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3rd Edition

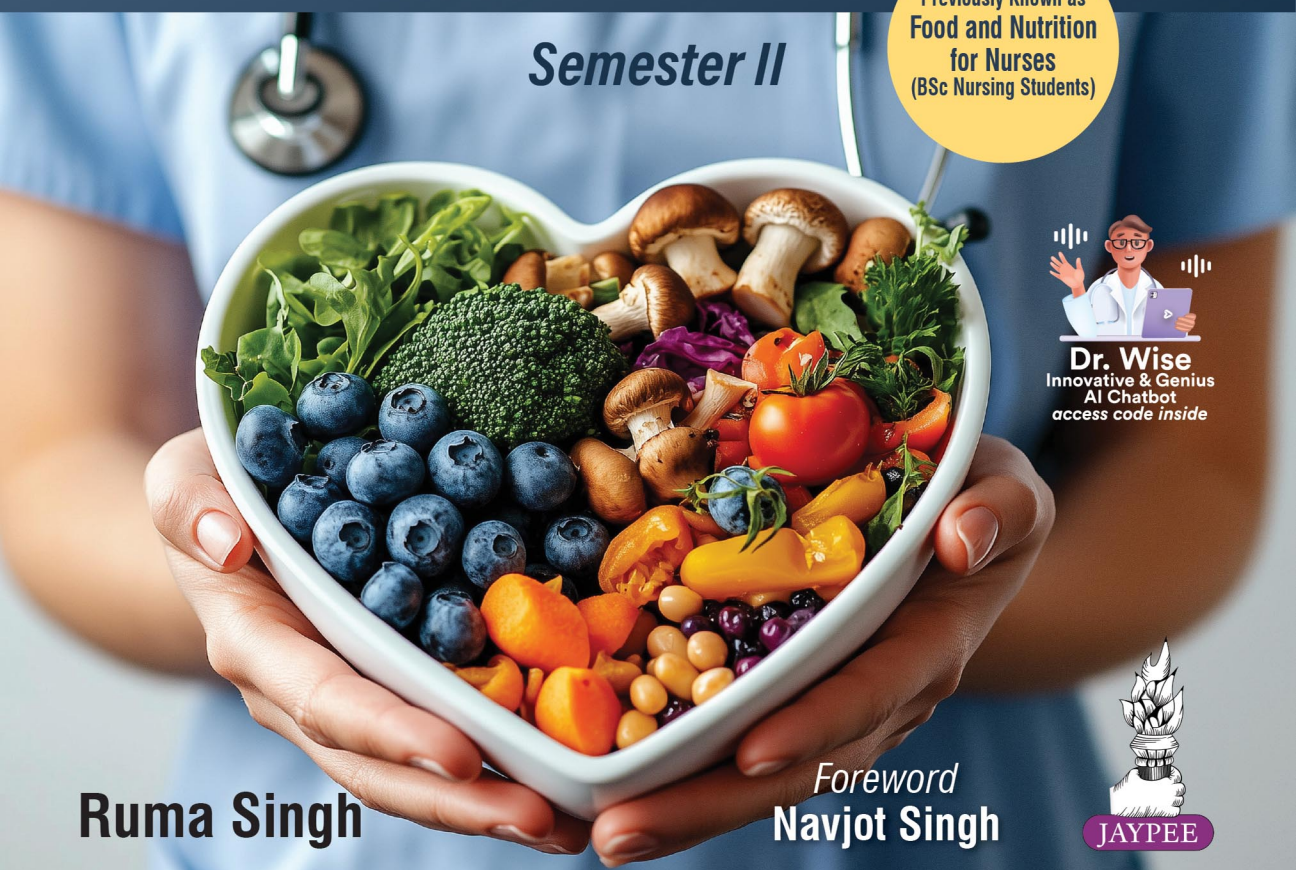
Applied Nutrition & Dietetics

for BSc Nursing Students

As per the Revised INC Syllabus

Previously Known as
Food and Nutrition for Nurses
(BSc Nursing Students)

Semester II



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Foreword
Navjot Singh

JAYPEE

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3 CHAPTER

Carbohydrates

Chapter Highlights

- Introduction
- Classification of Carbohydrates
  - » Monosaccharides
  - » Disaccharides
  - » Polysaccharides
    - ◊ Dietary Fibers
    - ◊ Starches
    - ◊ Cellulose
- Functions of Carbohydrates
- Recommended Dietary Allowances
- Dietary Sources
- Digestion and Absorption of Carbohydrates
- Metabolism of Carbohydrates
- Malnutrition
- Let Us Sum-Up

INTRODUCTION

Carbohydrates are widely distributed in plants in which they are formed from carbon dioxide of atmosphere by photosynthesis. They are found in a variety of easily grown plant such as grains, fruits and vegetables. Plant carbohydrates vary widely in sweetness, texture, rate of digestion and degree to which they are absorbed after passage through gastrointestinal tract. Carbohydrates are a source of quick and sustained energy for our body. They are the cheapest source of energy for the majority of people all over the world especially in the tropics. Starchy foods are generally considered unhealthy by many people which must be avoided if weight loss is desired.

CLASSIFICATION OF CARBOHYDRATES

Carbohydrates may be broadly classified as follows:

1. Monosaccharides
2. Disaccharides
3. Polysaccharides

Monosaccharides

Monosaccharides are the simplest form of carbohydrates and are commonly called simple sugars. The simple sugars include:

- ❖ Trioses : $C_3H_6O_3$
- ❖ Tetroses : $C_4H_8O_4$
- ❖ Pentoses: $C_5H_{10}O_5$
- ❖ Hexoses : $C_6H_{12}O_6$

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The most important of these in human nutrition is the 6-carbon hexose sugars. These simple sugars are formed during the breakdown of complex carbohydrates in the cells of an organism's body in the presence of water.

