



INDEX

S.No.	Topic
1.	Introduction
2.	Gastrointestinal tract
3.	Liver
4.	Gall bladder
5.	Pancreas
6.	Role in Digestion
7.	Enzymes of GI Tract
8.	Hormones of GI Tract
9.	Digestion Process
10.	Absorption of Nutrients
11.	Absorption of Water
12.	Gut-Brain Connection
13.	Gut Microbiota
14.	Role of Nervous System
15.	Summary of Digestive Organs
16.	Major Functions
17.	Conclusion



DIGESTIVE SYSTEM

Structure, Functions, Digestion, Absorption and
Gut - Brain Connection

Introduction

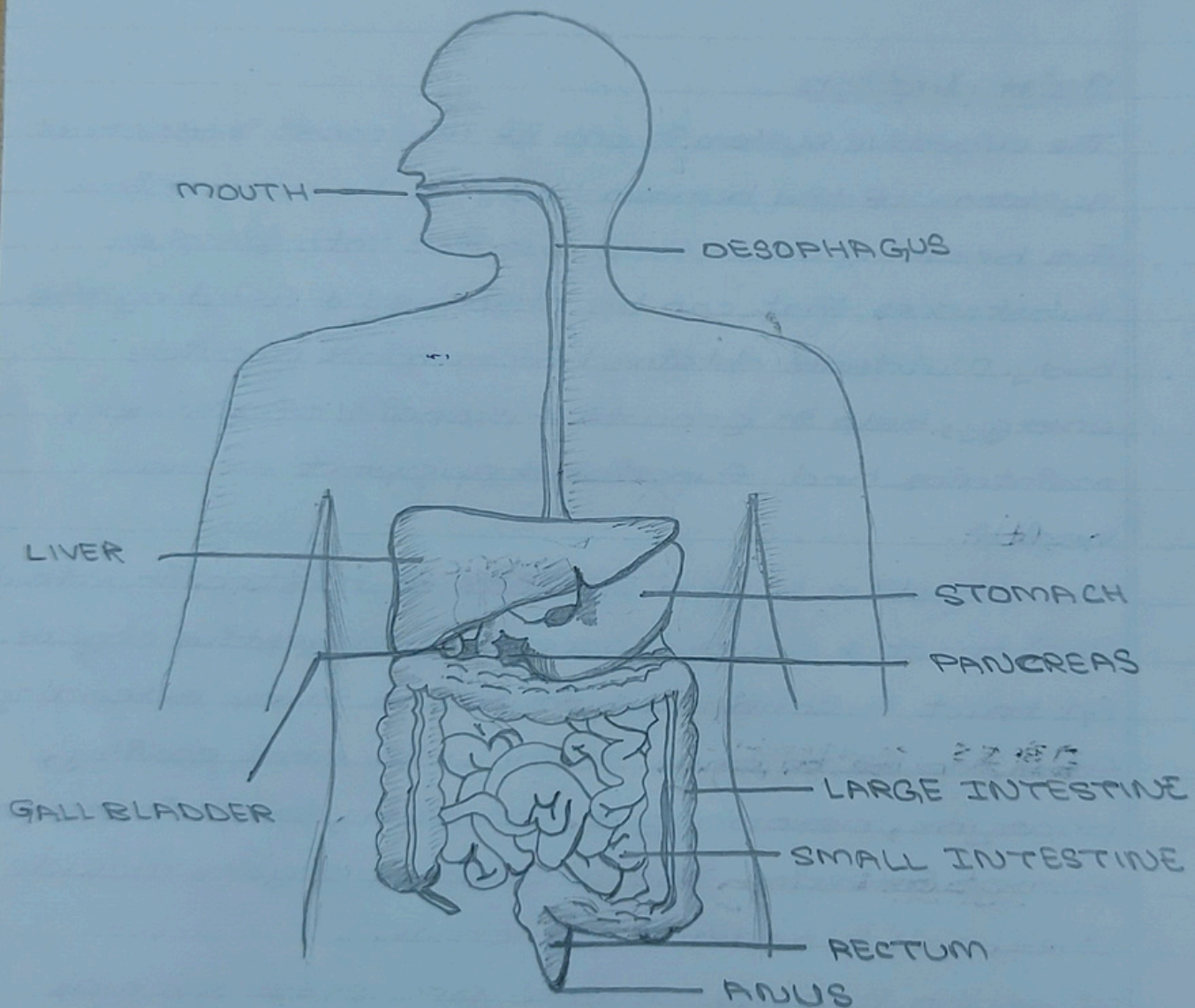
The digestive system is one of the most important systems of the human body. It is responsible for breaking down food we eat into simpler substances that can be absorbed & used by the body. Nutrients obtained from food provide energy, help in growth & repair of tissues, maintains body function & support overall health.

