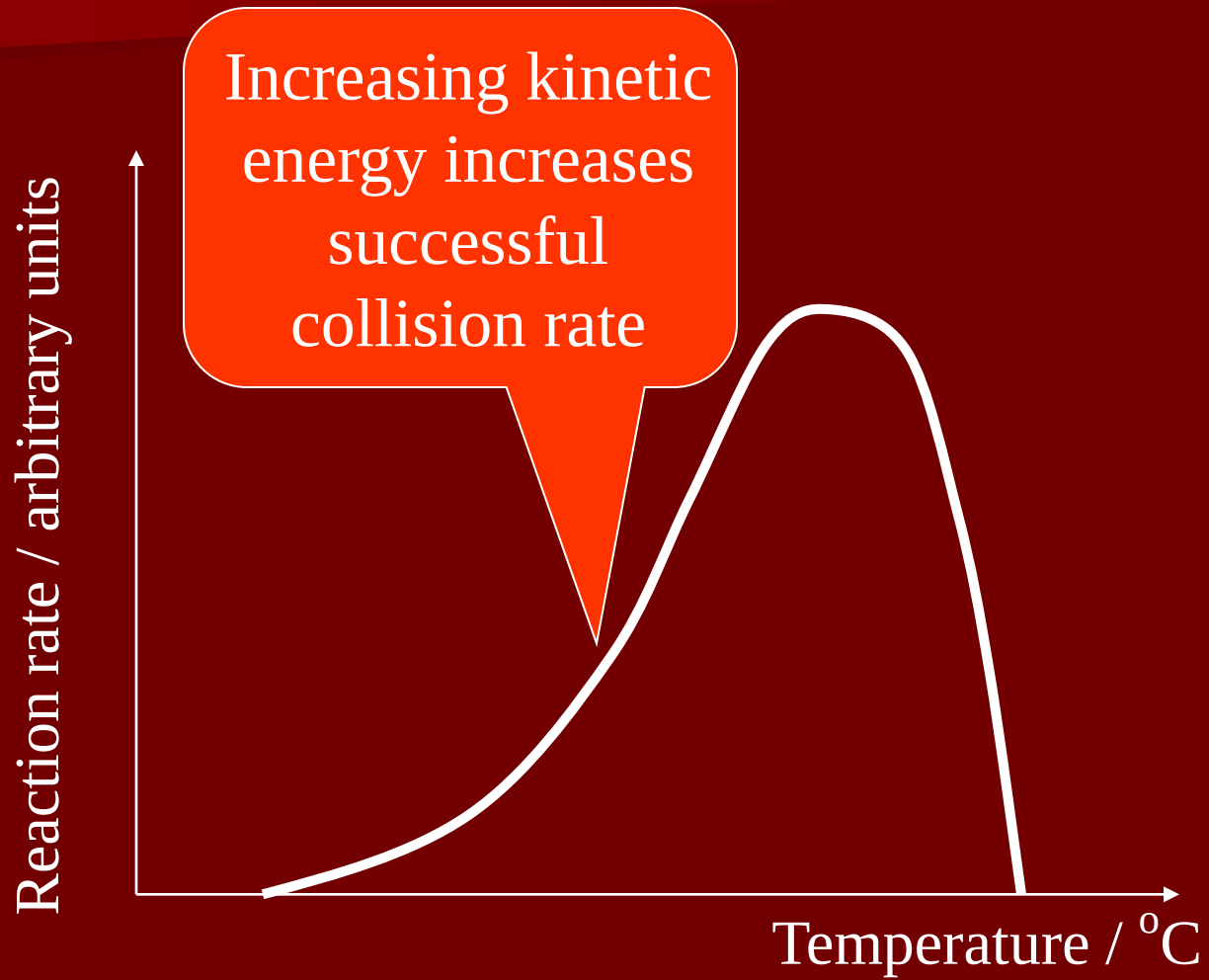
Enzymes and temperature: a tale of two effects



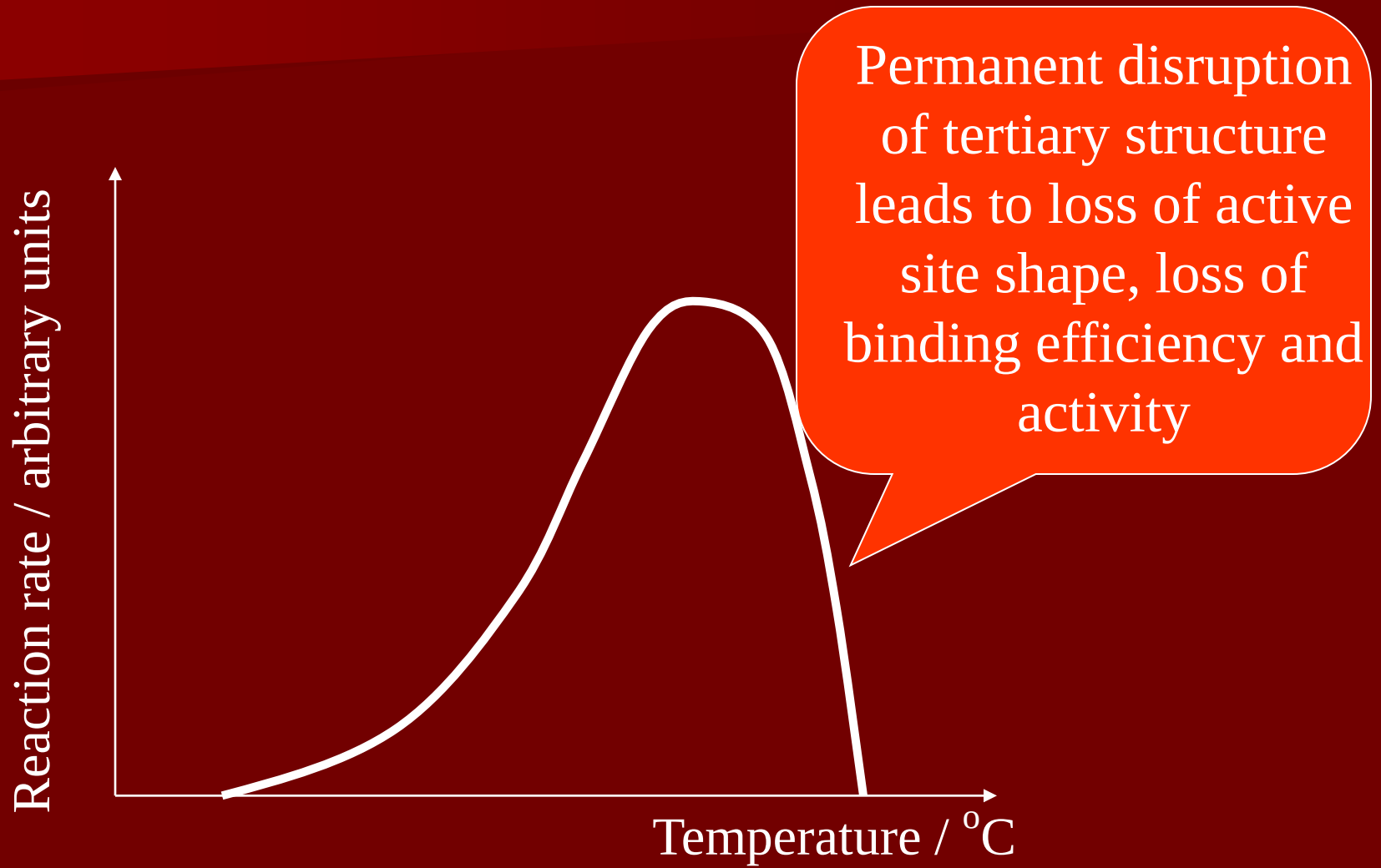
Collision rate of enzymes and substrates

Number of enzymes remaining undenatured

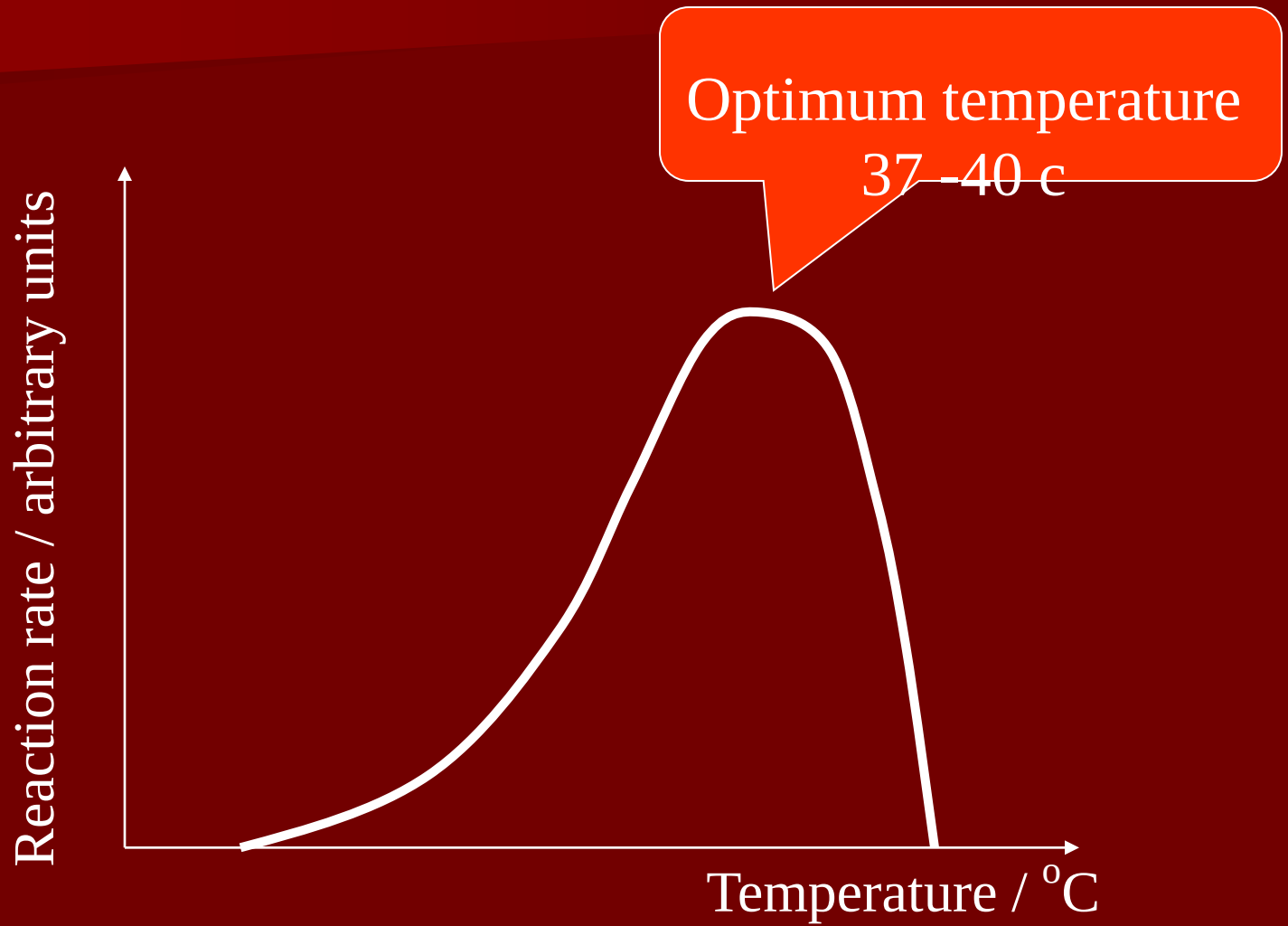
Enzymes and temperature



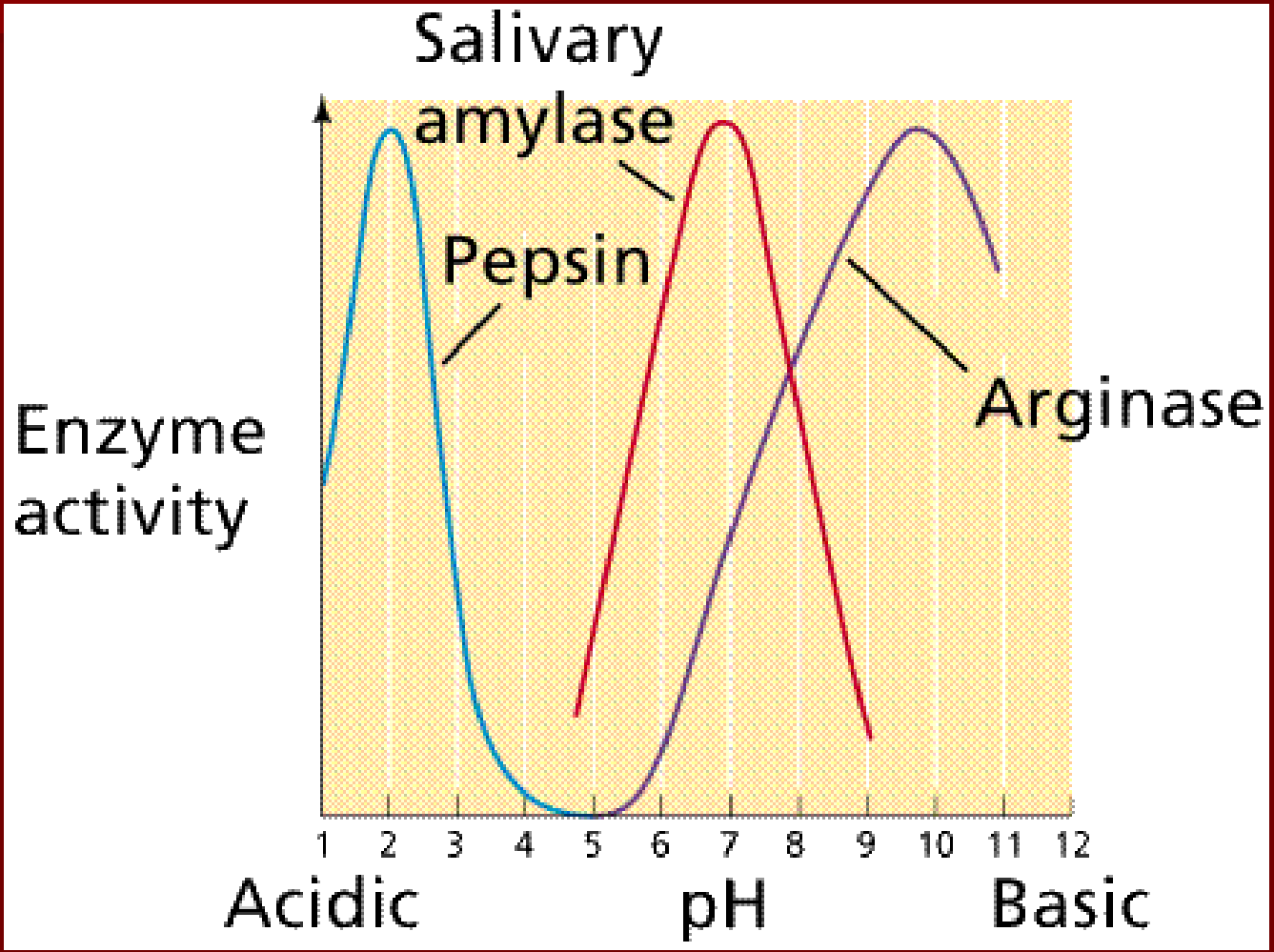
Enzymes and temperature



Enzymes and temperature



3-Enzymes and pH



4-Enzymes and inhibitors

- Inhibitors are molecules that prevent enzymes reaching their maximum turnover numbers
- Some inhibitors compete with the substra
- Some inhibitors affect the active site shape by binding to the enzyme elsewhere on th