General Properties

They are seldom found free in nature. They are typically linked into disaccharide or polysaccharide form. The smallest carbohydrate unit is $(CH_2O)n$, where n can be any integer.

Hexoses

The three hexose (6-carbon) sugars, most important in human nutrition and physiology are glucose, galactose and fructose. Hexoses can be divided into two main categories:

1. **Aldoses:** Sugar with an aldehyde group, e.g., glucose and galactose.
2. **Ketoses:** Sugar with a ketone group, e.g., fructose.

Glucose is a moderately sweet sugar. It is chiefly formed in the body from starch digestion. In human metabolism, most of the sugars are eventually converted by the body into glucose. And this is then circulated in the bloodstream which provides major fuel for the body. Glucose occurs in free state in many fruits and in honey. The basic chemical structure (cyclic ring) is given in **Figure 3.1**.

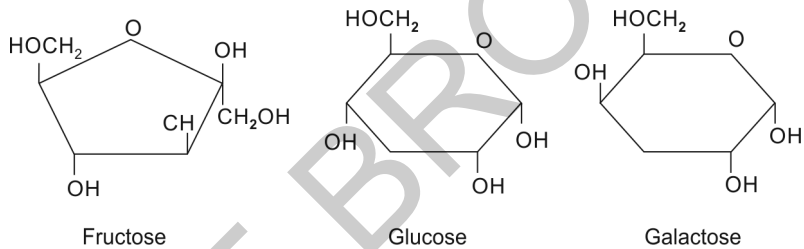

Figure 3.1: Structures of different monosaccharides.

Fructose occurs in the free state along with glucose in many fruits and in honey. It is the sweetest of the simple sugars. It is 1.5 times more sweet than sucrose (table sugar). Because it is the sweetest of the sugars, a very small amount usually suffices in preparing foods. Investigations have shown that fructose is better utilized as a source of energy for patients suffering from diabetes mellitus than glucose. As the fruit ripens, enzymes cleave sucrose into glucose and fructose resulting in a sweeter taste.

Galactose does not occur in the free form in foods but it can be produced from lactose (milk sugar) and then it is changed to glucose to supply energy. It is less soluble in water and less sweet than glucose. Galactose is also a constituent of the glycolipids and glycoproteins which are found in many tissues. Human body changes glucose to galactose so that the mammary glands can produce lactose. The basic chemical structure (cyclic ring) is shown in **Figure 3.1**.

Pentoses

- **Xylose:** Sources include fruits, vegetables, cereals, mushrooms and seaweeds.
- **Ribose:** It is formed through metabolic processes. Also it is a component element of nucleic acid and coenzymes, and ribonucleic acid.
- **Arabinose:** It dose not occur free in nature. Arabinose can be obtained from the hydrolysis of cherry gum or gum Arabic. The basic chemical structures of various pentoses are given in **Figure 3.2**.

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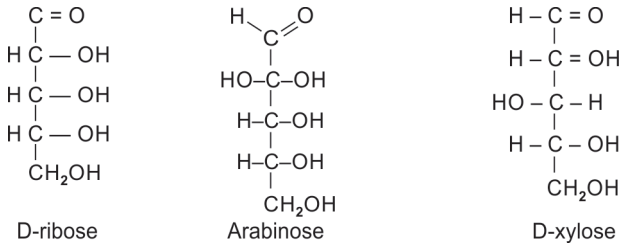

Figure 3.2: Structures of D-ribose, Arabinose and D-xylose.

Disaccharides

As it is clear from the name, when two monosaccharide units are joined by the glycosidic linkage, a disaccharide is formed. The three main disaccharides of physiologic importance are sucrose, lactose and maltose.

For example:

1. Sucrose = Glucose + Fructose
2. Lactose = Glucose + Galactose
3. Maltose = Glucose + Glucose

Here glucose is a major component in each of these disaccharides.

Sucrose, or table sugar is the most prevalent dietary disaccharide. Sucrose occurs in sugarcane and beetroot and it is also an additive in commercially processed foods. It is also present in certain fruits, vegetables and honey. Sucrose is formed by the condensation of one molecule of glucose and one molecule of fructose. Dietary sucrose can be hydrolyzed in glucose and fructose in dilute mineral acids by the enzyme, sucrase, present in the intestinal juices. Refer to **Figure 3.3** for chemical structure of sucrose.

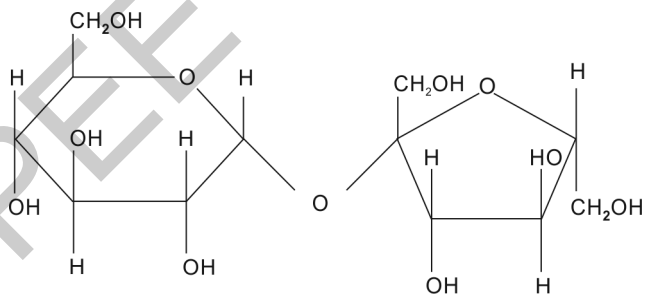

Figure 3.3: Structure of sucrose.

$$\text{Sucrose} + H_2O \xrightarrow{\text{Dilute HCl}} \text{Glucose} + \text{Fructose}$$

$$\text{Sucrose} + H_2O \xrightarrow{\text{Sucrase}} \text{Glucose} + \text{Fructose}$$

When sucrose is heated with dilute acid, it is hydrolyzed to a mixture of equal amounts of glucose and fructose. This mixture is called "invert sugar." Invert sugar is used commercially because it is sweeter than equal amount of sucrose. Because of this property invert sugar is preferred in preparation of delicate candies and icings. Honey is an invert sugar.