The digestive system consists of gastrointestinal (GI) tract & several accessory digestive organs.

GI tract is continuous muscular tube extending from mouth to anus. It includes oral cavity, pharynx, esophagus, stomach, small intestine & large intestine. The accessory organs include liver, gall bladder & pancreas.

Digestion involves several processes such as ingestion, mechanical digestion, chemical digestion, absorption & elimination. Enzymes, hormones, bile & gut microorganisms all contribute to proper functioning of digestive system.

DIGESTIVE SYSTEM



Human Digestive System

GASTROINTESTINAL TRACT

It is long muscular tube through which food passes. It's major functions are ingestion, movement of food, digestion, absorption & elimination.

The major organs are: ① Oral cavity

② Pharynx

③ Oesophagus

④ Stomach

⑤ Small intestine

⑥ Large intestine

⑦ Rectum

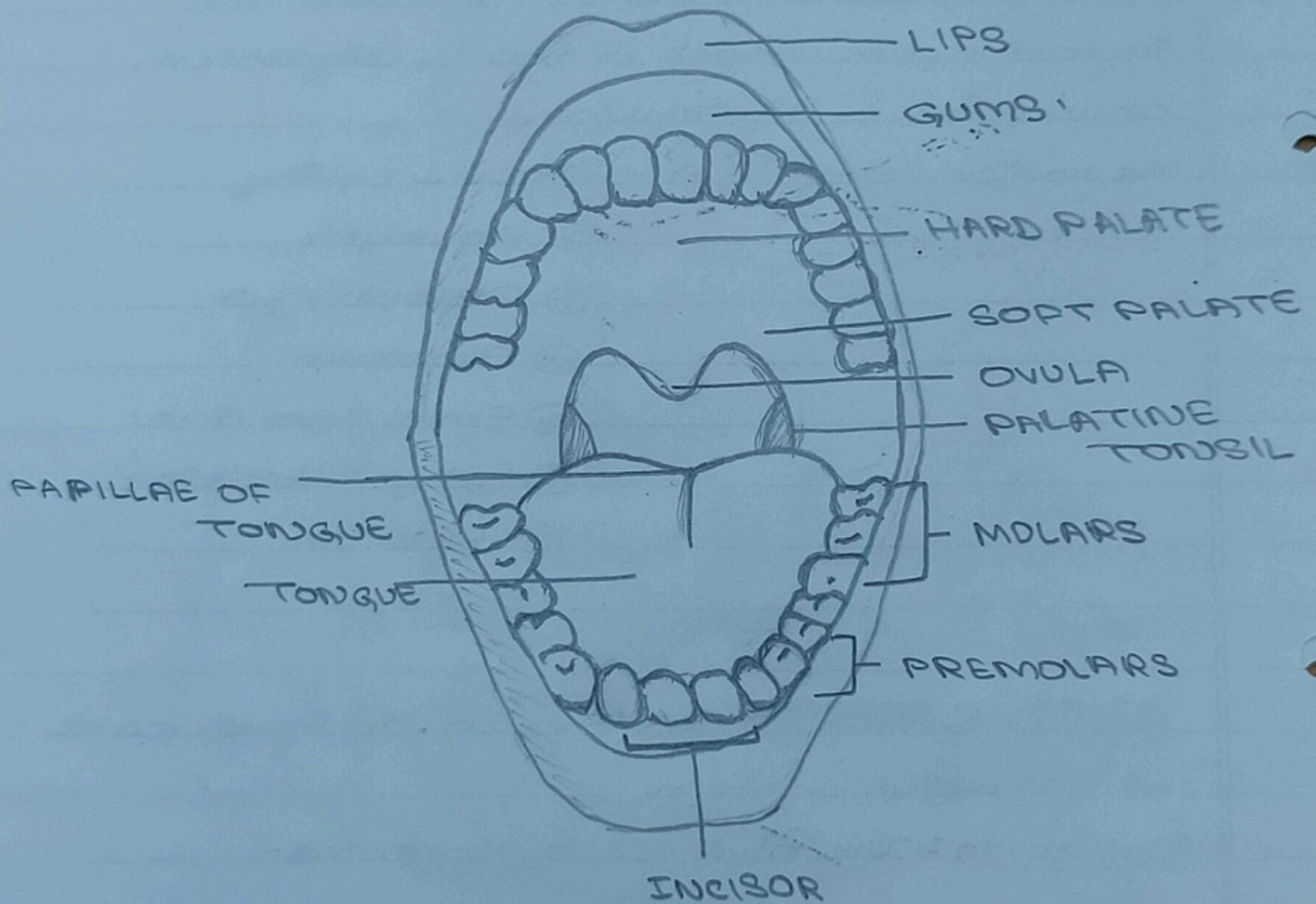
