# Lecture 5

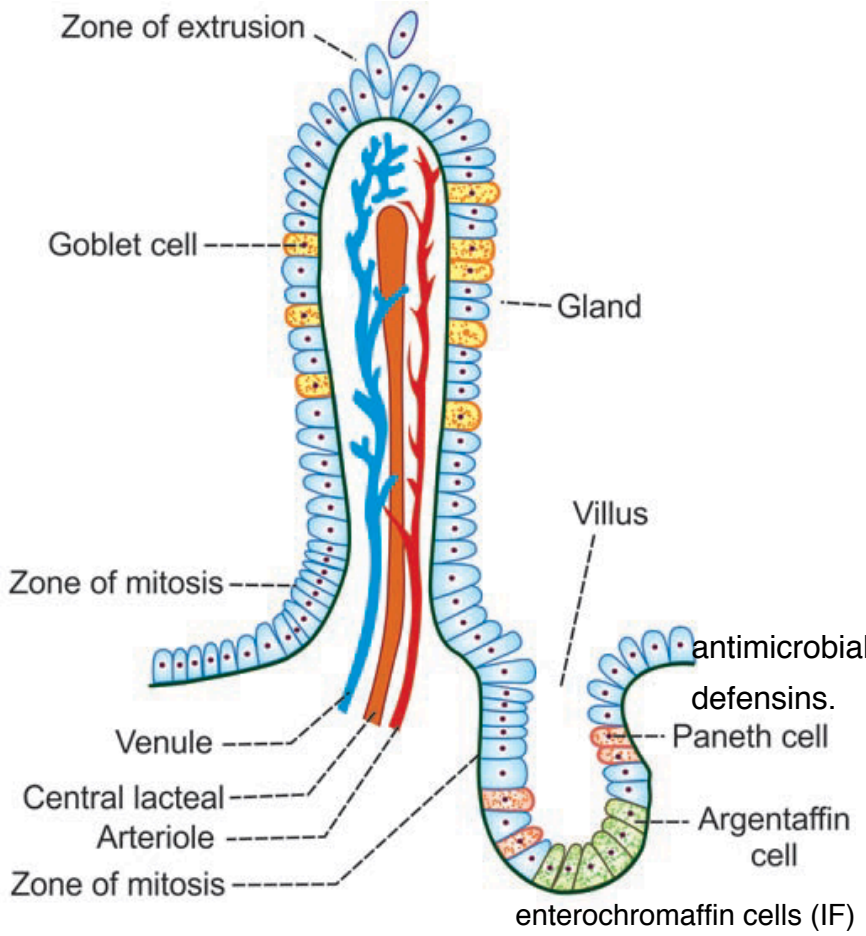
**Dr. Iman Aolymat**
**imank@hu.edu.jo**

# Secretory Functions of the Alimentary Tract

SI & LI

# Intestinal villi

- Minute projections from mucous membrane of SI
- lined by columnar cells called enterocytes
- microvilli are hair-like projections on enterocytes
- Villi and microvilli ↑surface area
- Within each villus blood vessels & central channel called lacteal→opens into lymphatic vessels.



# Secretions of Small Intestine=succus entericus.

- Brunner's glands in duodenum
  - Compound mucus gland in D between pylorus & papilla of Vater
  - Secrete alkaline (high HCO3) mucus
  - Protects mucosa from acidic chyme
  - **Stimulated by**
  1. Local irritation
  2. Vagus (Ach)→ ↑ secretion
  3. Secretin
  - **Inhibited by sympathetic**-excitement → unprotected D → 50 % of persons with peptic ulcers

# Secretions of Small Intestine

- Crypts of Lieberkühn= intestinal glands
- In D
- Lie between intestinal villi.
- Secrete alkaline water-like fluid

# Crypts of Lieberkühn

- ✓ Surfaces of crypts and villi are covered by 2 types of epithelial cells:

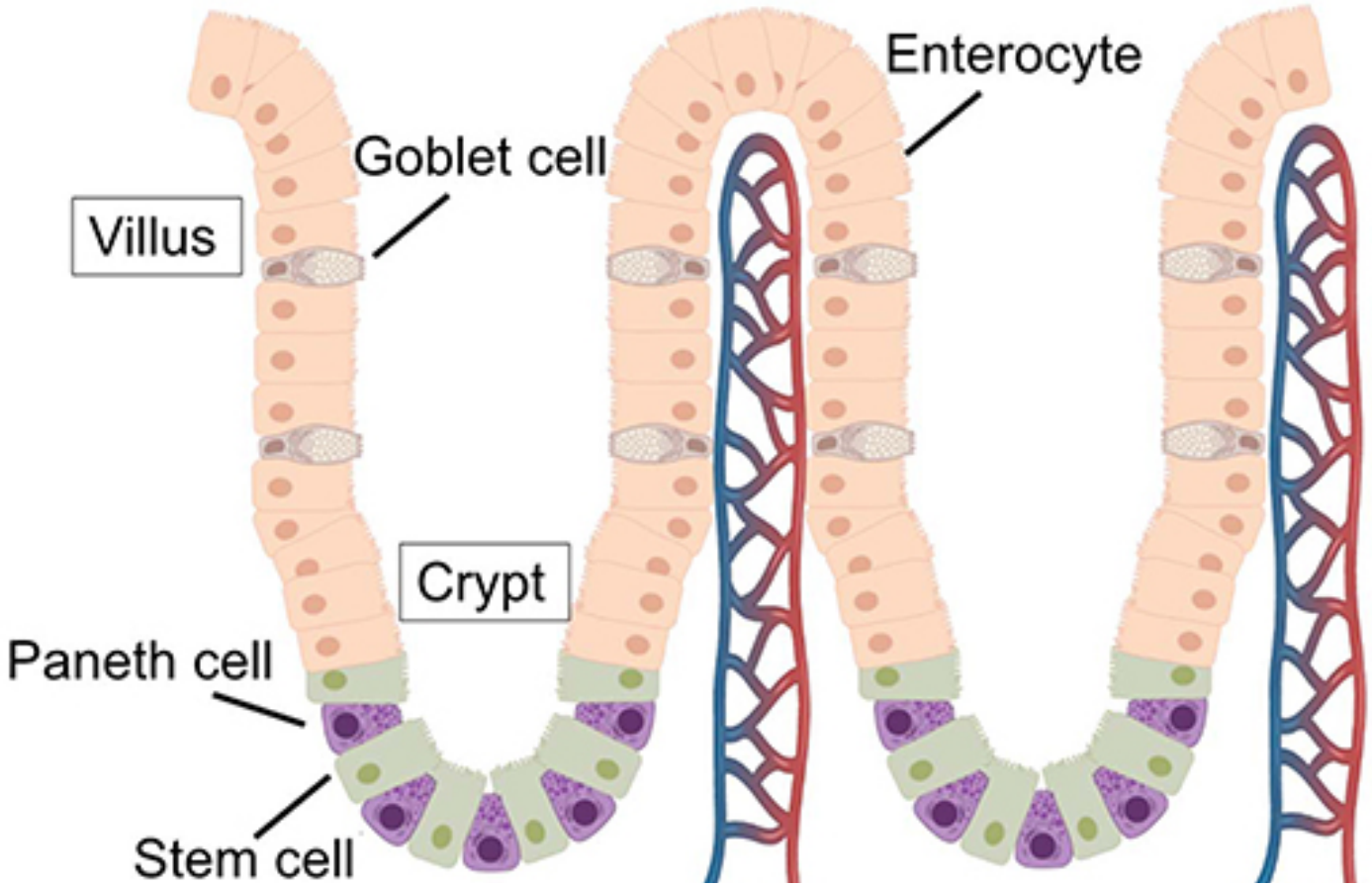
1. **Goblet cells**

- ✓ Moderate in number
- ✓ Secrete mucus → lubricating & protecting intestinal surfaces

2. **Enterocytes**

- ✓ Large in number
- ✓ Secrete large quantities of H2O & electrolytes
  - ✓ almost pure ECF
  - ✓ 1800 ml/day
  - ✓ pH 7.5 - 8.0
- ✓ Reabsorb H2O & electrolytes with end products of digestion.
- ✓ Secrete digestive enzymes

- The life cycle of an intestinal epithelial cell is about 5 days.
- The epithelial cells deep in the crypts of Lieberkühn continually undergo mitosis.
- As the villus cells age, they are finally shed into the intestinal secretions.