Active site directed inhibition

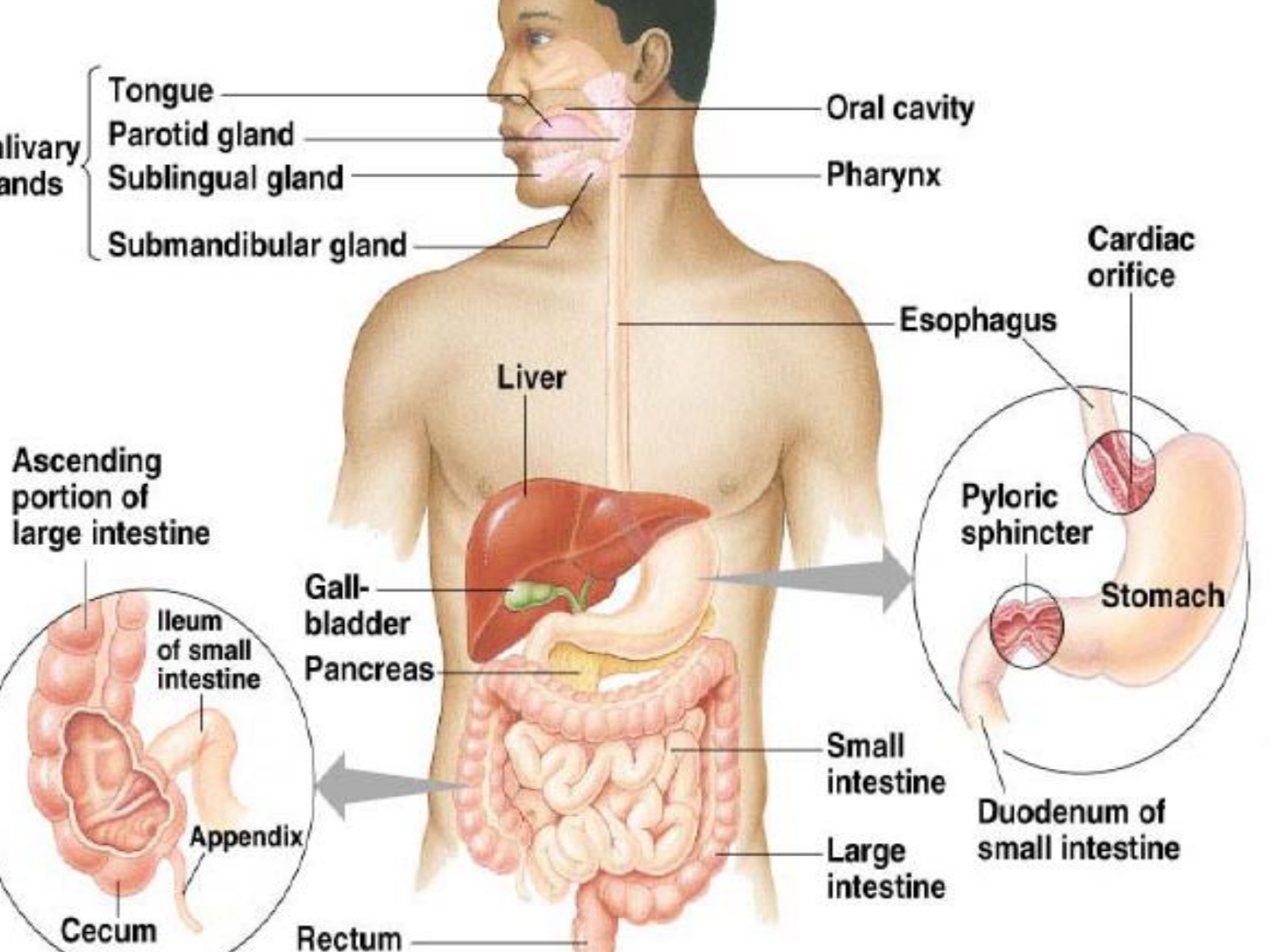
Non-active site directed inhibition

5-Factors of Enzymes

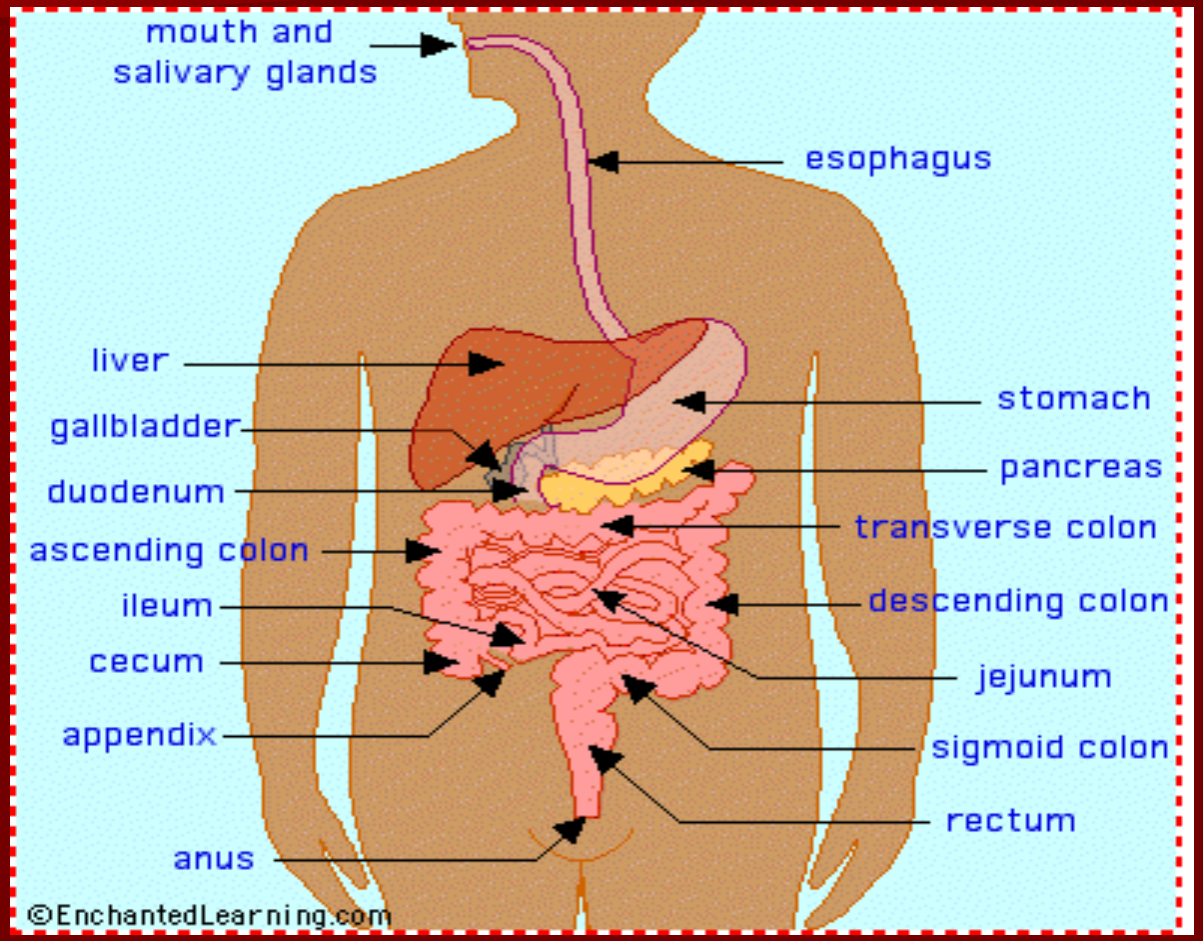
- Enzymes and activators
- Creatine ions or substances increase the activity of enzyme

6-kinases

- Some enzymes are secreted in an inactive
- Kinases change them into active


Tongue
Parotid gland
Sublingual gland
Submandibular gland
Oral cavity
Pharynx
Cardiac orifice
Esophagus
Liver
Gall-bladder
Pancreas
Ascending portion of large intestine
Ileum of small intestine
Appendix
Cecum
Rectum
Small intestine
Large intestine
Pyloric sphincter
Stomach
Duodenum of small intestine

DIGESTIVE SYSTEM



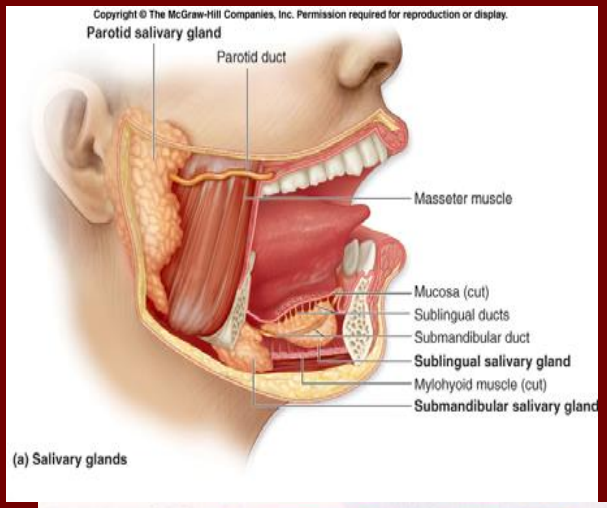
- **Accessory organs:**
  - Help the digestive system in digestion of food by:

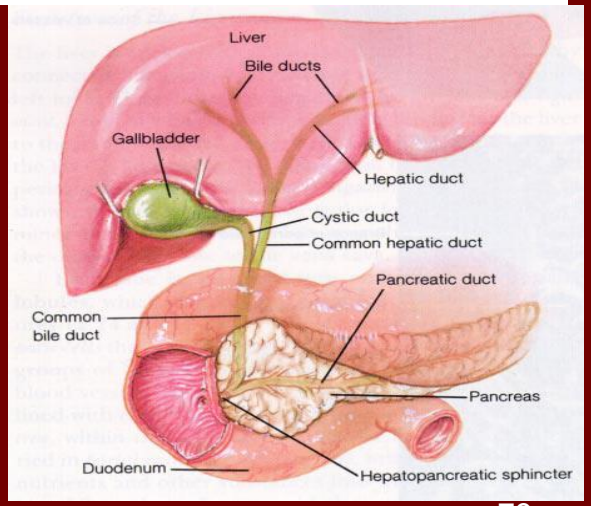
➔ Mechanical processes.

teeth, tongue, salivary glands.

➔ Secretion of digestive substances.

liver, gall bladder, pancreas.





1- Mechanical digestion

- Is the breakdown of food into smaller particles by:

➔ the cutting and grinding action of the teeth.

➔ the contractions of the stomach and small intestine.

In mechanical digestion ----- No change in the chemical structure.

2- Chemical digestion

- Is the breakdown of macromolecules into simpler particles by the effect of digestive enzymes (catabolism):

➢ Polysaccharides into monosaccharides.

➢ Proteins into amino acids

➢ Fats into glycerol and fatty acids

In chemical digestion ------ digestive enzymes are secreted from: Salivary glands, stomach, liver, Pancreas.

Digestive Process

Five basic activities are involved in the digestive process

1. **Ingestion:** The taking of food into the mouth (physical breakdown of food).
2. **Mixing and movement of food**- Involves the muscular contractions (peristalsis) that mix the food and move it through the digestive tract.
3. **Digestion**- The break down of food by mechanical and chemical means.
4. **Absorption**- The passage of digested food from the digestive tract into the blood.
5. **Defecation**- The elimination of wastes.

DIGESTION PROCESS

- **The start of the process - the mouth:** The digestive process begins in the mouth. Food is partly broken down by the process of chewing and by the chemical action of salivary enzymes (these enzymes are produced by the salivary glands and break down starches into smaller molecules).

On the way to the stomach: the esophagus - After being chewed and swallowed, the food enters the esophagus. The esophagus is a long tube that runs from the mouth to the stomach. It uses rhythmic, wave-like muscle movements (called peristalsis) to force food from the throat into the stomach. This muscle movement gives us the ability to eat or drink even when we're upside-down

- **In the small intestine** - After being in the stomach, food enters the duodenum, the first part of the small intestine. It then enters the jejunum and then the ileum (the final part of the small intestine). In the small intestine, bile (produced in the liver and stored in the gall bladder), pancreatic enzymes, and other digestive enzymes produced by the inner wall of the small intestine help in the breakdown of food.

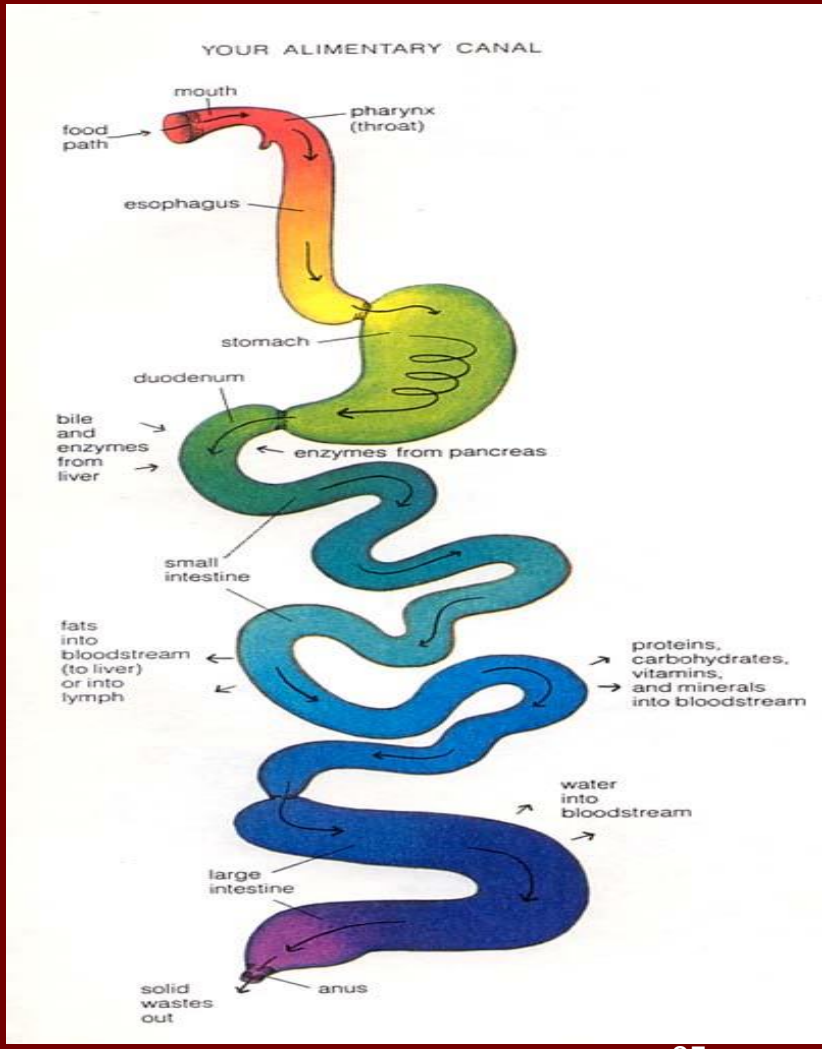
I- Structure:

Digestive system composed of 2 separate groups of organs:

a- Alimentary canal:

- It form a continuous tube that extends from the mouth to the anus (about 9–10 meters).
- Smooth muscle of the alimentary canal pushes materials from one part to another.

➔ Mouth, pharynx, esophagus, stomach, small intestine, large intestine.



Oral Cavity (mouth)

- It is the gate of the GI tract.
- The tongue and teeth are the first "organs" of the digestive tract.
- The digestive process begins in the mouth:

→ Mechanical digestion (via mastication)

→ Chemical digestion (via enzymes in saliva).

Oral Cavity (mouth)

- **During mechanical digestion** (mastication):

➔ The food is broken into small pieces and mixed with saliva to form a bolus that is easily swallowed.

