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## UNIT 2 CARBOHYDRATES

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## 2.0 OBJECTIVES

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After reading this unit, you will be able to:

- narrate the importance of carbohydrates in diet;
- explain chemical nature, sources and functions of carbohydrates in diet; and
- explain the importance of carbohydrates in treatment/prevention of many diseases.

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## 2.1 INTRODUCTION

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Whatsoever organic material present in a living system are mainly classified under carbohydrates, proteins and lipids. All these three play a vital role not only in the structure but also in the functionality of body. The literal meaning of carbohydrate is hydrate of carbons. Carbohydrates are compounds of carbon, hydrogen and oxygen represented by empirical formula  $C_n(H_2O)_n$ . As per the definition, carbohydrates are "polyhydroxy (more than one OH group) aldehyde or polyhydroxy ketone". Our body has been designed and developed to solve the basic survival problems such as energy to do its work, materials to build and maintain its form and agents to control these processes efficiently. Key nutrients

of the food we eat provide solution to these life-sustaining problems. Our body's primary fuel is carbohydrate, which provides energy. Energy is a primary necessity of life. (Energy is the capacity of an organism by which he can do work.)

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## 2.2 IMPORTANCE AND FUNCTIONS OF CARBOHYDRATES

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You have already studied that carbohydrates are primary fuel of the body i.e., the source of energy. Beside this, they also play various important roles in the body. Importance of carbohydrates in the body can be explained in the following way:

### 2.2.1 Carbohydrates as a Basic Fuel for Energy to Body

Starches and sugars are the basic fuel forms of carbohydrates that occur in our food.

Plants by the process of photosynthesis transform sun energy into a typical form of carbohydrate specially found in plant known as starch. In this process, carbon dioxide from the air and water from the soil are converted into starch and sugar by chlorophyll, the green pigment present in leaves.

Carbohydrates are called "quick energy" foods. This is because they are rapidly broken down in the body to provide energy. About 50 to 60 per cent of total kilocalorie requirement of a person comes from dietary carbohydrates. The amount of carbohydrates stored in the body is relatively small. Stored glycogen and glucose can provide energy sufficient for about half a day at moderate activity. Thus regular intake of carbohydrates containing food at moderately frequent intervals is essential to meet the constant energy demands of the body.

### 2.2.2 Carbohydrates as Chief Dietary Constituents

Carbohydrates are one of the major components of the diets all over the world. The reason behind this is their wide availability and lower cost. They may be grown and stored easily. Carbohydrates rich foods can be kept in dry storage for relatively longer period without spoilage. In some countries, carbohydrates constitute almost entire diet of the people.

### 2.2.3 Carbohydrates in Different Role in Biological Systems

**Glucose:** This is the most important carbohydrate. It is absorbed into the blood stream after the digestion of food. It can be converted into other forms of carbohydrates in the body. Glucose can also be obtained from complex carbohydrates by degradation in the liver. It is from glucose that all other carbohydrates in the body are formed. Glucose is a major fuel of the tissues of mammals (except ruminants) and a universal fuel of the fetus. It is converted to other forms of carbohydrates having highly specific functions. Some of the special functions of carbohydrates in body tissues are as follows:

- i) **Stored form of energy:** In living system glycogen and starch are stored form of energy. Glycogen is found in animals whereas starch in plants. Glycogen reserved in liver and muscle of animal provide a constant supply of glucose to fulfil energy needs of the body. Thus, this reserve protects cells from depressed metabolic functions and injury.