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Lactose is also known as milk sugar. It occurs in all mammals. Cow's and buffalo's milk contain about 4 percent and human milk contains about 7 percent lactose. It is produced in the mammary gland by the glucose supplied by the blood. It is least sweet in nature, about one-sixth as sweet as glucose. Lactose is formed by the condensation of one molecule of glucose and one molecule of galactose. Lactose can be hydrolyzed to glucose and galactose by the enzyme lactase present in the intestinal juice. The chemical structure of lactose is given in **Figure 3.4**.

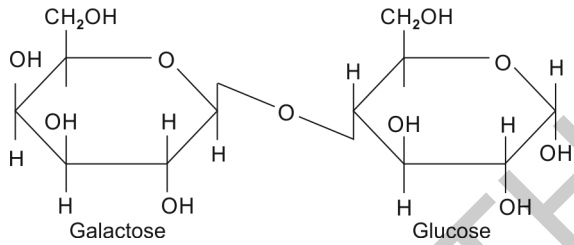

Figure 3.4: Structure of lactose.

$$\text{Lactose} + H_2O \xrightarrow{\text{Lactase}} \text{Glucose} + \text{Galactose}$$

Maltose is also called malt sugar. It is formed in grains (barley, jowar, ragi, etc.) by hydrolysis of starch polymers during germination by the enzyme, diastase (amylase). **Figure 3.5** shows the chemical structure of maltose.

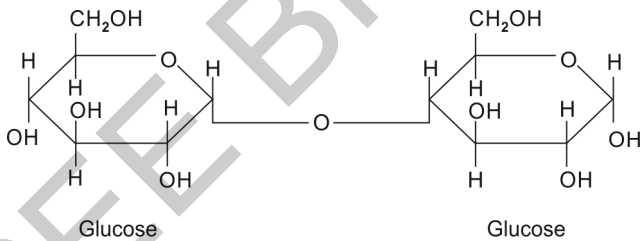

Figure 3.5: Structure of maltose.

$$\text{Starch} \xrightarrow{\text{Amylase}} \text{Maltose}$$

It is seldom found naturally in the food supply. Also it is used as an additive in numerous food products. Maltose is found in commercial products that are marketed as "sugar free" even though maltose and sucrose have some caloric value. Maltose is formed by the condensation of two molecules of glucose.

$$\text{Maltose} + H_2O \xrightarrow{\text{Maltase}} \text{Glucose} + \text{Glucose}$$

Polysaccharides

The complex carbohydrates are composed of many single monosaccharide units. These polysaccharides include starch, glycogen, dextrins, and several forms of dietary fibers.

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Dietary Fibers

In the past the general idea about the dietary fiber revolved around its role as "bulk" or "roughage" which help prevent constipation or maintain normal intestinal elimination. Dietary fibers refer to the total amount of naturally occurring material in food, mostly plants, that is not digested. Fibers add almost no fuel or energy value to the diet, but it does add volume. The sources of dietary fiber are—whole grains, legumes and other vegetables, fruits, seeds, and nuts.

Research suggests that the higher fiber diet, are protective against a wide variety of gastrointestinal diseases and some cancers. Nowadays a more preferred term is dietary fiber which refers to the non-digestible residues of plant foods—cellulose, hemicellulose, pectins, gums, mucilages and lignins. Eating too much fiber can be harmful also. Several studies suggest that an intake of more than 50 grams of fiber everyday can interfere with mineral absorption which can lead to mineral deficiency, such as anemia and osteoporosis. Recommendation for fiber is 30 g/2000 kcal. Therefore, it is suggested that one should not add fiber concentrates, such as (psyllium) in their diet, but should eat fresh fruits, vegetables, legumes and whole grain cereals because they not only provide the fibers but also are the excellent source of vitamins and minerals.

Fibers are classified on the basis of their solubility—soluble and insoluble fibers. Soluble fibers dissolve in the water whereas insoluble fiber does not. Soluble fibers and insoluble fibers act differently in the body and are needed for different purposes.

- **Soluble fibers:** Sources of soluble fibers include beans, oatmeal, barley, broccoli and citrus fruits. Oat bran is an excellent source of soluble fiber. Soluble fiber dissolves in water, swells and forms gels. Soluble fibers are beneficial in reducing cholesterol levels, it regulates the blood sugar levels and promotes weight loss (by controlling the appetite).
- **Insoluble fibers:** Sources of the insoluble fibers include the structural parts of plants, such as fruits and vegetable skins and the outer covering (bran) of wheat kernels. Insoluble fibers are helpful in promoting regularity of bowel movements and reduce the risk of diverticular disease and controls some forms of cancers.

Starchs

Starch is the most significant polysaccharide in human nutrition. It is a white, tasteless powder, insoluble in cold water. The important sources of starch are cereals, millets, roots and tubers. They are large polymers of glucose. Plants store carbohydrates as starch granules formed by α linkages in a very complex structure.