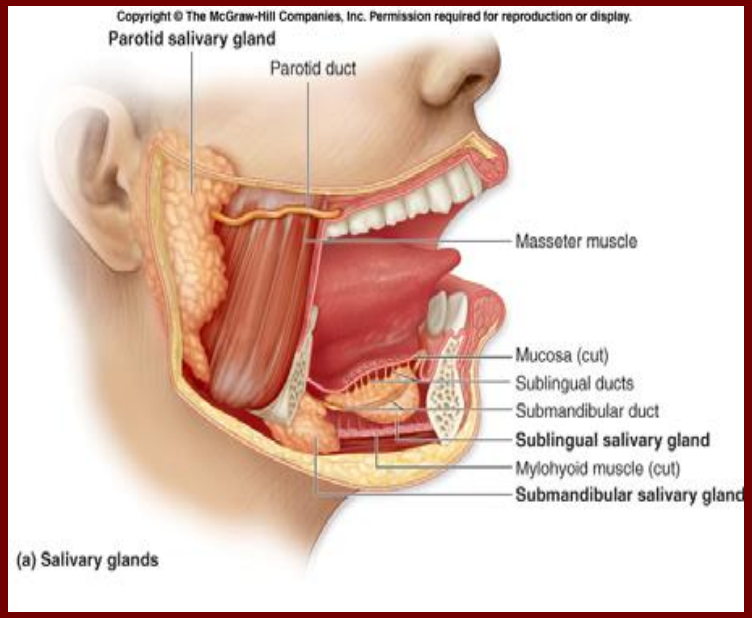
- **During chemical digestion:**

➔ The amylase (from the salivary gland) breaks the bonds between the polysaccharides, converting them to monosaccharides, which can be absorbed through the membrane of the GI(gastrointestinal tract) tract.

Salivary Glands

- They secrete saliva.
- Volume of saliva secreted daily 1.0 -1.5 L.

➔ Most is produced during mealtime.



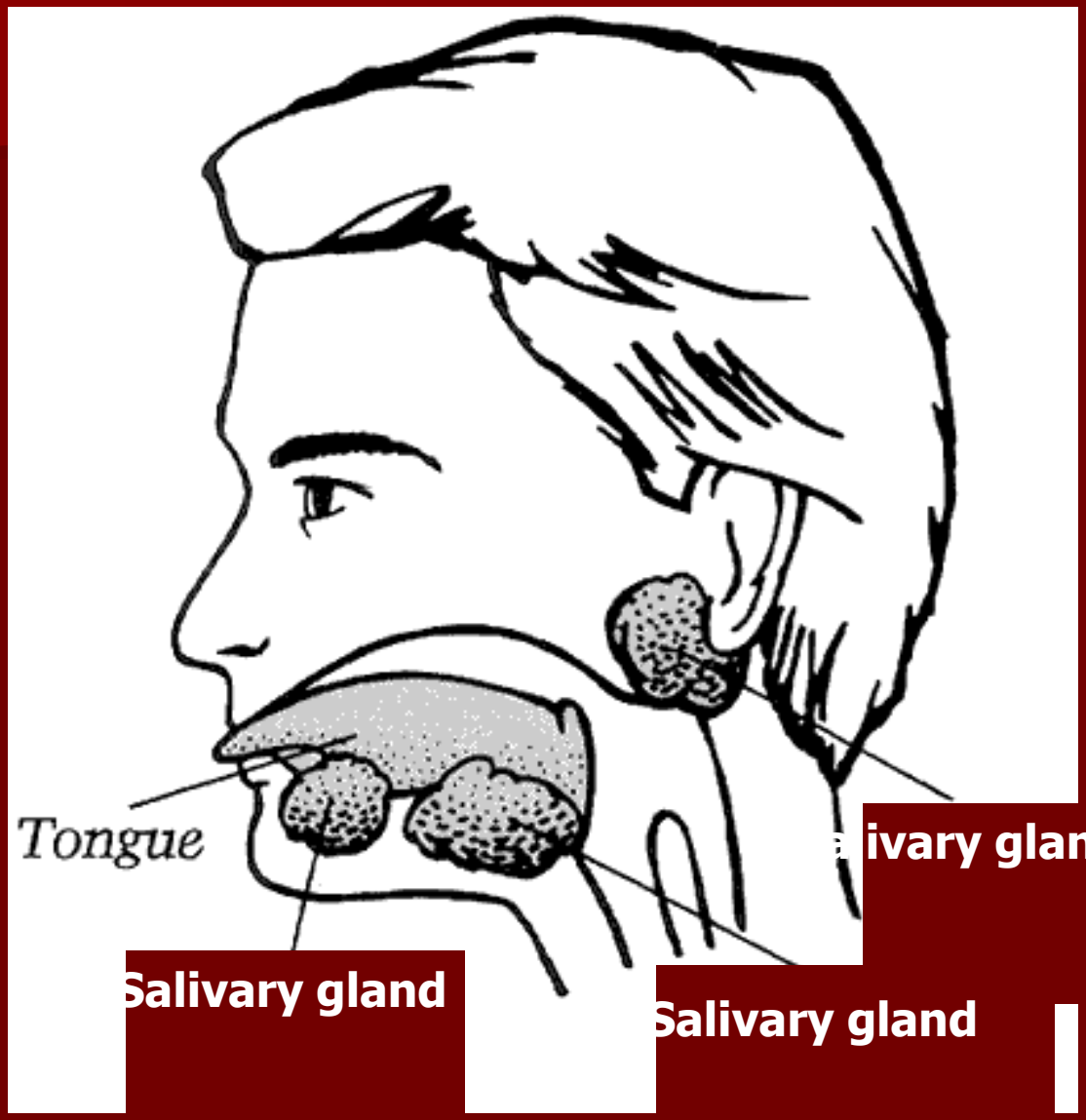
They are 3 pairs:

1- Parotid glands

2- Submandibular glands

3- Sublingual glands

2. Role of the Mouth



Teeth assist the mechanical breakdown of food

↓

Saliva is mixed with food during chewing

↓

Saliva contains the enzyme amylase which starts the digestion of food

↓

Saliva contains mucus that keeps the mouth moist and lubricates food for easier swallowing

Saliva

Composition of Saliva

Saliva is a hypotonic solution of :

- **99% water :** To dissolve food easily.

➔ so they can be tasted.

- **1% solutes:**
- **Salivary amylase-** an enzyme that begins starch digestion.
- **Mucous-** lubricates food for easy swallowing.
- **lysozyme-** destroys bacteria to protect the mucous membranes and the teeth from decay.
- **Electrolytes**- including sodium, potassium, chloride, phosphate, and bicarbonate ions

- **pH of saliva** = 6.8 to 7.0

Functions of Saliva

- Moistens and cleans the oral cavity.
- Moistens ingested food and helps it into a semisolid bolus that is easily swallowed.
- amylase in saliva break down carbohydrates.
- Contains enzyme called lysozyme that inhibit bacterial growth in the oral cavity.

Pharynx

- Passageway of both food and air
- Food passes through the oropharynx then laryngopharynx to reach the oesophagus
- Once a bolus of food reaches the pharynx, swallowing is involuntary

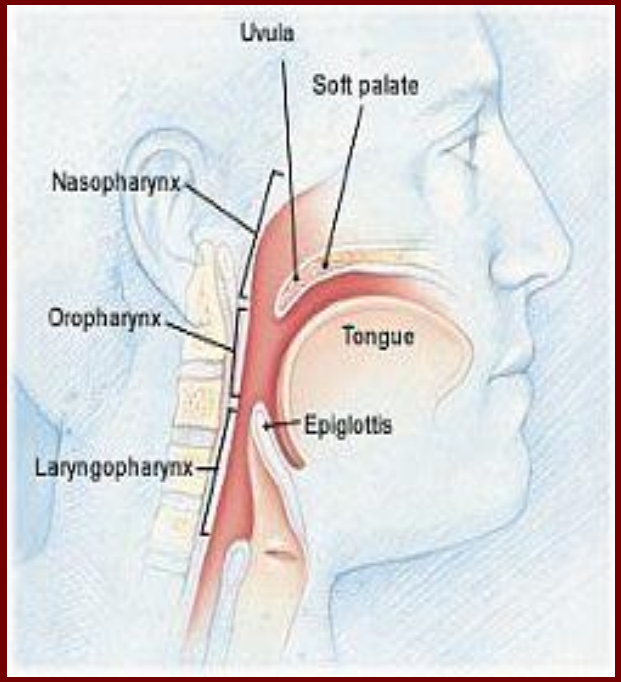
Swallowing

- Regulated by swallowing center in the medulla oblongata.

Stages of Swallowing

1- Buccal stage

- It is a voluntary stage.
- The tongue collects food and form a bolus.
- The tongue pushes the bolus into the oropharynx.



2- Pharyngeal stage

- It is involuntary stage.
- 3 actions block food and drink from re-entering the mouth, the nasal cavity or larynx

a- The root of the tongue blocks the oral cavity

b- The soft palate rises and blocks the nasopharynx

c- Epiglottis close the airway that leads to the trachea

Oesophagus

- Oesophagus is a straight muscular tube

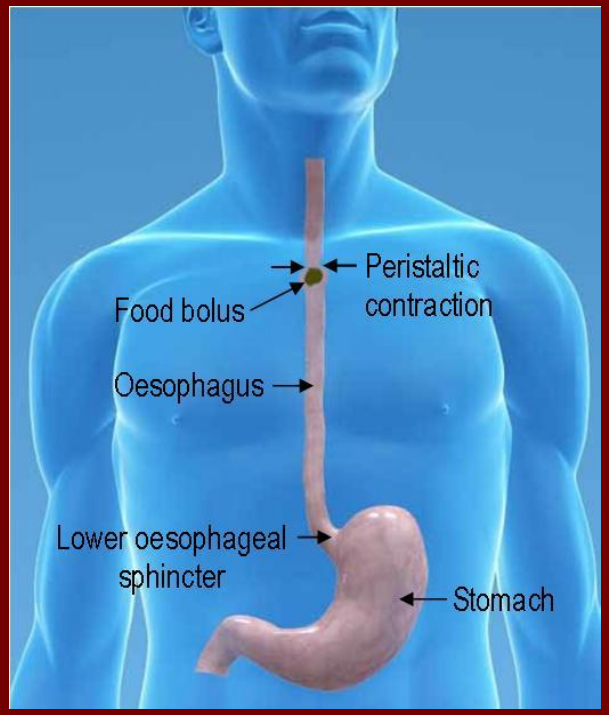
➔ about 25-30 cm long.

- It transports food from the pharynx to the stomach in about 7 seconds.
- it meets with the stomach at an opening called the lower oesophageal sphincter (LES).

Function:

Transport food into stomach by peristalsis

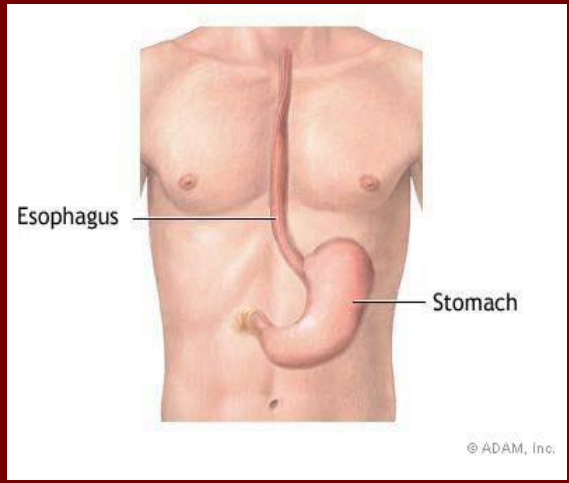
- **The normal function of LES** is one-way valve. It prevents reflux of stomach contents into the oesophagus
- LES is also known as the Cardiac Sphincter

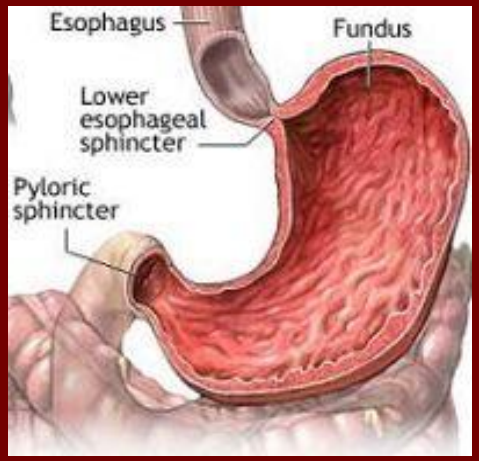


Stomach

- is a muscular elastic bag.
- between the oesophagus and the small intestine.
- Separated form the small intestine by the pyloric sphincter
- Has three regions:
  1. fundus 2. body 3. pylorus

- In stomach, food boluses moves slowly towards the pylorus (3- 4 h).
- During this period, food boluses are subjected again to:
  - Mechanical digestion.
  - Chemical digestion.
- ➔ The digestive enzymes interact to break down the food especially proteins.





Stomach

Functions of the Stomach

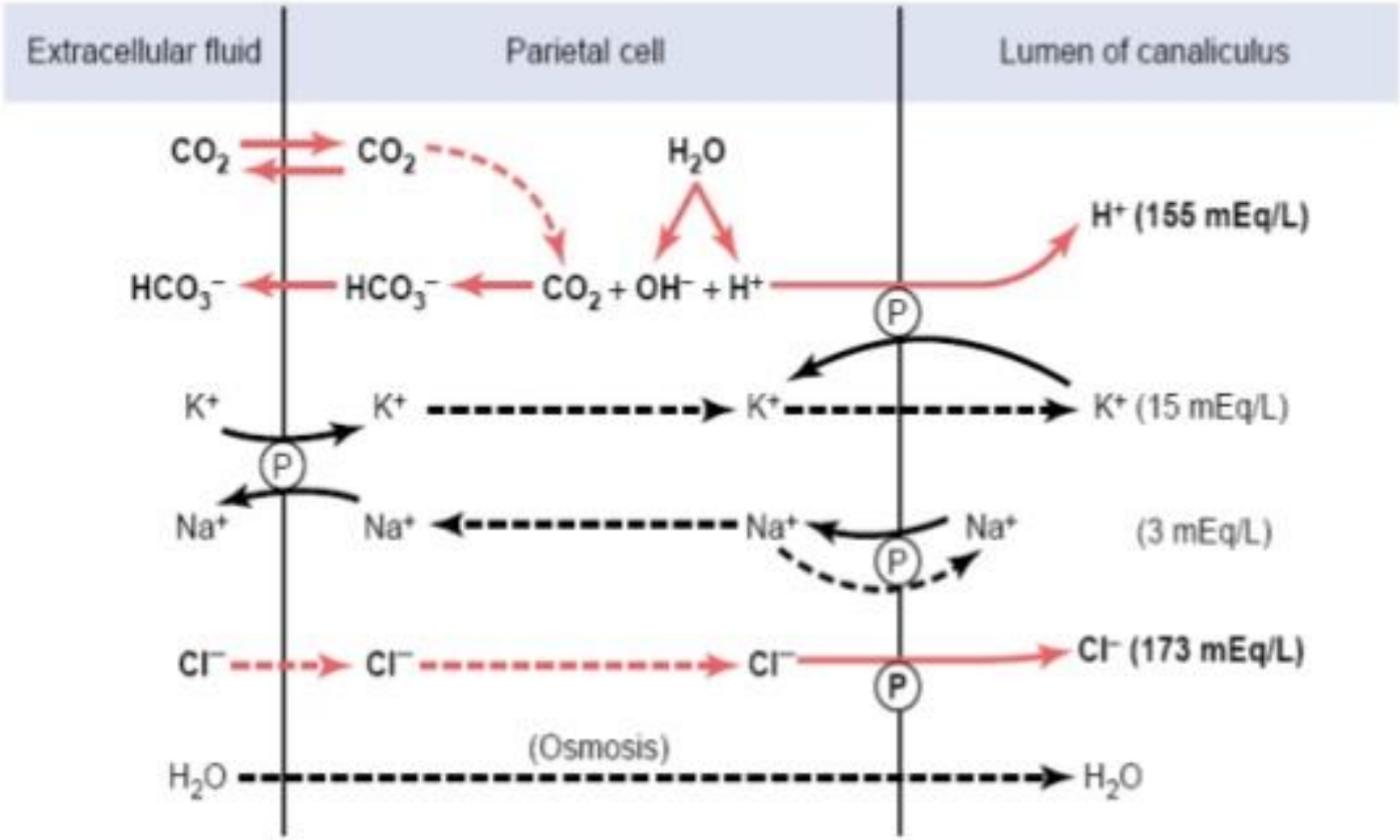
1- Temporary storage

2- Mixing

3- Secretion of:

- HCl change the polar molecules(protien)- intrinsic factor - pepsinogen – mucus (protect the stomach from the HCL)
- Pepsinogen in active through the HCL convert it to the pepsin active Breakdown the protien to the peptide
- Lipase breakdown the lipids.

