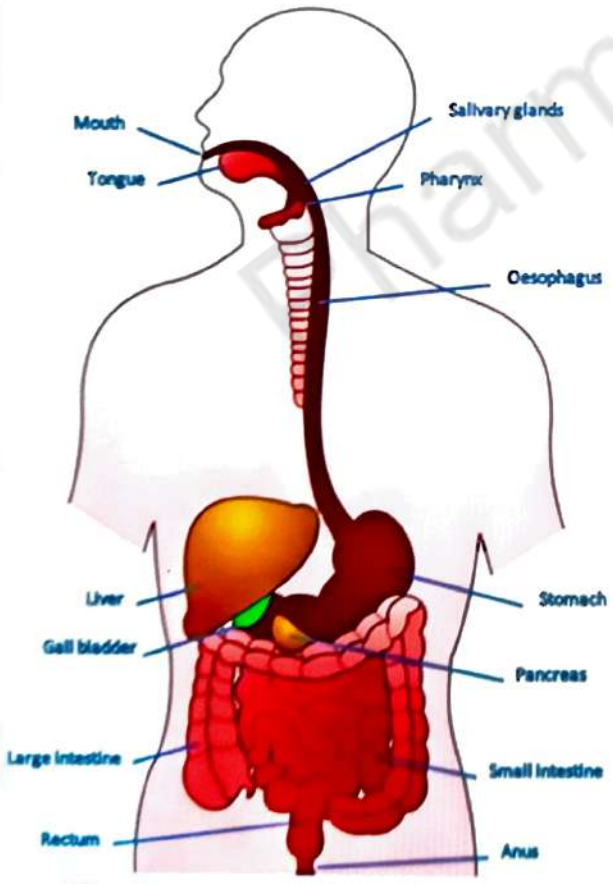
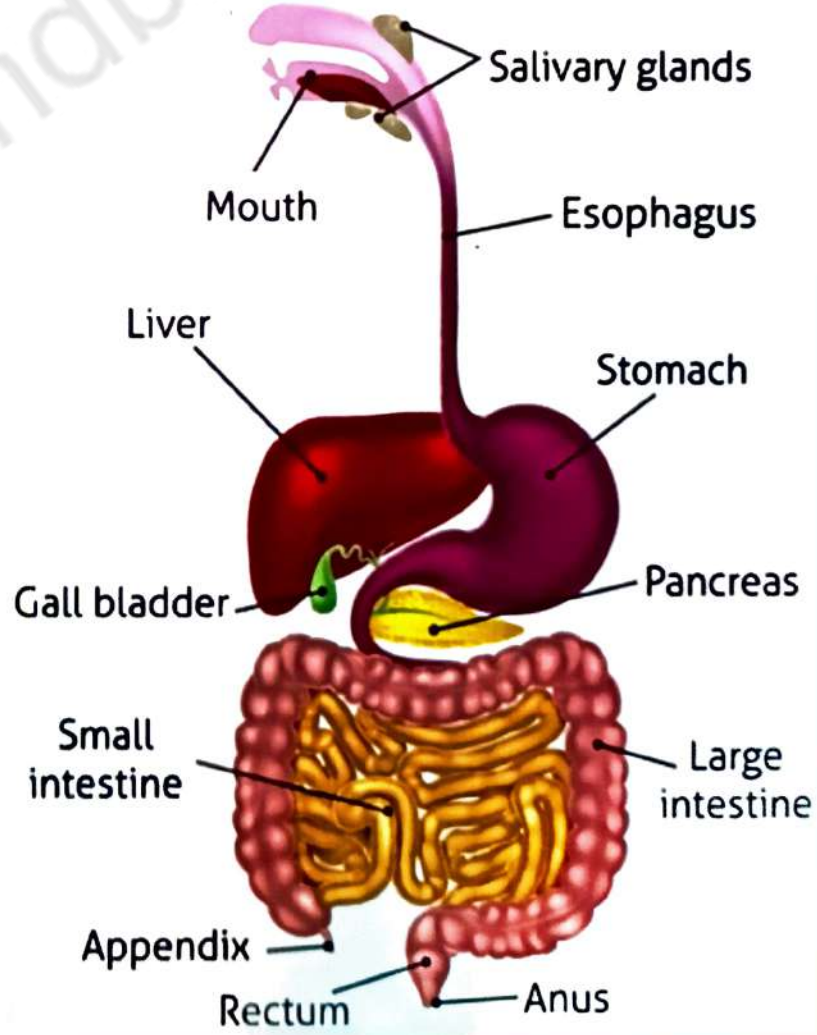
DIGESTIVE SYSTEM

PART - I

Points to be covered in this topic

1. INTRODUCTION
2. PARTS OF DIGESTIVE SYSTEM
3. ANATOMY AND FUNCTIONS OF ACCESSORY GLANDS



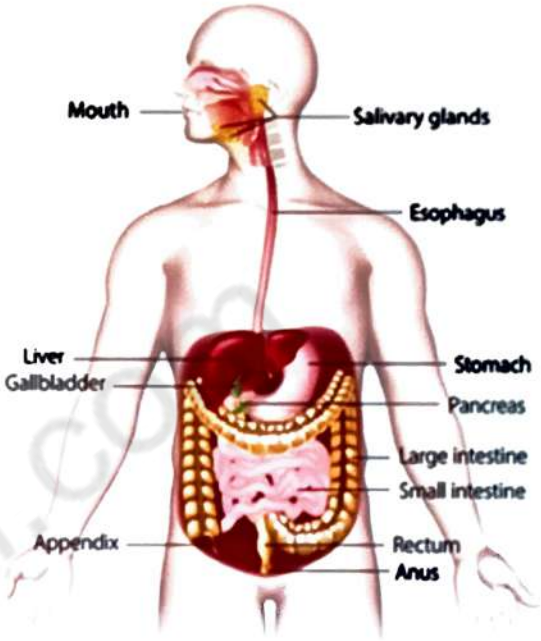


❑ INTRODUCTION

- The digestive system consists of **gastrointestinal tract** (alimentary canal) and its **glands**
- The functions of gastrointestinal tract are **ingestion**, **digestion** and **absorption** of food and **excretion** of waste products

❑ PARTS OF DIGESTIVE SYSTEM

1. Mouth
2. Pharynx
3. Esophagus
4. Stomach
5. Small intestine
6. Large intestine
7. Rectum
8. Anus



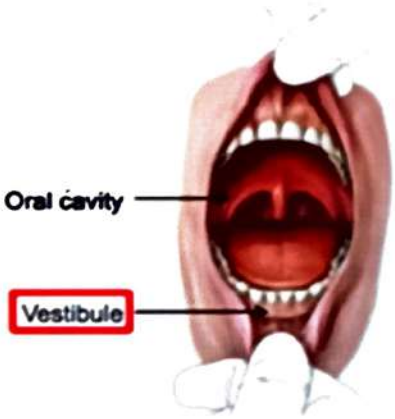
1. Mouth (Buccal Cavity)

It is the **upper expanded portion** which forms the beginning of Alimentary canal.

✓ **Divided into two parts**

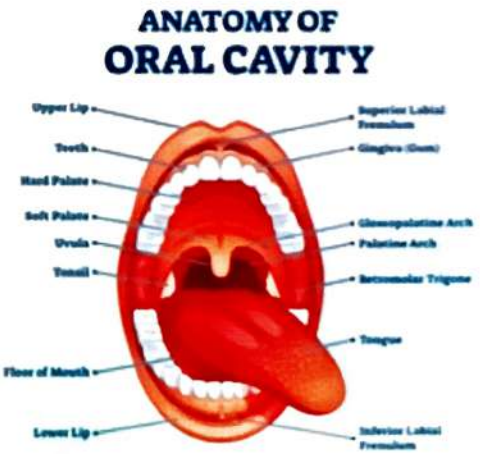
i. **Vestibule,** an outer part. It lies **between** lips and inner lining of cheeks externally and gums and teeth internally.

ii. **Cavity of mouth,** an inner part. It is **bounded** by teeth and mastoid bone at the sides, palate above and tongue below.



✓ **Important structures of mouth are**

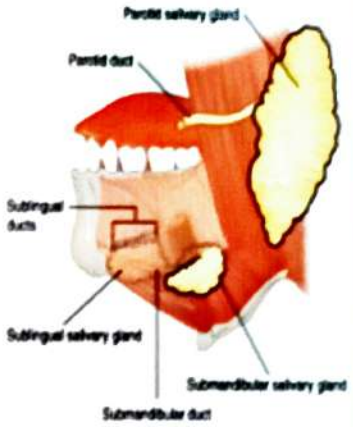
i. Tongue ii. Teeth iii. Salivary glands



i. Tongue

- It lies in the **floor of the mouth** and it is attached to hyoid bone.

ii. Teeth



- Teeth are concerned with mastication. Depending on the age at which they arise.