- ii) **Protein sparing function:** Carbohydrates regulate protein metabolism. Presence of sufficient carbohydrates prevents the breakdown of protein for energy requirement so that the proteins are used in the body for its basic structural purpose of tissue building. Excess of carbohydrates in body is utilized for the carbon skeleton of protein.
- iii) **Antiketogenic effect:** Carbohydrates also regulate the fat metabolism. The amount of carbohydrates in the diet decides the formation and disposal rate of ketones from lipids. If a carbohydrate is inadequate or unavailable for energy needs, excess fat is oxidized leading to accumulation of ketones and results in ketoacidosis. Excess of carbohydrate is transformed into fats. It should be noted that fat and protein always burn in flame of carbohydrate i.e., even for oxidation of fat or protein as energy source, some carbohydrate or its metabolite is required.
- iv) **Heart action:** Heart action is a life sustaining muscular exercise. Glycogen reserve in cardiac muscle is an important emergency source of contractile energy. Low carbohydrate intake or poor glycogen stores may cause cardiac symptoms and angina.
- v) **Central nervous system function:** The brain, central nervous system regulatory centre do not contain stored glucose and are dependent on glucose supply from the blood. Hypoglycemia, (decrease in blood glucose level), may cause irreversible brain damage. So, carbohydrates are necessary for functional integrity of nerve tissue.

**Check Your Progress 1**

1) Why carbohydrates are known as quick energy foods?

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2) What is the percentage of energy provided by carbohydrates for normal functioning of the body?

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3) Name any two stored form of carbohydrates.

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4) Why carbohydrates are the major component of our diet?

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5) What are the functions of carbohydrates in our body?

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6) Discuss (a) Antiketogenic effect (b) Protein sparing function of carbohydrates?

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7) Name the emergency source of contractile energy of cardiac muscle.

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8) Write the role of glucose in central nervous system.

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## 2.3 CLASSIFICATION

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Carbohydrates or saccharine (Greek: Sacharon, sugar) means "carbon hydrate" which is  $(CH_2O)_n$  wherein  $n > 3$ . Carbohydrates are classified according to the number of basic sugar or saccharide unit.

### 2.3.1 Monosaccharides

Monosaccharides are the simplest form of carbohydrate known as simple sugar. Monosaccharides are classified according to their functional group and number of carbon atoms.

**Aldoses:** If the functional group is aldehyde, as in glucose, it is referred as aldose.

**Ketoses:** If the functional group is ketose, as in fructose, it is referred as ketoses. Trioses are the smallest monosaccharides of three carbon atoms. Those with four, five, six, seven carbon atoms are tetroses, pentoses, hexoses, and heptoses respectively. Six-carbon aldose is an aldohexose and of ketose is ketohexose.

The three main monosaccharides important in human nutrition are glucose, fructose and galactose.

**Glucose:** Naturally preformed sweet sugar, glucose is found only in few foods such as corn syrup. Digestion of starch produces glucose. In body, all other types of sugars are converted to glucose. It is also known as "dextrose". (Normal blood sugar level is about 70 -110 mg /100 ml.) Glucose is the ultimate energy fuel, which is oxidized in cell to give energy.

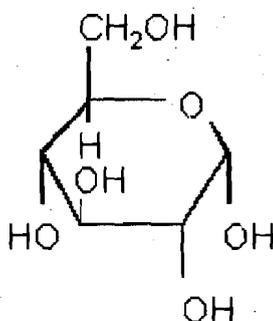


Fig. 2.2: Structure of Glucose

**Fructose:** It is the sweetest simple sugar. Fructose is found in fruits as honey. Fructose is converted into glucose in our body to provide energy.

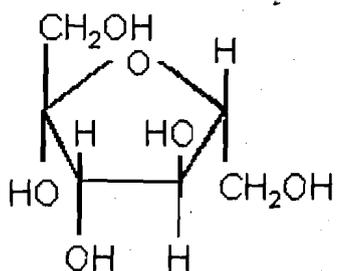


Fig. 2.3 Structure of Fructose

**Galactose:** It is not found in free-form in food, but is produced from lactose (milk sugar). Galactose is also changed to glucose for energy, which is a reversible reaction. During milk production, glucose is converted to galactose. Galactosemia, a genetic disorder, is due to the absence/ deficiency of the enzyme required for the conversion of galactose to glucose and thus galactose accumulates.