Formation of HCL



Digestive Chart: The Stomach

AREA	PROCESSES	SECRETIONS	CONTROLS	HISTOLOGY
Stomach	storage (up to 4 hrs) mechanical digestion some absorption chemical digestion: polypeptides --> shorter chains	pepsinogen + HCl ★ mucus *gastrin*	cephalic; contact; gastric phase: *gastrin* intestinal phase: *gastrin*, *GIP*, enterogastric reflex	simple columnar gastric pits specialized cells 3-layered smooth muscle

Mostly on an empty stomach substances absorbed include: alcohol, water, electrolytes, glucose, fat-soluble molecules

Pepsinogen + H^+ → pepsin

pH 1.5-3.5

Polypeptides → shorter chains

Gastrin is a hormone involved in control of gastric activity.

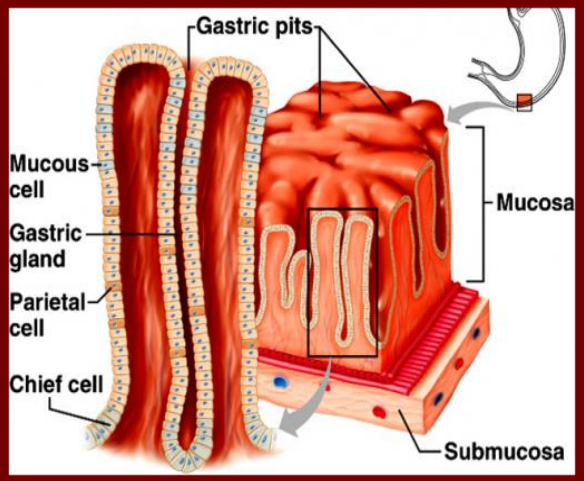
Secretory cells

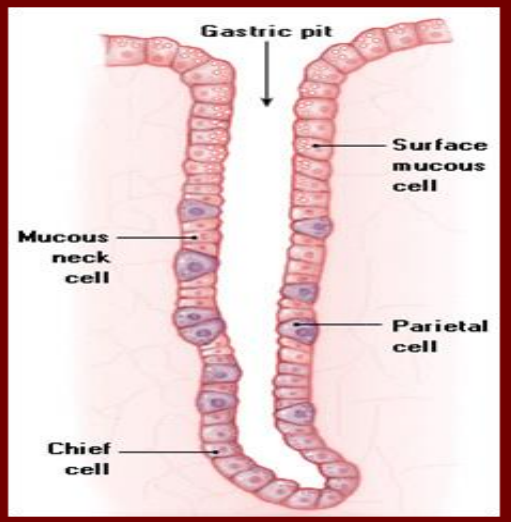
1- Mucous cells:

secrete an alkaline watery mucus

➔ protects the gastric mucosa against friction and HCl.

➔ so stomach wall will not be digested by the acid or enzymes.





Secretory cells

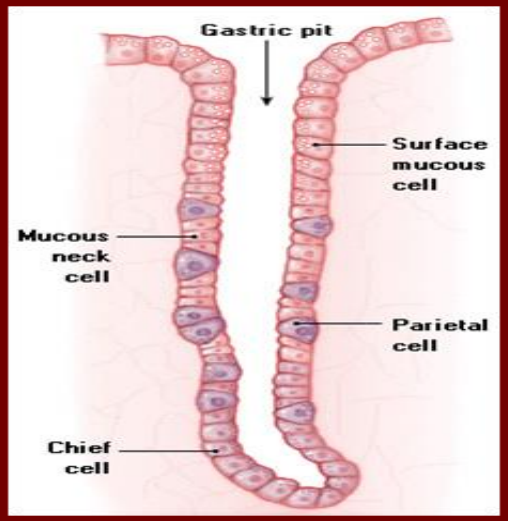
2- Parietal cells:
secrete HCl and intrinsic factor.

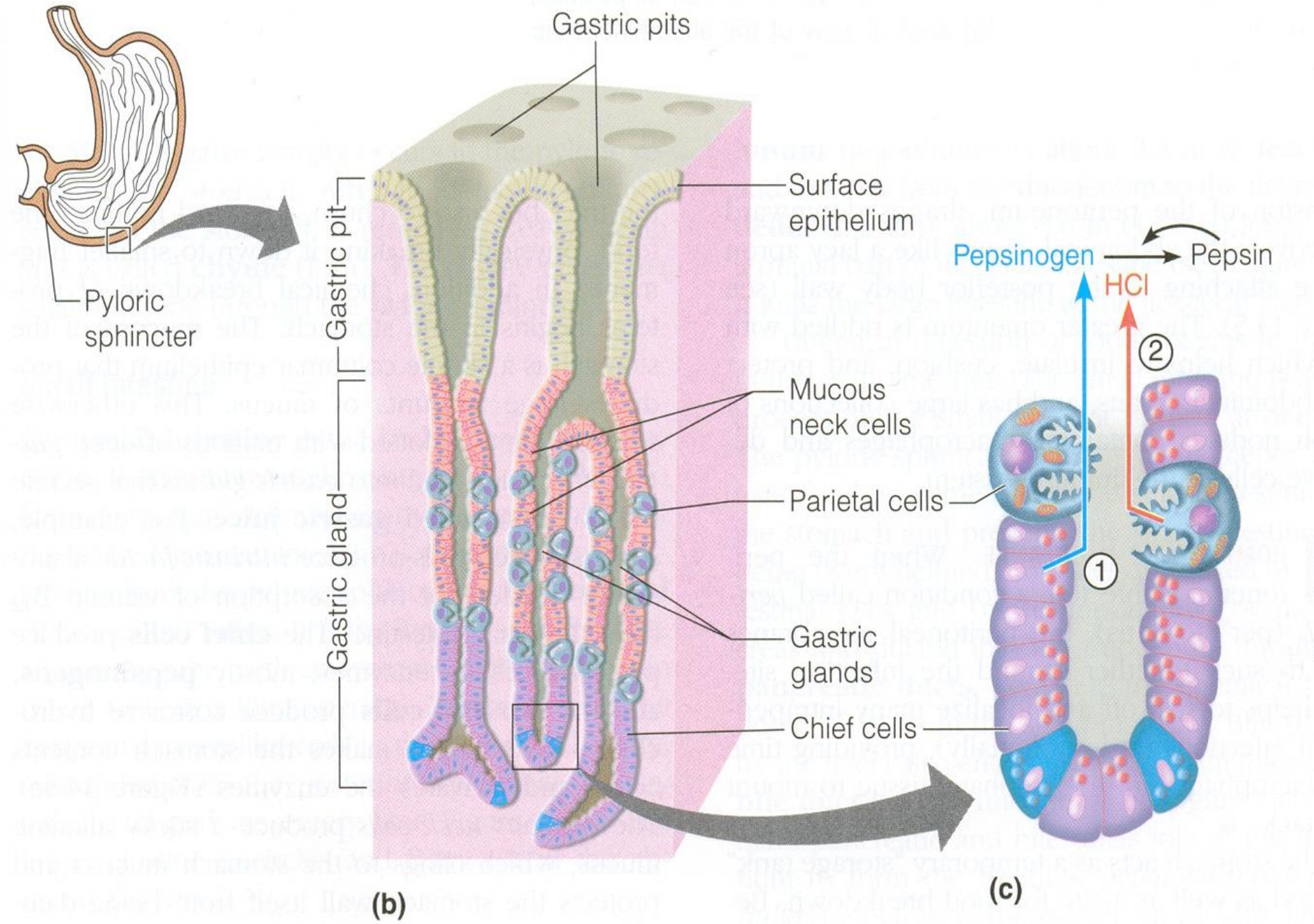
Functions of HCL:

- Activates pepsinogen into pepsin
- Breaks up connective tissues and plant cell walls.

➔ Liquefy food and form chyme

- kills m.o and other pathogens that may present in the food.
- Converts ingested ferric ions (Fe^{3+}) to ferrous ions (Fe^{2+}), a form of iron that can be absorbed and used for Hb synthesis.




Pyloric sphincter
Gastric pits
Gastric pit
Gastric gland
Surface epithelium
Mucous neck cells
Parietal cells
Gastric glands
Chief cells
(b)
Pepsinogen
Pepsin
HCl
2
1
(c)

Secretory cells

3- Chief cells:

Secrete pepsinogen.

➔ Activated by HCl into pepsin (proteolytic enzyme).

Functions of Pepsin

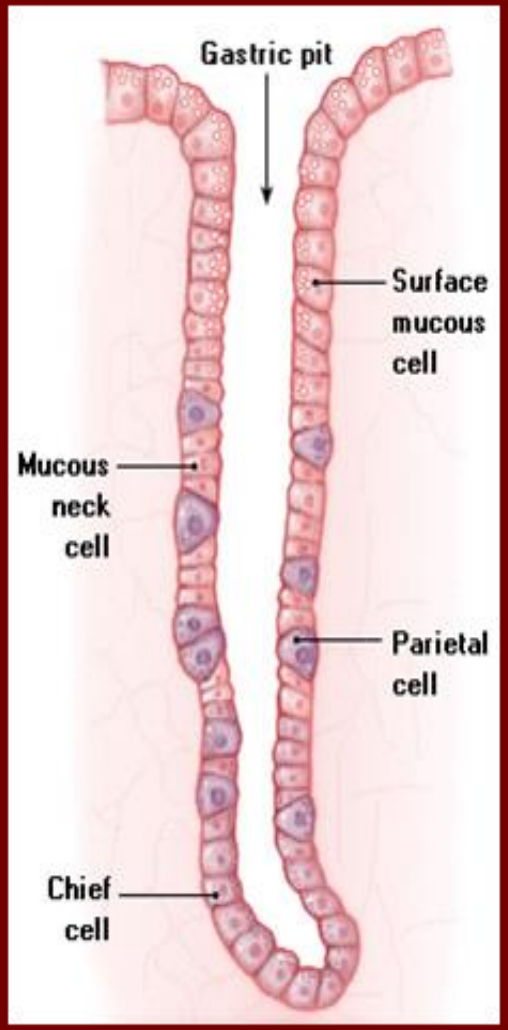
- digest dietary proteins to a shorter peptide chain which can pass to the small intestine, where their digestion is completed

4- G cells:

secrete the hormone gastrin.

Functions of gastrin:

Increases acid secretion in stomach



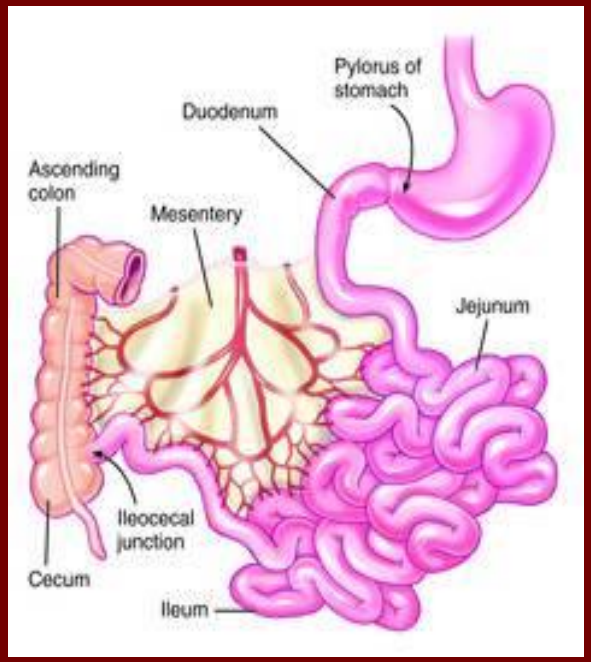
Small Intestine (SI)

- SI is the longest part of the alimentary canal.

➔ 6 m long.

➔ Fills most of the abdominal cavity.

- Food particles spend 10-12 h in SI.
- During this period, digestion and absorption are completed.



Small Intestine

- **SI consists of 3 parts:**

1. Duodenum
2. jejunum
3. ileum.

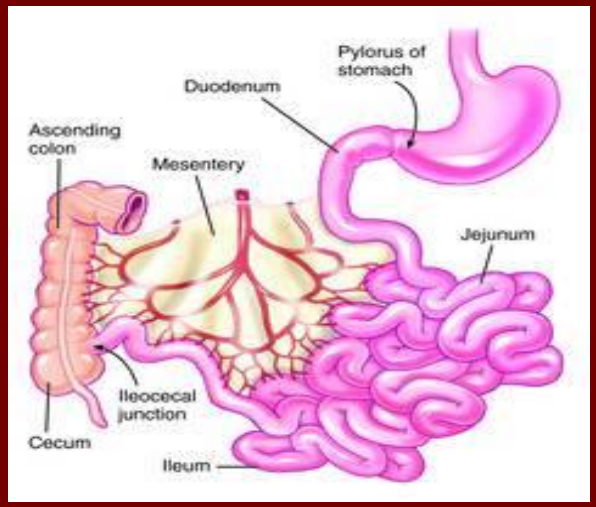
- Duodenum is responsible for completing the digestive process.

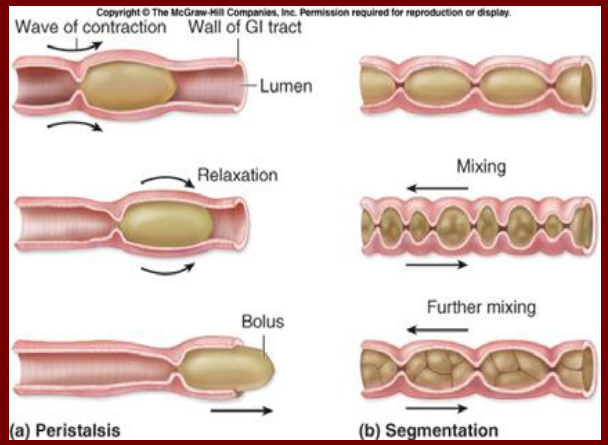
- Jejunum and ileum are responsible for absorption of nutrients into the bloodstream.

- The SI use peristalsis:

➔ To mix food particles with digestive juices.

➔ To transport food particles from one part to another.





Small Intestine

The duodenum :

➔ It is the shortest part of SI (25 cm).

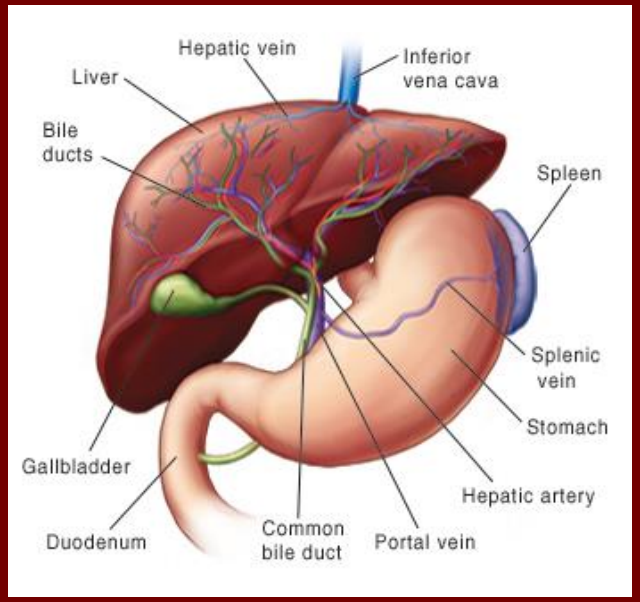
➔ Manufactures the intestinal juice.