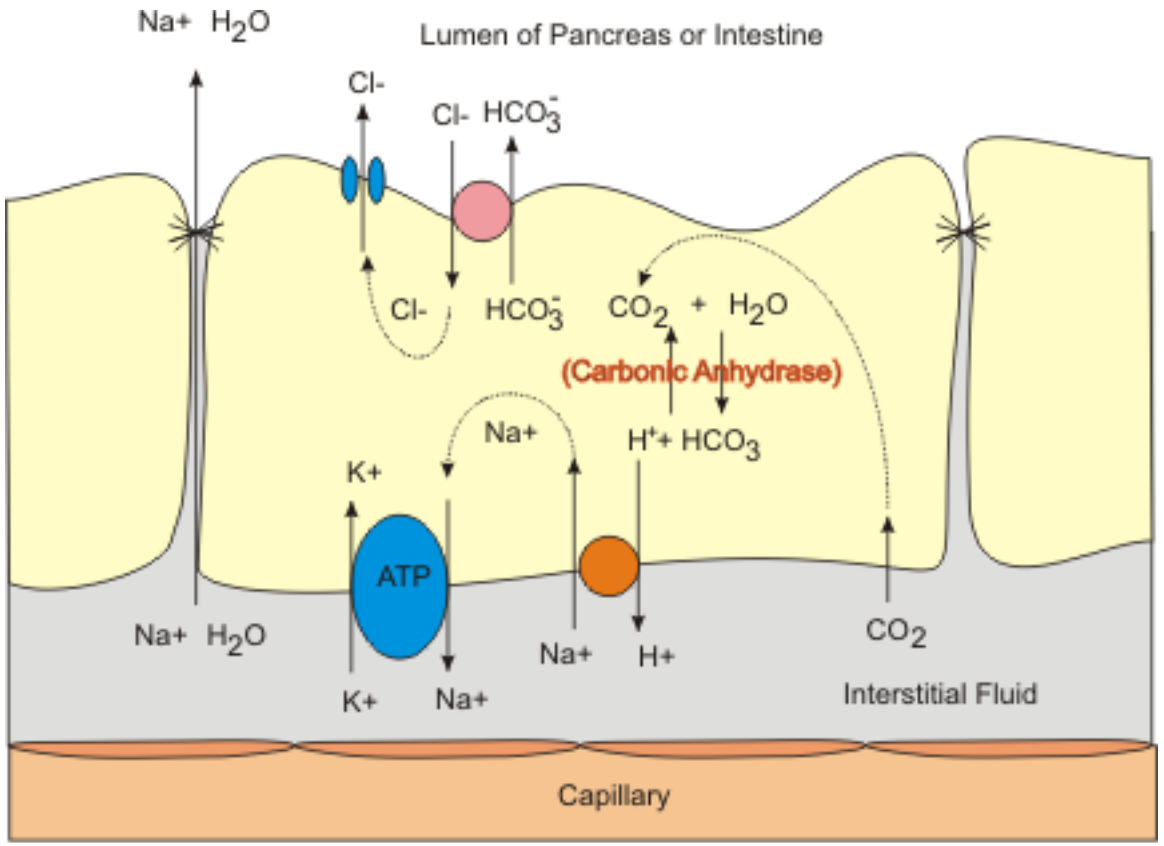
- **Mechanism of Secretion of Watery Fluid**

