Faculty of Pharmacy
Biochemistry-2

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Lecturer of Biochemestry

Introduction to Metabolism

Metabolism

Definition of metabolism:

All chemical reactions occur inside the body

Metabolism divided into

A- catabolism: digestion of the food to give energy = ATP.

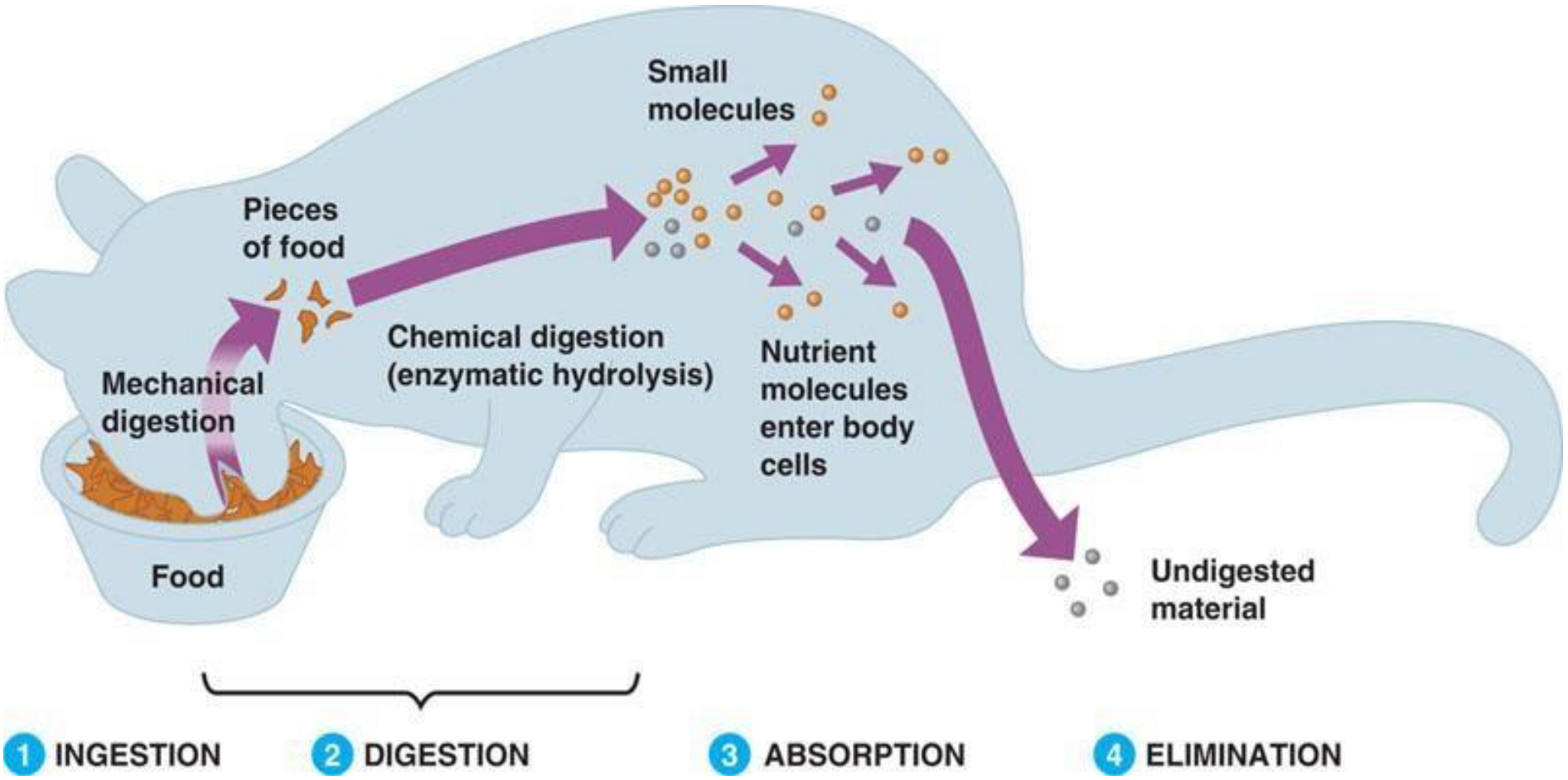
B- Anabolism : building of the tissues.

Metabolic sources of energy:

energy which extracted from food via oxidation.

Carbohydrates metabolism, Proteins metabolism, and Lipid metabolism.

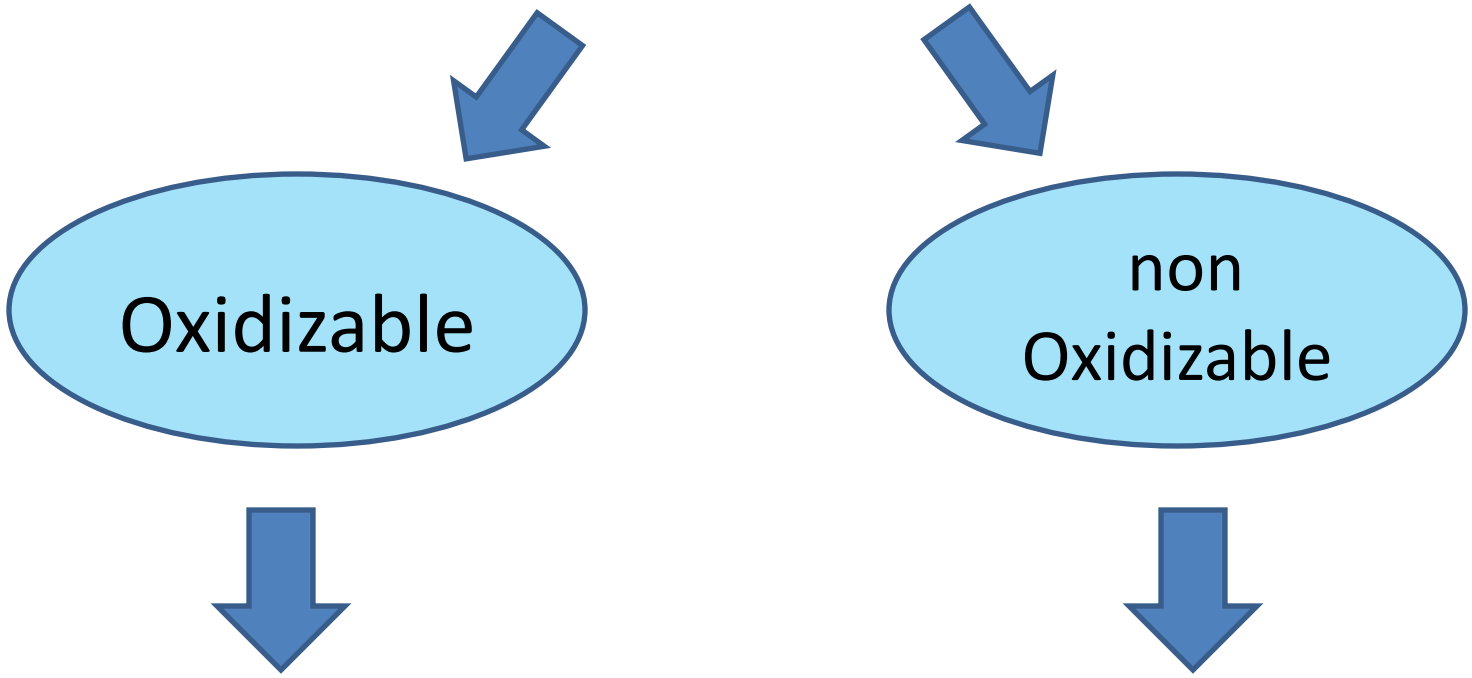
The end result of metabolism is energy + CO_2 + H_2O energy in the form of ATP


Small molecules
Pieces of food
Chemical digestion (enzymatic hydrolysis)
Mechanical digestion
Nutrient molecules enter body cells
Food
Undigested material
1 INGESTION
2 DIGESTION
3 ABSORPTION
4 ELIMINATION

Metabolism includes:

1. Digestion
2. Absorption
3. Catabolism
4. Anabolism
5. Excretion

Food Stuff



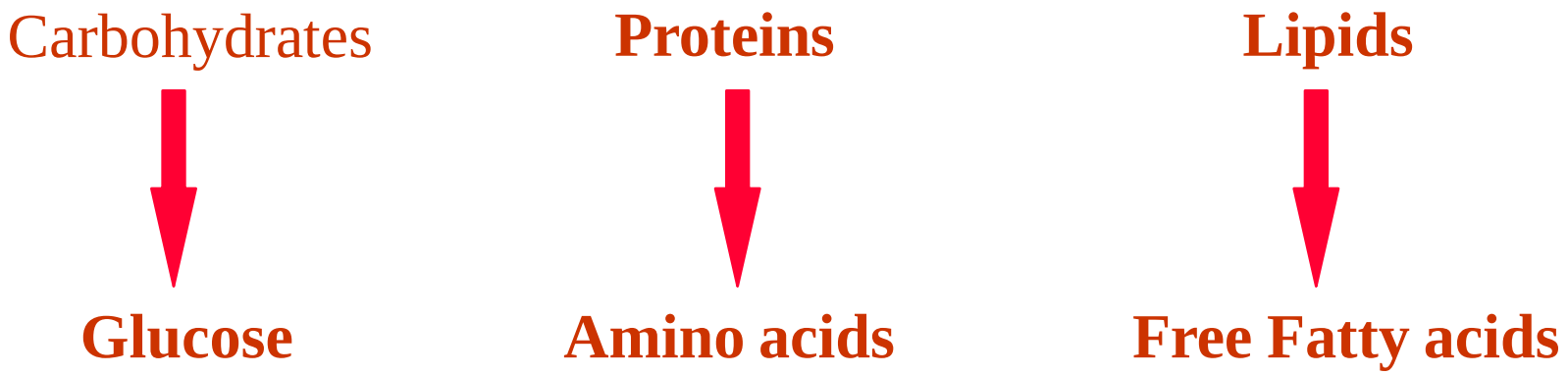
Carbohydrates
Proteins
lipids

Vitamins
Minerals
water

Stages of Metabolism

Stage 1: digestion absorption

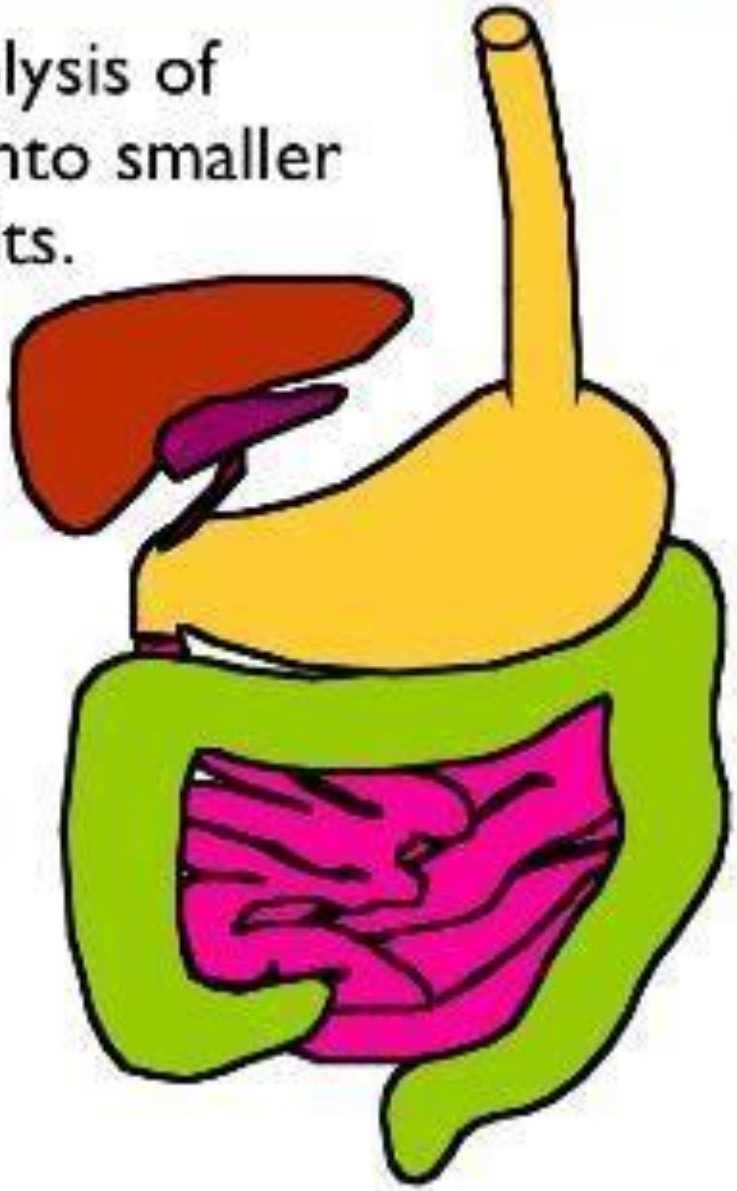
It is the breakdown & degradation of polysaccharides, proteins & lipids into their simplest units (glucose – amino acids and fatty acids which are absorbed)



1st Stage of Metabolism

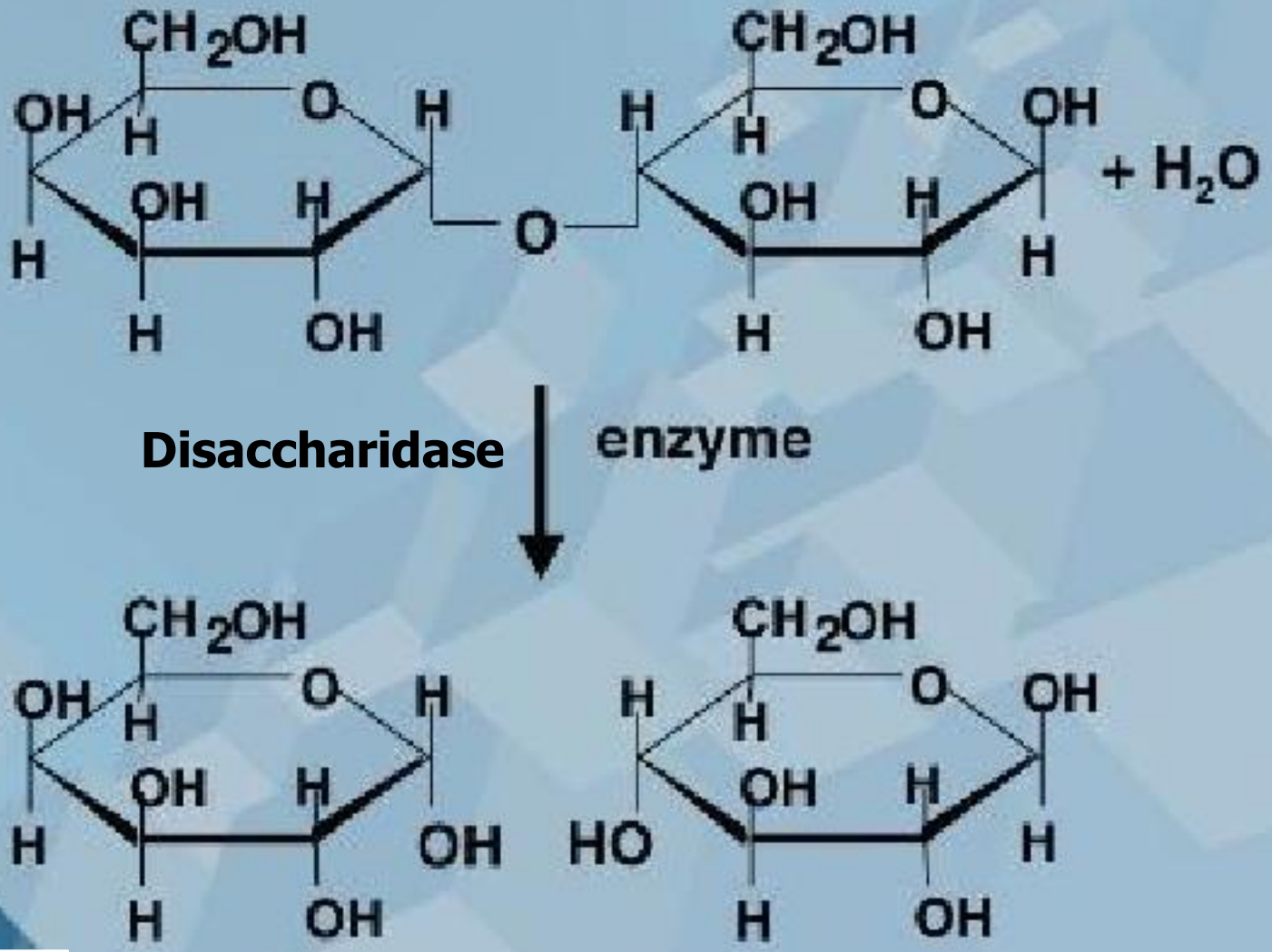
Stage one

Hydrolysis of food into smaller subunits.