  Teeth can be classified into two types

(a) Permanent teeth **(b) Temporary test**

iii. Salivary glands

There are **3 pairs** of salivary glands. They are

a) Parotid glands

- They are the **largest salivary glands** and located just in front of the ears
- **Stenson's duct** is a duct in each gland which opens on the inner side of cheek opposite to the second upper molar tooth

b) Submandibular glands

- They are **smaller** than parotid glands
- Each gland lies under the angle of jaw
- They have duct called **Wharton's duct** and it opens near the midline under the tongue.

c) Sublingual glands

- They are the **smallest** salivary glands and lies under the tongue.
- They have **several small openings** through which they pour the secretions directly

❖ Functions of salivary glands

i. **Cleanses** the mouth due to the **bactericidal action** of lysozyme and IgA (Immunoglobulin A [one of the immune system's antibodies])

ii. Creates a feeling of oral comfort by its **lubricating action**

iii. **Dissolve food chemicals** so that they can stimulate the tongue's taste

iv. Help to form a **bolus** (ball of food) by the action of mucins thus **facilitating swallowing.**

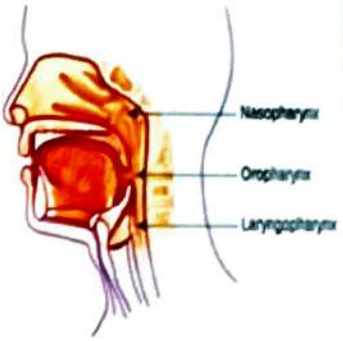
2. PHARYNX

- It lies between the mouth and esophagus. It consists of **3 parts-**

  I. Nasopharynx- It lies behind the **nasal cavity** and extends from base of skull to the palate

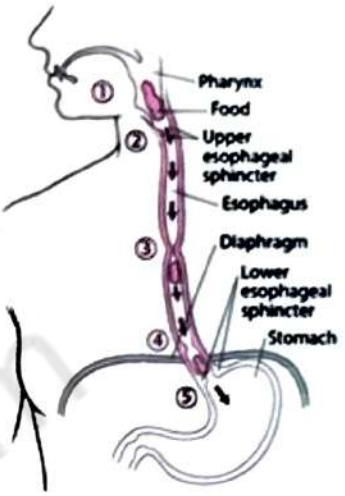
II. Oropharynx- It lies behind the **mouth** and extends between soft palate above and upper opening of larynx below

III. Laryngopharynx- It is the lowest part and lies **behind** the **larynx**



3. OESOPHAGUS

- It is a **muscular tube** which extends between **pharynx** and **cardiac orifice** of stomach below
- It lies between trachea in front and vertebral column at the back.
- Esophagus contains sphincters at its **upper** and **lower** ends.
- These sphincters **relax** during swallowing.



4. STOMACH AND ITS DIGESTIVE FUNCTION

- Stomach is the **dilated** portion of alimentary canal
- It **receives** food from esophagus.
- It lies in the **upper** part of abdominal cavity below the left half diaphragm.

✓ **Structure of stomach:** it consists of the following four coats

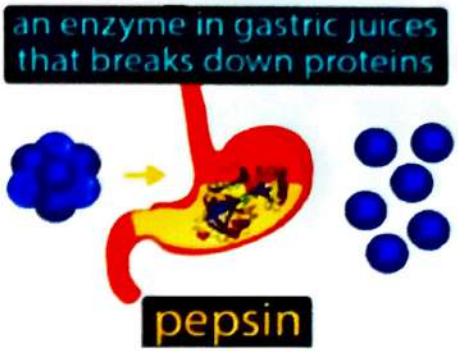
i. **Peritoneal coat-** made of serous covering.
ii. **Muscular coat-** made of longitudinal, circular and oblique fibers.
iii. **Submucous coat-** made of areolar tissue.
iv. **Mucous coat-** made of mucous membrane.

✓ **Secretions of stomach**

Glands of mucous membranes of stomach continuously secrete **gastric juice**. The secretion of gastric juice occurs due to-

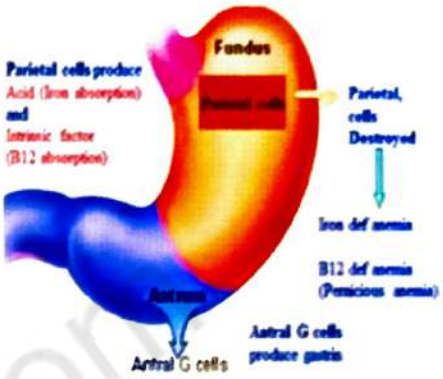
i. **A reflex mechanism** through vagus nerve.
ii. **Gastrin**, a hormone secreted by the action of food stuffs on gastric mucous membrane.
iii. **Psychological effects** produced by taste or smell of food.

✓ **Gastric juice contains**



i. Pepsin

- It is an **enzyme** produced by glands present in the **fundus** and **body of stomach**.
- In presence of hydrochloric acid, pepsin converts protein into peptone.



ii. Rennin

- It is the **enzyme** which **curdles** milk.
- It involves the conversion of **caseinogen**, the soluble protein of milk into **insoluble casein.**

iii. Hydrochloric acid

- It is secreted by **parietal cells** of **gastric glands.**
- Its concentration is about **0.4 percent** in gastric juice.
- The chloride is derived from sodium chloride in the blood. Now, the hydrogen ion combines with chloride ion to form hydrochloric acid.

✓ **Functions of hydrochloric acid are:**

1. **Neutralization** of saliva and **acidification** of food.
2. Helping the action of pepsin in **converting** into peptone.
3. **Antiseptic action** by killing bacteria.

vi. Intrinsic factor

- It is a content of gastric juice which is necessary for the **absorption** of Vitamin B12.
- This vitamin is necessary for the **development** of **red blood cells.**

v. Chyme

- It is the **product** of **digested** food in the stomach.
- It is in a **semi-liquid form** and it is **passed** on to duodenum.

✓ Functions of stomach

i. Mechanical function

a) Storage Function

- Food is stored in the stomach for a long period, and then emptied into the intestine slowly.
- This provides enough time for proper digestion and absorption of food in small intestine.

b) Formation of Chyme

- Peristaltic movements of stomach mix the bolus with gastric juice and convert it into the semisolid material known as chime.

ii. Digestive function

- Gastric juice acts mainly on proteins. Proteolytic enzymes of the gastric juice are pepsin and rennin Gastric juice also contains some other enzymes like gastric lipase, gelatinase, urase and gastric amylase.

iii. Protective function

i. Mucus Protects the stomach wall from irritation or mechanical injury, by virtue of its high viscosity.

ii. Prevents the digestive action of pepsin on the wall of the stomach, particularly gastric mucosa.

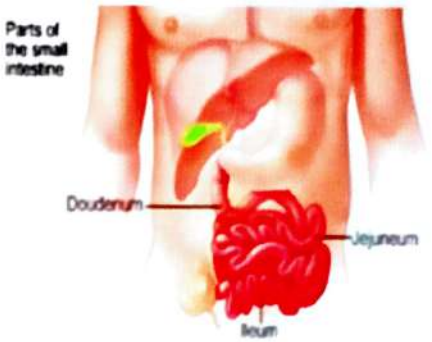
iv. Hemopoietic function

- Intrinsic factor of Castle, secreted by parietal cells of gastric glands plays an important role in erythropoiesis. It is necessary for the absorption of vitamin B12 from GI tract into the blood.

v. Excretory function

- Many substances like toxins, alkaloids and metals are excreted through gastric juice.

5. SMALL INTESTINE



- It is the part of **alimentary canal** which extends from the **pyloric end** of stomach to **caecum** (first part of large intestine).

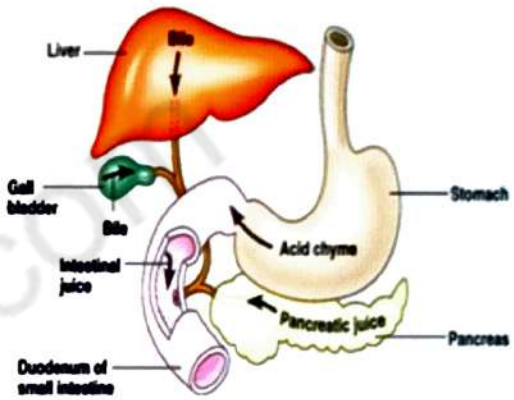
✓ **Three parts of small intestine**

i. **Duodenum** (Shortest and wider part)

ii. **Jejunum** (Thicker and vascular)

iii. **Ileum** (Thinner than jejunum and less vascular)

✓ **Digestion in small intestine**



- The acidic chyme from the stomach **enters** into the **duodenum.**
- Then, it **mixes** with
  1. Alkaline intestinal juice called succus entericus
  2. Alkaline secretions from liver and pancreas.