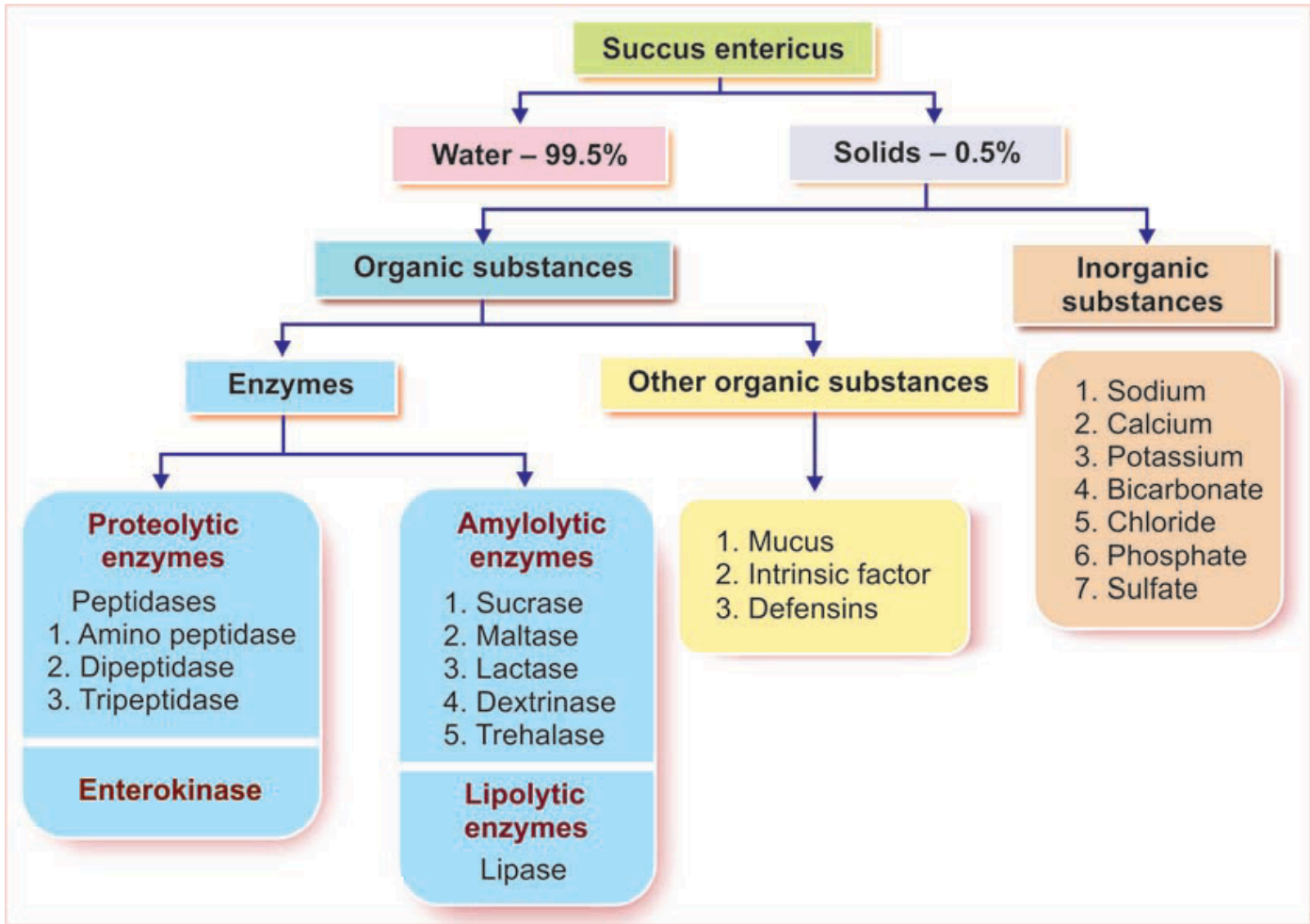
(1) Active secretion of Cl into the crypts

(2) Active secretion of HCO3

(3) Active secretion of Cl & HCO3 causes electrical attractiveness of Na

(4) All these ions together cause osmotic movement of H2O.




Succus entericus
Water – 99.5%
Solids – 0.5%
Organic substances
Inorganic substances
Enzymes
Other organic substances
1. Sodium
2. Calcium
3. Potassium
4. Bicarbonate
5. Chloride
6. Phosphate
7. Sulfate
Proteolytic enzymes
Peptidases
1. Amino peptidase
2. Dipeptidase
3. Tripeptidase
Enterokinase
Amylolytic enzymes
1. Sucrase
2. Maltase
3. Lactase
4. Dextrinase
5. Trehalase
Lipolytic enzymes
Lipase
1. Mucus
2. Intrinsic factor
3. Defensins