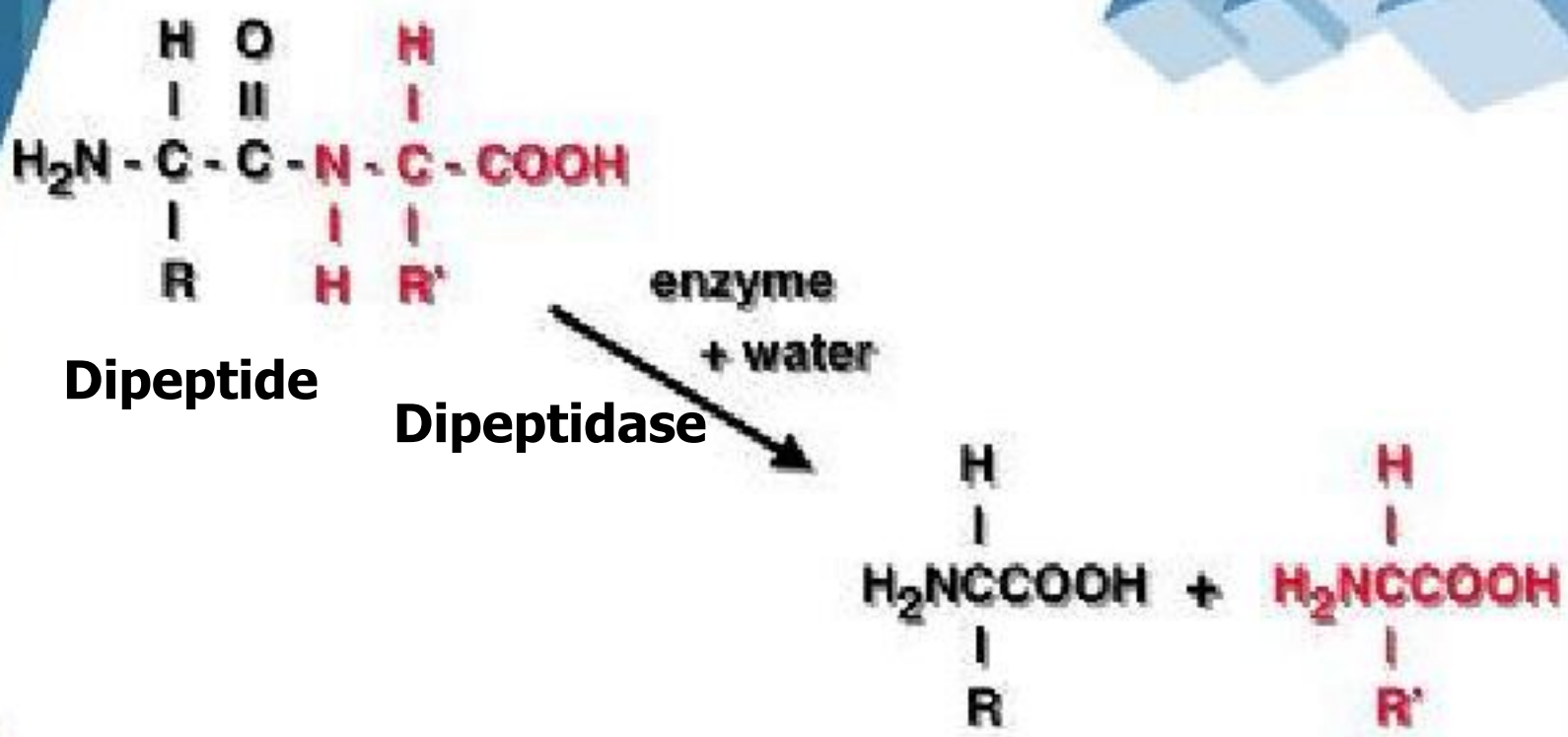


Handled by the digestive system.

Stage one types of hydrolysis

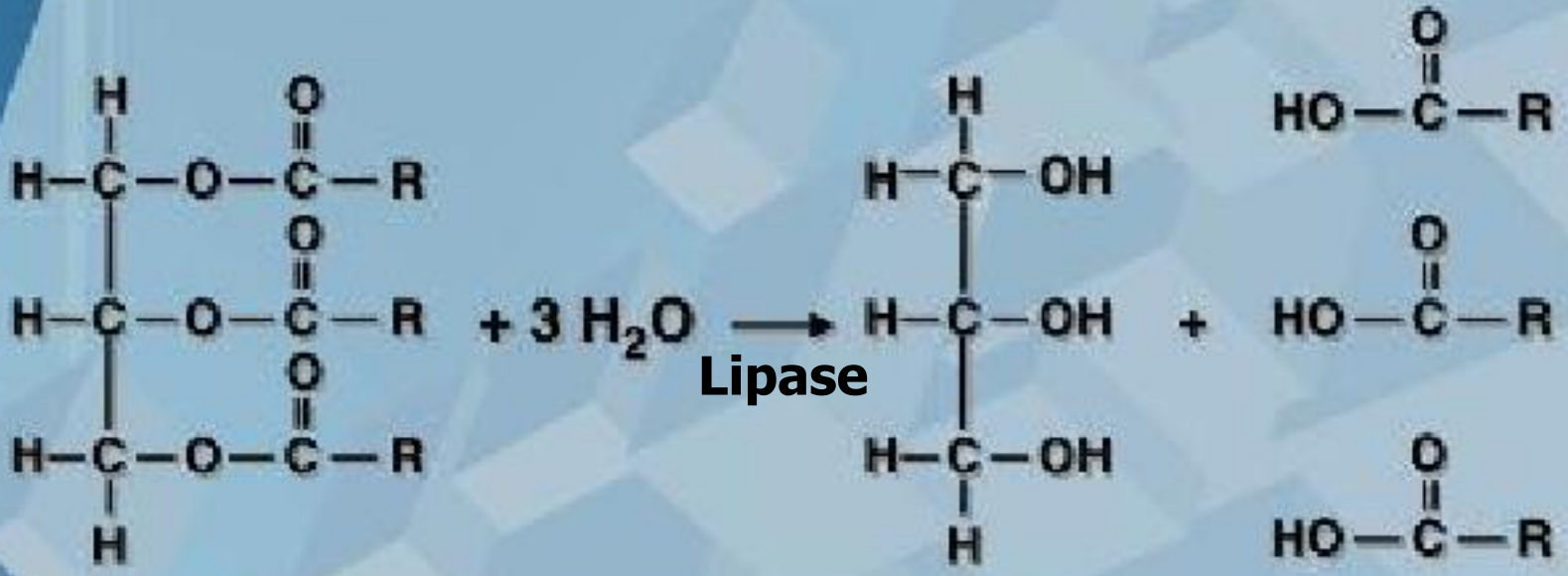


Stage one types of hydrolysis



Dipeptide

Stage one types of hydrolysis



Fats

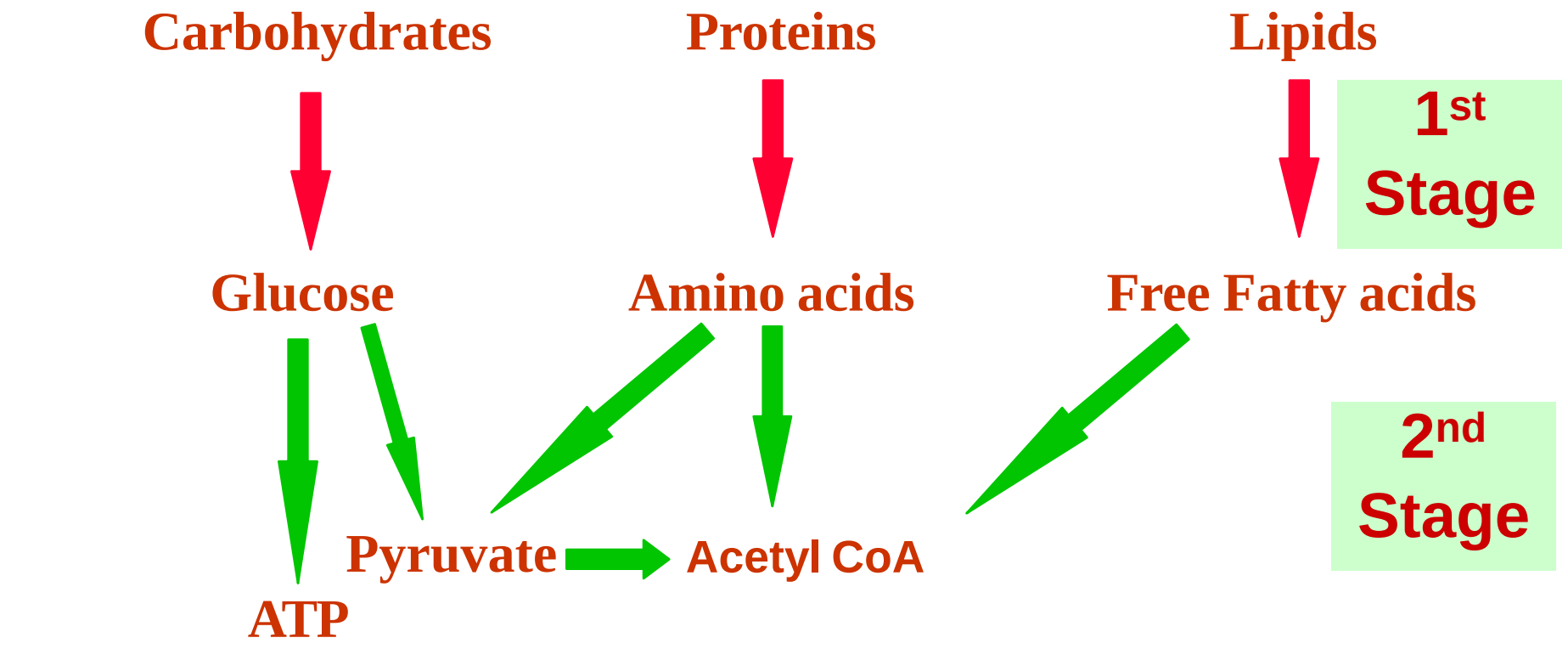
Stage two

Conversion of monomers into a form that can be completely oxidized.