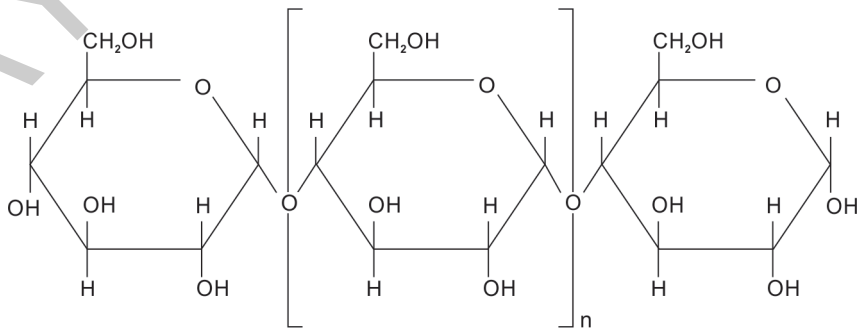

Figure 3.6: Structure of starch.

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Edible plants make two types of starch—amylose and amylopectin. Amylose is a smaller, linear molecule that is less than 1% branched and amylopectin is highly branched, containing up to 5% branches with a very high molecular weight. Because of its larger size, amylopectin is more abundant in food supply, e.g., starch in grains and starchy tubers. The structure of starch is illustrated in **Figure 3.6**.

Glycogen is the polysaccharide in the animal body that compares to starch in plants. It is a storage form of energy. Its chemical structure differs from starch. It is a much more and highly branched compound than plant starch. It consists of 11 to 18 glucose units which make-up the overall molecular structure. Glycogen is stored in liver and muscle tissue. The liver contains enzymes which can convert glucose into glycogen and vice versa.

Dextrins are polysaccharide compounds formed as intermediate products in the breakdown of starch by enzymatic action in cooking. Dextrins are formed when bread or cereals are toasted or flour is browned.

$$\text{Starch} + H_2O \longrightarrow \text{Soluble starch} + \text{Maltose}$$
$$\text{Soluble starch} + H_2O \longrightarrow \text{Dextrins} + \text{Maltose}$$
$$\text{Dextrins} + H_2O \longrightarrow \text{Maltose}$$
$$\text{Maltose} + H_2O \longrightarrow \text{Glucose} + \text{Glucose}$$

Cellulose

Cellulose is a complex carbohydrate and consists of oxygen, carbon, and hydrogen. It is the most abundant organic compound with a chemical formula of $(C_6H_{10}O_5)_n$. It is tasteless and has no odour. It is used as a fiber supplement. Refer to **Figure 3.7** for the structure of cellulose.

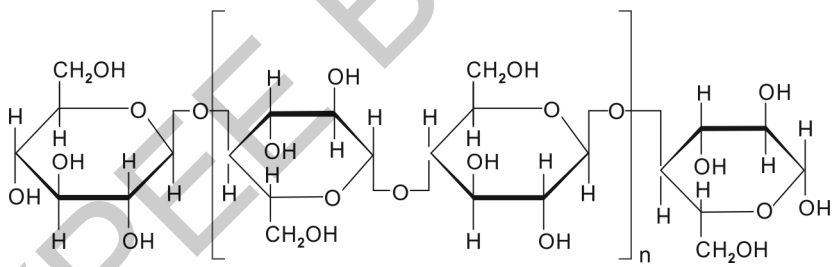

Figure 3.7: For the structure of cellulose.

FUNCTIONS OF CARBOHYDRATES

- **Energy:** Primary function of dietary carbohydrates in human nutrition is to provide fuel for energy. One gram of carbohydrate provides approximately 4 kcal (17 kJ).
- Carbohydrates take relatively small part of the total food budget, therefore, *economic benefits*, easy storage for longer period of time without spoilage.
- Available carbohydrates can be stored as glycogen and can be used at the time of need.
- **Liver:** Glycogen protects the liver against bacterial toxins and poisonous substances.
- **Heart:** Carbohydrates provide fuel for the heart to pump efficiently.
- **Muscle contraction** requires energy for every movement, which is provided by carbohydrates.
- **Central nervous system:** Glucose supplies energy to the brain for its proper functioning.

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- **Protein-sparing action:** The body will use carbohydrates first to supply energy if supplied adequately in the diet, therefore, it spares protein for its main function that is tissue building.

  Since meeting energy needs is a priority over any other functions, any deficiency of calories in the diet will be recovered by adipose and protein tissues.
- **Regulation of fat metabolism:** Some carbohydrates are essential in the diet so that the oxidation of fats can proceed normally. When diet is severely restricted in carbohydrate, fats will be metabolized faster than the body can handle its intermediate products. The accumulation of these incompletely oxidized products leads to dehydration, loss of body fluids and ketosis. As little as 50 grams of carbohydrate is sufficient to prevent ketosis.
- **Role in gastrointestinal function:** Lactose has many functions in the gastrointestinal tract. It promotes the growth of desirable bacteria, some of which are helpful in the synthesis of B-complex vitamins. Lactose also enhances the absorption of calcium.

Dietary fiber is a neligible source of energy to the body but it stimulates the peristaltic movements in the gastrointestinal tract. It gives bulk to the intestinal contents, and reduces the length of time that food wastes remain in the colon.

RECOMMENDED DIETARY ALLOWANCES (RDA)

Human body requires energy to maintain day-to-day life. This energy can be provided by either carbohydrates or fats. In other words carbohydrates and fats are interchangeable. There is no specific requirement for carbohydrate as long as the adequate calories are provided, but at least 100–150 g carbohydrate daily is needed to prevent ketosis. Intake considerably above this are desirable.