✓ **Enzymes responsible for the digestion**

1. **Enterokinase** - It converts trypsinogen of pancreatic juice into trypsin.
2. **Erepsin** - it converts polypeptides into amino acids
3. **Sucrase, maltase and lactase**- It converts the corresponding disaccharides into monosaccharides

✓ **Absorption in Small intestine:**

- The absorption of digested food occurs in small intestine through **villi.**

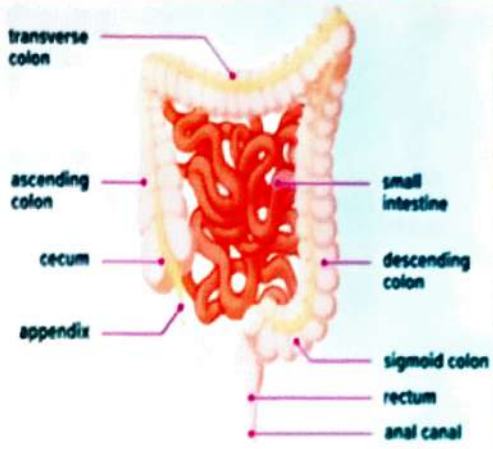
❖ **VILLI**

- They are **minute projections** present in the **inner** mucous coat of the intestine.
- It gives a velvety appearance to the intestinal mucous membrane.

Each villus **has**:

1. A central core composed of **one artery** and **one vein** a **strand of muscle**
2. A centrally located lymphatic capillary **(lacteal)**
3. **Connective tissue** that adds support to the structures

6. LARGE INTESTINE



- Large intestine (colon) extends from the **end of ileum** to **rectum**.
- Large intestine consists of the following parts

1. Appendix 2. Ascending colon 3. Transverse colon 4. Sigmoid colon 5. Cae cum

✓ Functions of large intestine

1. Digestion

- It carried out by **microorganisms** of colon.
- They act on **undigested** and **unabsorbed** residue from small intestine.

2. Absorption

- After small intestine, only **water** and **glucose** are absorbed in the colon.

3. Secretion

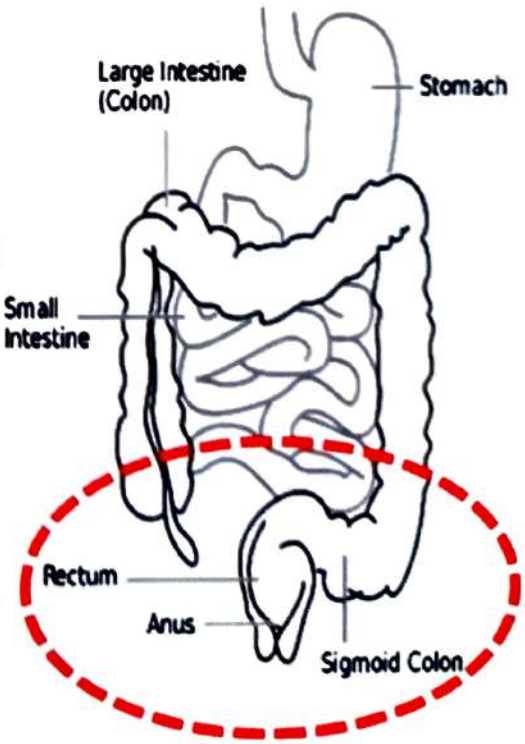
- **Mucin** is the only secretion which lubricates the colon and facilitates the passage of fecal matter.

4. Excretion

- **Iron** and some **purgatives** are excreted in large intestine.

7. RECTUM

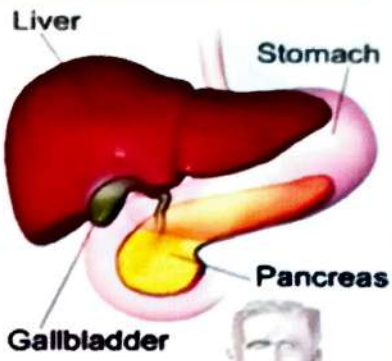
- It occupies the **lower posterior part** of pelvis and extends between sigmoid colon and anus.
- The lower part of rectum is dilated and it is called **rectal ampulla.**



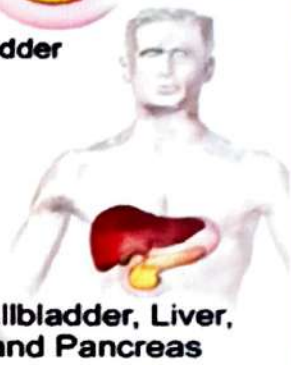
8. ANUS

- It is a small canal measuring about **one inch** in length.
- The opening of anus is guarded by a sphincter called **anal sphincter**.
- This sphincter is under **voluntary control**.

ANATOMY AND FUNCTIONS OF ACCESSORY GLANDS



- There are **Three accessory organs** that aid the process of digestion which are located **outside** the alimentary canal.
- They are
  1. **Liver**
  2. **Bile ducts**
  3. **Gall bladder**
  4. **Pancreas**

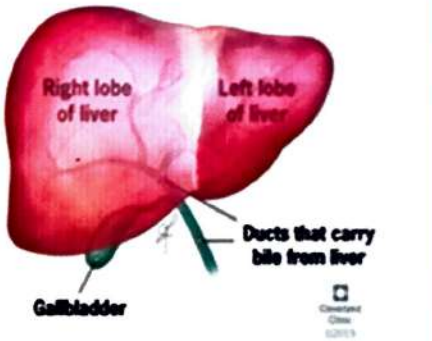


1. Liver

- Liver is the **largest** abdominal organ.
- It lies in the right **upper** quadrant of abdominal cavity inferior to the diaphragm.

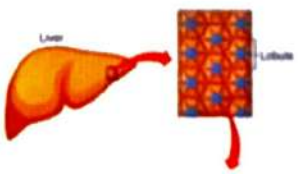
➢ Anatomy

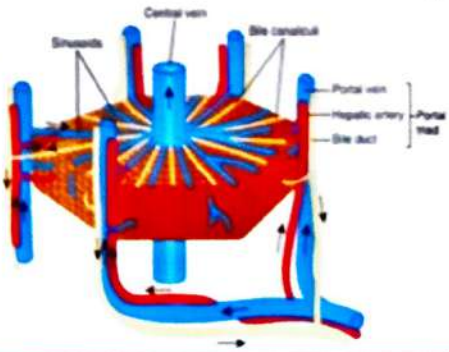
- It contains, two lobes- i) Right lobe ii) Left lobe
- They have Four surfaces-
  1. Superior surface
  2. Inferior surface
  3. Anterior surface
  4. Posterior surface



✓ Microscopic structure

- The liver made up of a small **hexagonal** units present in **large** number called **Lobules.**
- Each lobule has a **Central vein** or **Intralobular vein** surrounded by several **Portal triads.**

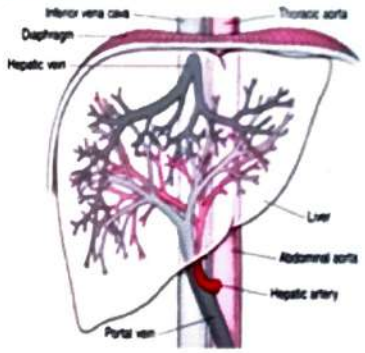




- The portal triads consist of
  i. **Portal vein**
  ii. **Bile duct**
  iii. **Hepatic artery**

✓ **Blood Supply** - Blood is brought to liver by:

1. **Hepatic artery:**
   - It supplies **oxygenated** blood to liver.
   - It is a **branch** of **coeliac plexus** which arises from abdominal aorta.
2. **Portal vein:**
   - It carries aveins which lie in between the **lobules of liver.**
   - They subdivide and ultimately form **central veins.**
3. **Hepatic veins:**
   - It carries the **deoxygenated** blood from liver to inferior vena cava.
   - The central veins of each lobule join to form **sub lobular veins.**
   - The sub lobular veins unit to form several **hepatic veins.**
   - The hepatic veins join with **inferior vena cava.**



✓ Functions of Liver:

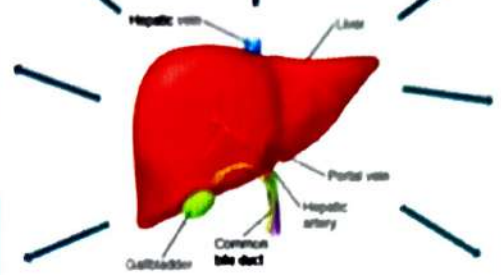
1. **Secretion** of bile.
2. **Synthesis** and **storage** of glycogen.
3. **Formation** of urea by the de-amination of amino acids
4. Synthesis of **plasma proteins** like albumin and globulin.
5. Metabolism of fats, proteins and carbohydrates
6. **Storage** of vitamins and minerals
7. **Synthesis** of heparin (natural anticoagulants)
8. **Detoxification** and **purification** of blood

Detoxification:
- Drugs/Alcohol
- Fatty acids
- Steroid hormones
- Ammonia → Urea
- Environmental toxins/allergens

Production of Cholesterol:
- Precursor to sex hormones, Vitamin D

Storage of Micronutrients:
- Minerals: Copper, Zinc, Magnesium, Iron
- Vitamins: Vitamin A, D, E, K, B12

Metabolism:
- Conversion of T4 → T3
- Detoxification of fat



Blood Sugar Balance:
- Storage of glycogen

Immune System:
- Contains viruses and pathogens
- Maintenance of the hepatic and portal vein immune system

Production of Bile:
- Needed for digestion
- GI anti-microbial

Protein Synthesis:
- Blood clotting (prothrombin)
- Cholesterol transport (lipoproteins)
- Immune Function (globulins)
- Oncotic pressure (albumin)
- Copper bioavailability (ceruloplasmin)

2. BILE DUCTS:

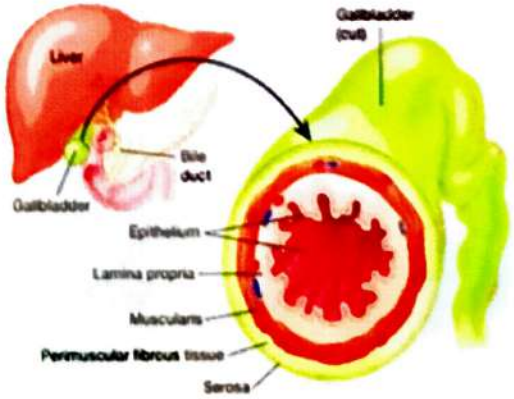
- The secretion of liver (bile) is carried through **bile ducts** which are formed by the **union** of **biliary canaliculi.**
- They present in **between** the **lobules** of liver.
- The Bile ducts from the **right** and **left** lobes of liver **unite** to form common hepatic duct.
- Later, the common bile duct **unites** with **pancreatic duct** in the duodenum at a papilla called **ampulla of Vater**.

3. GALLBLADDER

- It is a **pear-shaped, hollow** structure located on the **inferior** surface of the liver.

✓ It is divided into **three regions:**

i. **Fundus** 2. **Body** 3. **Neck**



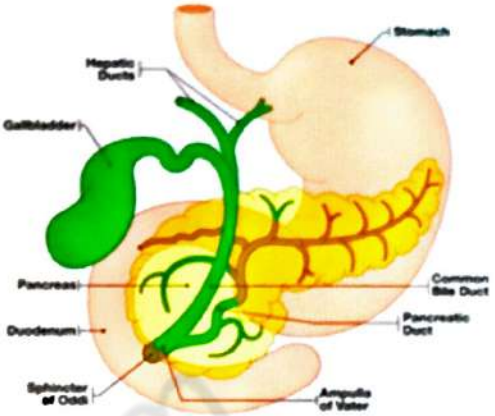
✓ **Layers of the gallbladder** - Three layers

i. **Serosa**: (Outer covering)

ii. **Muscularis**: (Middle layer helps the gallbladder to contract and squirt its bile into the bile duct.)

iii. **Mucosa:** (Inner layer folded in rugae that allow the gallbladder to expand)

✓ Duct of gallbladder



i. The duct through which gall bladder opens is called **Cystic duct.**

ii. It joins with the hepatic duct to form the **common bile duct.**

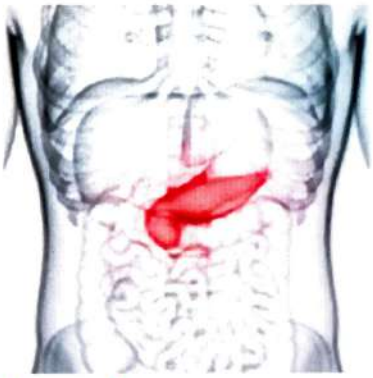
iii. The common bile duct then joins with pancreatic duct which then **opens** into the **duodenum.**

✓ Functions of gallbladder

i. Reservoir of Bile

- Bile is an **alkaline fluid** produced by **hepatocytes** in liver and stored in gall bladder.
- It is a **mixture** of water, bile salts, bile pigments, electrolytes, cholesterol, phospholipids and triglycerides.
- Liver produces 500 ml to 1000ml of bile per day. But the **capacity** of gall bladder is only 30ml, so it is **concentrated** in gallbladder.

ii.Bile salts



- Bile salts present in the bile are **sodium taurocholate** and **sodium glycocholate**.
- They act as **emulsifying agents**
- It absorbs of digested lipids.

iii.Bile pigments

- Two important bile pigments are **bilirubin** and **biliverdin.**
- They are **waste products** produced from **hemoglobin**

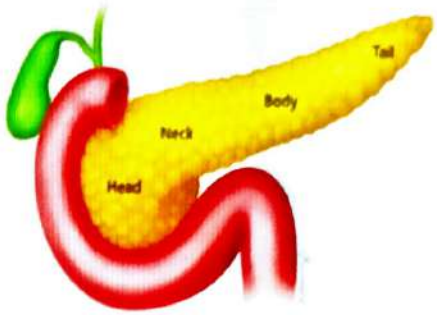
4. PANCREAS

- The pancreas is located **behind** the stomach in the upper left abdomen and surrounded by other organs.

✓ It consists of head, body and tail

i. **Head** (wide part of pancreas), is positioned toward the center of the abdomen.

ii. The central section of the pancreas is called the **neck** or **body**.



iii. The thin end is called the **tail** and extends to the left side.

✓ Structure of Pancreas

- Substance of pancreas contains a number of **lobules** of secretory cells called **Acini**.
- In between the acini there are groups of endocrine cells called **Islets of Langerhans**.
- Small ducts emerge from these lobules.
- These ducts unite and reunite to form the pancreatic duct (**Duct of Wirsung**).
- This duct begins at the tail and emerges from the head of pancreas.
- It **enters** the duodenum along with **common bile duct**.

✓ **Secretions of pancreas** – two types:

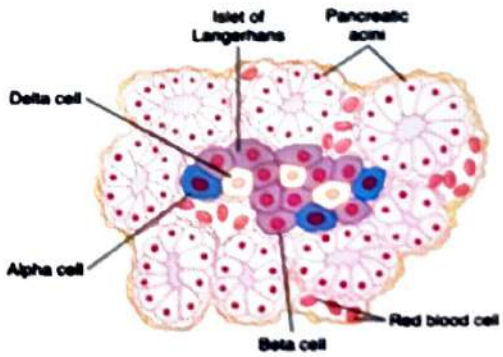
i. Exocrine secretion- (pancreatic juice with **digestive** in function).

- It is **transferred** to duodenum through pancreatic duct
- Pancreatic juice contains the following **digestive enzymes-**

✓ **Lipase-** it converts fats into fatty acids and glycerol.

✓ **Amylase-** it converts starch into maltose.

✓ **Trypsin-** it converts peptones into amino acids.



ii. Indocrine secretion: (Secreted by **Islets of Langerhans**)

- It is directly poured into **circulation**.
- This secretion contains two different hormones which are secreted by the two different cells of islets of Langerhans.

i) **Glucagon-** secreted by alpha cells

ii) **Insulin-** secreted by beta cells

DIGESTIVE SYSTEM

PART - II

Points to be covered in this topic

1. MOVEMENTS OF GIT
2. PHYSIOLOGY OF DIGESTION AND ABSORPTION
3. ACID PRODUCTION IN THE STOMACH
4. DIGESTION AND ABSORPTION OF NUTRIENTS
4. DISORDERS OF GIT

MOVEMENTS OF GIT

➢ MASTICATION

- Mastication or chewing is the **first** mechanical process in the gastrointestinal (GI) tract, by which the food substances are **torn** or cut into small particles and crushed or ground into a **soft bolus**.