Sugars - start as glucose or fructose
- converted to acetyl **CoA.**

Amino acids - all are deaminated,
- might enter at any stage **of Kreb's cycle.**

Fatty acids - converted to acetyl CoA **&glycerol.**



1st and 2nd Stages of Metabolism

Stage 3: Krebs cycle

The citric acid (Krebs, tricarboxylic = TCA=) cycle oxidized

acetyl CO-A ⟶ $CO_2 + H_2O + ATP$

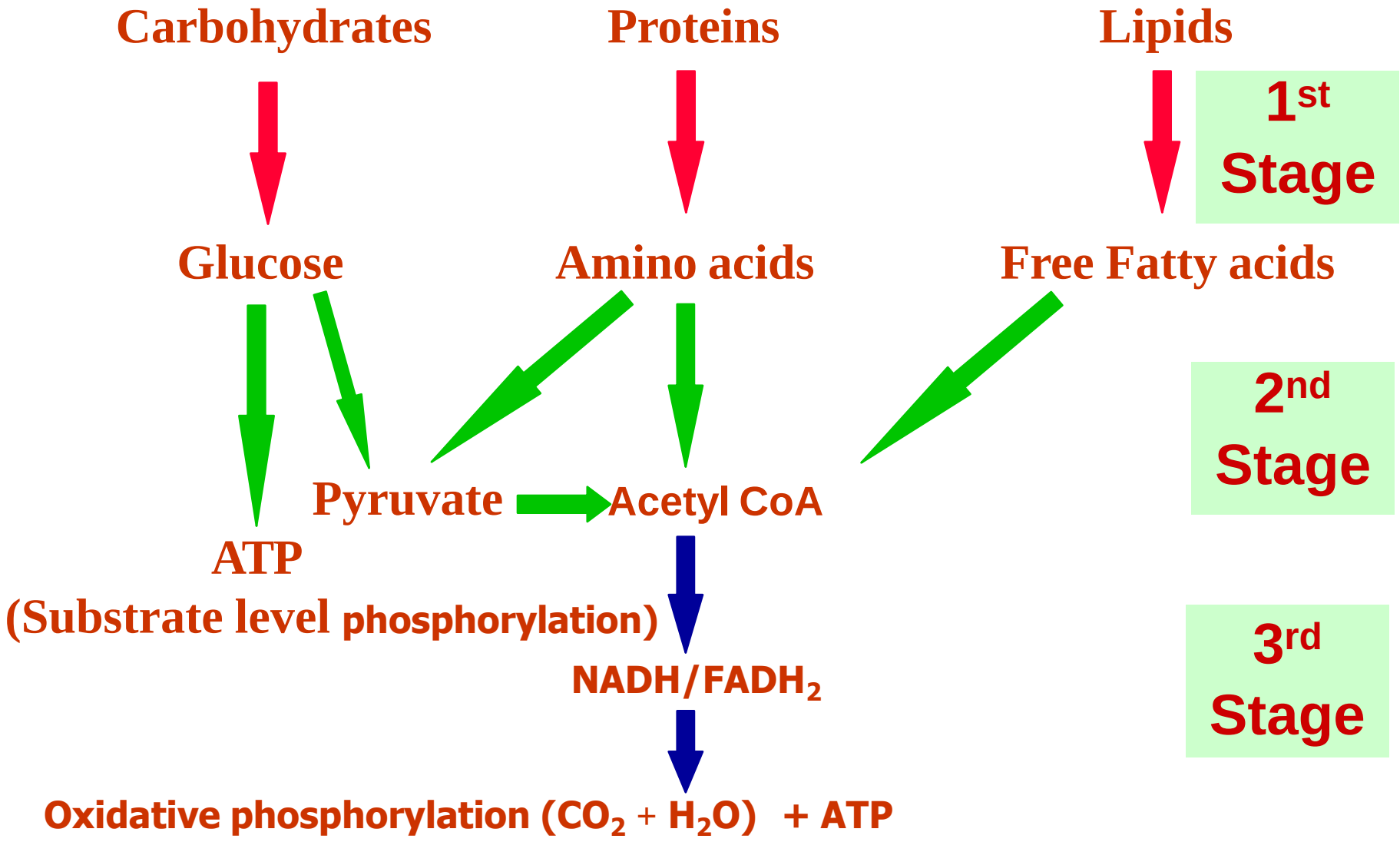
The energy which released in this process conversed by reducing the

- Nicotinamide adenine dinuceutide (NAD ⟶ NADH+H)
- Flavin adenine dinuceutide (FAD ⟶ $FADH_2$)

Stage three

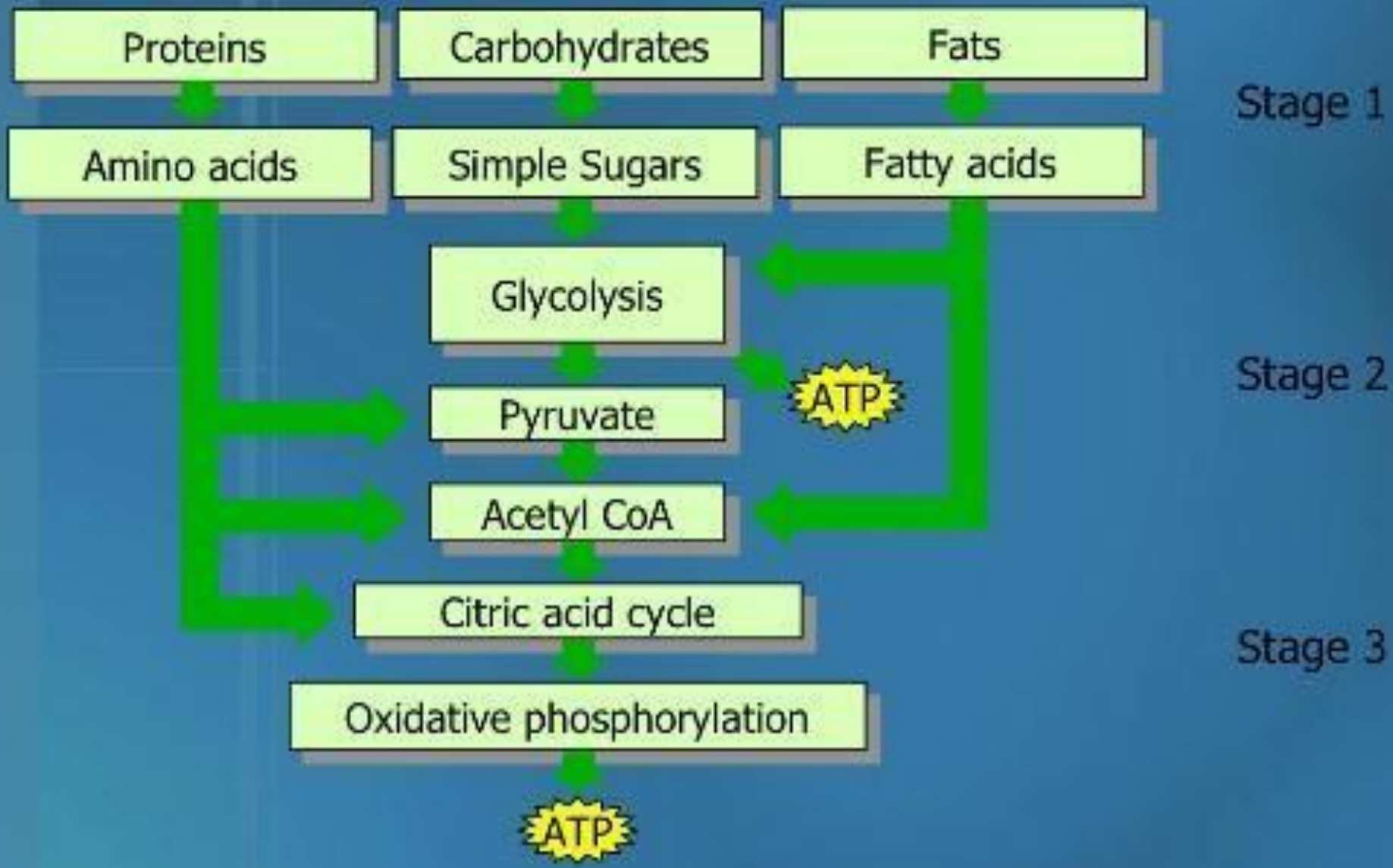
Complete oxidation of nutrients and the production of ATP.