DIETARY SOURCES

Sucrose: Table sugar, cane sugar, beet sugar, grape sugar are the rich sources. Invert sugar is a form of sugar used commercially because it is sweeter than equal concentration of sucrose. Invert sugar is used in preparation of delicate candies and icings.

Lactose: Milk sugar.

Maltose: Malt sugar is formed by hydrolysis of starch polymers.

Dextrose: Dextrose is glucose that is produced after the hydrolysis of cornstarch and is commonly used in food production.

Honey: Honey is made from plant nectar, contains fructose. It is calorie dense because monosaccharides pack more closely than disaccharides.

Starch: Wheat, rice, corn, potatoes, sweet potatoes, dried beans and dried fruits.

Glycogen: It is also known as 'animal starch.' It is synthesized from glucose in the liver and muscle.

Other sources: Include syrups, jellies and jams. Fruits and vegetables vary widely in their carbohydrate concentration. **Figure 3.8** shows the carbohydrate rich foods and **Table 3.1** lists the carbohydrate content of some foods.



Figure 3.8: Carbohydrate rich foods.

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Table 3.1: Carbohydrate content of some foods (values per 100 g).

Foods	*Carbohydrates*	*Foods*	*Carbohydrates*
Wheat, whole	71.2	Groundnut	26.1
Rice, raw	76.7	Apricot, dry	73.4
Wheat flour (whole)	69.4	Banana	27.2
Wheat flour, refined	73.9	Currents, black	75.2
Wheat, semolina	74.8	Dates dried	75.8
Wheat, bread (brown)	49.0	Raisins	74.6
Wheat, bread (white)	51.9	Sapota	21.4
Rajma	60.6	Milk cow's	4.4
Bengal gram, whole	60.9	Milk buffalo's	5.0
Black gram, *dal*	59.6	Milk human	7.4
Potato	22.6	Curds (cow's milk)	3.0
Sweet potato	28.2	Sugar cane	99.4
Yams	26.0	Honey	79.5
Colocasia	21.1	Jaggery (cane)	95.0
Sago	87.1		

Source: NIN

DIGESTION OF CARBOHYDRATES

Digestion is aided by mechanical or muscle actions that produce smaller particles of the food mass. In the chemical processes specific enzymes breakdown nutrients into usable metabolic products. **Figure 3.9** shows general structure of gasrointestinal tract involved in digestion process.

In the Mouth

Mastication breaks down the food into small particles and mixes it with saliva. During this process, salivary amylase (or ptyalin) is secreted by the parotid glands which begin the breakdown of starch into dextrin and maltose. This is the only chemical digestion that occurs in the mouth. The function of salivary amylase is to break the chemical bonds between some of the monosaccharides that make-up polysaccharides.

In the Stomach

Salivary amylase in the masticated food mass (or bolus) continues to act on polysaccharides for another 15 to 30 minutes in the stomach before the acids in the stomach eventually make it inactive. The esophagus secretes mucus and transports food to the stomach. Food is pushed through the esophagus by muscular movements called peristalsis and mixed with gastric secretions. The gastric secretions contain hydrochloric acid, a protease, gastric lipase, mucus, intrinsic factor (a glycoprotein that facilitates vitamin B_{12} absorption in the ileum) and the gastrointestinal hormone, gastrin. Here the food becomes semi-liquid (chyme) which contains approximately 50 percent water. If digestible carbohydrates remained in the stomach long enough, acid hydrolysis would eventually reduce much of it into monosaccharides. However, the stomach usually empties itself before significant digestion can take place, and carbohydrate digestion occurs almost entirely in the small intestine.

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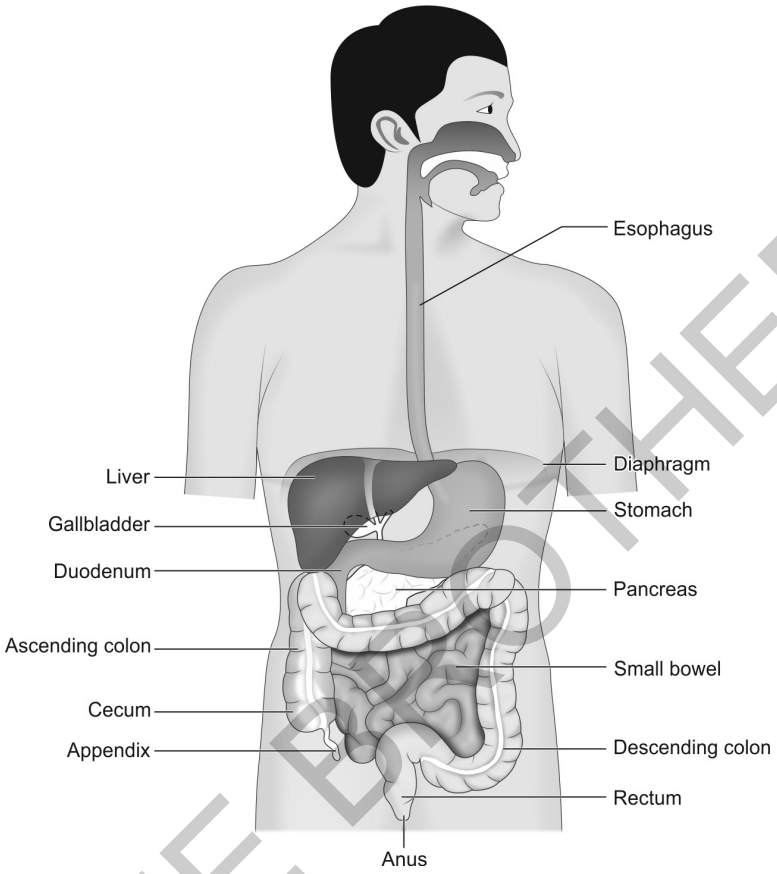

Figure 3.9: Gastrointestinal tract (general structure).