# Digestive Enzymes Secretion by enterocytes

**(1) Peptidases** for splitting small peptides into amino acids

**(2) Sucrase, maltase, isomaltase, and lactase**—for splitting disaccharides into monosaccharides

**(3) Intestinal lipase** for splitting neutral fats into glycerol and fatty acids.

| Enzyme | Substrate | End products |
|---|---|---|
| Peptidases | Peptides | Amino acids |
| Sucrase | Sucrose | Fructose and glucose |
| Maltase | Maltose and maltriose | Glucose |
| Lactase | Lactose | Galactose and glucose |
| Dextrinase | Dextrin, maltose and maltriose | Glucose |
| Trehalase | Trehalose | Glucose |
| Intestinal lipase | Triglycerides | Fatty acids |

## Regulation of secretion of succus entericus

### Nervous regulation

parasympathetic → vasodilatation & ↑ secretion
Sympathetic → vasoconstriction & ↓ secretion
local nervous reflexes (stimulated by tactile stimuli or irritation)
→ ↑ secretion

### Hormonal regulation

Enterocrinin, secretin and cholecystokinin → ↑ secretion

# Pathophysiology of SI

## 1. Malabsorption

Failure to absorb nutrients such as proteins, carbohydrates, fats and vitamins.

## 2. Malabsorption syndrome

- ✓ Failure of digestion and absorption in SI.
- ✓ Caused by Crohn’s disease, tropical sprue, steatorrhea and celiac disease.

**Crohn's disease or enteritis**

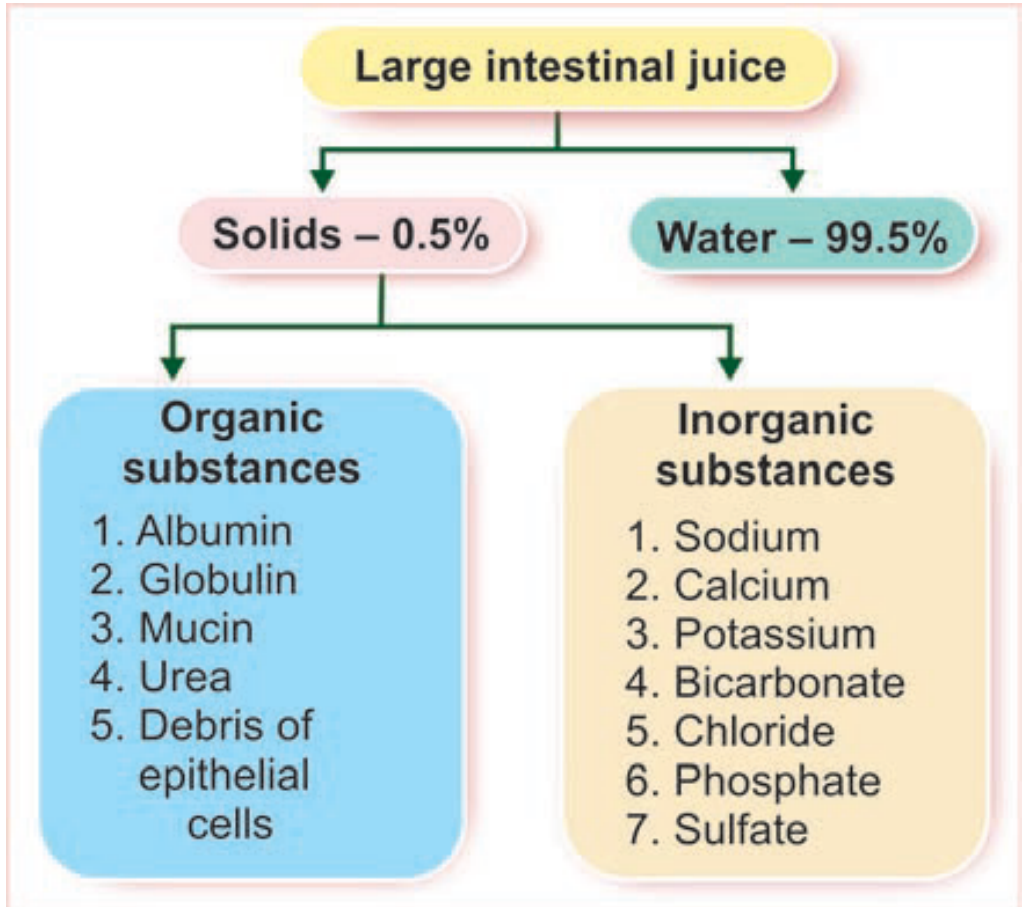
- Enteritis is an inflammatory bowel disease (IBD)= inflammation of SI.
- affects lower part of SI, the ileum.
- Caused by abnormalities of the immune system resulting in inflammation of intestine.
- Malabsorption of vitamin
- Diarrhea
- Delayed or stunted growth in children.