- Everything has been converted to acetyl CoA.
- The acetyl group is taken to the citric acid cycle.
- There it is converted to CO_2 + H_2O+ energy (ATP).



Stages of Metabolism

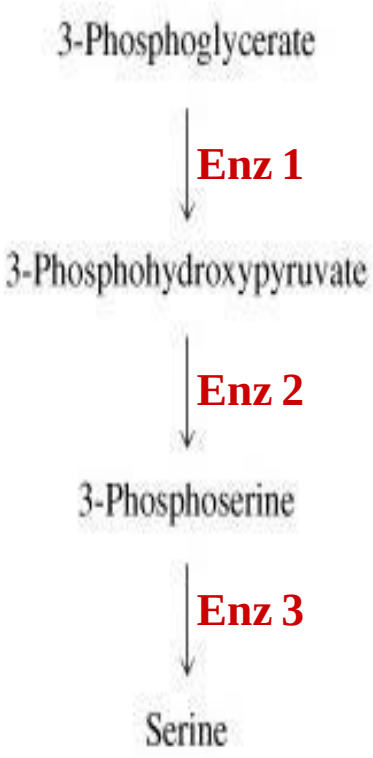
Overview of catabolic processes



Different Types of Metabolic Pathways

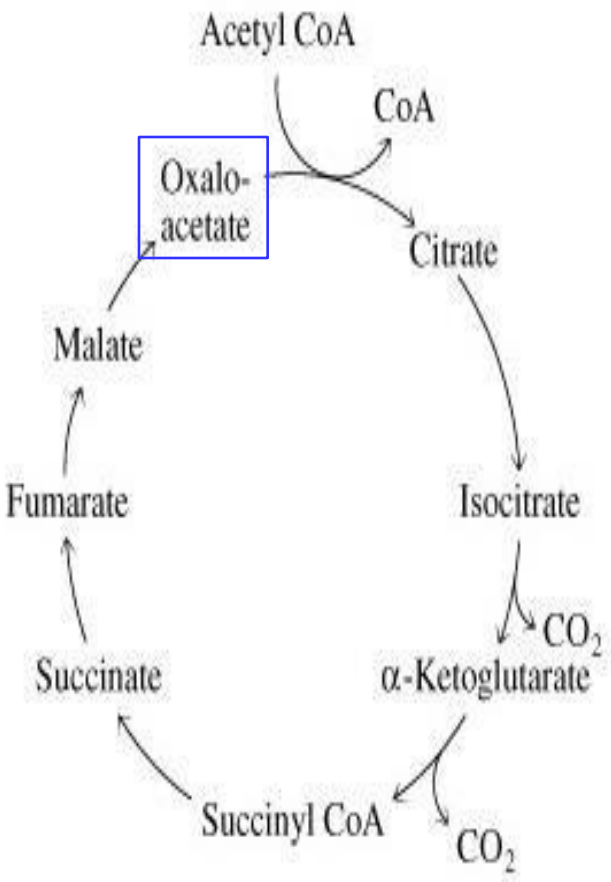
Linear pathway

Conversion of 3-phospho-glycerate into serine



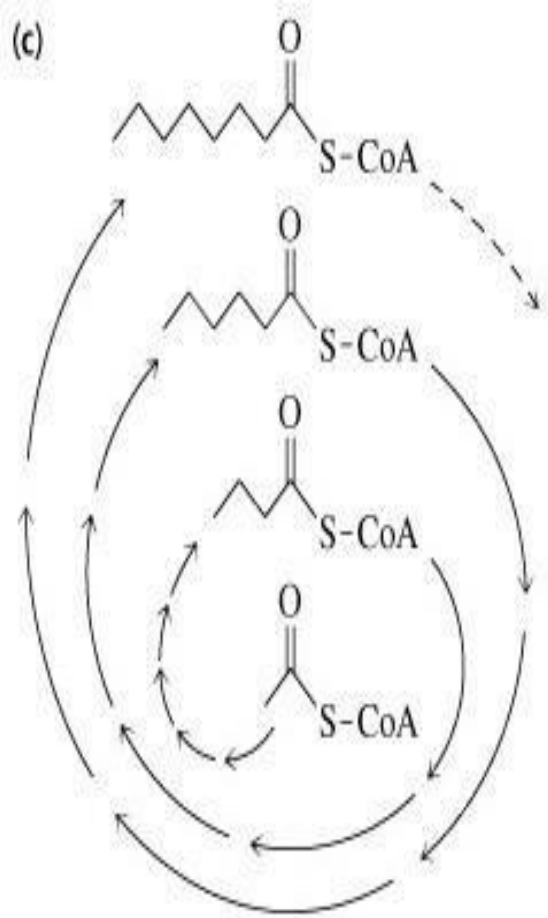
Cyclic pathway

Kreb'sycle



Spiral pathway

Fatty acid synthesis



Carbohydrate Digestion

1. Digestion

Digestion of Carbohydrates

It is the breakdown & degradation of polysaccharides & oligosaccharides into their simplest units (Monosaccharides)

Carbohydrates

Digestible

Starch

Glycogen

Lactose

Sucrose

Non-Digestible

Cellulose

Do not need digestion

Monosaccharides

Hexoses

Pentoses

Digestion of Carbohydrates

Monosaccharides

Do not need hydrolysis before absorption

Di- and poly-saccharides

Relatively large molecules

Must be hydrolyzed prior to absorption

Hydrolyzed to monosaccharides

Only monosaccharides can be absorbed

Carbohydrate Digestion

In the mouth

♦ **Salivary amylase**: produced by salivary glands

♦ Activated by chloride ion

♦ Act on starch and glycogen converting them to maltose , isomaltose and starch to dextrin

♦ Plays only a small role in breakdown because of the short time food is in the mouth

Carbohydrate Digestion

In the stomach

The action of amylase on carbohydrates is blocked in the stomach by high acidity of the stomach.

Carbohydrate Digestion

- **Small intestine**

enzyme: Pancreatic amylase

Source : pancreas

hydrolyzing starch and glycogen to maltose and isomaltose

Amylase

Polysaccharides ⟶ Disaccharides

Digestion in Small Intestine

- Digestion mediated by enzymes synthesized by cells lining the small intestine (brush border)