In the Small Intestine

When the food enters the small intestine, pancreatic amylase breaks the large starch molecules at α 1-4 linkages to create maltose, and dextrins remaining from the amylopectin branches. Enzymes from the brush border of enterocytes further break the disaccharides and oligosaccharides into monosaccharides. For example, maltase from the mucosal cells breaks down the disaccharide maltose into two molecules of glucose. These outer cell membranes also contain the enzymes sucrase and lactase which act on sucrose and lactose respectively **(Table 3.2)**.

Table 3.2: Summary of carbohydrate digestion.

Organ	*Enzyme*	*Action*
Mouth	Salivary amylase: Ptyaline	Starch → Dextrins → Maltose
Stomach	None	Starch hydrolysis continued briefly
Small intestine	Pancreatic amylase: Amylopsin Intestinal disaccharidases: Sucrase Lactase Maltase	Starch → Dextrins → Maltose Sucrose → Glucose + Fructose Lactose → Glucose + Galactose Maltose → Glucose + Glucose

Source: Nutrition and Diet Therapy, Williams, SR.

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ABSORPTION OF CARBOHYDRATES

The end products of carbohydrate digestion, monosaccharide, such as glucose, galactose and fructose pass through the mucosal cells and into the bloodstream via the capillaries of the villi. From here they are transported by the portal vein to the liver. Liver is the storage site of carbohydrates where it is stored as glycogen and dispensed according to the needs. Most of the glucose and galactose is absorbed through active transport, primarily by a sodium-dependent carrier. Glucose and galactose can also be absorbed by passive diffusion when intraluminal concentrations of sugars are high, but it accounts for a very small amount of the total glucose absorbed. But fructose is not absorbed by active transport. It is more slowly absorbed by facilitated diffusion, which utilizes a carrier but is not energy dependent. This process is probably also sodium-dependent.

Most absorption of sugars occurs in the jejunum, but some absorption occurs all along the length of the small intestine. The rate at which glucose and galactose are absorbed is equal but fructose is absorbed about half as rapidly.

Glucose is transported from the liver to the tissues, although some glucose is stored as glycogen in the liver and muscles as glycogen. A small amount of fructose may be converted into glucose before it passes from the intestinal cell into the blood. Most of it is transported as fructose to the liver. Like galactose, fructose is also converted to glucose. Some complex carbohydrates, e.g., cellulose, hemicellulose, pectin, gum and other forms of fibers, cannot be digested, because humans do not have the enzymes which have the ability to break the β1-2 and 1-4 linkages.

These carbohydrates are passed on to the colon unchanged where they are partially fermented by the bacteria.

METABOLISM OF CARBOHYDRATES

Glucose metabolism is a series of interrelated biochemical reactions which are facilitated by enzymatic actions. Glucose metabolism cannot be separated from the metabolism of fats and protein. On one hand proteins can be utilized as a source of glucose and on the other, glucose can be converted to the fatty acids, glycerol, and certain amino acids. A number of points in the sequence of glucose metabolism are also the cross-roads for amino acid and fatty acid metabolism as can be seen in the Embden-Meyerhof pathway. And in the time of need during starvation one nutrient can substitute for other, e.g., proteins and fats can be used up to supply energy if glycogen stores are depleted.

Traces of magnesium, iron and other minerals and several B-complex vitamins are essential for the enzyme activity. Since the metabolism of nutrients is interdependent, the lack of any one of them will affect the total metabolism, and the particular reaction cannot occur.

Role of the Liver in Carbohydrate Metabolism

After the absorption from the small intestine, the monosaccharides are transported by the portal vein to the liver. The liver controls the pathways of glucose as well as the other nutrients. The liver converts fructose and galactose to intermediates in glucose metabolism. Liver synthesizes glycogen (glycogenesis) from glucose, stores it, and reconverts at the time of need to glucose (glycogenolysis). It deaminates amino acids and provides carbon skeleton which then is used for the synthesis of glucose (gluconeogenesis) if glycogen stores are depleted. Liver can also convert excess glucose into fatty acids (lipogenesis) and can also utilize the glycerol fraction of lipids to form glucose. The liver can also synthesize nonessential amino acids

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from the carbon skeleton donated by carbohydrate. All these chemical transformations are facilitated by the specific enzymes specially meant for each reaction. These enzymes act under the influence of hormones secreted by the pancreas, the adrenals, pituitary, and thyroid gland.

Oxidation of Glucose

Oxidation of glucose is continuously taking place within each cell of the body. The end products of this oxidation are carbon dioxide, water and energy. The cell utilizes energy efficiently by releasing a small amount of it at a time and this happens in a series of steps that take place in mitochondria of cells. The energy released in these steps is stored in the form of ATP (adenosine triphosphate). ATP consists of adenine which is a nitro-genous base, ribose and three phosphate groups. Two of these phosphate groups are high energy phosphate bonds. One of these bonds is broken and energy is released, whenever there is a need in the cell (ADP → ATP). Whenever the energy is liberated in the catabolism of glucose, fatty acid or amino acid, ATP is reformed (ADP → ATP).