❖ Significances of Mastication:

1. Breakdown of foodstuffs into **smaller** particles
2. **Mixing** of saliva with food substances thoroughly
3. **Lubrication** and **moistening** of dry food by saliva, so that the bolus can be easily swallowed
4. Appreciation of **taste** of the food

❖ Control of mastication

- Action of mastication is mostly a **reflex process**. It is carried out voluntarily also.
- The center for mastication is situated in medulla and cerebral cortex.
- Muscles of mastication are supplied by mandibular division of **5th cranial (trigeminal) nerve.**

➢ DEGLUTITION

- Deglutition or swallowing is the process by which food **moves** from mouth into stomach.

❖ Stages of Deglutition It occurs in three stages

i. **Oral stage,** when food moves from **mouth** to **pharynx**

ii. **Pharyngeal stage,** when food moves from **pharynx** to **esophagus**

iii. **Esophageal stage**, when food moves from **esophagus** to **stomach**

❑ MOVEMENTS OF STOMACH

- Activities of **smooth muscles** of stomach increase during gastric digestion (when stomach is filled with food) and when the stomach is empty.

❖ Types of movements in stomach

i. Hunger contractions
ii. Receptive relaxation
iii. Peristalsis

➢ FILLING AND EMPTYING OF STOMACH

❖ Filling of stomach

- While taking food, it arranges itself in the stomach in different layers.
- The first eaten food is placed against the greater curvature in the fundus and body of the stomach.
- The successive layers of food particles lie nearer, the **lesser curvature**, until the last portion of food eaten.

❖ Emptying of stomach

- Gastric emptying is the process by which the **chyme** from stomach is **emptied** into intestine.
- Food that is swallowed enters the stomach and remains there for about 3 hours. During this period, digestion takes place.

➢ MOVEMENTS OF SMALL INTESTINE

- They are essential for **mixing** the **chyme** with digestive juices, propulsion of food and absorption.

❖ Types of Movements of Small Intestine. they are of four types:

1. Mixing movements:

i. Segmentation movements
ii. Pendular movements.

2. Propulsive movements:

i. Peristaltic movements
ii. Peristaltic rush.

3. Peristalsis in fasting – migrating motor complex

4. Movements of villi

➢ MOVEMENTS OF LARGE INTESTINE

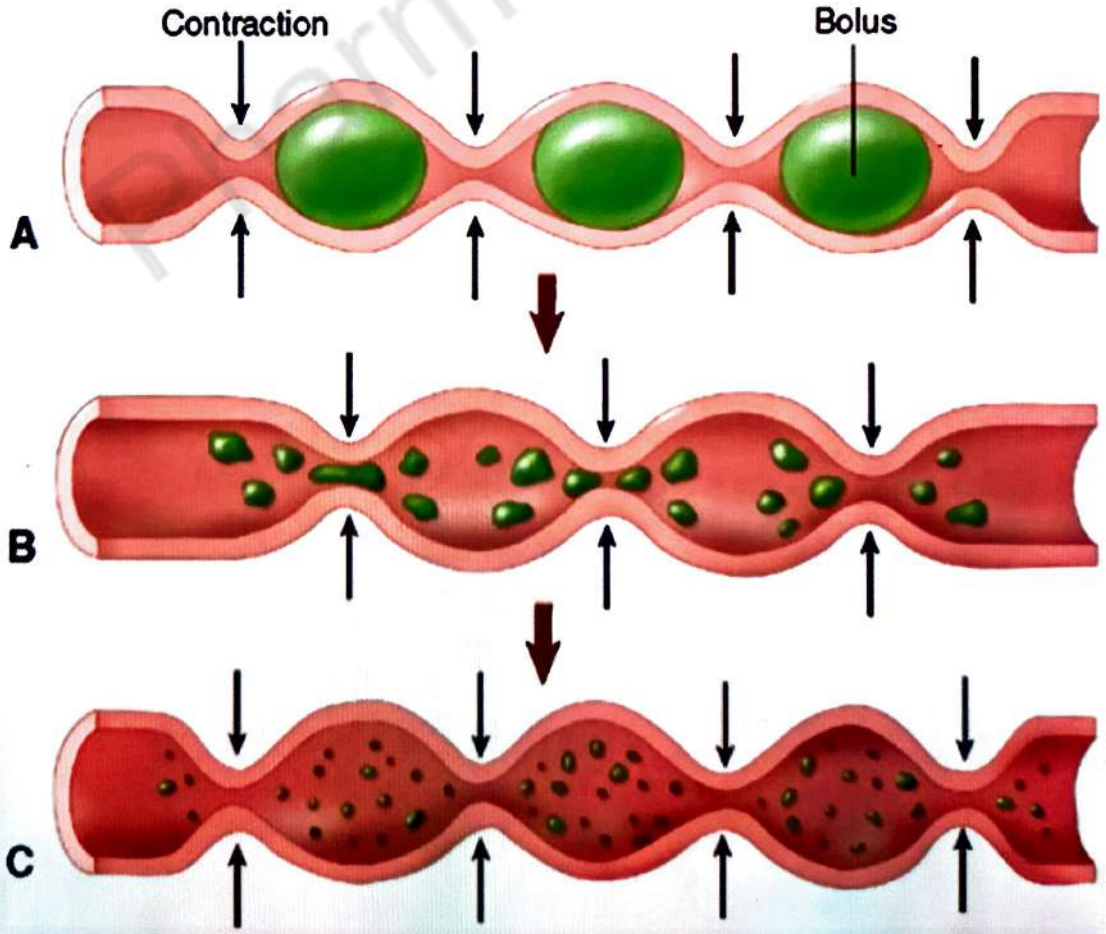
- Usually, the large intestine shows sluggish movements. Still, these movements are important for mixing, propulsive and absorptive functions.

❖ **Types of Movements of Large Intestine** they are of two types:

1. **Mixing movements**: Segmentation contractions
2. **Propulsive movements**: Mass peristalsis.

❑ DEFECATION

- **Voiding** of feces is known as defecation.
- Feces is formed in the **large intestine** and stored in sigmoid colon.
- By the influence of an appropriate **stimulus**, it is expelled out through the anus.
- This is prevented by **tonic constriction** of anal sphincters, in the absence of the stimulus.



PHYSIOLOGY OF DIGESTION AND ABSORPTION

❖ Digestion of food in alimentary canal

➢ Mouth

- The breaking down of food takes place in mouth by **chewing** or **mastication**.
- **Teeth** and **muscles** help in mastication.
- Salivary **amylase** enzyme from parotid and submandibular glands begins **carbohydrate** digestion.
- It **breaks** the **complex sugars**. (polysaccharides) into disaccharides such as maltose and isomaltose.

❖ Digestion in the Stomach

- Stomach contains cells produce **gastric secretions**. which help to continue chemical digestion in the stomach
- **Pepsinogen** is secreted by chief cells that combine with **HCl** secreted by parietal cells to form **pepsin**.
- Pepsin along with HCl breaks **proteins** into smaller **polypeptides**, which then travel to the **small intestine**

❖ Digestion in small intestine

- The digestion in small intestine is carried out by the **pancreatic enzymes** and **intestinal enzymes**.

❖ Pancreatic enzymes

Pancreatic Enzyme	Functions	Product
Trypsin and Chymotrypsin	Act upon proteins	Smaller peptides
Pancreatic lipase	Breaks down of triglycerides	Free fatty acids and monoglycerides
Pancreatic amylase	Breaks down of carbohydrates	Maltose and oligosaccharides
Carboxypeptidase	Breaks down of proteins	Peptides and amino acids

Nucleases	Breaks nucleic of acids	Nucleases
maltase	Acts on maltose	Glucose
Sucrase	Acts on sucrose	Glucose and fructose
Lactase	Acts on lactose	Glucose and fructose
Aminopeptidase and dipeptidase	Breaks peptide chain	Peptides and amino acids
Nucleosidase and phosphatase	Breaks	Pentoses, phosphates and nitrogenous

➢ Absorption of food in the alimentary canal

❖ Absorption in the mouth

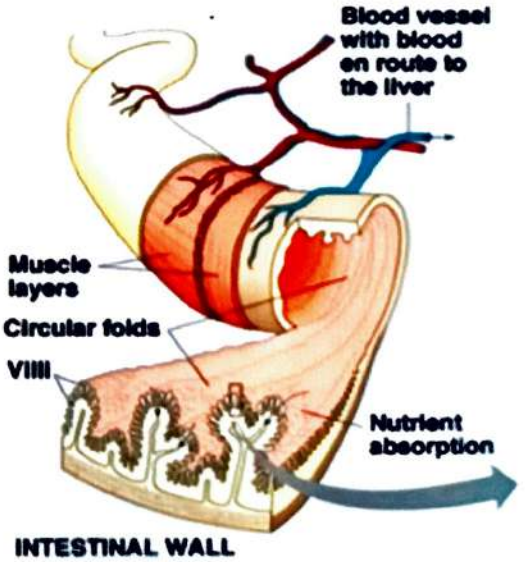
- Absorption of food does not take place in mouth however some chemicals like **nitroglycerin** and some **vitamins** can be absorbed.