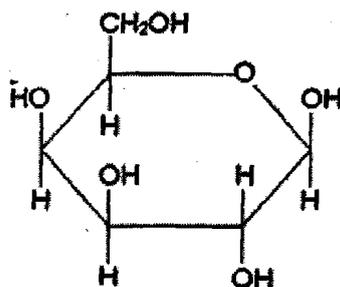


Fig. 2.4: Structure of Galactose

### 2.3.2 Oligosaccharides

Oligosaccharides are composed of 2 -10 monosaccharides linked together. Those with two monosaccharides unit are called disaccharides. The three main disaccharides of physiological importance are sucrose, lactose and maltose.

**Sucrose:** Sugarcane beet is a rich source of sucrose. It is a common disaccharide. Sucrose can be found in all molasses, some fruits and vegetables such as pineapple, carrot etc.

**Lactose:** Lactose is also known as milk sugar. During lactation, it is formed in the body from glucose. It is 1/6<sup>th</sup> as sweet as sucrose. Cheese, a milk product, has very little or no lactose.

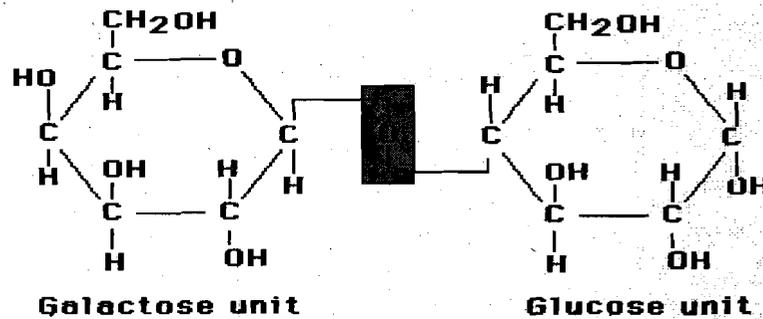


Fig. 2.5: Structure of Lactose

**Maltose:** Commercial malt products of starch breakdown and germinating cereal grains are the rich source of maltose. It is an important metabolic carbohydrate and an intermediate product of starch digestion.

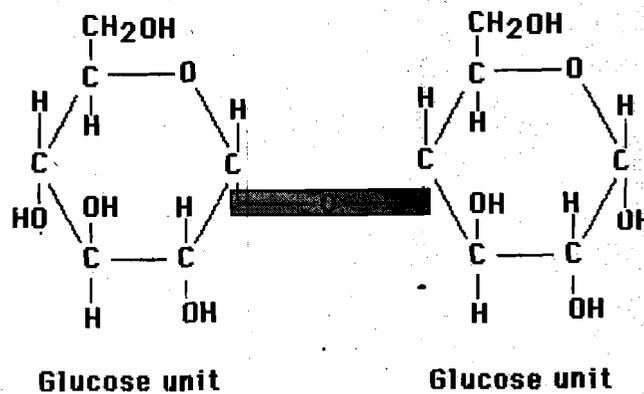


Fig. 2.6: Structure of Maltose

### 2.3.3 Polysaccharides

Polysaccharides are made up of many saccharides (simple sugar) units. The most important polysaccharide in human nutrition is starch. Other polysaccharides are glycogen and dextrin. The bulk of animal diet is composed of non-digestible forms of dietary fiber e.g., cellulose. Polysaccharides are of two types: Homopolysaccharides and Heteropolysaccharides.

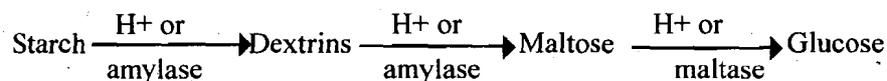
#### i) Homopolysaccharides

They yield only one type of monosaccharide (glucose) upon complete hydrolysis. Some important homopolysaccharides are as follows:

**Starch:** It is made up of many glucose units attached in a branch chain manner. Actually, it is a mixture of two polymers, amylose (10-20 per cent) and

amylopectin (80-90 per cent). It yields only glucose on digestion. Starch is the most important source of dietary carbohydrate in the world. It is an important part/component of human nutrition and health. In many countries, starch is the staple food material forming the bulk of the diet. Cereal grains, legumes, potatoes and many vegetables are rich in starch.