The first step in glucose metabolism is **glycolysis** (also known as the Embden-Meyerhof pathway). **Figure 3.10** takes place in the cytoplasmic matrix of the cell. This is an anaerobic phase which produces two molecules of pyruvic acid from each glucose molecule. The second phase in glucose catabolism is aerobic phase which includes decarboxylation of pyruvic acid to acetic acid, condensation of acetic acid with coenzyme A, and the transfer through the tricarboxylic acid cycle (TCA cycle or Krebs cycle) which yields hydrogen and electrons, carbon dioxide and water. This is the common pathway for oxidation of deaminized amino acids and fatty acids as well as for glucose (**Figure 3.11**).

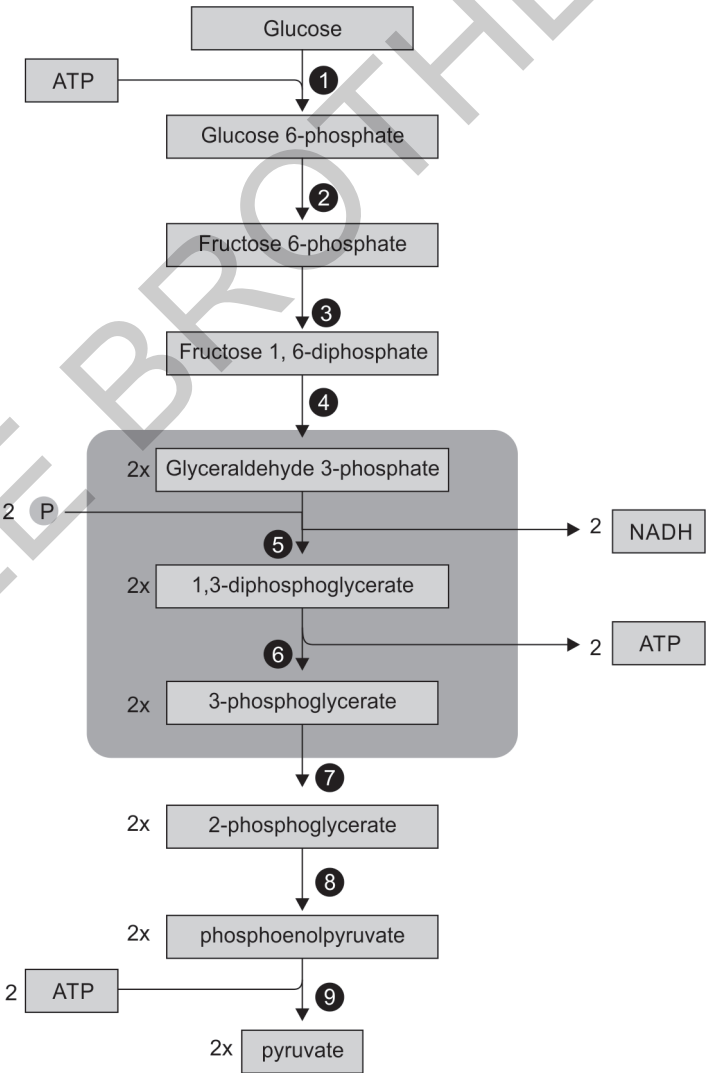

Figure 3.10: Glycolysis.

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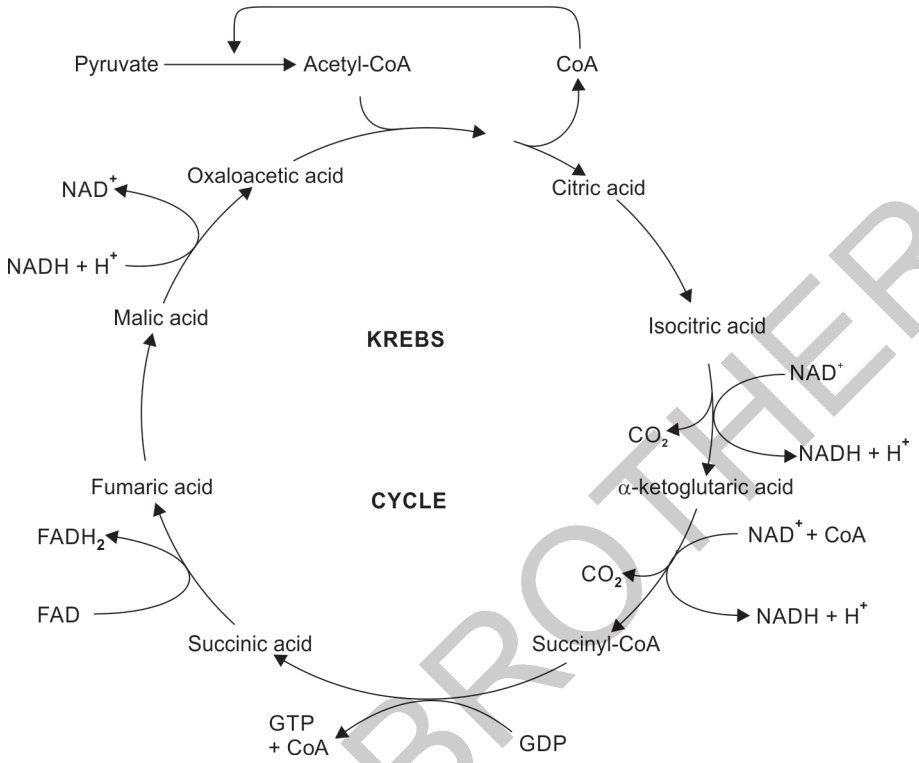

Figure 3.11: Krebs cycle.