**Celiac disease/ gluten-sensitive enteropathy/celiac sprue/ non-tropical sprue**

- Autoimmune disorder
- Damage of mucosa and atrophy of villi in small intestine→impaired digestion and absorption.
- Caused by gluten (present in wheat, oats, rye, barley and other grains)
- Diarrhea & Steatorrhea

# Secretions of the Large Intestine

- Large intestine also contains crypts of Lieberkühn but there are no villi or enzymes.
- Crypts mainly secrete alkaline ($HCO_3$, pH of 8.0.) fluid
- Neutralize acids formed by bacterial action in LI
- Mucus in LI protects intestinal wall against excoriation & provides an adherent medium for holding fecal matter together
- LI excretes heavy metals like mercury,lead, bismuth & arsenic


Large intestinal juice
Solids – 0.5%
Water – 99.5%
Organic substances
1. Albumin
2. Globulin
3. Mucin
4. Urea
5. Debris of epithelial cells
Inorganic substances
1. Sodium
2. Calcium
3. Potassium
4. Bicarbonate
5. Chloride
6. Phosphate
7. Sulfate

# Regulation of Secretions of the Large Intestine

- Regulated principally by direct, tactile stimulation of LI & local nervous reflexes
- Mucus secretion increased by parasympathetic stimulation (pelvic nerves )
- Irritation → Excess Secretion of $H_2O$ & Electrolytes → Diarrhea

# Digestion in the Gastrointestinal Tract

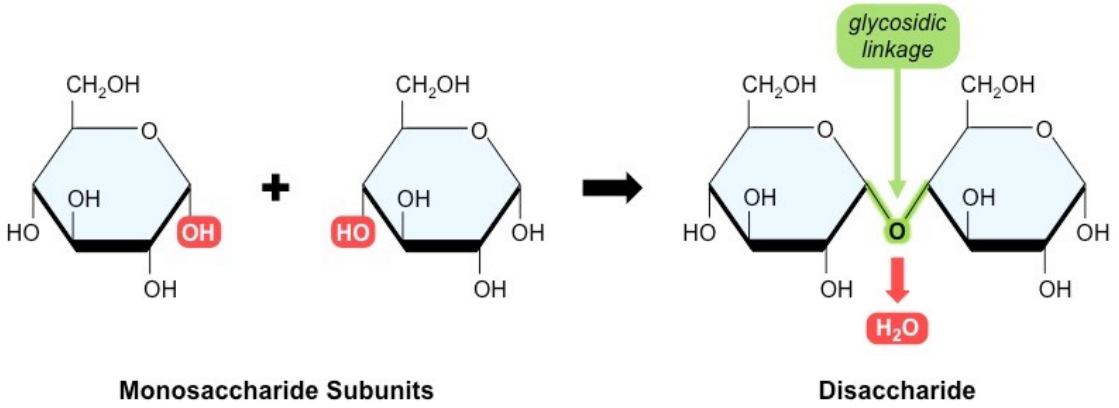
# Digestion in the Gastrointestinal Tract

**Major foods**: carbohydrates, fats & proteins
Cannot be absorbed in their natural forms through GI mucosa→ digestion into small compounds for absorption
**Minors**: vitamins and minerals

# Digestion of the various foods by hydrolysis

**Hydrolysis of Carbohydrates**.

Monosaccharides bound to one another by **condensation**. H+& OH− removal →H2O & disaccharides