⑧ Anus

ORAL CAVITY or mouth, is first part of digestive system.

Structure: The oral cavity contains -

- Lips
- Teeth
- Tongue
- Salivary glands
- Hard palate
- Soft palate

ANATOMY OF THE ORAL CAVITY



Oral Cavity



Functions: The major functions of oral cavity are:

- Receiving food
- Chewing food
- Mixing food with saliva
- Beginning carbohydrate digestion
- Helping in swallowing
- Forming a soft mass of food called a bolus.

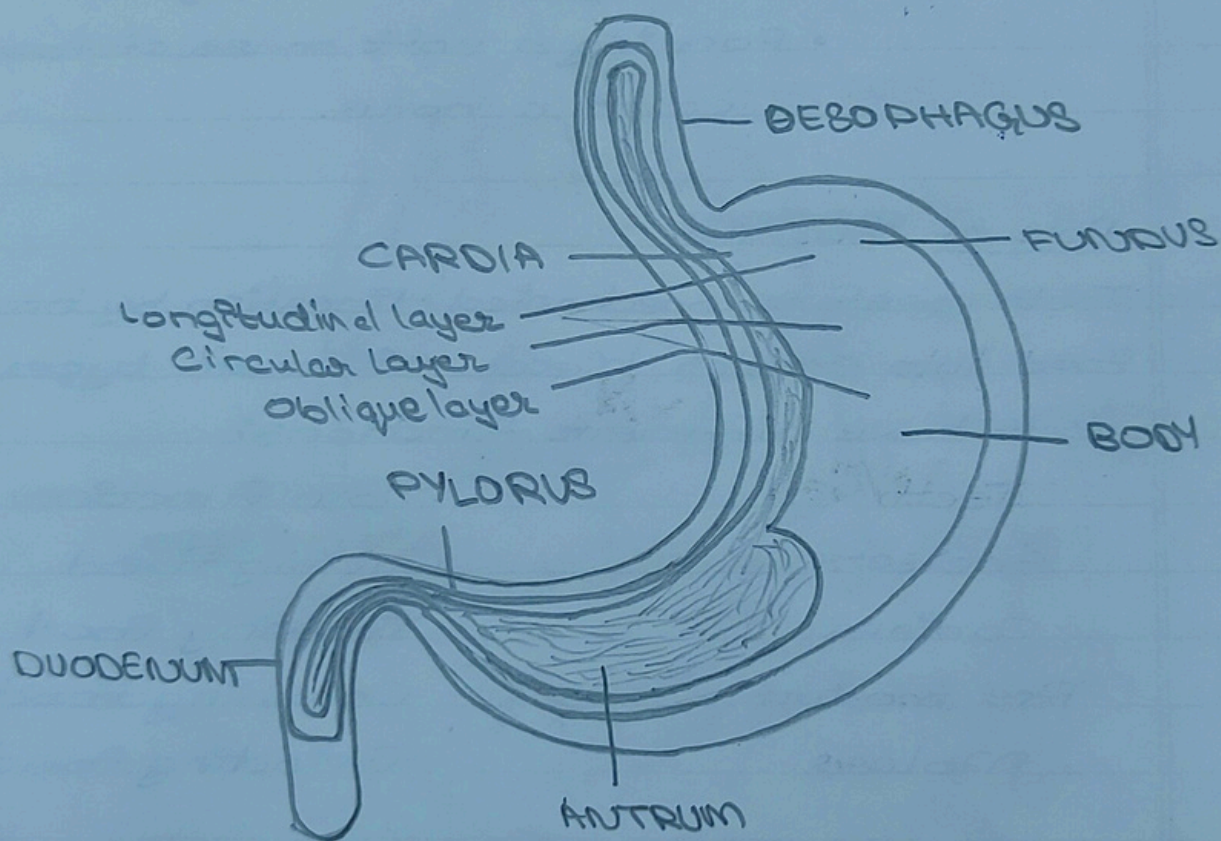
➤ Role of TEETH

Teeth perform mechanical digestion by breaking food into smaller pieces. Different types of teeth have different functions:

Teeth	Main function
Incisors	Cutting food
Canines	Tearing food
Pre molars	Crushing food
Molars	Grinding food

➤ Role of TONGUE:

- Moves food around the mouth
- Mixes food with saliva
- Helps in forming the bolus
- Helps in swallowing
- Contains taste receptors.