❖ Absorption in the Stomach

- There is **little absorption** in stomach as the food is not **digested** completely.
- **Water**, **alcohol** and **lipid soluble drugs** are absorbed in the stomach.

❖ Absorption in the Small intestine

- **Glucose** and **galactose** are absorbed through the intestinal **villi** cells
- **Monosaccharides** are absorbed by facilitated diffusion.
- **Amino acids** and **Dipeptides** are also absorbed through villi cells by facilitated diffusion.
- **Glycerol** and **fatty acids** are absorbed through the villi cells
- **Vitamins** are absorbed by small intestine via simple diffusion.
- **Mineral** absorption takes place throughout the entire small intestine

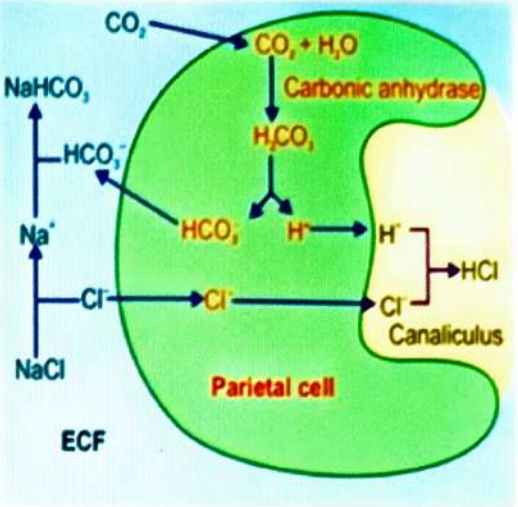


❖ Absorption in large intestine

- The absorption is **complete** when the material reaches the **large intestine.**
- **Water** and certain **salts** are **absorbed** through the mucous membrane of the large intestine.

ACID PRODUCTION IN THE STOMACH

- Hydrochloric acid secretion is an **active process** that takes place in the canaliculi of **parietal cells** in gastric glands.
- **Carbon dioxide** is derived from metabolic activities of parietal cell.
- It combines with **water** to form **carbonic acid** in the presence of **carbonic anhydrase.**



- This enzyme is present in **high concentration** in parietal cells.
- **Carbonic acid** is the most **unstable** compound and immediately **splits** into **hydrogen ion** and **bicarbonate ion.**
- The **hydrogen** ion is actively **pumped** into the canaliculus of parietal cell.
- Simultaneously, the **chloride** ion is also **pumped** into canaliculus actively.

❑ Nerve supply of GIT

Extrinsic nerves that control the enteric nervous system are from **autonomic nervous system**. They are-

❖ Sympathetic Nerve Fibers

- Preganglionic sympathetic nerve fibers to GI tract arise from **lateral horns** of spinal cord between **fifth thoracic** and **second lumbar segments** (T5 to L2).
- From here, the fibers leave the spinal cord, pass through the ganglia of sympathetic chain without having any synapse and then terminate in the celiac and mesenteric ganglia.
- The postganglionic fibers from these **ganglia** are distributed throughout the **GI tract.**

✓ Functions of sympathetic nerve fibers

- They inhibit the **movements** and **decrease** the **secretions** of GI tract by secreting the neurotransmitter **noradrenaline.**
- It also causes **constriction of sphincters**

❖ Parasympathetic Nerve Fibers

- Parasympathetic nerve fibers to GI tract pass through some of the **cranial nerves** and **sacral nerves.**
- The preganglionic and postganglionic parasympathetic nerve fibers to mouth and salivary glands pass through facial and glossopharyngeal nerves
- Preganglionic parasympathetic nerve fibers to esophagus, stomach, small intestine and upper part of large intestine pass-through vagus nerve.
- Preganglionic nerve fibers to lower part of large intestine arise from second, third and fourth sacral segments (S2, S3 and S4) of spinal cord and pass-through pelvic nerve.
- All these preganglionic parasympathetic nerve fibers synapse with the postganglionic nerve cells in the myenteric and sub-mucus plexus.

✓ Functions of parasympathetic nerve fibers

- Parasympathetic nerve fibers accelerate the movements and increase the secretions of GI tract.
- The neurotransmitter secreted by the parasympathetic nerve fibers is acetylcholine (Ach)

DIGESTION AND ABSORPTION OF NUTRIENTS (Carbohydrates, Proteins and Lipids)

❖ DIGESTION OF CARBOHYDRATES IN THE MOUTH

- Enzymes involved in the digestion of carbohydrates are known as **Amylolytic enzymes.** The only amylolytic enzyme present in saliva is the **salivary amylase or ptyalin**.

✓ IN THE STOMACH

- Gastric juice contains a weak amylase, which plays a minor role in digestion of carbohydrates.

✓ IN THE INTESTINE

- Amylolytic enzymes present in the small intestine are derived from **pancreatic juice** and **succus entericus**
- **Amylolytic Enzyme in Pancreatic Juice**: Pancreatic juice contains pancreatic amylase.
- **Amylolytic Enzymes in Succus Entericus**: Amylolytic enzymes present in succus entericus are **maltase, sucrase, lactase, dextrinase** and **trehalase**

❖ ABSORPTION OF CARBOHYDRATES

- Carbohydrates are absorbed from the small intestine mainly as monosaccharides, viz. **glucose, galactose** and **fructose.**

✓ ABSORPTION OF GLUCOSE

- Glucose is transported from the lumen of **small intestine** into the **epithelial cells** in the mucus membrane of small intestine, by means of sodium cotransport.
- From the epithelial cell, glucose is absorbed into the **portal vein by facilitated diffusion**. However, sodium ion moves laterally into the intercellular space.
- From here, it is transported into blood by active transport, utilizing the energy liberated by breakdown of ATP.

✓ ABSORPTION OF GALACTOSE

- Galactose is also absorbed from the small intestine in the same mechanism as that of glucose.

✓ ABSORPTION OF FRUCTOSE

- Fructose is absorbed into blood by means of **facilitated diffusion**. Some molecules of fructose are converted into glucose. Glucose is absorbed as described above.

❑ DIGESTION, ABSORPTION OF PROTEINS

❖ DIGESTION OF PROTEINS

Enzymes responsible for the digestion of proteins are called **Proteolytic enzymes.**

✓ IN THE MOUTH

- Digestion of proteins does not occur in mouth, since saliva does **not** contain any proteolytic enzymes. So, the digestion of proteins starts only in **stomach**

✓ IN THE STOMACH

- **Pepsin** is the only proteolytic enzyme in gastric juice
- **Rennin** is also present in gastric juice. But it is **absent** in human.

❖ IN THE SMALL INTESTINE

- Most of the proteins are digested in the duodenum and jejunum by the proteolytic enzymes of the pancreatic juice and succus entericus.