**Dextrin:** Dextrin is formed as an intermediate product in the break down of starch.



**Glycogen:** The storage carbohydrate in animals is glycogen, also known as animal starch. In fact, it is a polymer of glucose similar to amylopectin but with high branching and its branches are smaller. It is formed during cell metabolism and stored in small amounts in liver and muscle tissues. During fasting period such as sleep hours, glycogen provides immediate energy fuel or glucose for muscle action. Dietary carbohydrates are needed to maintain glycogen stores. Low dietary carbohydrate intake causes symptoms like fatigue, dehydration and excessive protein breakdown.

**Cellulose:** Cellulose is the main component of the framework of plant cell wall. The repeating unit is a disaccharide cellobiose which is made up of two units of D glucose joined by  $\beta$ -1, 4 glucosidic linkage. It provides most of the substances labeled "crude fiber". The main food sources are stem and leaves of vegetables, seed and grain coverings, skin and hulls. Humans cannot digest cellulose. Humans lack the necessary digestive enzymes which can break  $\beta$ -1, 4 glucosidic linkage. Therefore, cellulose remains undigested. Non-cellulose fibers absorb water and have slow gastric emptying time. They are gum like water-soluble substances that aid in binding cholesterol and controlling its absorption. They provide bulk for normal intestinal muscle action to prevent colon pressure.

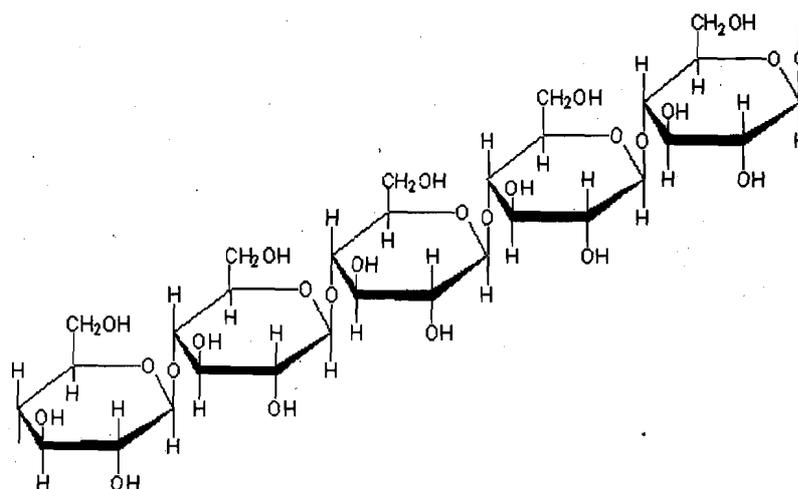


Fig. 2.7: Structure of Cellulose

## ii) Heteropolysaccharides

These are the polysaccharides, which on complete hydrolysis yield more than one particular type of components (sugar acids, amino sugars as non-carbohydrates). These are also referred as non-cellular portion of plant. Some of the important heteropolysaccharides are:

**Hemicellulose:** The constituents of hemicellulose are xylose, arabinose, uronic acid, glucose and galactose. It is more digestible than cellulose.

**Chitin:** It forms the structural element in lower plants and in invertebrates. Its subunits are 2-acetamido-2-deoxy-D-glucopyranose linked by  $\beta$ -1, 4, glycosidic bonds.

**Pectin:** It is composed of galactouronic acid chain with arabinose, glucose and xylose. It is used in fruit conserving industry.

**Gums:** The complete hydrolysis of gums yields arabinose, glucose, rhamnose, glucuronic and galacturonic acids. In nature, it occurs in the form of copper and magnesium salt.

**Mucilages:** According to source, their constituents differ. Mainly composed of arabinose, galactose, rhamnose and galacturonic acid.