- **SALIVA**: Produced mainly by salivary glands. It moistens food & contains enzymes. The important enzyme is salivary amylase, which begins digestion of starch.

oesophagus is muscular tube connecting pharynx to stomach. Food is moved by rhythmic muscular contractions called peristalsis.

Peristalsis ensures that food moves in correct direction even when person is not standing upright.

STOMACH is J-shaped muscular organ located between the oesophagus and small intestine.

Main Parts:

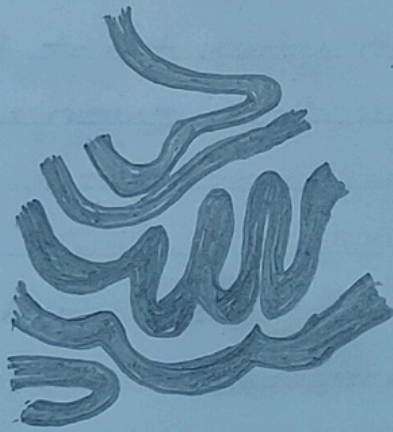
- Cardia
- Fundus

- Body

- Pylorus

Functions: The stomach:

- stores food temporarily
- mixes food mechanically
- begins significant protein digestion
- produces gastric juice
- helps kill many microorganisms present in food



Small Intestine



- converts food into semi-liquid mixture called chyme.
- releases chyme gradually into small intestine.

> **GASTRIC JUICE** contains:

- Hydrochloric acid (HCl)
- Pepsinogen
- Gastric Lipase
- Mucus
- Intrinsic factor

HCl creates an acidic environment & helps convert pepsinogen into pepsin, which digests proteins.

mucus protects stomach lining from acid & digestive enzymes.

SMALL INTESTINE is major site of digestion and absorption of nutrients. It is divided into 3 parts:

- Duodenum
- Jejunum
- Ileum

Functions: The small intestine:

- completes digestion of carbohydrates, proteins & fats
- receives bile from liver / gall bladder.

- Receives pancreatic enzymes
- Produces intestinal secretions
- Absorbs nutrients
- Moves undigested material towards large intestine