- There are 2 ducts open into the duodenum:
- One carry the bile from the gall bladder.
- The other carry the pancreatic juice from the **pancreas**.
- In the duodenum, the acidic fatty chyme stimulates the release of 3 different digestive juices:

I- Bile.

II- Pancreatic juice.

III- Intestinal enzymes.

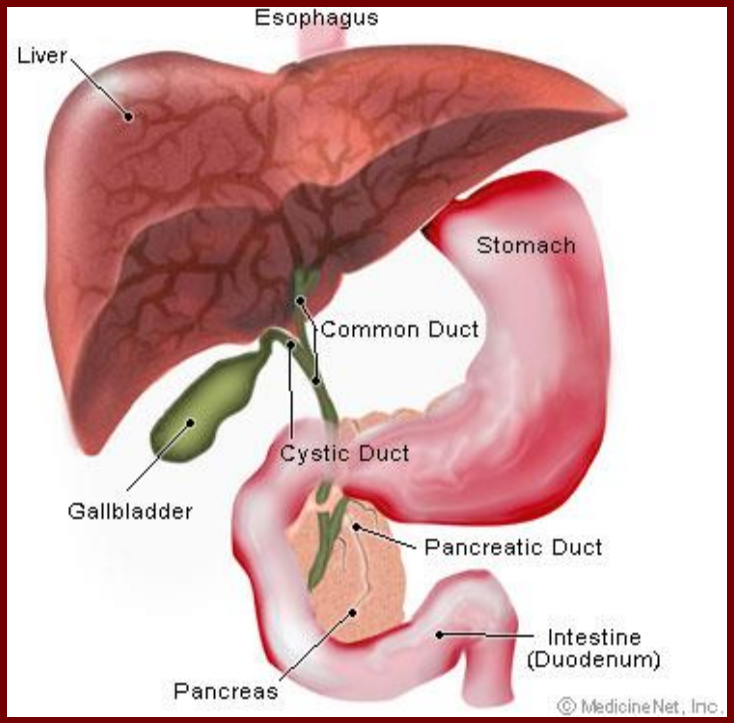


I. Bile:

➔ Secreted by the liver.

➔ Stored and released by the gall bladder.

- Entering of the fatty chyme into the duodenum, stimulate the release of cholecystokinin hormone.
- The hormone stimulates the gall bladder to contract and release its bile into the duodenum.



Small Intestine

II. Pancreatic juice :

- The pancreas consists of:

➔ Endocrine cells (the islets of Langerhans).

➔ Exocrine cells which secrete the pancreatic juice into the duodenum.

- **Pancreatic juice contains:**

1-Sodium bicarbonate: Neutralizes the acidity of the chyme (due to HCl of the stomach).

➔ Raising its pH to about 8.

2-Pancreatic enzymes:

✓ **Amylase enzyme**: Hydrolyzes **starch** into a mixture of maltose and glucose.

✓ **Lipase enzyme**: Hydrolyzes **fat** droplets into a mixture of fatty acids and monoglycerides.

3- Zymogens:

- They are digestive enzymes that released in inactive forms (so, called Proenzymes).

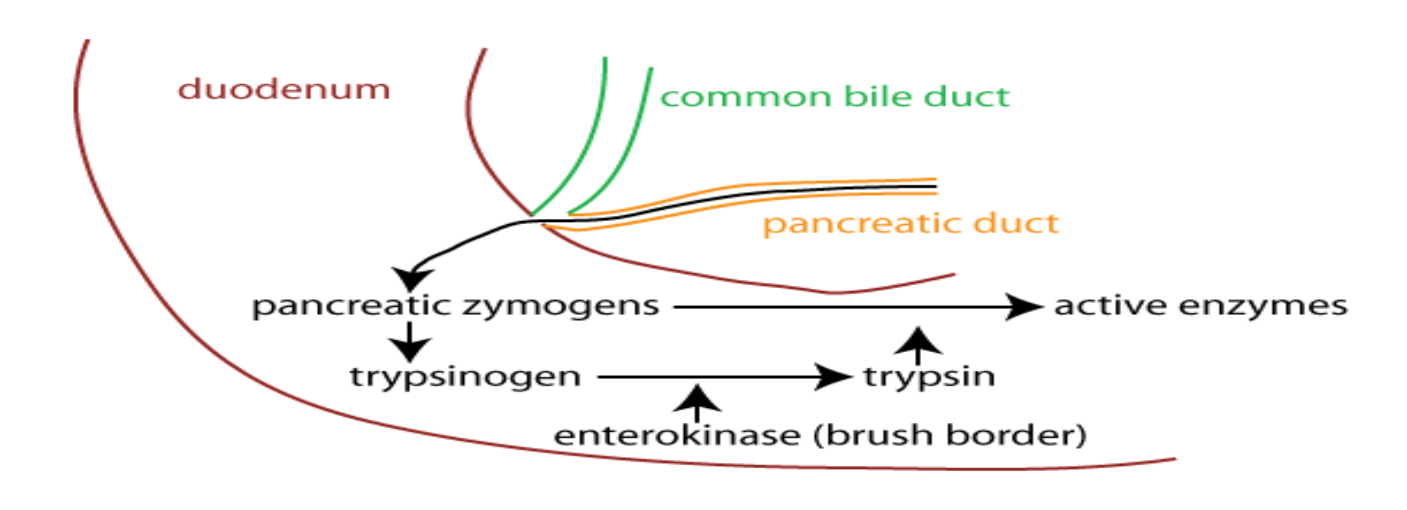
➔ To avoid self-digestion.

Small Intestine

- Examples of pancreatic zymogens:

➔ **Trypsinogen** & **Chymotrypsinogen.**

- They pass into the duodenum where they are activated by **Enterokinase enzyme.**
- **Inactive Trypsinogen** ➔ active enzyme **Trypsin.**
- **Inactive Chymotrypsinogen** ➔ active enzyme **Chemotrypsin.**
- **Trypsin** and **Chemotrypsin** are proteolytic enzymes (digest proteins).

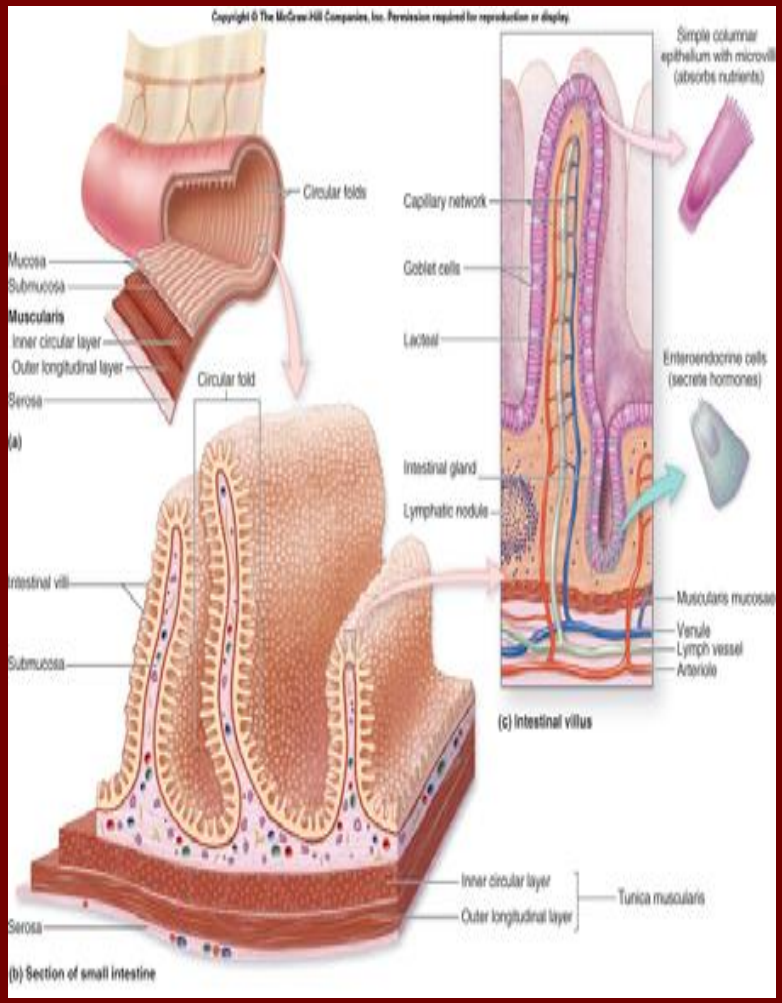


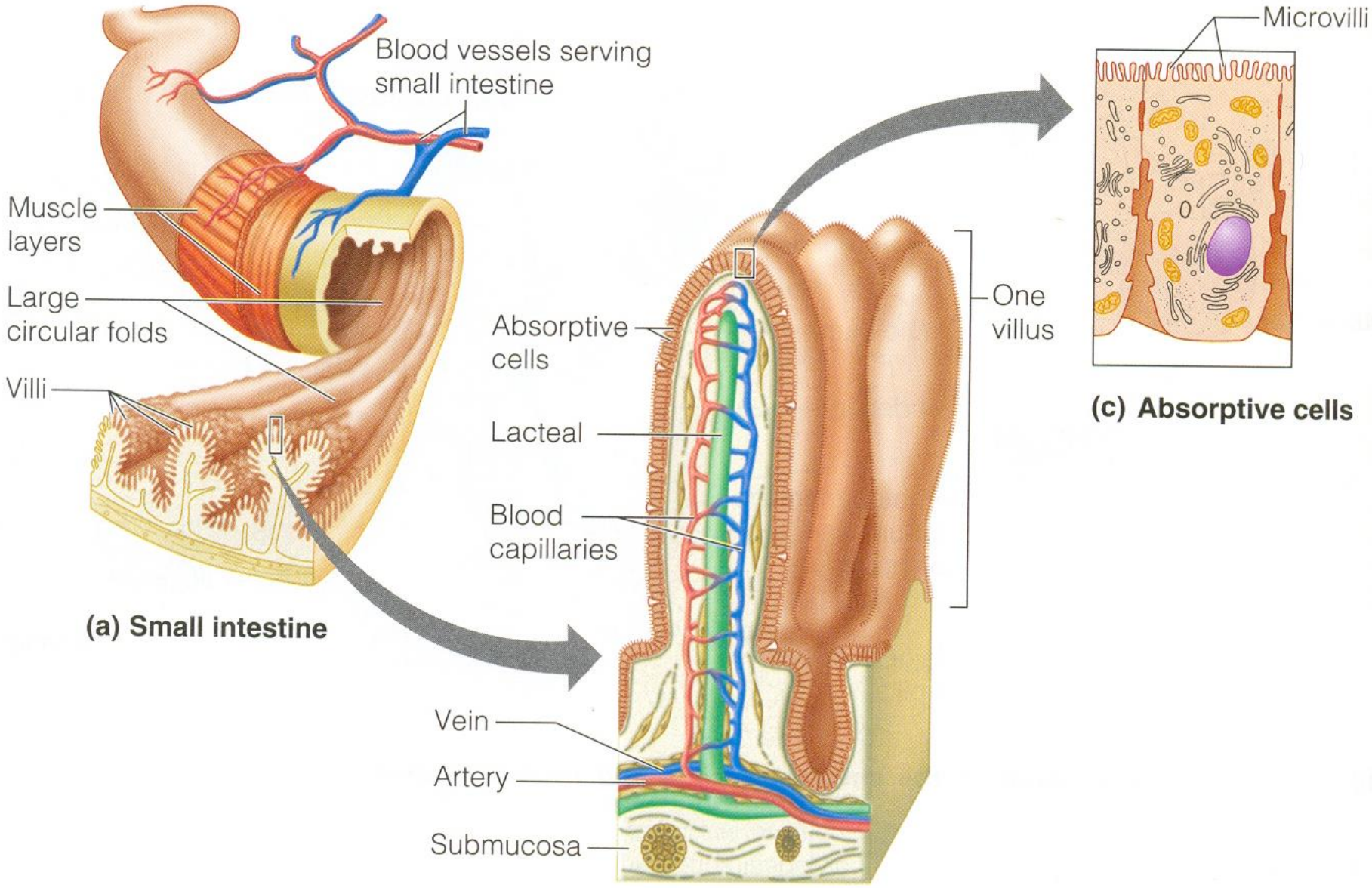
Small Intestine

III. Intestinal enzymes:

- They incorporated in the plasma membrane of the microvilli.

- **Intestinal enzymes includes:**
  - **Aminopeptidases:** hydrolyzes the peptides producing amino acids.
  - **Disaccharidases:** hydrolyzes disaccharides into monosaccharides.
    - **maltase** hydrolyzes maltose into glucose.
    - **sucrase** hydrolyzes sucrose (common table sugar) into glucose and fructose.
    - **lactase** hydrolyzes lactose (milk sugar) into glucose and galactose.




Blood vessels serving small intestine
Muscle layers
Large circular folds
Villi
(a) Small intestine
Absorptive cells
Lacteal
Blood capillaries
One villus
Vein
Artery
Submucosa
(b) Villi
Microvilli
(c) Absorptive cells

Digestion & Absorption

- **Digestion**
- Digestion is the process of breakdown of food and liquids into smaller and simpler parts so that the body can use them to build cells and tissues and to provide energy.
- **Absorption**
- Absorption is the movement of digested material from the GIT into the bloodstream.

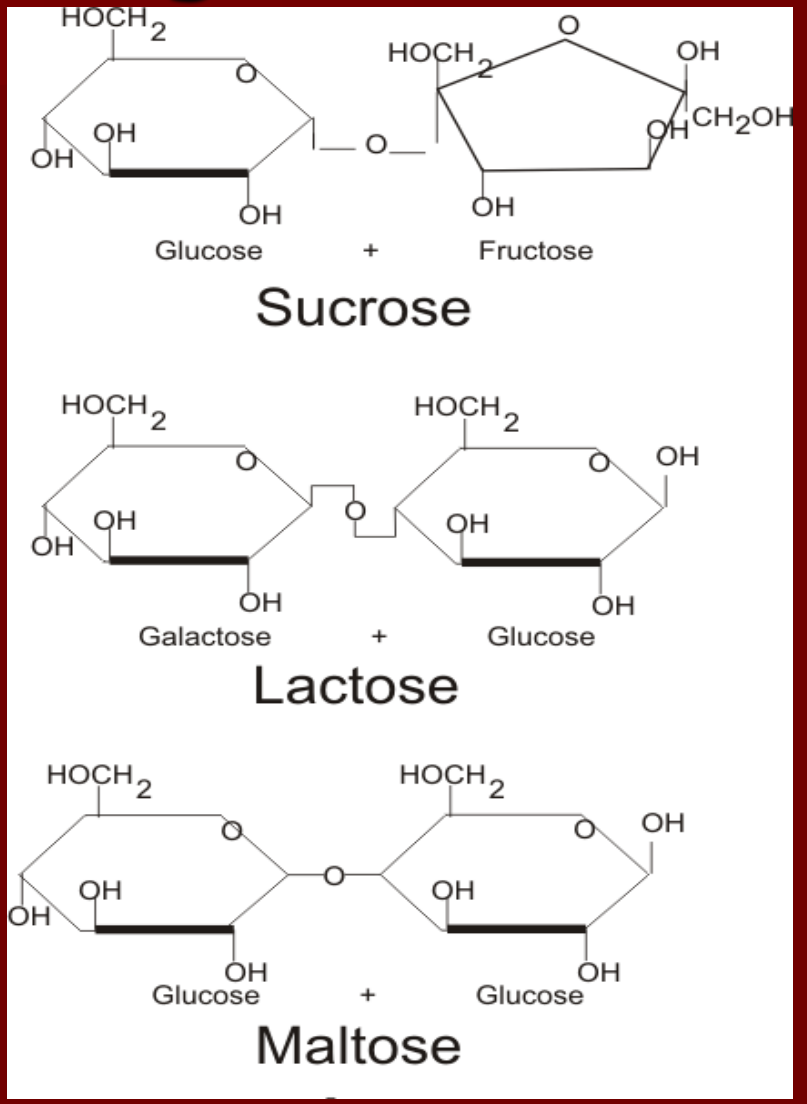
The digestible carbohydrates are broken into simpler molecules by enzymes in the saliva, in juice produced by the pancreas, and in the lining of the small intestine.