Disaccharides $\xrightarrow{\text{Brush Border Enzymes}}$ Monosaccharides

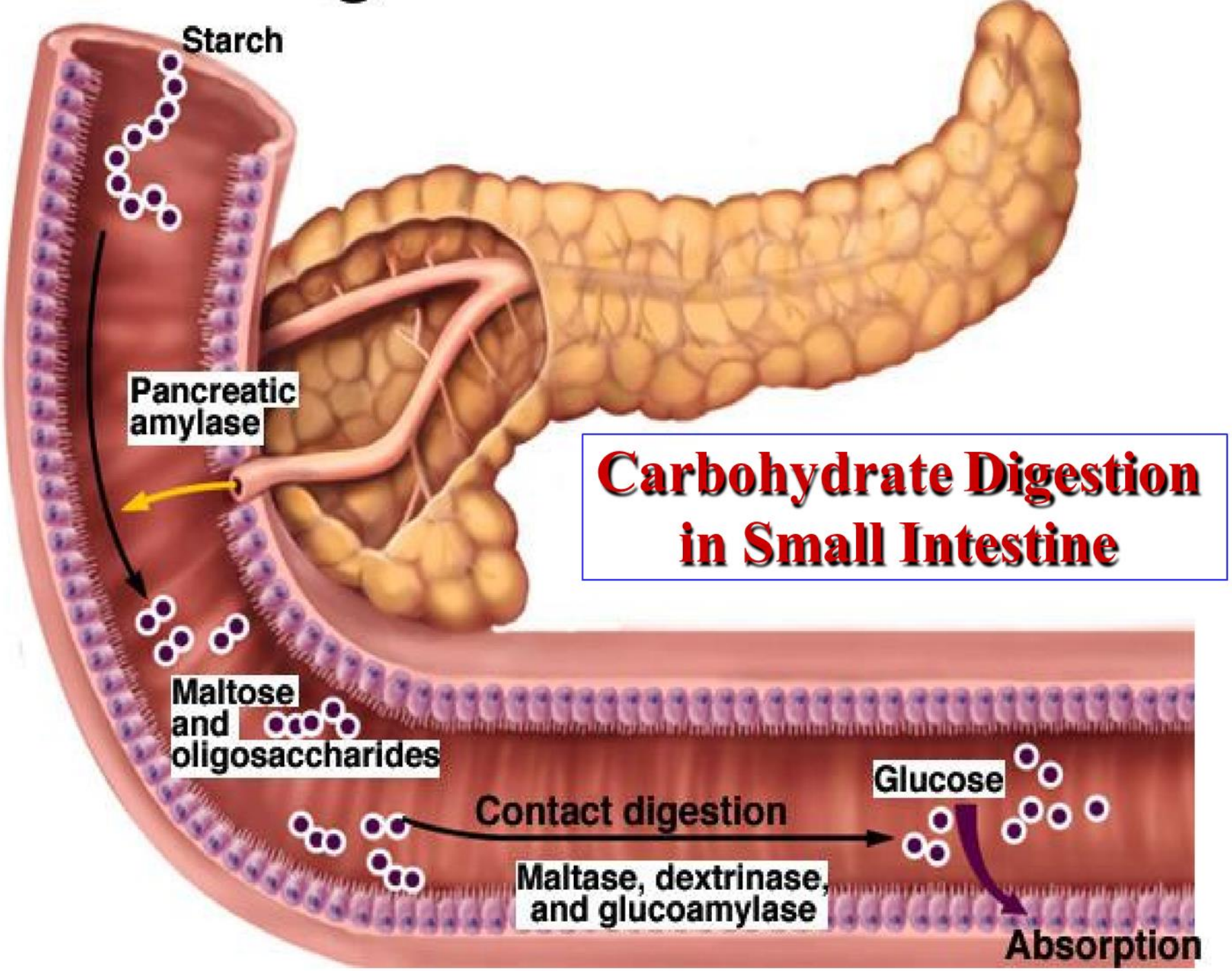
* Exception is β-1,4 bonds in cellulose

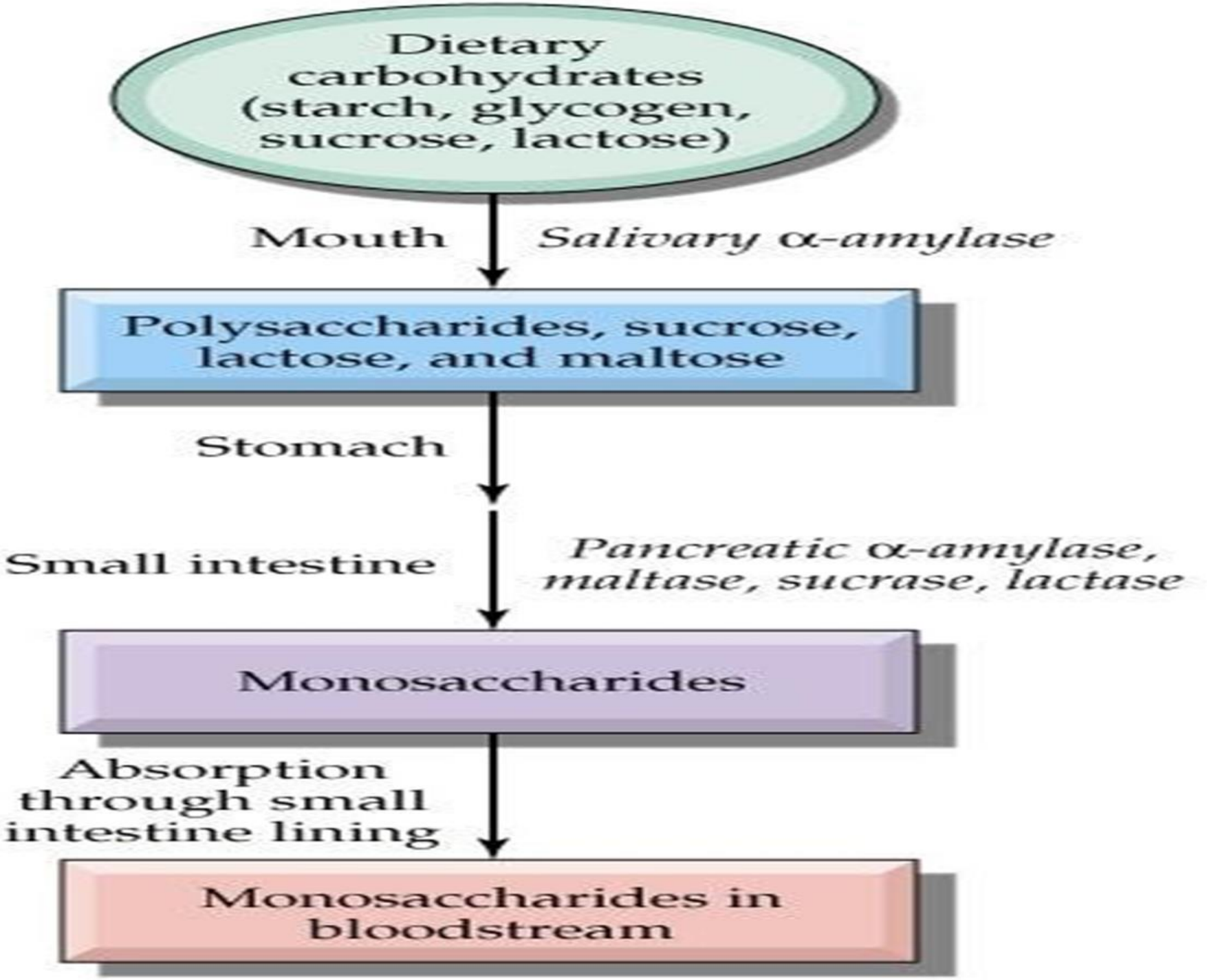
Digestion in Small Intestine

Sucrose $\xrightarrow{\text{Sucrase}}$ Glucose + Fructose

Maltose $\xrightarrow{\text{Maltase}}$ Glucose + Glucose

Lactose $\xrightarrow{\text{Lactase}}$ Glucose + Galactose


Starch
Pancreatic amylase
Carbohydrate Digestion in Small Intestine
Maltose and oligosaccharides
Glucose
Contact digestion
Maltase, dextrinase, and glucoamylase
Absorption


Dietary carbohydrates (starch, glycogen, sucrose, lactose)
Mouth
Salivary α-amylase
Polysaccharides, sucrose, lactose, and maltose
Stomach
Small intestine
Pancreatic α-amylase, maltase, sucrase, lactase
Monosaccharides
Absorption through small intestine lining
Monosaccharides in bloodstream

Digestion of cellulose

- It is contain : β-1,4 bonds between glucose molecules.
- **In human** : No β-1,4 glucosidase which digest such bonds, so the cellulose passes as such in stool,
- it is help in water retention during the passage of food along the intestine and it produce larger and softer feces which prevent constipation.

Overview of Carbohydrate Digestion

Location	Enzymes	Form of Dietary CHO
Mouth	Salivary Amylase	Starch, Maltose, Sucrose, Lactose
Stomach	(amylase from saliva)	Dextrin → Maltose
Small Intestine	Pancreatic Amylase	Maltose
	Brush Border Enzymes	Glucose + Glucose; Fructose + Glucose; Galactose + Glucose
Large Intestine	None	Bacterial Microflora Ferment Cellulose