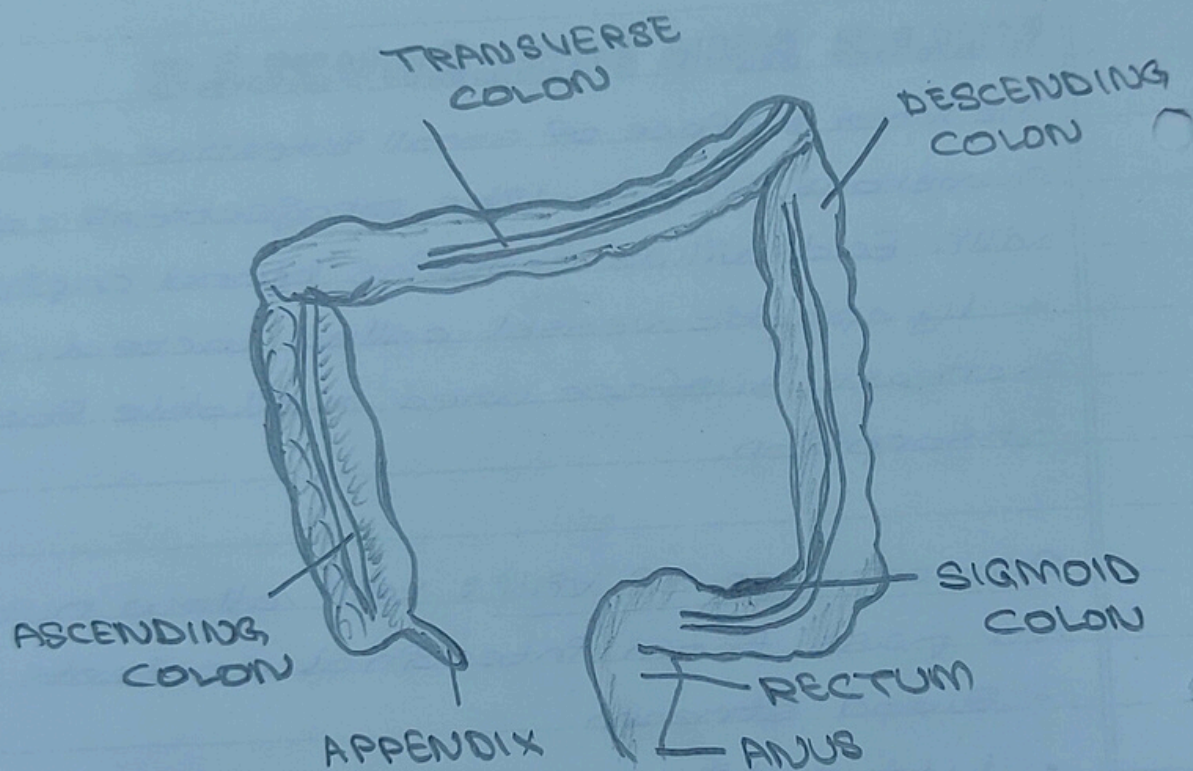
VILLI AND MICROVILLI

The inner surface of small intestine contains numerous finger-like projections called villi. Each villus contains blood capillaries & lymphatic vessel called lacteal. Villi increase surface area available for absorption.

Importance of Villi: Villi allow nutrients to pass from intestinal contents into:

- Blood stream
- Lymphatic system

Water soluble nutrients such as glucose and amino acids mainly enter blood capillaries, while most dietary fat is transported initially through lymphatic system.



~~Large Intestine~~

LARGE INTESTINE is final

major part of GI tract. It includes:

- Caecum
- Colon
- Rectum
- Anus

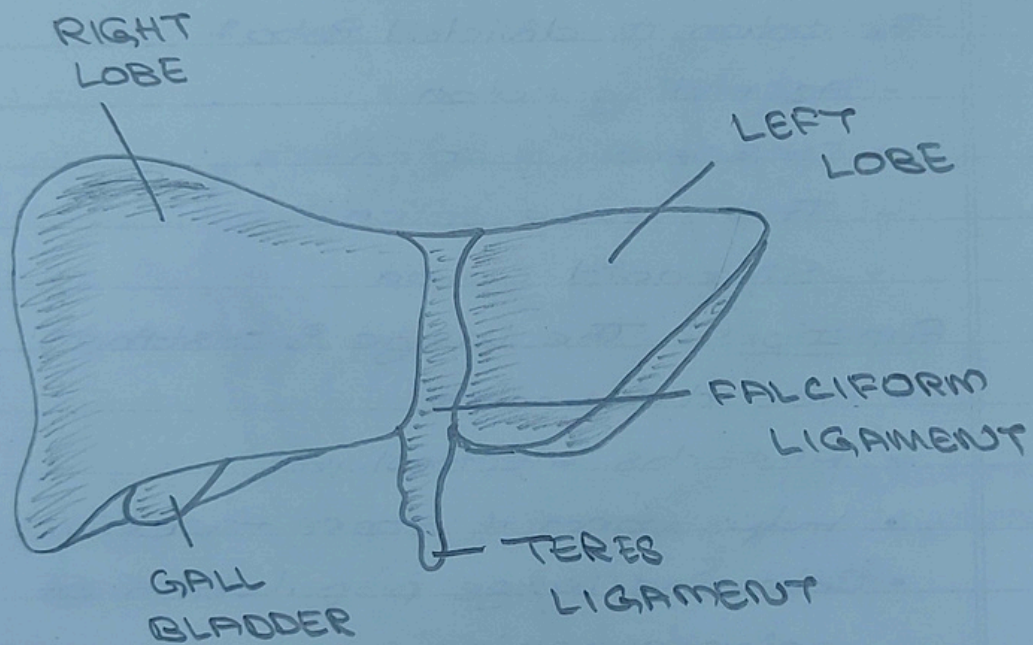
The colon is divided into:

- Ascending colon
- Descending colon
- Transverse colon
- Sigmoid colon

Functions: The large intestine:

- Absorbs water
- Absorbs electrolytes
- Helps form + store faeces.
- Contains large population of microorganisms
- Participates in production and absorption of certain microbial metabolites + vitamins.

➤ **COLON** is largest part of large intestine. It absorbs water and electrolytes and provides habitat for gut microbiota.