○ Proteolytic Enzymes in Pancreatic Juice

- Pancreatic juice contains trypsin, chymotrypsin and carboxypeptidases. **Trypsin and chymotrypsin** are called **endopeptidases**, as these two enzymes break the interior bonds of the protein molecules

✓Proteolytic Enzymes in Succus Entericus

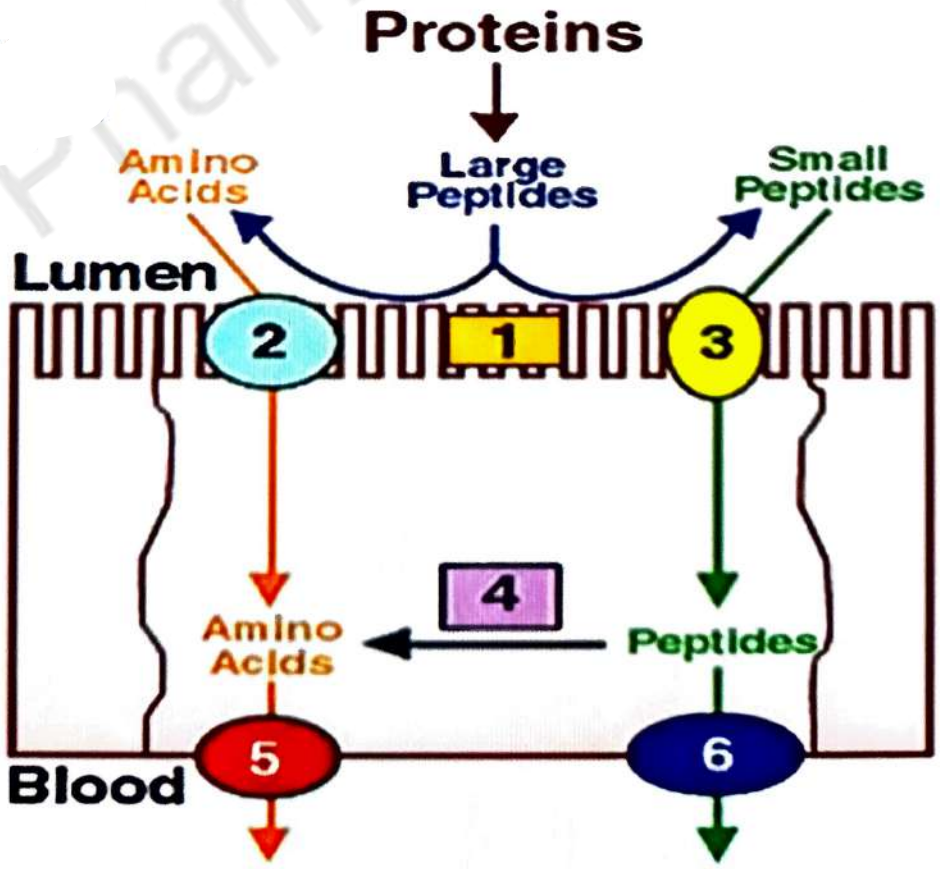
- Final digestion of proteins is by the proteolytic enzymes present in the succus entericus. It contains **dipeptidases, tripeptidases and aminopeptidases.**

FINAL PRODUCTS OF PROTEIN DIGESTION

Final products of protein digestion are the **amino acids,** which are absorbed into blood from intestine.

❖ ABSORPTION OF PROTEINS

- Proteins are absorbed in the form of amino acids from small intestine. The **levo amino acids** are actively absorbed by means of **sodium cotransport**,
- The **dextro amino acids** are absorbed by means of **facilitated diffusion.** Absorption of amino acids is faster in duodenum and jejunum and slower in ileum.



DISORDERS OF GIT

1. GASTRITIS

- Inflammation of **gastric mucosa** is called gastritis. It may be acute or chronic.
- Acute gastritis is characterized by inflammation of superficial layers of mucus membrane
- Chronic gastritis involves inflammation of even the deeper layers and infiltration with more lymphocytes.

2. GASTRIC ATROPHY

- It is the condition in which the **muscles** of the stomach shrink and become weak.
- Gastric glands also shrink, resulting in the deficiency of gastric juice.

3. PEPTIC ULCER

- Peptic ulcer means an ulcer in the **wall of stomach or duodenum**, caused by digestive action of gastric juice.

4. HEPATITIS

- It is characterized by swelling and inadequate **functioning of liver**. Hepatitis may be acute or chronic.

5. GALLSTONES

- Gallstone is a **solid crystal deposit** that is formed by cholesterol, calcium ions and bile pigments in the gallbladder or bile duct.

6. CROHN'S DISEASE OR ENTERITIS

- Enteritis is an inflammatory bowel disease (IBD), characterized by **inflammation** of small intestine.
- It affects the lower part of small intestine, the ileum. The inflammation causes malabsorption and diarrhea.

ENERGETICS

Points to be covered in this topic

1. FORMATION AND ROLE OF ATP
2. CREATININE PHOSPHATE
3. BASIC METABOLIC RATE

FORMATION AND ROLE OF ATP

❑ INTRODUCTION

- **Metabolism** is an **energy-balancing act** between **catabolic** (decomposition) reactions, and **anabolic** (synthesis) reactions.
- The **molecule** that participates most often in energy exchanges in living cells is **ATP** (adenosine triphosphate), which couples **energy-releasing** catabolic reactions to **energy-requiring** anabolic reactions

❖ ATP- Adenosine triphosphate

- **Adenosine triphosphate** or **ATP** is the **"energy currency"** of living systems.
- ATP transfers the energy liberated in **exergonic** catabolic reactions to **power** cellular activities that require energy **(endergonic reactions).**
- ATP consists of **three phosphate groups** attached to **adenosine**, a unit composed of **adenine** and the **five-carbon sugar ribose.**
- When a **water** molecule is added to **ATP**, the **third phosphate group** (PO_4^{3-}), symbolized by P in the following discussion, is **removed**, and the overall reaction liberates **energy**.

- The enzyme that catalyzes the hydrolysis of ATP is called ATPase. Removal of the third phosphate group produces a molecule called adenosine diphosphate (ADP) in the following reaction:

ATP(Adenosine tri Phosphate) + H2O ⟶ Adenosine diphosphate +Phosphate group+ energy

- The energy supplied by the catabolism of ATP into ADP is constantly being used by the cell.
- As the supply of ATP at any given time is limited, a mechanism exists to replenish it.
- The enzyme ATP synthase catalyzes the addition of a phosphate group to ADP.

ADP+ Phosphate group+ Energy ⟶ ATP+ Water

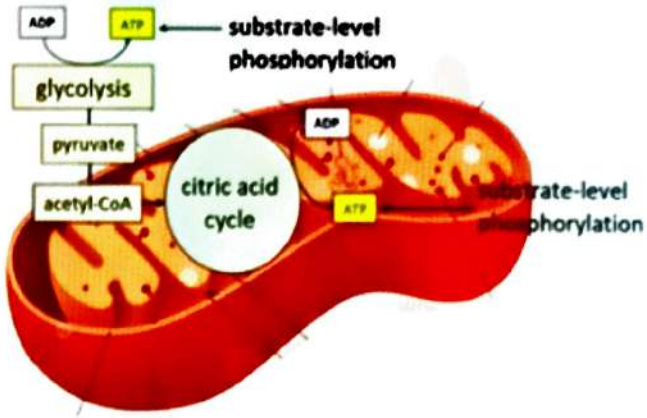
- The energy needed to attach a phosphate group to ADP is supplied mainly by the catabolism of glucose in a process called cellular respiration.
- Cellular respiration has two phases: **anaerobic** and **aerobic**

1. **Anaerobic phase :** In a series of reactions that do not require oxygen, glucose is partially broken down by a series of catabolic reactions into pyruvic acid. Each glucose molecule that is converted into a pyruvic acid molecule yields two molecules of ATP.
2. **Aerobic phase :** In the presence of oxygen, glucose is completely broken down into carbon dioxide and water.
    - These reactions generate heat and 36 or 38 ATP molecules

❖ MECHANISM OF ATP FORMATION

- The high-energy phosphate bond that attaches the third phosphate group contains the energy stored in this reaction.
- The addition of a phosphate group to a molecule, called phosphorylation, increases its potential energy.
- Organisms use three mechanisms of phosphorylation to generate ATP:

1. **Substrate-level phosphorylation** : Generates ATP by **transferring** a high-energy phosphate group from an **intermediate phosphorylated** metabolic compound-a substrate- directly to ADP. In human cells, this process occurs in the **cytosol**

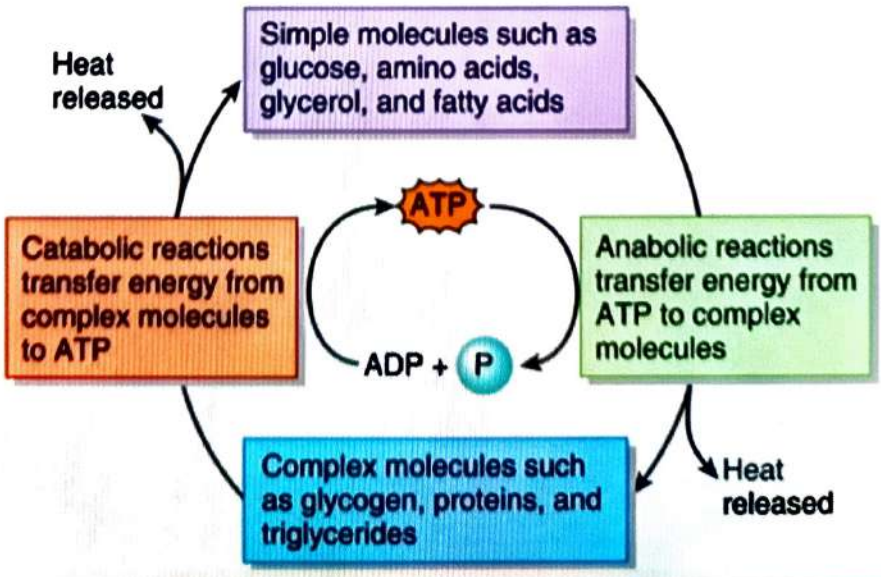


2. **Oxidative phosphorylation** : Removes **electrons** from organic compounds and passes them through a series of **electron acceptors**, called the **electron transport chain**, to molecules of oxygen. This process occurs in the **inner mitochondrial** membrane of cells.
3. **Photophosphorylation** : Occurs only in chlorophyll containing plant cells or in certain bacteria that contain other **light-absorbing pigments**