Starch is digested in two steps: First, an enzyme in the saliva and pancreatic juice breaks the starch into molecules called maltose; then an enzyme in the lining of the small intestine (maltase) splits the maltose into glucose molecules that can be absorbed into the blood.

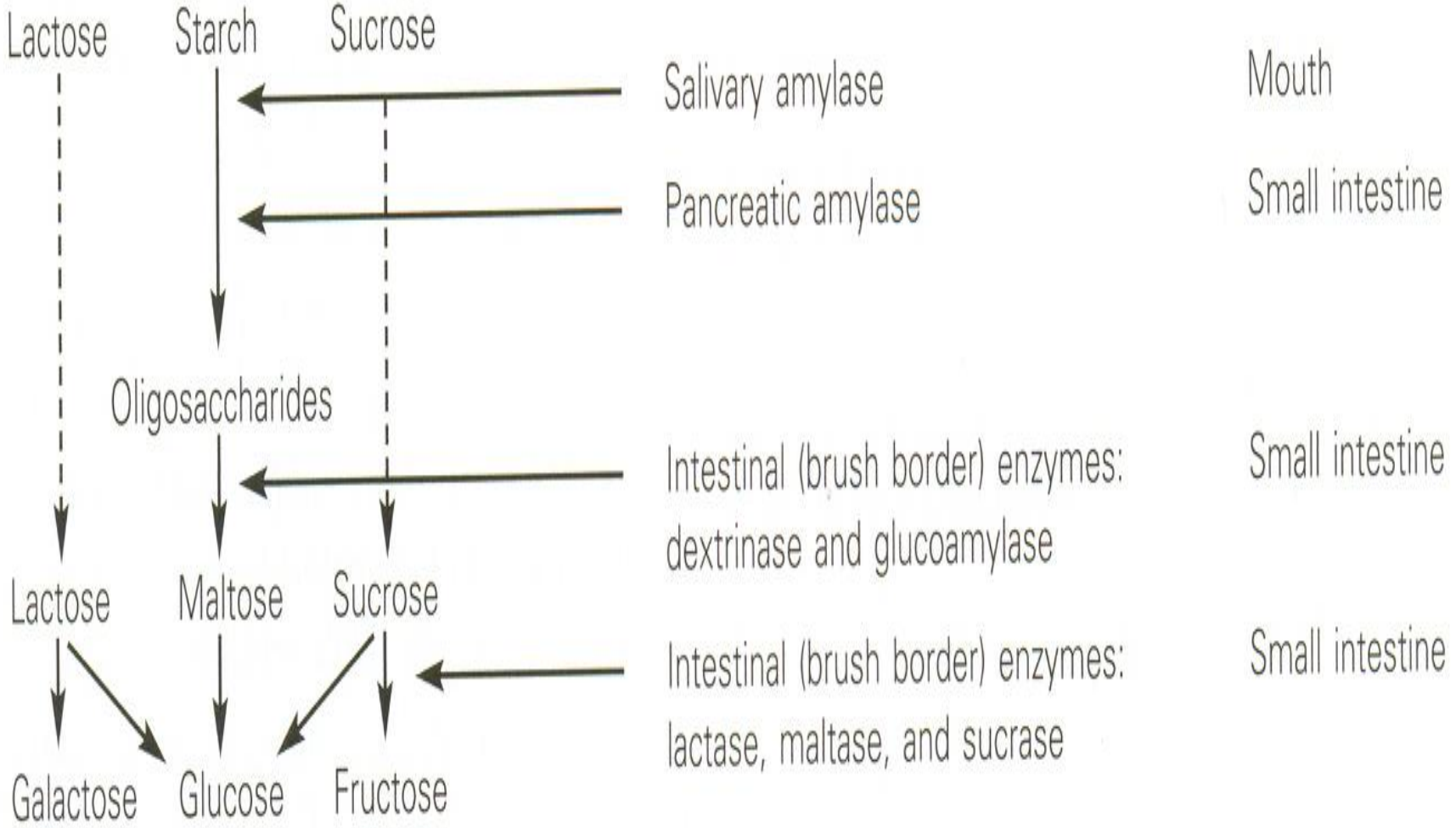
Glucose is carried through the bloodstream to the liver, where it is stored or used to provide energy for the work of the body.

Carbohydrate Digestion

- Any remaining starch and polysaccharides are broken down to disaccharides by pancreatic amylases
- Disaccharidases break down disaccharides into 2 molecules of glucose



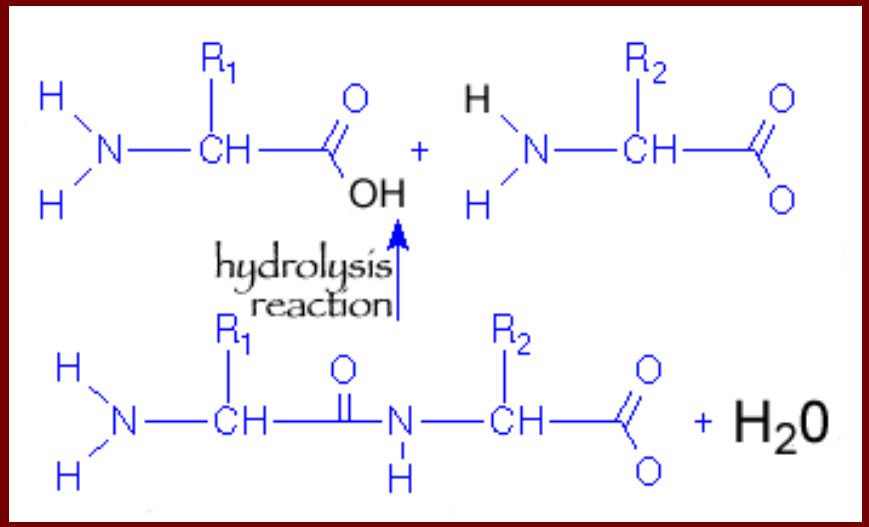
(a) Carbohydrates: sequence and sites of chemical digestion



Absorption: Monosaccharides (glucose, galactose, and fructose) enter the capillaries of the villi and are transported to the liver via the hepatic portal vein.

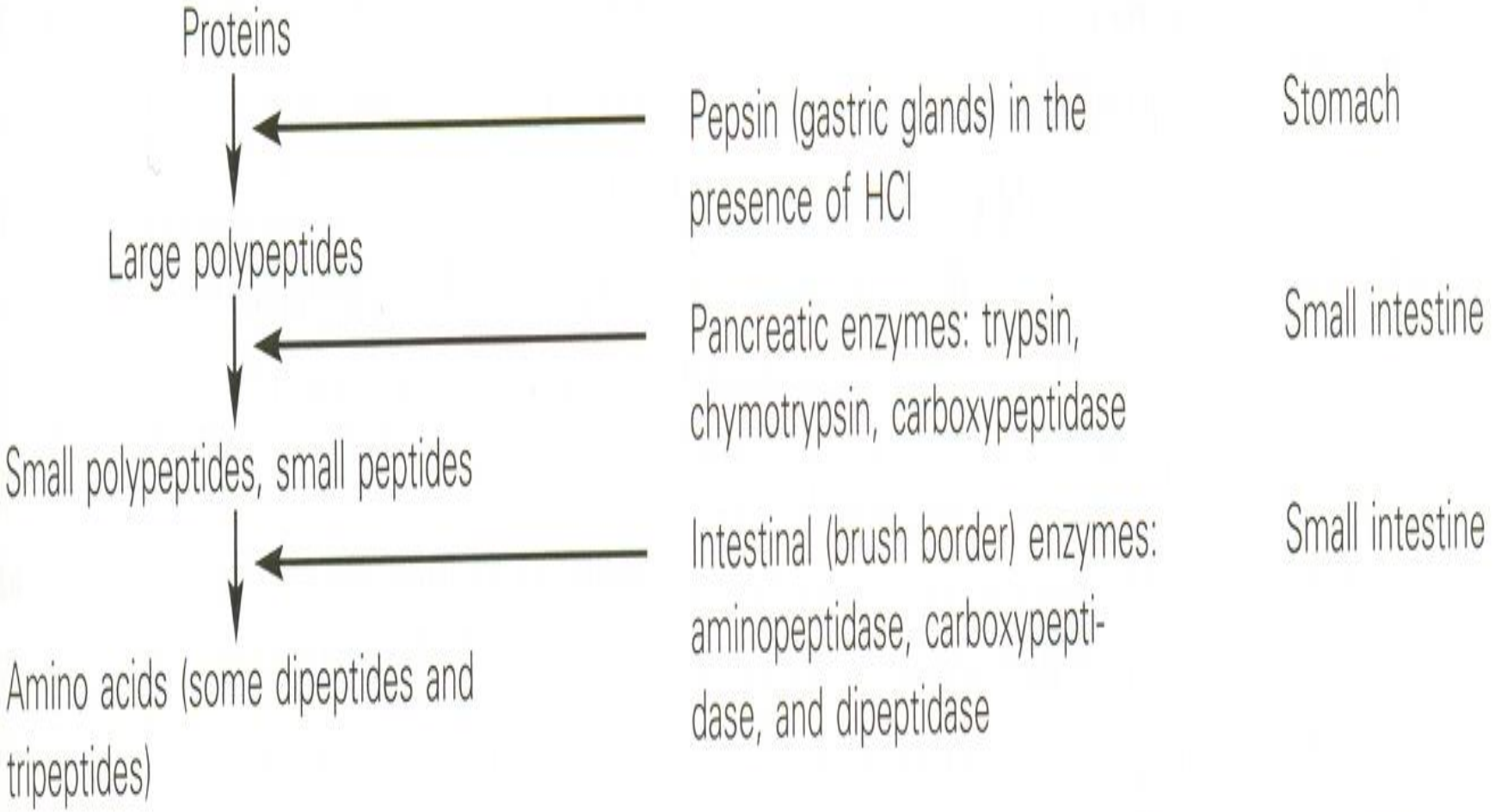
- **Protein.** Foods such as meat, eggs, and beans consist of giant molecules of protein that must be digested by enzymes before they can be used to build and repair body tissues.
- An enzyme in the juice of the stomach starts the digestion of swallowed protein.
- Further digestion of the protein is completed in the small intestine. Here, several enzymes from the pancreatic juice and the lining of the intestine carry out the breakdown of huge protein molecules into small molecules called amino acids.
- These small molecules can be absorbed from the hollow of the small intestine into the blood and then be carried to all parts of the body to build the walls and other parts of cells.

Protein Digestion



- Any remaining proteins are broken down to polypeptides by trypsin and chymotripsin
- Polypeptides are broken down to amino acids by carboxypeptidase and aminopeptidase

(b) Proteins: sequence and sites of chemical digestion

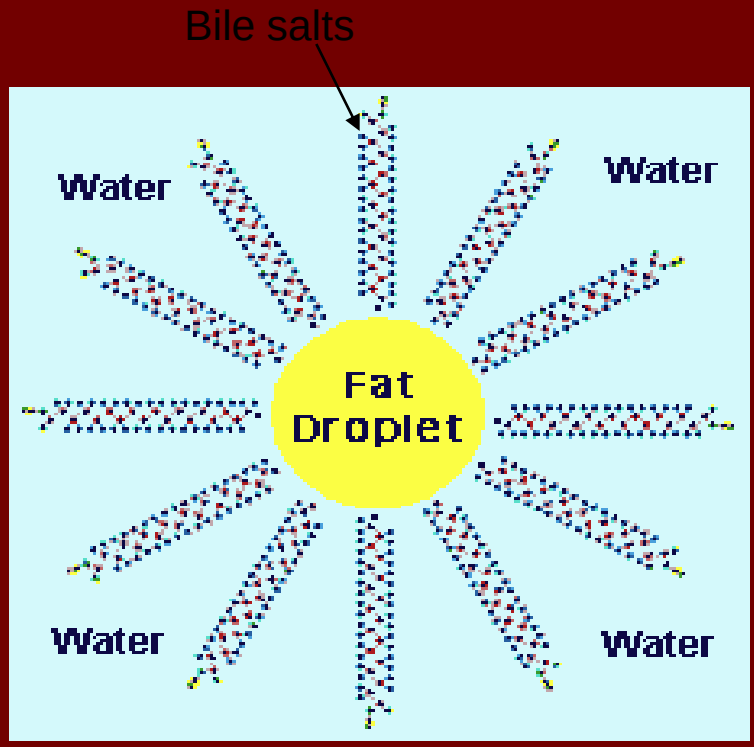


Absorption: Amino acids enter the capillaries of the villi and are transported to the liver via the hepatic portal vein.

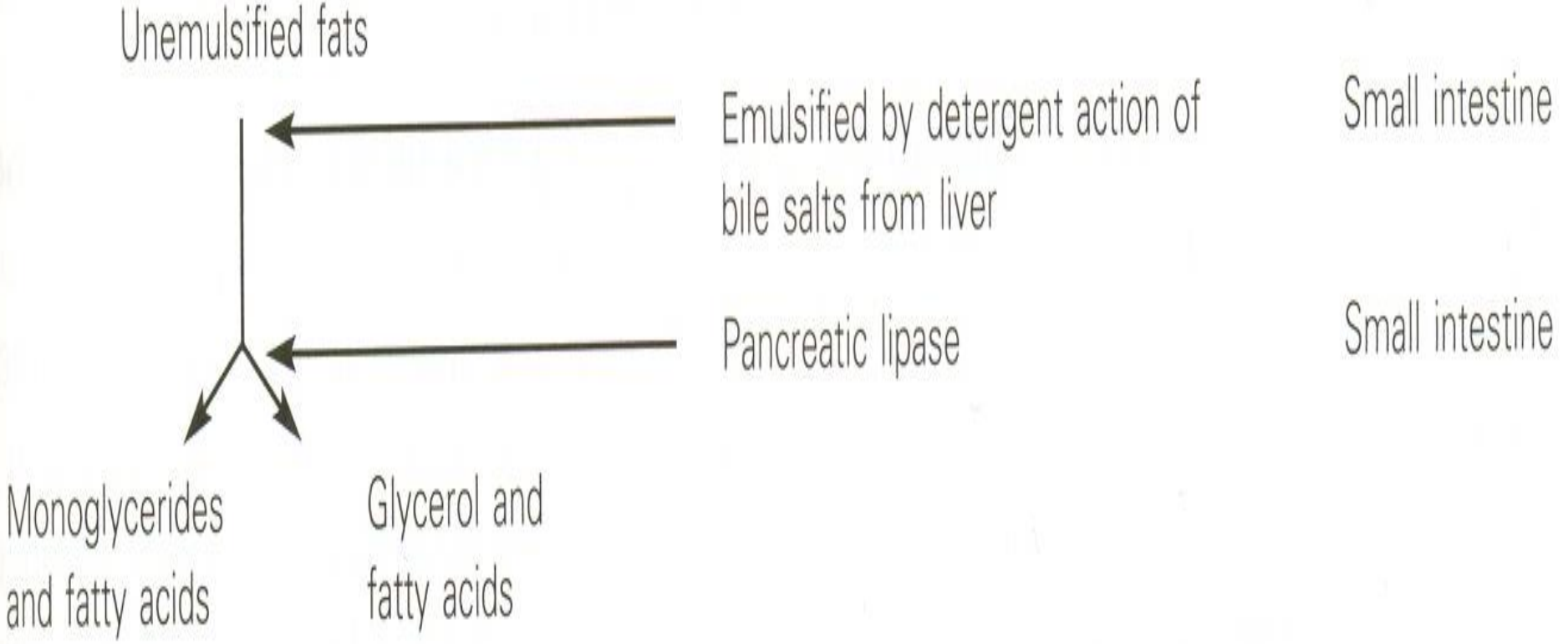
- **Fats.** Fat molecules are a rich source of energy for the body.
- The first step in digestion of a fat such as butter is to dissolve it into the watery content of the intestinal cavity.
- The bile acids produced by the liver act as natural detergents to dissolve fat in water and allow the enzymes to break the large fat molecules into smaller molecules, some of which are fatty acids and cholesterol.
- The bile acids combine with the fatty acids and cholesterol and help these molecules to move into the cells of the mucosa.
- In these cells the small molecules are formed back into large molecules, most of which pass into vessels (called lymphatics) near the intestine.
- These small vessels carry the reformed fat to the veins of the chest, and the blood carries the fat to storage depots in different parts of the body.