Liver

LIVER is largest internal gland and one of most important accessory organs of digestion. It is located mainly in upper right side of abdomen.

Functions: Liver performs many functions,

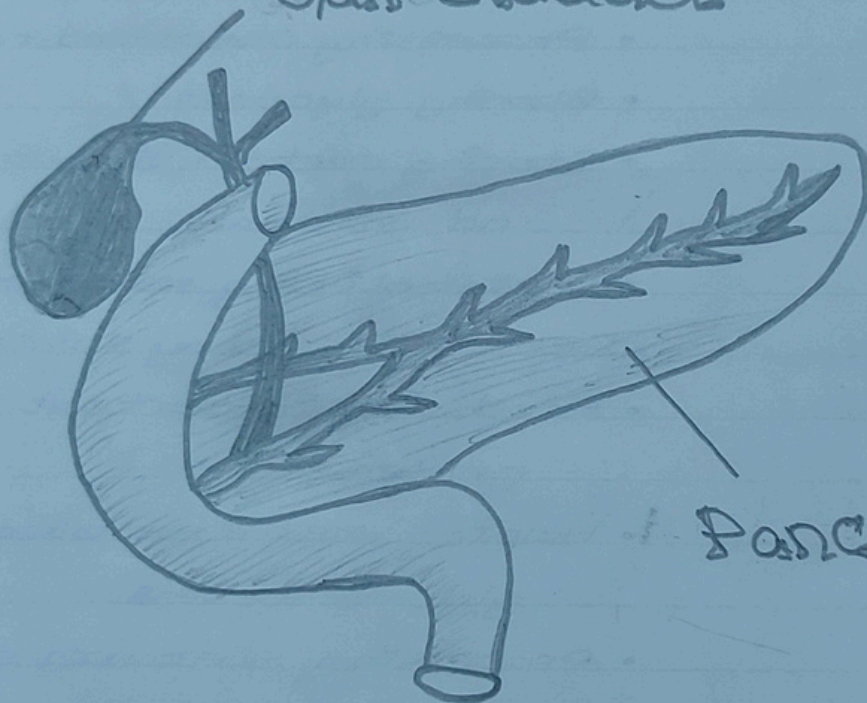
- including:
- Producing bile
 - Processing absorbed nutrients
 - Storing glycogen
 - Storing certain vitamins and minerals
 - Metabolizing nutrients
 - Detoxifying many substances
 - Producing important blood proteins
 - Helping regulate blood glucose levels
 - Processing substances absorbed from digestive tract.

Role in Digestion:

most direct digestive function of liver is production of bile.

Bile contains bile salts that help emulsify fats into smaller droplets, increasing surface area available for pancreatic lipase.

Gall Bladder



Pancreas

GALL BLADDER is small pear-shaped organ located underneath liver.

Main Function:

The gall bladder:

- Stores bile
- Concentrates bile
- Releases bile into duodenum when required.

When fatty meal enters small intestine, hormones including cholecystokinin (CCK) stimulate gall bladder contraction and bile release.

PANCREAS is an accessory digestive organ located behind the stomach.

It has both digestive and hormonal functions.

➤ Exocrine Function:

Important pancreatic enzymes include:

- Pancreatic amylase
- Trypsin
- Chymotrypsin
- Carboxypeptidase
- Pancreatic lipase
- Nucleases

The pancreas also releases bicarbonate, which helps neutralize acidic chyme entering duodenum from stomach.

➤ Endocrine Function:

Pancreas also produces hormones such as:

- Insulin
- Glucagon

These hormones help regulate blood glucose levels.

ROLE OF LIVER, GALL BLADDER AND PANCREAS IN DIGESTION

ORGAN	IMPORTANT DIGESTIVE ROLE
- Liver	Produces bile
- Gall bladder	Stores & concentrates bile
- Pancreas	Produces digestive enzymes & bicarbonate, hormones involved in glucose regulation



ENZYMES OF GI TRACT

Digestive enzymes break large food molecules that can be absorbed.