Defects of carbohydrate digestion

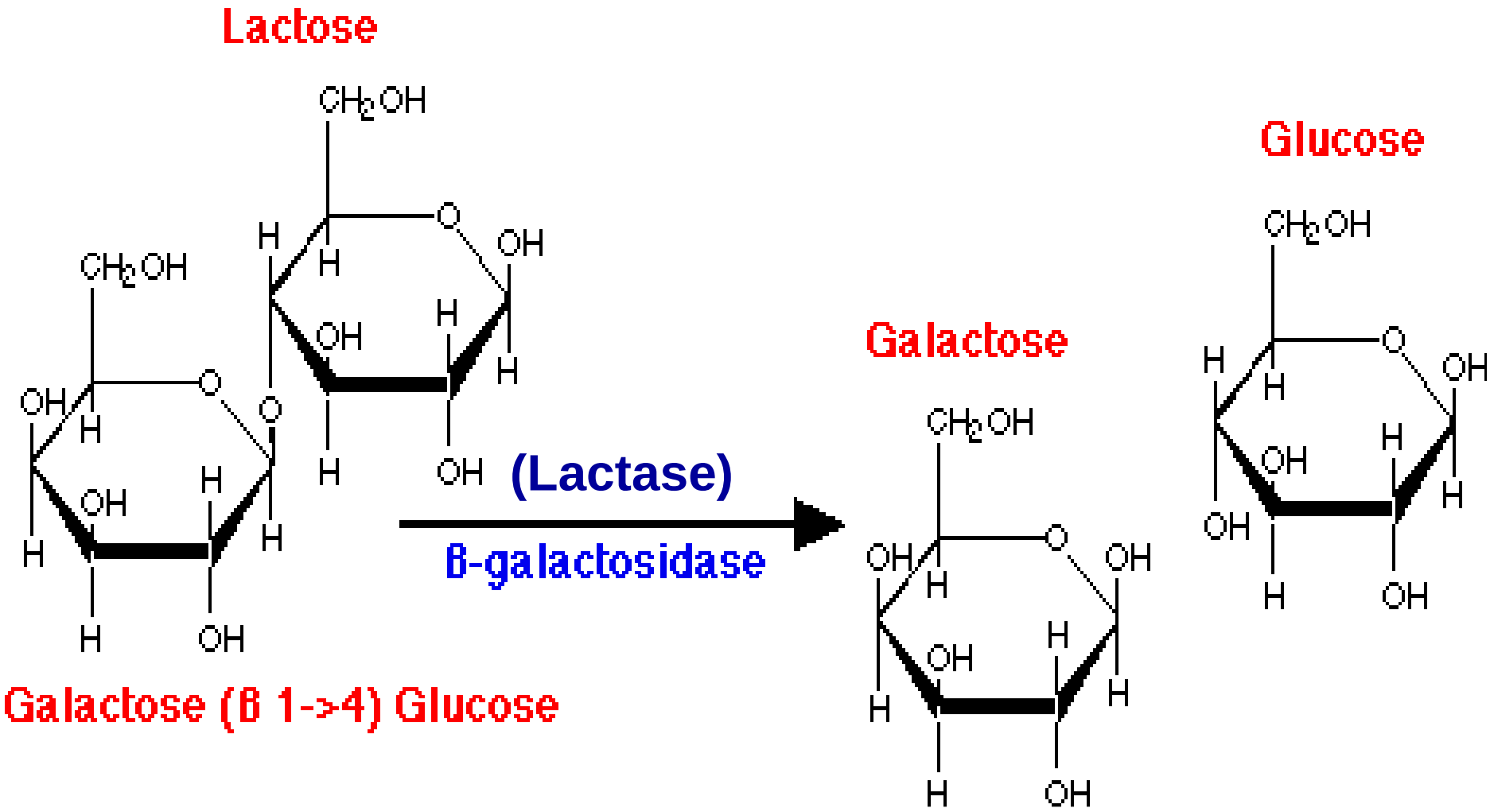
I- lactase deficiency (lactose intolerance):

Def. deficiency of lactase enzyme which digests lactose into glucose and galactose, it may be

A- congenital : occurs after birth (rare)

B- acquired : occurs later on life (common)