Fat Digestion

- Fat is not digested at all until the intestine
- Fats are not soluble in water, which presents a problem
- Bile salts bind with the fat (called **emulsification**) to keep the fat



(c) Lipids: sequence and sites of chemical digestion



Absorption: Absorbed primarily into the lacteals of the villi and transported in the lymph to the systemic circu lation via the thoracic duct and then to the liver via the hepatic artery. Glycerol and short-chain fatty acids are absorbed into the capillary blood in the villi and are transported to the liver via the hepatic portal vein.

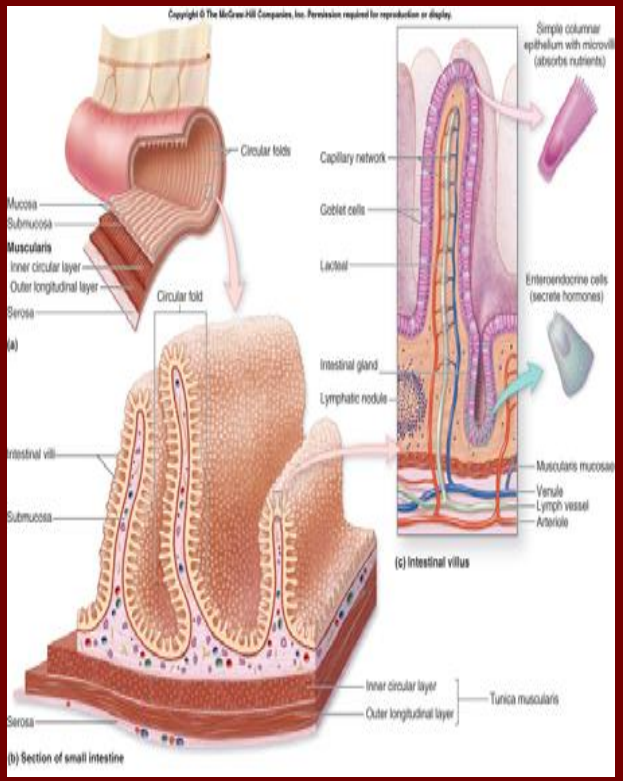
Absorption

- After digestion, the end products of protein, carbohydrate, lipid, in addition to water and most vitamin are absorbed in SI through the villi.

➔ Each villus is connected to the circulatory and lymphatic systems.

- Most nutrients are absorbed in the SI by 4 mechanisms:

(1) active transport.
(2) passive diffusion.
(3) endocytosis.
(4) facilitative diffusion.



Absorption

- Nutrients are absorbed from SI through the portal vein to the liver:

➔ for filtration, removal of toxins and nutrient processing.

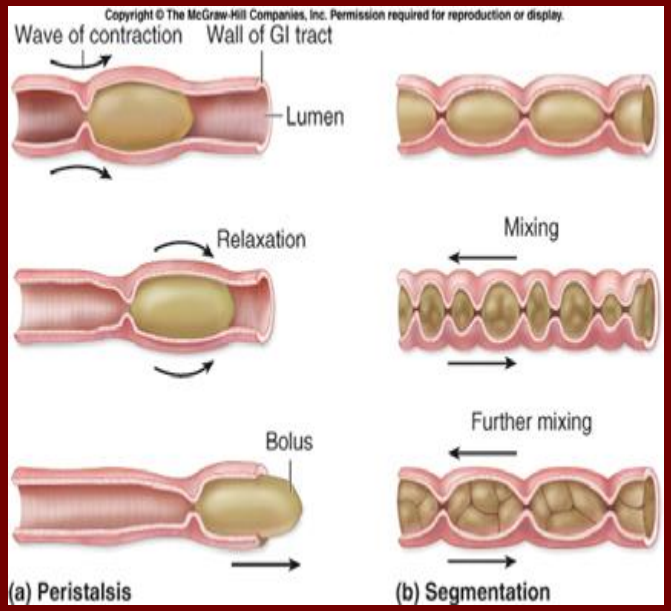
- This process called "first pass metabolism" .
- Glucose is converted into **glycogen**.
- The absorbed substances are transported from the liver to different organs:

➔ used to build the cells and tissues.

➔ To provide energy.

Absorption

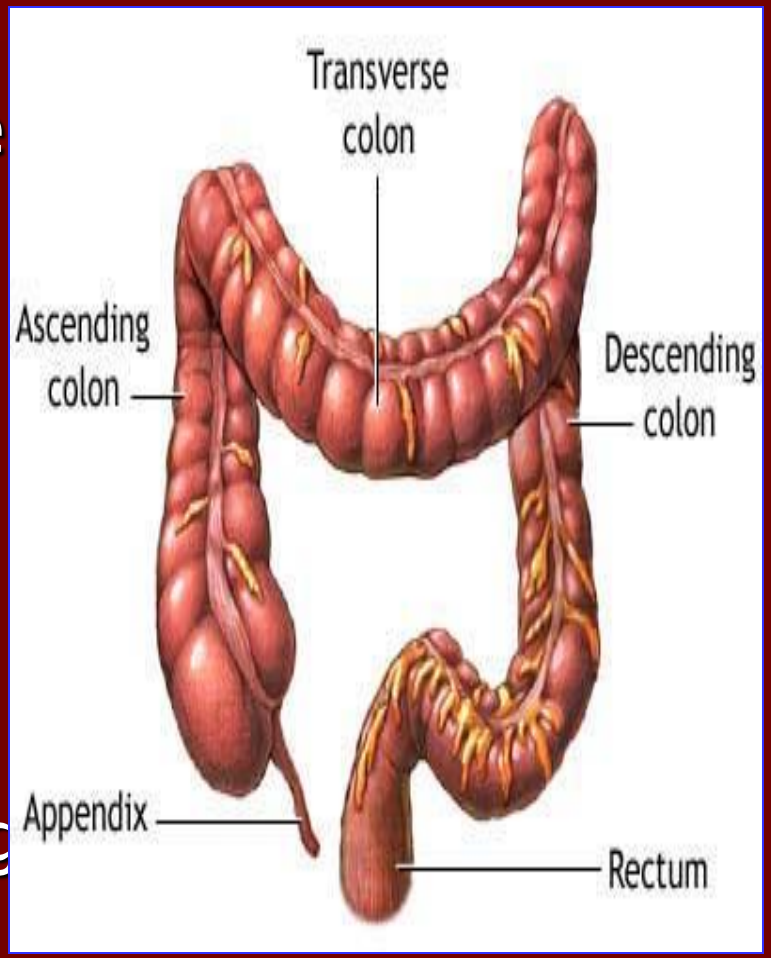
- At the end of the SI, the chyme losses about 90% of its nutrients, vitamins and minerals.
- In addition, about 8 -10 L of fluid is absorbed in the SI each day.
- Complex carbohydrates that resist digestion (as fibre) and 3-5% of ingested protein normally passes to the LI without digestion.

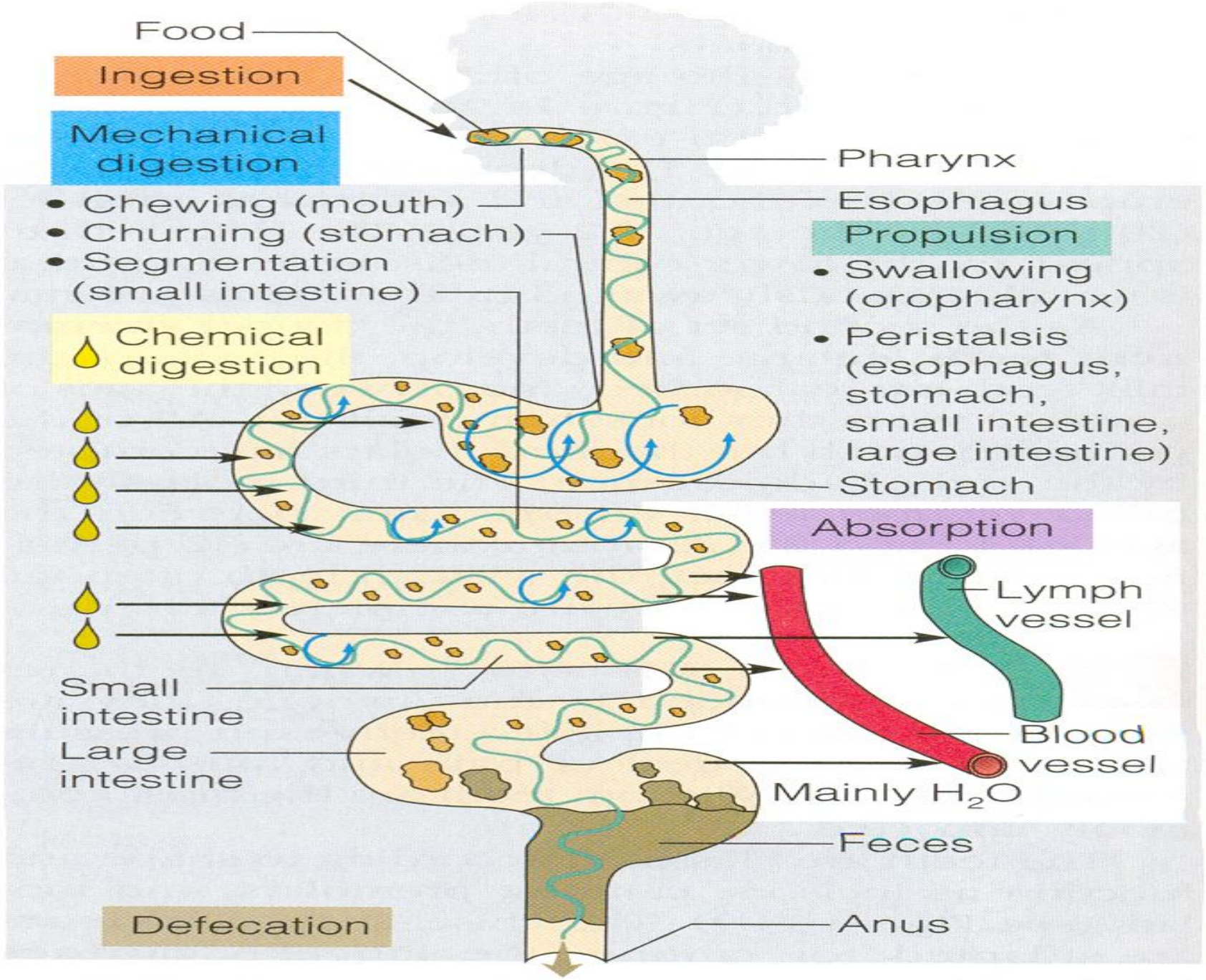


Large Intestine
0r Colon

- About 1.5 meters in length.
- Composed of 4 segments: the cecum, colon, rectum, anal canal (ends with anus).
- Colon consists of the ascending, transverse and descending colon
- The main function of the LI is the absorption of large amounts of water and electrolytes from the remaining digested material.

➔ to avoid dehydration.




Food
Ingestion
Mechanical digestion
• Chewing (mouth)
• Churning (stomach)
• Segmentation (small intestine)
Chemical digestion
Pharynx
Esophagus
Propulsion
• Swallowing (oropharynx)
• Peristalsis (esophagus, stomach, small intestine, large intestine)
Stomach
Absorption
Lymph vessel
Blood vessel
Mainly H_2O
Small intestine
Large intestine
Feces
Defecation
Anus

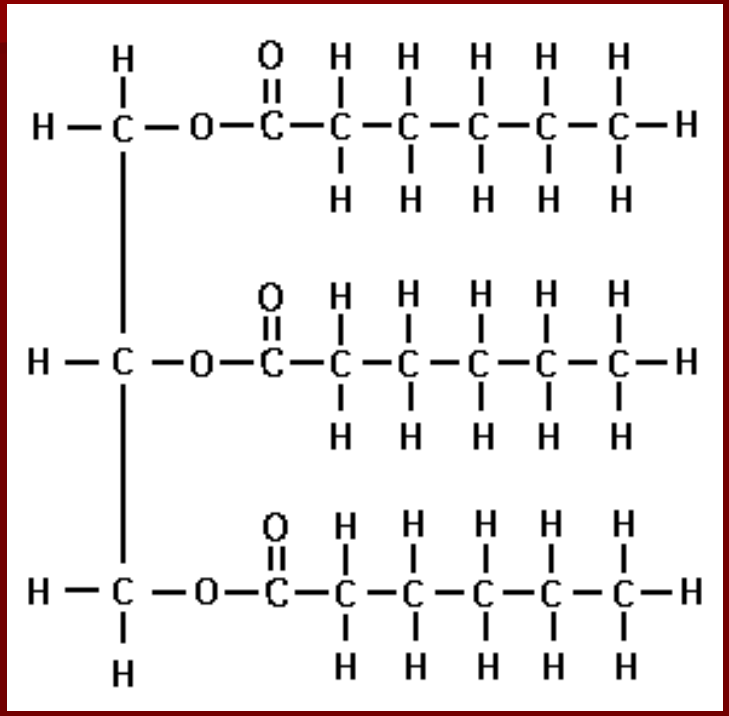
ABSORPTION AND TRANSPORT OF NUTRIENTS

- Digested molecules of food,
- as well as water and minerals from the diet, are absorbed from the cavity of the upper small intestine. Most absorbed materials cross the mucosa into the blood and are carried off in the bloodstream to other parts of the body for storage or further chemical change
- **Vitamins.** Another vital part of our food that is absorbed from the small intestine is the class of chemicals we call vitamins.