**Table 2.1: Classification of Carbohydrates**

Class (Degree of Polymerization)	Subgroup	Components
Sugars (1-2)	Monosaccharides	Glucose, Galactose, Fructose
	Disaccharides	Sucrose, Lactose, Trehalose
	Polyols	Sorbitol, Mannitol
Oligosaccharides (3-9)	Malto-Oligosaccharides	Maltodextrins
	Other Oligosaccharides	Raffinose, Stachyose, Fructo- Oligosaccharides
Polysaccharides (>9)	Starch	Amylose, Amylopectin, Modified starches
	Non-starch polysaccharides	Cellulose, Hemicellulose, Pectins, Hydrocolloids

## 2.4 SOURCES OF CARBOHYDRATES

Starch and sugars constitute the main carbohydrates in human diet. Grains and vegetables constitute the primary source of the starch while fruits may contain considerable amount of sugars. Small amount of glycogen is present in the meat and seafood. The common sources of different carbohydrates are as follows:

**Monosaccharides:** Corn syrup, fruits, honey.

**Disaccharides:** Sugarcane, sugar beets, milk, germinating cereal grains.

**Polysaccharides:** Cereal grains, legumes, potatoes and other vegetables, liver, muscle tissues, algae and seaweeds.

Many fruits contain large amounts of organic acids like citric and malic acids. Though these acids are not carbohydrates, they contribute to the total intake because of their rapid conversion to carbohydrates in the body.

### Check Your Progress 2

1) What are the main sources of carbohydrates?

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2) Define carbohydrate.

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3) Monosaccharide contains.....saccharide unit.

4) Aldoses are carbohydrates with .....functional group.

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## 2.5 CLINICAL APPLICATIONS OF CARBOHYDRATES

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You all learnt how much important is carbohydrate for our body. The carbohydrates should be supplied to body in a continuous manner. Both excess as well as lack of carbohydrates is detrimental for body. There are a number of diseases associated with carbohydrates such as hypoglycemia, lactose intolerance, diabetes mellitus, galactosemia, glycogen storage disease etc. Diseases associated with carbohydrate are given below.

### 2.5.1 Hypoglycemia

Hypoglycemia means low sugar level in blood.

**Symptoms:** Nervousness, anxiety, hunger, palpitations and headache.

**Causes:** Clinicians have identified two types of hypoglycemia and their causes.

- i) **Reactive hypoglycemia:** Reactive hypoglycemia occurs after a meal if persons had abdominal surgery or has diabetes.
- ii) **Fasting hypoglycemia:** Fasting hypoglycemia occurs due to inadequate food or from poor eating habits. Several drugs may cause hypoglycemia e.g., alcohol which blocks glucose production in the liver.

Other clinical conditions which cause hypoglycemia are: (i) Tumors in pancreas stimulate excessive insulin secretion (ii) Adrenal insufficiency: Stress conditions increases metabolic demands of the body and contribute to hypoglycemia which is due to adrenal insufficiency.

**Diagnosis:** Normal blood glucose range is 70 - 110 mg/100ml. Below 70mg/100ml of blood sugar level is the sign of hypoglycemia.

**Treatment:** A diet of frequent small meals, rich in complex carbohydrates and a good dietary fiber content with fewer carbohydrates and sugars.

### 2.5.2 Lactose Intolerance

One of the most common problems throughout the world is lactose intolerance. In this condition, the man is unable to digest product with lactose such as non-fermented milk.

**Symptoms:** Abdominal cramps, nausea, bloating or diarrhea when milk is consumed.

**Cause:** The problem is due to deficiency of lactase, a digestive enzyme found in the microvilli of small intestine that converts milk sugar and lactose (by hydrolysis) into its component monosaccharide, glucose and galactose for

absorption. Children are born with high level of lactase to utilize high lactose level in mother's milk. In animals, lactase activity decreases shortly after birth and in human after five years of age.