❖ ROLE OF ATP

1. Role of ATP in linking anabolic and catabolic reactions

- When **complex molecules** and **polymers** are split apart (catabolism, at left), some of the **energy** is transferred to form **ATP** and the rest is given off as **heat**.
- When **simple molecules** and **monomers** are combined to form **complex molecules** (anabolism, at right), **ATP** provides the energy for **synthesis**, and again some energy is given off as **heat**



2. Active Transport

- ATP plays a critical role in the transport of **macromolecules** such as **proteins** and **lipids** into and out of the cell.
- The **hydrolysis** of **ATP** provides the required energy for **active transport** mechanisms to carry such molecules across a **concentration gradient.**

3. Cell Signaling

- ATP has key functions both in **intracellular** and **extracellular signaling**.
- ATP is also involved in **signal transduction** - its **phosphate** groups are used up by **kinases** in phosphate transfer reactions which activate a cascade of **protein kinase reactions.**

4. Structural Maintenance

- ATP plays a very important role in **preserving** the **structure** of the cell by helping the assembly of the **cytoskeletal elements.**
- It also supplies energy to the **flagella** and **chromosomes** to maintain their appropriate **functioning**.

5. Muscle contraction

- ATP is critical for the **contraction** of muscles
- It binds to **myosin** to provide energy and facilitate its binding to actin to form a cross-bridge.
- ADP and phosphate are then released and a new ATP molecule binds to myosin. This breaks the cross-bridge between myosin and actin filaments, thereby releasing myosin for the next contraction.

6. Synthesis of DNA and RNA

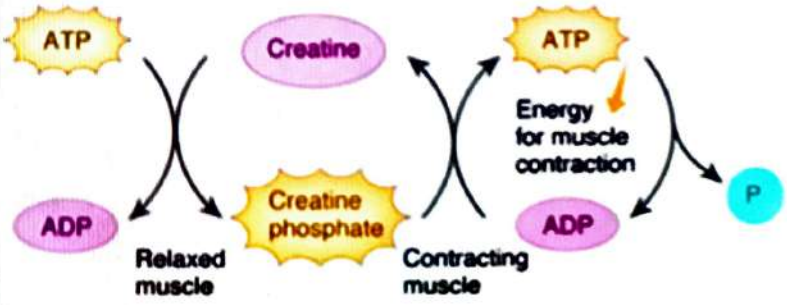
- During DNA synthesis, **ribonucleotide reductase** (RNR) reduces the sugar residue from **ribonucleoside diphosphates** to form **deoxyribonucleoside diphosphates** such as dADP.
- The **adenosine** from ATP is a building block of **RNA** and is directly added to RNA molecules during RNA synthesis by **RNA polymerases**. The removal of **pyrophosphate** provides the **energy** required for this reaction.

CREATININE PHOSPHATE

- While muscle fibers are **relaxed**, they produce **more ATP** than they need for **resting** metabolism.
- The **excess** ATP is used to **synthesize** creatine phosphate, an **energy-rich** molecule that is found only in **muscle fibers.**
- The enzyme **creatine kinase** (CK) catalyzes the transfer of one of the **high-energy phosphate** groups from **ATP** to **creatine**, forming **creatine phosphate** and **ADP**.

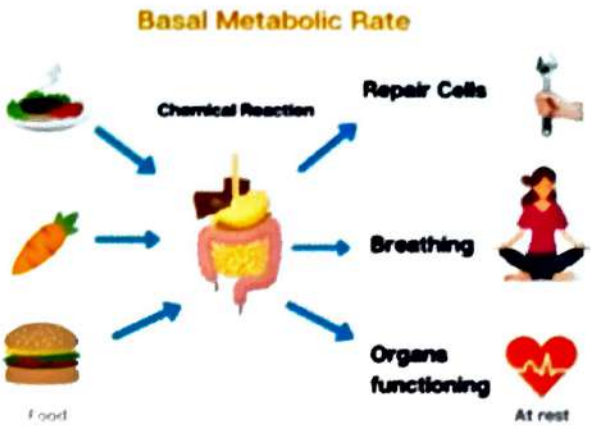
> **Creatine** is a small, **amino acid**–like molecule that is synthesized in the liver, kidneys, and pancreas and then transported to **muscle fibers.**

- When **contraction** begins and the **ADP** level starts to rise, **CK catalyzes** the transfer of a **high-energy phosphate** group from creatine phosphate back to **ADP**.
- This direct **phosphorylation** reaction quickly **regenerates** new **ATP molecules.**
- Together, **creatine phosphate** and **ATP** provide enough energy for muscles to **contract** maximally for about 15 seconds.
- This amount of **energy** is sufficient for maximal short bursts of activity.
- Once inside the **cells** it is transformed into **phosphocreatine** by the enzyme complex **creatine kinase**, which makes it able to donate its **phosphate group** to convert **adenosine diphosphate** (ADP) into adenosine triphosphate (ATP).
- This process is an **important** component of all **vertebrates'** bioenergetic systems
- Creatine phosphate can be broken down into **creatinine**, which is then **excreted** in the urine.



BASAL METABOLIC RATE

- The overall **rate** at which **metabolic reactions** use energy is termed the **Metabolic rate.**
- Some of the energy is used to produce **ATP**, and some is released as **heat**. Because many **factors** affect **metabolic rate.**



- It is **measured** under **standard** conditions, with the body in a, **resting**, and **fasting** condition called the **Basal state.**
- The measurement obtained under these **conditions** is the basal metabolic rate **(BMR).**
- The most common way to determine **BMR** is by measuring the **amount** of **oxygen** used per **kilocalorie** of food metabolized.
- When the body uses **1 liter of oxygen** to oxidize a typical dietary mixture of triglycerides, carbohydrates, and proteins, about **4.8 Cal** of energy is released.

✓ Factors affecting the metabolic rate

➢ Exercise

- During heavy exercise, the **metabolic rate** may **increase** to as much as 15 times the basal rate.

➢ Hormones

- Thyroid hormones are the main regulators of **BMR.**
- BMR **increases** as the blood levels of thyroid hormones **rise.**
- **Thyroid hormones increase** BMR in part by stimulating aerobic cellular respiration. As cells use more oxygen to produce ATP, more heat is given off, and body temperature rises.
- Other hormones have minor effects on BMR.
- **Testosterone, insulin, and human** growth hormone can increase the **metabolic** rate by 5–15%.

Nervous system

- The **sympathetic division** of the autonomic nervous system is stimulated, During **exercise** or in a **stressful** situation.
- Its **postganglionic neurons** release **norepinephrine (NE)**, and it also stimulates release of the hormones **epinephrine** and **norepinephrine** by the adrenal medulla.
- Both epinephrine and norepinephrine **increase** the metabolic rate of body cells.

Body temperature

- The **higher** the body temperature, the higher the **metabolic rate**. Each 1°C rise in core temperature increases the rate of **biochemical reactions** by about 10%.
- As a result, **metabolic rate** may be increased substantially during a **fever**.

Ingestion of food

- The ingestion of food **raises** the metabolic rate 10–20% due to the energy "costs" of **digesting**, **absorbing**, and **storing** nutrients. This effect, food-induced **thermogenesis**, is greatest after eating a **high-protein** meal and is less after eating carbohydrates and lipids.

> ✓ **BMR(ADULTS) = 1200–1800 Cal/day, or about 24 Cal/kg of body mass in adult males**
>
> ✓ **BMR = 22 Cal/kg in adult females**

Age

- The metabolic rate of a child, in relation to its **size**, is about double that of an **elderly person** due to the high rates of reactions related to growth.

Other factors

- Other factors that affect metabolic rate are **gender** (lower in females, except during pregnancy and lactation), **climate** (lower in tropical regions), **sleep** (lower), and **malnutrition** (lower)