The final step in the release of energy is the immediate trapping of the energy in ATP through the electron transport system. **Figure 3.11** clearly describes these steps.

MALNUTRITION

Lack of carbohydrates in the diet as well as the excessive use of carbohydrate both conditions can cause malnutrition.

1. **Lack of carbohydrates** in the diet can lead to use of protein to meet the energy requirement of the body because it is the priority. When the protein is not available to fulfill its primary function which is tissue building and repair the damaged tissue, there will be tissue depletion. Ultimately the person loses weight and in case of children, they develop diseases like protein-energy malnutrition (kwashiorkor and marasmus) and develop further complications.
   Decreased use of fiber which is a form of carbohydrate can lead to multiple problems such as constipation, diverticulitis, obesity, diabetes, etc. High fiber intake is a preventive measure for obesity, constipation, and many gastrointestinal disorders such as hemorrhoids, cancer of the colon and coronary heart disease, etc.
2. **Excessive use of carbohydrates** in the diet can lead to dental carries and obesity. Obesity can ultimately lead to many complications such as diabetes, hypertension, and coronary heart disease. High carbohydrate diets do not cause diabetes but there is a high association between obesity and type 2 diabetes mellitus. Obesity is the origin of many other diseases.

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High intake of sugar has been found to cause hyperactivity in children. Carbohydrates, mainly sucrose, are easily fermented and during this process weak inorganic acids are produced which in turn has the capacity to dissolve the mineral constituents of the enamel of the teeth. This sticky material which is a combination of sugar and certain bacteria, can attack the tooth and lead to decay. Limiting the use of sweets, certain snacks, good oral hygiene will help reduce the chances of dental caries.

LET US SUM-UP

Carbohydrates are the main source of energy. They are produced by the process of photosynthesis and widely distributed in nature. They form the bulk of our diet. Carbohydrates are classified in three major categories. Besides energy, they also provide good amount of fiber. They play very important role in many life processes. Once it is ingested, they pass through the gastrointestinal tract and get digested and absorbed. After they are absorbed, they get metabolized to supply much needed energy to sustain life.

Both too much and too little carbohydrates in day-to-day are harmful for life. Therefore, it should be consumed in appropriate amount which should not exceed 55–60% of total calories for the day.

STUDY QUESTIONS

1. Classify carbohydrates.
2. Name the monosaccharides and draw their chemical structures.
3. What are the functions of carbohydrates, write in detail?
4. Explain the digestion and absorption of carbohydrates.
5. Explain the glycolysis process.
6. Explain the effect of carbohydrate abuse.

FILL-UPS

1. The kind of carbohydrate present in honey.....
2. One gram of carbohydrate provides ..... kcals.
3. Lactose is also known as .....
4. Dietary fiber prevents .....
5. The minimum amount of carbohydrate required to prevent ketosis .....
6. The enzyme present in the mouth which acts on carbohydrate is .....
7. One teaspoon of sugar provides ..... kcals.
8. Most absorption of carbohydrates occur in the .....
9. ..... is produced when bread or cereals are toasted.
10. Carbohydrates are stored in the liver as .....

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Applied Nutrition & Dietetics
for BSc Nursing Students

Due to overwhelming response from the students this book has reached its third edition. The students of nursing profession and from other professions found it very helpful to have the whole syllabus compiled in the form of a book. Since there was not a single book available in the market to give them compact and comprehensive approach in this subject.

This book, especially meant for nursing students, encompasses all the aspects of food science and nutrition which are included in their curriculum.

An attempt has been made to cover the undergraduate syllabus set by Indian Nursing Council (INC). Besides the basic information of nutrition, aspects of applied nutrition, dietetics and community nutrition are also covered. As per the revised syllabus by INC, some of the topics have been removed and new topics have been included in this edition. Current issues of nutritional problems in India have been covered supported by relevant tables and figures.

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- Introduction
- Foundation of Nutrition
- Nutrition in the Community
- Nutrition in Health Care
- Cookery Rules and Preservation of Nutrients

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- Every chapter has study questions at the end to help the students prepare for the examination.
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Ruma Singh BHSc BS (Dietetics USA) BEd MSc (F and N) is Associate Professor, College of Nursing (Affiliated to Baba Farid University of Health Sciences), Faridkot, Punjab, India, and Chief Dietician, Department of Dietetics, Christian Medical College and Hospital, Ludhiana, Punjab. She earned BHSc from Rani Durgavati Vishwavidyalaya, Jabalpur, Madhya Pradesh, India and got BS (Dietetics) from Eastern Mennonite College (now Eastern Mennonite University), Harrisonburg, Virginia, USA. She also earned BEd degree from Annamalai University and received MSc (Food and Nutrition) from Raipur, Chhattisgarh, India. She has been appointed as an Academic Counsellor of Nutrition for Post-Basic BSc Nursing students at Indira Gandhi National Open University. She was felicitated as Fellow-SIOP-PODC in 2016 from Tata Memorial Hospital, Mumbai, Maharashtra, India. She has a long teaching experience of nutrition to the medical, dental, nursing and physiotherapy students. She was elected as Vice-President, Indian Dietetic Association, Ludhiana Chapter for the year 2018 and was re-elected for the same post for the year 2019 for the second term. She has published research papers in national and international journals. Her another book Food and Nutrition for Nurses (GNM Nursing), 2nd edition is already in use.

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