**Diagnosis:** Based on symptoms along with history of non-fermented milk consumption.

**Treatment:** Treatment consists simply cutting down of milk consumption. Most lactose intolerant patients digest fermented milk products (cheese, butter milk, yogurt) very well and they can consume these as their primary source of calcium instead of milk. Low lactose milk and sweet acidophilus milk have been developed for lactose intolerant people.

### 2.5.3 Diabetes Mellitus

It is a metabolic disorder in which the ability to oxidize the primary fuel glucose is almost lost. It also affects the fat and protein metabolism.

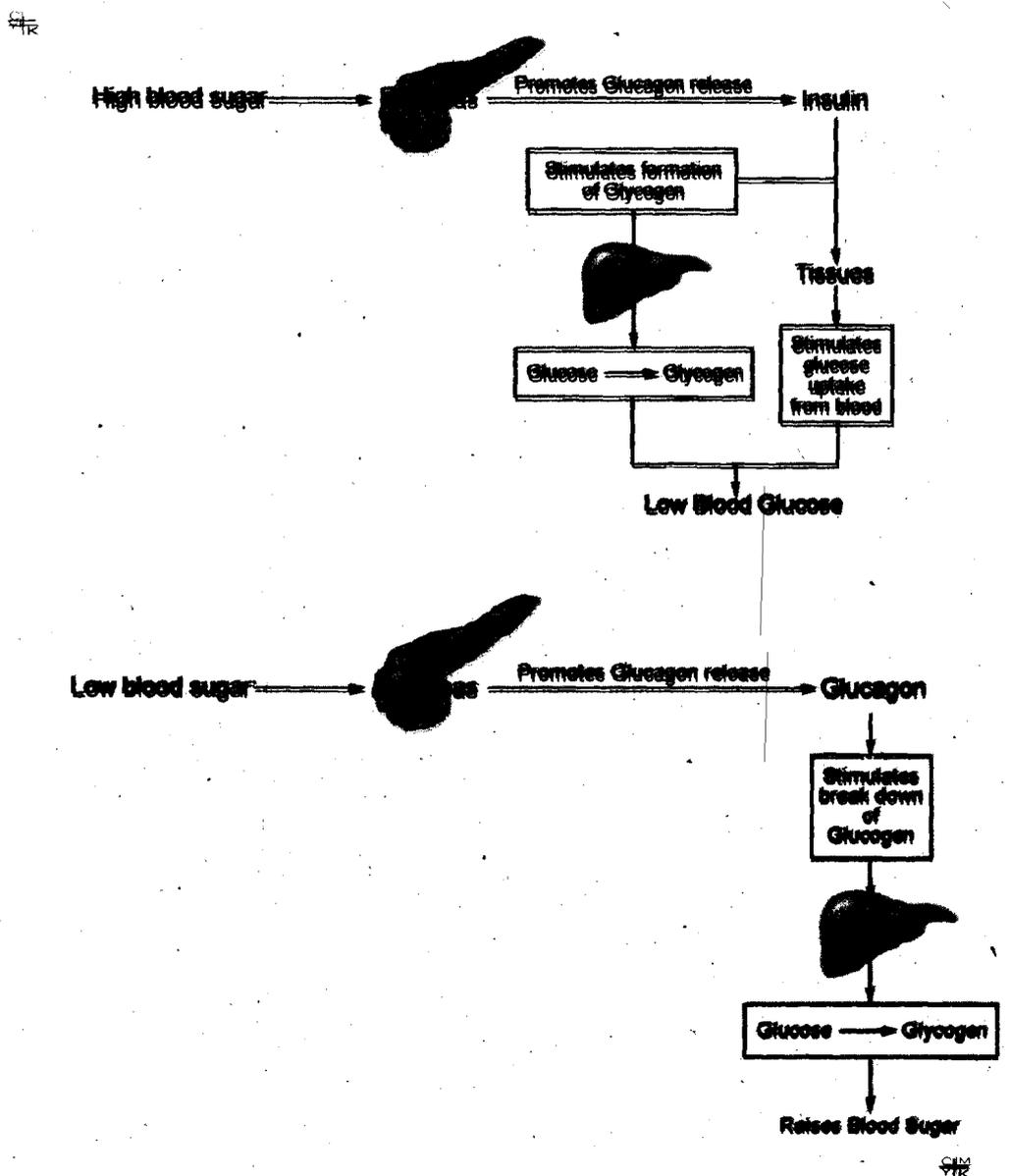


Fig. 2.8: Normal Physiological Functions of Pancreas

**Symptoms:** Glucose level increases in the blood and is lost in the urine, causing excessive urination, thirst and hunger and on prolonged disease develops multiple system complications.

**Cause:** Sugar and other simple carbohydrates can contribute to blood glucose level in persons with diabetes. Sugar does not cause diabetes but the cause is due to lack of available insulin, the pancreatic hormone.

**Diagnosis:** Diagnosis of diabetes can be done by different methods like:

- i) **Estimation of sugar in urine (Glycosuria):** Presence of sugar in urine is detected by colorimetric method.
- ii) **Elevation of blood sugar (Hyperglycemia):** Normal level of blood sugar is 70 - 100 mg/100ml. In diabetes, blood sugar level increases from the normal level.
- iii) **Glucose tolerance test:** In this test, 75 gram dose of glucose is given to patients. The patient is kept on fasting and two hour plasma was collected. The glucose level is estimated. A two hour plasma glucose value of 200mg/100ml or above indicates diabetes and 140 - 200mg/100ml indicates the impaired glucose tolerance.
- iv) **Glycosylated Hemoglobin A1c:** It is a relatively stable molecule within the red blood cells. Higher the level of circulating glucose over the life of the red blood cells, the higher the concentration of glycohemoglobin. It provides an effective tool for evaluating long-term management of diabetes and degree of control.

**Treatment and control:** Treatment of diabetes includes:

- Well-planned food habits and exercise
- Insulin therapy
- Self-monitoring of blood glucose level