Nucleic Acid Digestion

- Nucleases hydrolyze DNA and RNA into nucleotides
- Other enzymes can also break a nucleotide down further

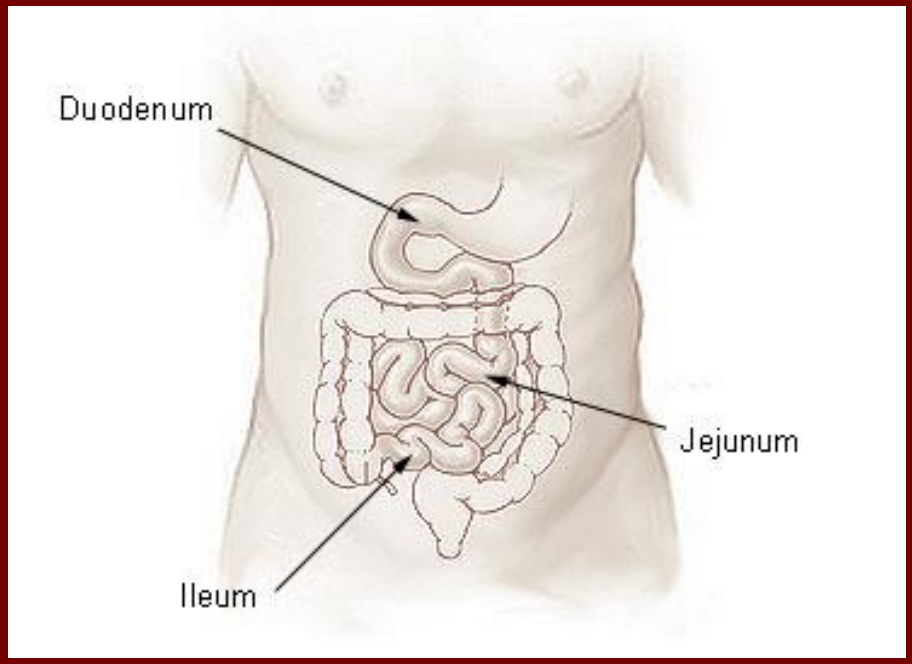
Breakdown of Fat



Glycerol Fatty Acids

- Once the bile salts have separated fat droplets, **lipase** can hydrolyze the molecule to fatty acids and

Absorption



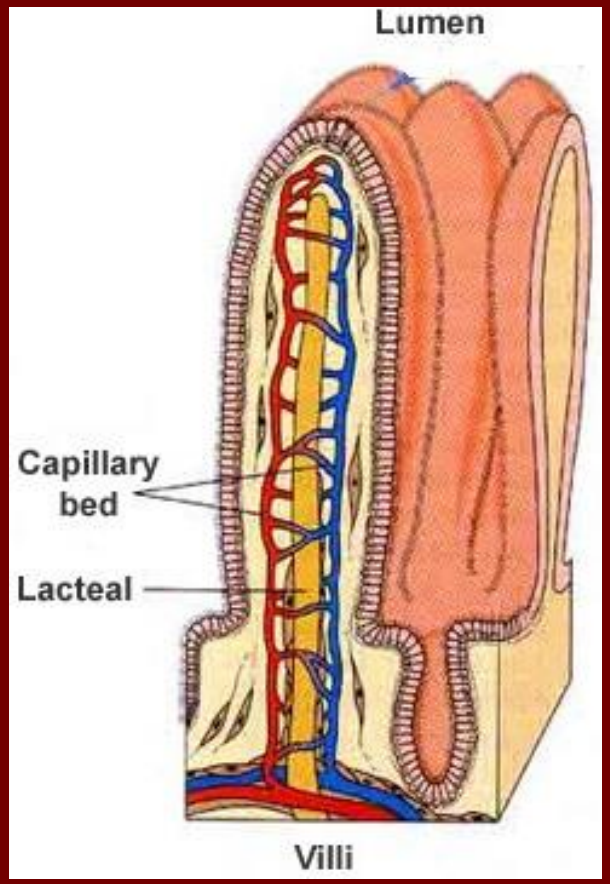
- Food is mostly digested by the time it leaves the **duodenum**
- Most absorption takes place in the **jejunum** and the **illium**

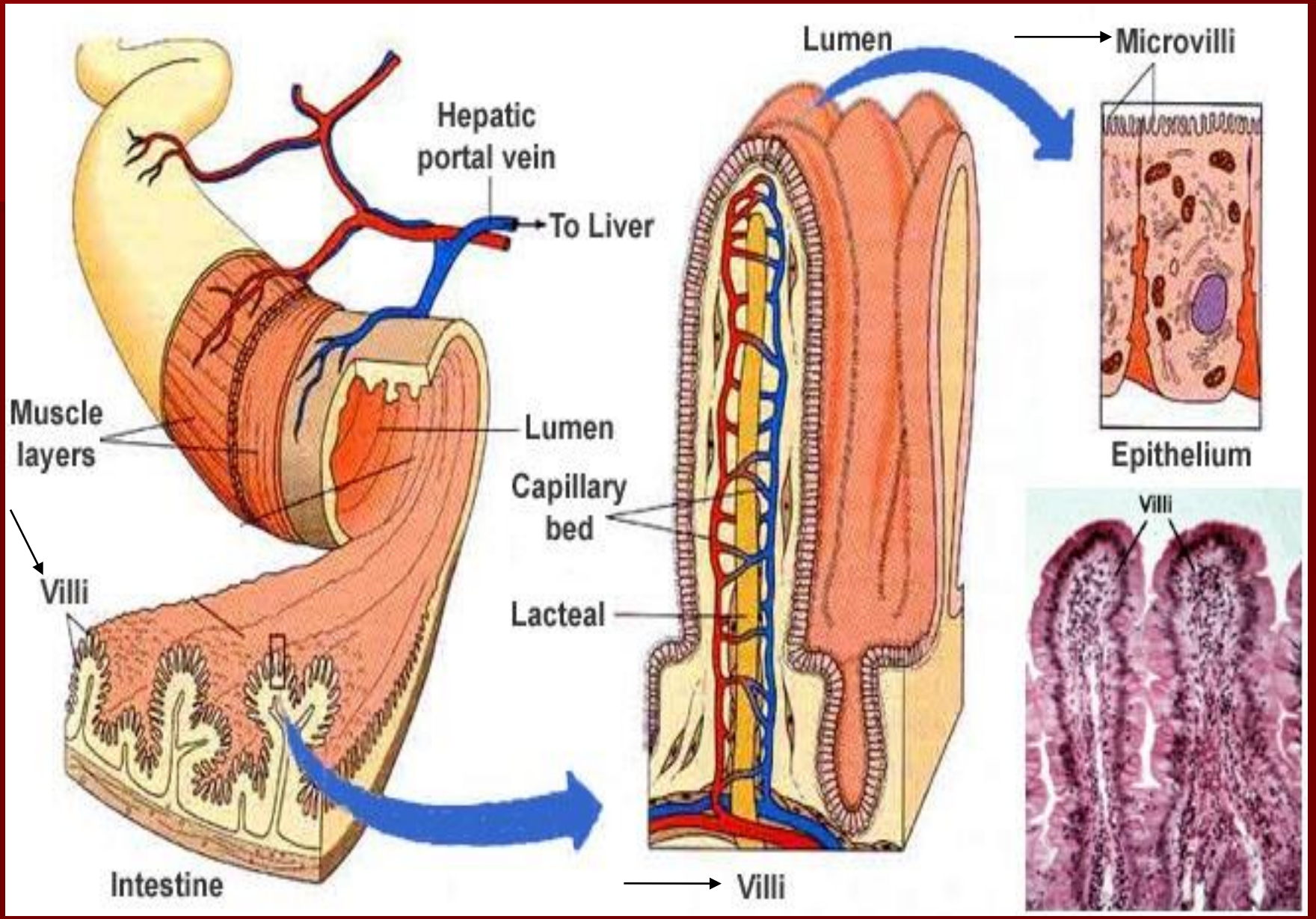
Villi and Microvilli

- The lining of the intestine has in-foldings called **villi**
- Each villus has tiny appendages called **microvilli**
- This dramatically increases the surface area available to absorb

Entering the Blood Stream

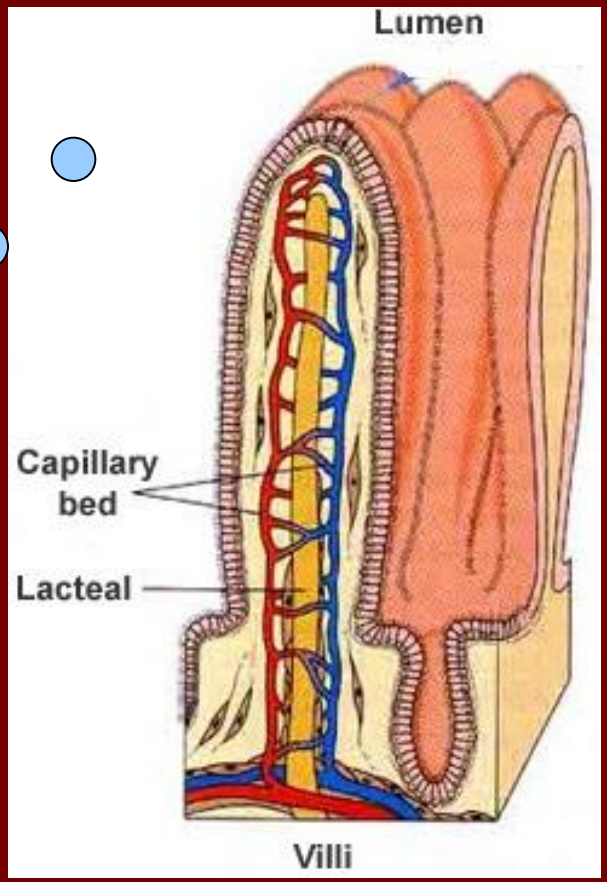
- Each villus has small blood vessels called **capillaries** that absorb the nutrients
- Also lymphatic vessels called **lacteals**



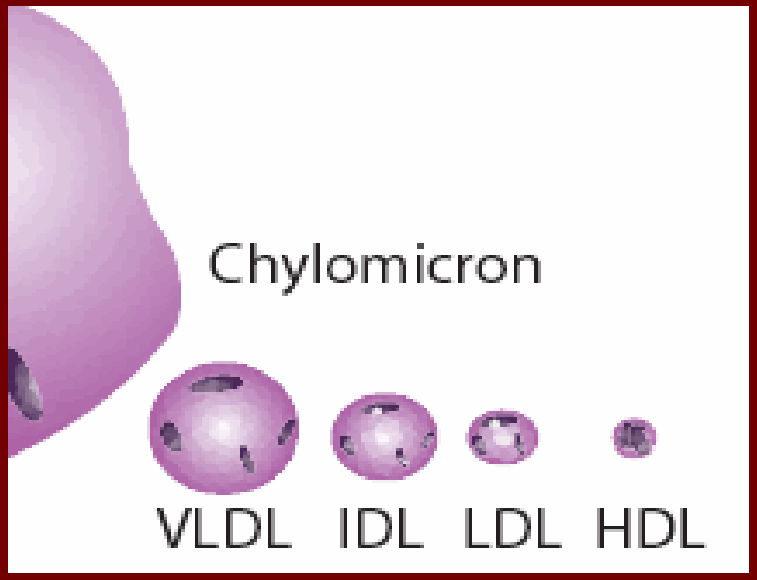

Lumen
Microvilli
Hepatic
portal vein
To Liver
Muscle
layers
Lumen
Capillary
bed
Villi
Lacteal
Epithelium
Villi
Intestine
Villi

Absorption of Non-Fat nutrients

- Can be passive or active
- Nutrients diffuse or are pumped across the epithelial cells and into the capillaries
- Blood takes them to the liver which will regulate the blood

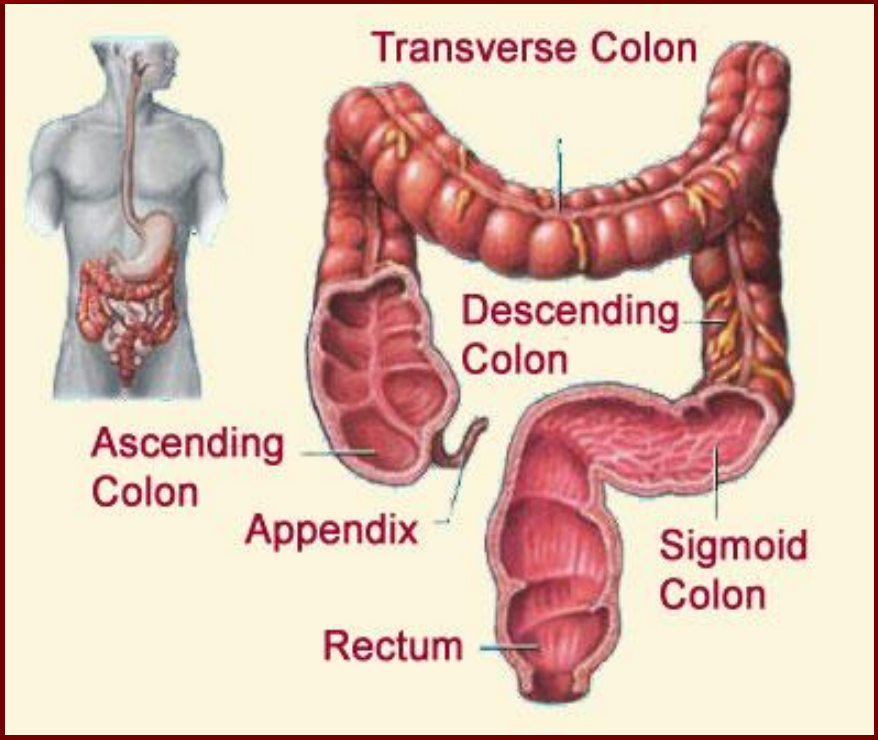


Absorption of Fats



- After glycerol and fatty acids cross the epithelium, they reform a fat and enter the lacteal
- The fat is mixed with cholesterol to form a chylomicron and enters the

Large Intestine aka Colon



- Reclaims 90% of water
- Feces becomes more and more solid as it moves through
- Feces exits at the rectum

HOW IS THE DIGESTIVE PROCESS CONTROLLED?

The hormones that control digestion are gastrin, secretin, and cholecystokinin (CCK):

- **Gastrin** causes the stomach to produce an acid for dissolving and digesting some foods. It is also necessary for the normal growth of the lining of the stomach, small intestine, and colon.

- **Secretin** causes the pancreas to send out a digestive juice that is rich in bicarbonate. It stimulates the stomach to produce pepsin, an enzyme that digests protein, and it also stimulates the liver to produce bile.

- **CCK** causes the pancreas to grow and to produce the enzymes of pancreatic juice, and it causes the gallbladder to empty.

carbohydrates

	Enzymes	**Digestive glands**	**Digestive juices**	**Location**
Disacchrides	Salivary amylase			**Mouth**
	-			stomach
maltose-2 glucose	**amylase**	**Pancreas**	**Pancreatic juice**	**Duodenum**
Maltose ------2 glucose Sucrose ------2 glucose lactose ------2 glucose	**amylase**		**Intestinal juice**	**small intestine**

lipids

	Enzymes	Digestive glands	Digestive juices	Location
Only melting	**-**			**Mouth**
	Slow digestion of fats			stomach
Glycerole + fatty acids	**Lipase**	**Pancreas**	**Pancreatic juice**	**Duodenum**
Glycerole + fatty acids	**Lipase**		**Intestinal juice**	**small intestine**

protein

	Enzymes	Digestive glands	Digestive juices	Location
Only melting	-			Mouth
	Pepsine	Chief cells		stomach
amino acids	Trypsin	Pancreas	Pancreatic juice	Duodenum
amino acids	Trypsin		Intestinal juice	small intestine

final	Place secretion	First converts	Place secretion	enzime	Location	نوع الطعام
Mono -Sa	Pancreatic - Intestinal	Di-Sac	،saliva Pancreatic - Intestinal	amylase	Mouth intestine	carbohydrate
Amino acid	Pancreatic - Intestinal	Poly peptide	Pancreatic - Intestinal	pepsin trypsin	المعدة، الأمعاء الدقيقة	protein ا
Glycerole + fatty acids	Pancreatic - Intestinal	emulsificayi on		bile	small intesti ne	lipids

Summary

The function of the digestion system:

1- digestion.

2-secretion.

3- absorption.

4- motility.

5- Expel the feces.

ربنا تقبل منا انك
أنت السميع العليم

أي أسئلة متعلقة بالدرس؟

جزآكم الله خيرا

د / عمرو شلبي

بالتوفيق ان شاء الله