Carbohydrates (polysaccharides/disaccharides) → Monosaccharides by hydrolysis

Enzymes in digestive juices return H+& OH− from H2O

$$R'' - R' + H_2O \xrightarrow[\text{enzyme}]{\text{Digestive}} R''OH + R'H$$

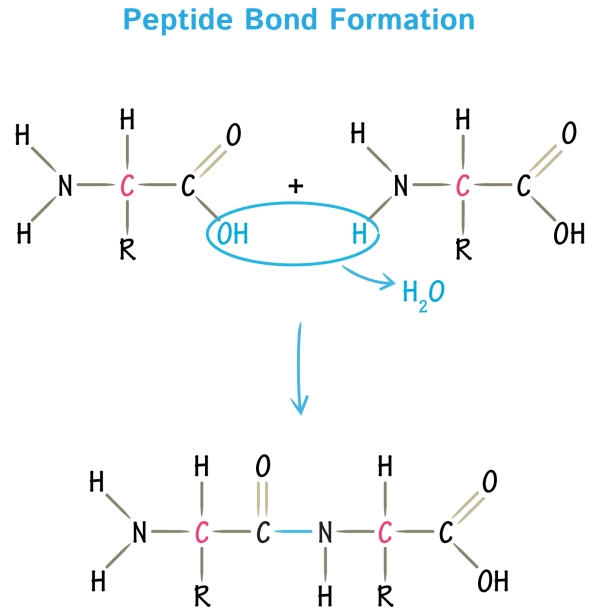
**Formation of Proteins**

Multiple amino acids bound by peptide linkages.

H+& OH− removal→ H2O & dipeptide

**Hydrolysis**. proteolytic enzymes return

H+& OH− from H2O to protein molecules to split them into amino acids.

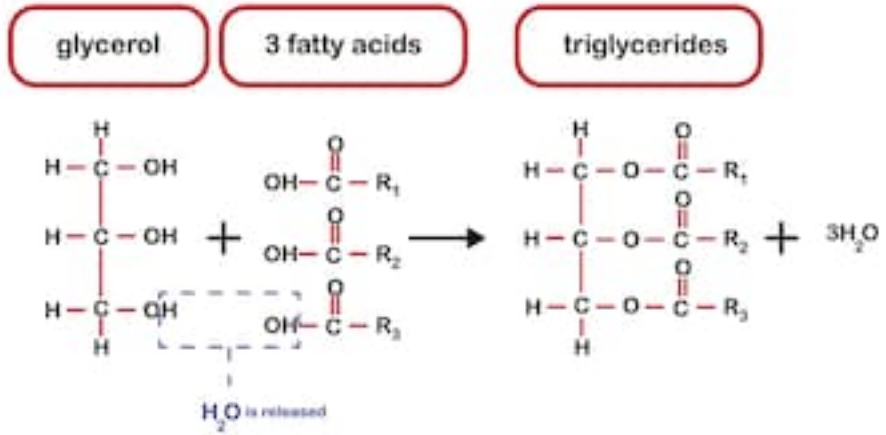



**Formation of TG**

Diet mainly consists of TG = 3 fatty acid + glycerol

During condensation, 3 H2O molecules removed.

**Hydrolysis** :reverse process: fat-digesting enzymes return 3 H2O molecules to TG splitting fatty acid from the glycerol



## 3 types of carbohydrates:

### 1. Polysaccharides

glycogen, amylose and amylopectin, which are in the form of starch (glucose polymers).
Glycogen is available in non-vegetarian diet.
Amylose and amylopectin are available in vegetarian diet because of their plant origin.

### 2. Disaccharides

Two types of disaccharides are available in the diet.
Sucrose (Glucose + Fructose)= table sugar or cane sugar
Lactose (Glucose + Galactose), milk sugar

### 3. Monosaccharides

glucose and fructose.

Other carbohydrates in the diet include
i. Alcohol
ii. Lactic acid
iii. Pyruvic acid
iv. Pectins
v. Dextrins
vi. Carbohydrates in meat
vii. Cellulose

# Carbohydrate Foods of the Diet

- **3 major sources of carbohydrates in diet**

1. sucrose (disaccharide)
2. lactose (milk disaccharide)
3. starches (polysaccharides)

- Others -amylose, glycogen, alcohol, lactic acid, pyruvic acid, pectins, dextrins

- Large amount of cellulose, no human enzymes for hydrolyzing cellulose →cellulose cannot be considered food for humans.