IMPORTANT DIGESTIVE ENZYMES

Enzyme	Site	Substrate	Main Product
- Salivary amylase	Mouth	Starch	Smaller carbohydrates
- Pepsin	Stomach	Proteins	Peptides
- Gastric Lipase	Stomach	Fats	Fatty acids + other lipid products
- Pancreatic amylase	Small Intestine	Starch	Smaller carbohydrates
- Trypsin	Small Intestine	Proteins/ Peptides	Smaller peptides
- Chymo- trypsin	Small Intestine	Proteins/ Peptides	Smaller peptides
- Peptidases	Small Intestine	Peptides	Amino acids
- Pancreatic Lipase	Small Intestine	Triglycerides	Fatty acids and monoglycerides
- Nucleases	Small Intestine	Nucleic acids	Nucleotides

HORMONES OF GI TRACT

Hormones coordinate digestive activities such as secretion, movement and release of digestive juices.

IMPORTANT GI HORMONES

Hormone	Main Source	Main Function
- Gastrin	Stomach	Stimulates gastric acid secretion
- Secretin	Duodenum	Stimulates bicarbonate secretion
- Cholecysto- -kinin (CCK)	Small Intestine	Stimulates pancreatic enzyme secretion + gall bladder contraction
- GIP	Small Intestine	Helps regulate Insulin secretion + reduces gastric activity.
- Motilin	Small Intestine	Helps regulate Intestinal motility.
- Somato- statin	Stomach/ Pancreas	Inhibits several digestive secretions

DIGESTION PROCESS

Digestion is process by which large food molecules are broken down into smaller molecules.

It involves 2 major types:

- Mechanical Digestion → physical breakdown of food into smaller pieces.

Examples:

- Chewing
- Stomach mixing
- Intestinal movements

- Chemical Digestion → Enzymes break complex nutrients into simple molecules

Examples:

- Starch → simple sugars
- Proteins → amino acids
- Triglycerides → fatty acids and monoglycerides

DIGESTION OF CARBOHYDRATES

Carbohydrate digestion begins in mouth.

Process

- Mouth: Salivary amylase begins starch digestion.
- Stomach: Carbohydrate digestion is greatly reduced because acidic environment inactivates salivary amylase.
- Small Intestine: Pancreatic amylase continues starch digestion.
Brush-border enzymes such as maltase, sucrase + lactase produce monosaccharides.

Final Products

Carbohydrates are mainly absorbed as:

- Glucose
- Galactose
- Fructose

DIGESTION OF PROTEINS

Protein digestion begins mainly in stomach.

- Stomach: Hydrochloric acid denatures proteins and helps activate pepsin.
Pepsin breaks proteins into smaller peptides.

Small Intestine

Pancreatic proteases continue protein digestion.

Peptidases on intestinal surface complete digestion.

Final Products

Proteins are mainly absorbed as:

- Amino acids
- Small peptides

DIGESTION OF FATS

Most fat digestion takes place in small intestine.

Bile salts help emulsify fats, breaking large fat droplets into smaller droplets.

Pancreatic lipase then acts on triglycerides.

DIGESTION OF NUCLEIC ACIDS

Nucleic acids include DNA and RNA.

They are digested by enzymes called nucleases.

They are ultimately broken down into smaller components such as nucleotides, which can be further processed into bases, sugars & phosphate-containing compounds.

ABSORPTION OF NUTRIENTS

Absorption is movement of digested nutrients from gastrointestinal tract into blood or lymph.

Small intestine is major site of nutrient absorption.

Main Absorption Sites

Nutrient	Main Absorption
- Glucose	Small Intestine → Blood
- Amino acids	Small Intestine → Blood
- Fatty acids/ Lipid products	Small Intestine → Mainly Lymph Initially
- Vitamins	Small Intestine
- Minerals	Small Intestine
- Water	Small Intestine and Large Intestine

ABSORPTION OF WATER

Water is absorbed mainly in small intestine, with additional absorption occurring in large intestine.

Water follows osmotic gradients created by absorption of solutes such as sodium and other electrolytes.



- Diet
- Dietary fibre
- Age
- Physical activity
- Medication use
- Stress
- Sleep
- Environment
- Illness

Varied diet containing adequate fibre from foods such as fruits, vegetables, whole grains and pulses can provide substrates for beneficial microbial fermentation.

GUT-BRAIN CONNECTION

Gut and brain communicate continuously through system commonly called gut-brain axis.

Communication occurs through several pathways:

- Nervous system
- Hormones
- Immune system
- Microbial metabolites
- Vagus nerve

ABSORPTION OF VITAMINS & MINERALS

The digestive tract also absorbs vitamins and minerals. Examples include:

- Iron
- Calcium
- Magnesium
- Sodium
- Potassium
- Vitamin B12
- Folate
- Fat-soluble vitamins A, D, E and K

Vitamin B12 absorption requires intrinsic factor, which is produced by parietal cells of stomach.