Digestion of Lactose



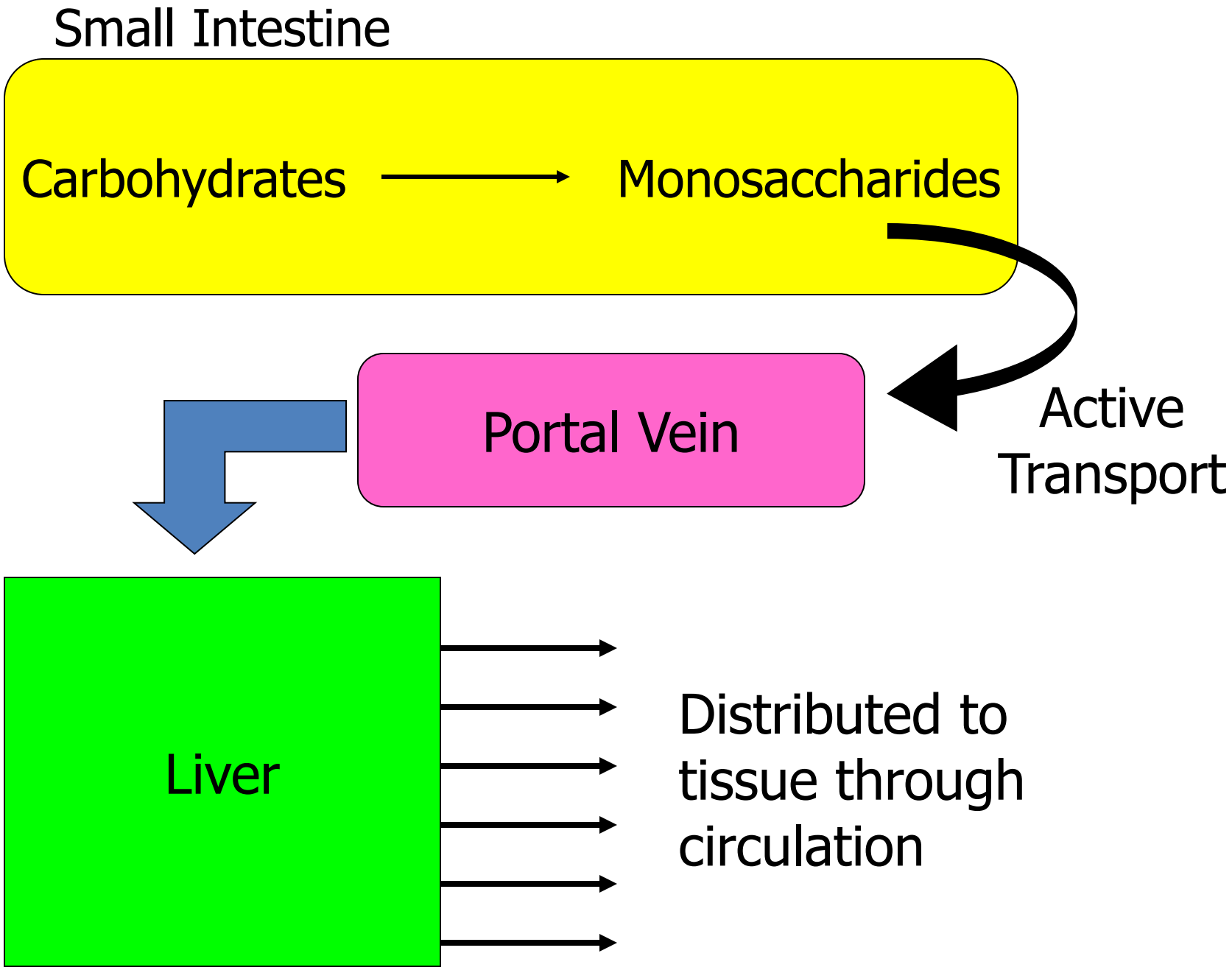
Lactose Intolerance

1. **Abdominal pain**
2. **Nausea**
3. **Bloating**
4. **Watery diarrhea**

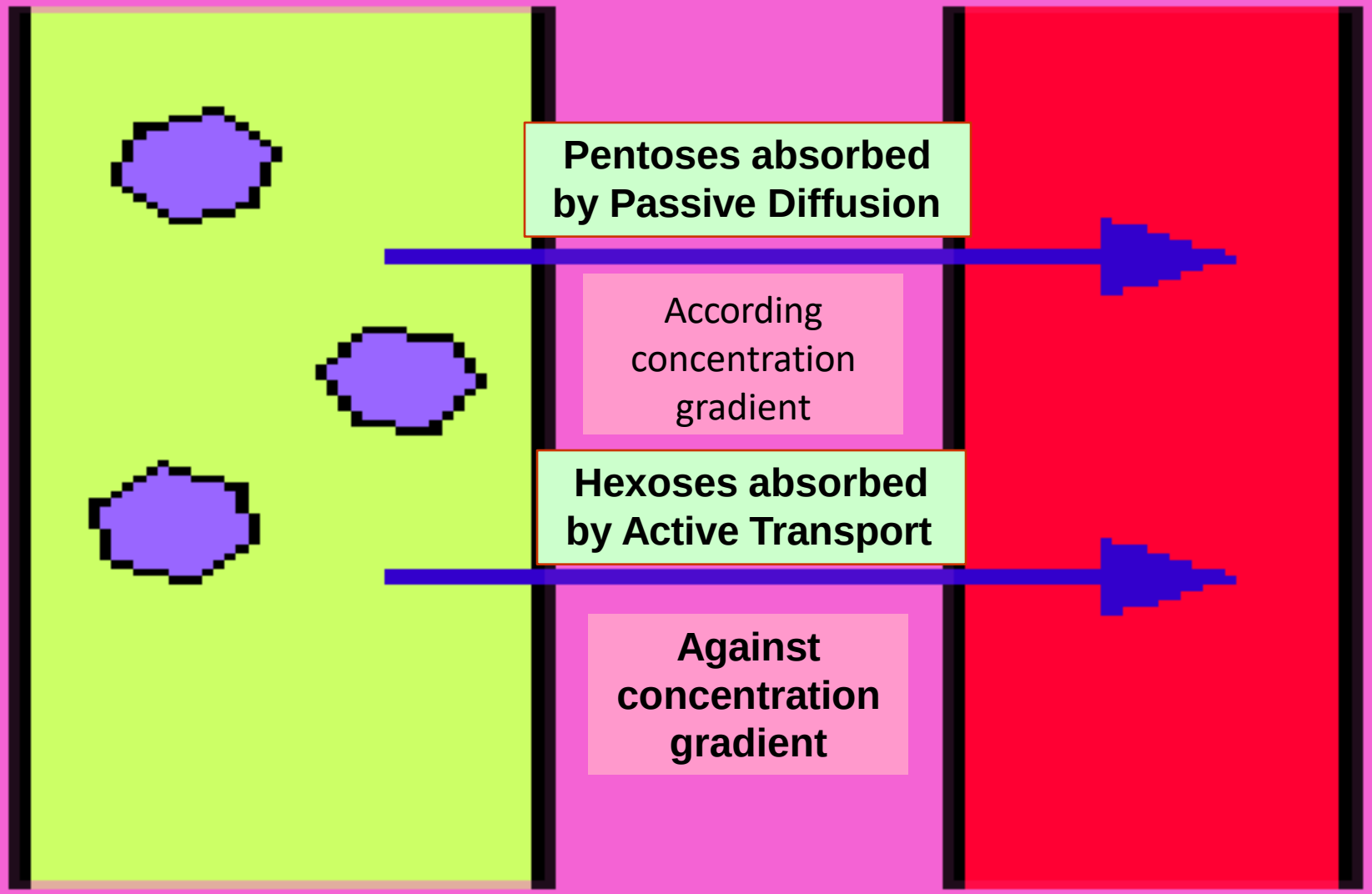
Carbohydrate Absorption

- The end product of carbohydrate digestion are monosaccharides (glucose , galactose and fructose)
- They are absorbed from the small intestine to portal vein to liver where fructose and galactose are transformed to glucose
- Monosaccharides absorbed primarily in duodenum and jejunum

- Little absorption in stomach and large intestine


Small Intestine
Carbohydrates
Monosaccharides
Active Transport
Portal Vein
Liver
Distributed to tissue through circulation

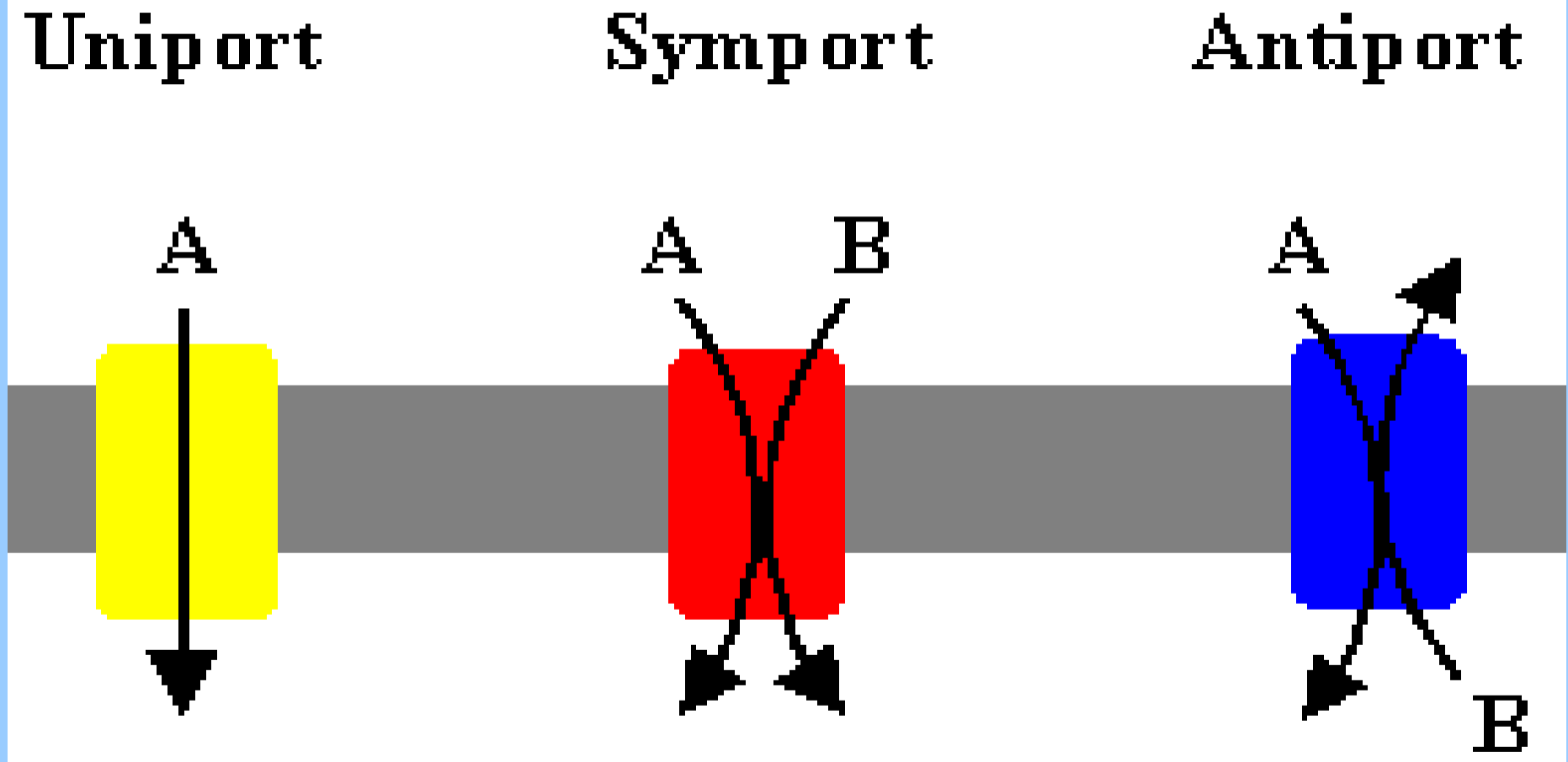
intestine



blood

Absorption of Pentoses & Hexoses

Types of Transport Carriers



Mechanisms of absorption

1- Simple diffusion:

It is passive process in which the monosaccharides transferred from high concentrated area to low concentrated area (from intestine to blood) depend on concentration gradient it need no energy and no carrier

ex. Fructose and pentose sugar.

Mechanisms of absorption

2- Facilitated (diffusion) passive transport

Diffusion of monosaccharide from high concentration to low concentration. It is need protein carrier which is called: glucose transporter (Glu T)

glucose transporter have 5 types

1- in RBCs, 2- in liver,

3- in brain, 4- in muscle and adipose tissues and

5 – in intestine

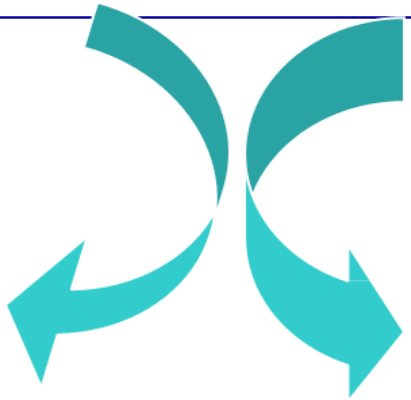
Ex.: Specific for glucose

Mechanisms of absorption

3- Active transport

- Its active process
- It need energy and protein carrier
- It is specific for glucose, galactose and mannose
- Its carrier called Sodium glucose transporter (SGLT-1)
- This carrier have 2 sides one for Na and the other for glucose.
- sodium (Na +) : transported from high to law concentration and the glucose transported in against concentrated gradient
- Active transport is much more faster than Passive transport
- Sites: intestinal epithelium and renal tubules

Utilization of Glucose



Anabolic Reactions

1) Storage in the form of Glycogen (Glycogenesis)
2) Storage in the form of TAG (Lipogenesis)
3) Synthesis of sugar alcohols and amino sugars
4) Interconversion between monosaccharides

Catabolic Reactions

1) Glycolysis
2) Kreb's Cycle
3) Pentose Shunt
4) Formation of Uronic acids


Thank You