# Digestion of Carbohydrates

- Starch digestion

  - **Mouth**-Begins with ptyalin (α-amylase) in saliva (5% digestion in mouth (short Time stay, Starch→Maltose & 3 -9 glucose polymers

  - **Stomach**- up to 40% in stomach, mainly maltose -1 hr digestion, salivary amylase is blocked by gastric acid

  - **Small intestine-**powerful pancreatic amylase-15-30 min after chyme emptying to D →all carbohydrates digested, totally converted into maltose and/or other small glucose polymers.

# Digestion of Carbohydrates

- Starch digestion -
  - Final digestion occurs at the intestinal microvilli brush border
  - Enterocytes lining villi of SI contain enzymes (lactase, sucrase, maltase, α-dextrinase & trehalase → splitting disaccharides lactose, sucrose, and maltose, trehalose, plus other small glucose polymers → monosaccharides.

- **Final products of carbohydrate digestion are all monosaccharides/all water soluble and are absorbed immediately into the portal blood.**

| | |
|---|---|
| 80% | glucose |
| 10% | fructose |
| 10% | galactose |

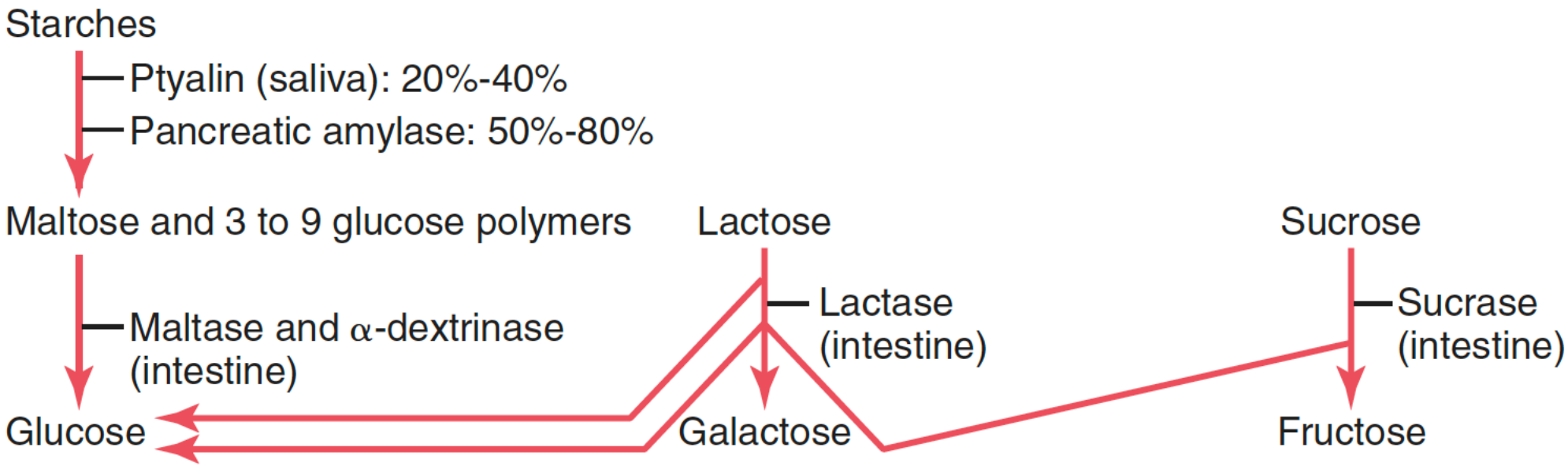



**Figure 66-1.** Digestion of carbohydrates.

## TABLE 45.1: Digestion of carbohydrates

| Area | Juice | Enzyme | Substrate | End product |
|---|---|---|---|---|
| Mouth | Saliva | Salivary amylase | Polysaccharides – cooked starch | Disaccharides – dextrin and maltose |
| Stomach | Gastric juice | Gastric amylase | Weak amylase | The action is negligible |
| Small intestine | Pancreatic juice | Pancreatic amylase | Polysaccharides | Disaccharides – Dextrin, maltose and maltriose |
| | Succus entericus | Sucrase | Sucrose | Glucose and fructose |
| | | Maltase | Maltose and maltriose | Glucose |
| | | Lactase | Lactose | Glucose and galactose |
| | | Dextrinase | Dextrin, maltose and maltriose | Glucose |
| | | Trehalase | Trehalose | Glucose |