GUT MICROBIOTA

Gut microbiota refers to large community of microorganisms living in gastrointestinal tract.

These include mainly bacteria, along with other microorganisms.

The colon contains particularly large and diverse microbial population.

Functions:

Gut microorganisms can:

- Ferment undigested carbohydrates and dietary fibre.
- Produce short-chain fatty acid (SCFAs)
- Support intestinal barrier
- Interact with immune system
- Influence intestinal movement
- Contribute to vitamin production and metabolism.
- Influence communication between gut and brain
- Compete with harmful microorganisms.

Short-chain Fatty Acids:

Important SCFAs include:

- Acetate
- Propionate
- Butyrate

These compounds can be used by body and have important effects on intestinal environment and metabolism.

FACTORS AFFECTING GUT MICROBIOTA

Gut microbiota can be influenced by:



Gut-brain connection is bidirectional, meaning signals travel from gut to brain to gut.

For example, stress can affect gastro-intestinal movement and sensations, while signals originating in gut can influence brain functions and behaviour.

ROLE OF NERVOUS SYSTEM IN DIGESTION

Nervous system helps coordinate digestive activities.

Enteric Nervous System (ENS) is network of neurons located within GI tract.

It helps control:

- Intestinal movement
- Digestive secretions
- Blood flow
- Local responses to food

Autonomic nervous system also influences digestion.

Parasympathetic nervous system generally supports digestive activity, while sympathetic activity can reduce gastrointestinal activity during stress.

GUT-BRAIN AXIS AND NUTRITION

Nutrition plays important role in maintaining healthy gut environment.

Dietary fibre is particularly important because certain gut microorganisms ferment fibre & produce SCFAs.

Other dietary factors, overall dietary pattern, hydration & regular eating habits can also influence gastrointestinal function.

∴ Digestive health is closely connected with overall nutrition & well-being.

SUMMARY OF DIGESTIVE ORGANS

ORGAN	MAJOR FUNCTION
Oral Cavity	→ Ingestion, chewing & beginning of carbohydrate digestion
Esophagus	→ Transport of food
Stomach	→ Storage, mixing, protein digestion
Small Intestine	→ Major site of digestion & absorption
Large Intestine	→ Water/electrolyte absorption & faeces

ORGAN

MAJOR FUNCTION

Formation.

Colon → Water absorption and microbial fermentation

Liver → Bile production and nutrient processing

Gall bladder → Storage & release of bile

Pancreas → Digestive enzymes & bicarbonate

Rectum → Temporary storage of faeces

Anus → Elimination

MAJOR FUNCTIONS OF DIGESTIVE SYSTEM

- Ingestion: Taking food and fluids into mouth.
- Propulsion: Moving food through GI tract using swallowing and peristalsis.
- Mechanical Digestion: Breaking food into smaller pieces.

- Chemical Digestion : Breaking macro-nutrients down using enzymes.
- Absorption : Moving nutrients, water and electrolytes into blood or lymph.
- Elimination : Removing undigested material from body as faeces.

IMPORTANCE OF DIGESTIVE SYSTEM IN NUTRITION

Digestive system is essential for nutrition because body cannot use most food in its original complex form.

For example:

- Complex carbohydrates must be broken down into smaller sugars.
- Proteins must be broken down into amino acids and small peptides.
- Fats must be digested into absorbable lipid products.

After absorption, nutrients are transported to different tissues where they are used for:

- Energy production
- Growth
- Tissue repair
- Hormone and enzyme production
- Immune function
- Maintenance of normal body functions.

CONCLUSION

The digestive system is a complex and highly coordinated system responsible for processing food and making nutrients available to body. It consists of gastrointestinal tract and accessory organs such as Liver, gall bladder and pancreas.

Digestion begins in oral cavity and continues through stomach and small intestine.



The small intestine is major site for digestion and absorption, while large intestine plays important role in water absorption and houses a large population of gut microorganisms.

Digestive Enzymes break carbohydrates, proteins, fats and nucleic acids into smaller molecules. Hormones such as gastrin, secretin and cholecystikinin coordinate digestive secretions & movements. The liver produces bile, gall bladder stores & releases bile, & pancreas provides digestive enzymes & bicarbonate.

Gut microbiota contribute to digestion, fermentation of dietary fibre, production of microbial metabolites & communication with immune & nervous systems.

Thus, proper digestion & absorption are essential for obtaining nutrients from food & maintaining overall health.

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