- Nutrient balance: Ratio of carbohydrate, protein and fat in the diet is based on the recommendation of ideal glucose regulation. Majority of carbohydrate in the form of complex carbohydrate, starch should be used. About 50 - 55 per cent of total kilocalorie of the diet is of complex carbohydrates. It gives simple sugars slowly over a time. Fiber rich diet (polysaccharides) also has some effect on blood glucose level.

### 2.5.4 Other Conditions

**Hyperactivity:** Greater activity, ease of stimulation and other hyperactive signs suggesting an association of sugar intake and hyperactivity.

**Dental caries:** Dental caries is the only health problem caused by sugar. Better dental care can greatly reduce the incidence of caries.

#### Check Your Progress 3

1) What is the level of blood sugar in normal condition and in hypoglycemic condition?

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2) Name any four diseases related to carbohydrates.

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3) What are the symptoms of hypoglycemia?

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4) What is the cause of diabetes?

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5) List the methods of diagnosis of diabetes.

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6) How the diabetes can be controlled?

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## **2.6 DIETARY FIBERS AND ITS IMPORTANCE**

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Dietary fibers are also known as crude fibers and these are made of polysachharide. Importance of dietary fibers in body physiology, specially in relation to consumption of meat is discussed below:

### **2.6.1 Carbohydrate Content of Meat**

Meat provides calories from proteins, fats and limited quantities of carbohydrates. It's more vital contributions to diets are derived from protein, B vitamins, certain minerals and essential fatty acids. Carbohydrates constitute less than one per cent of the weight of meat, most of which is present as glycogen and lactic acid. The liver is the main storage site of glycogen. Meats are poor source of carbohydrates except those processed products to which sugars or other carbohydrates have been added.

The lack of carbohydrates content in meat and meat products induces constipation and particularly for old age group. Now-a-days the introduction of dietary fiber in diet and even in meat product formulation is being practiced. Besides reducing the cost, it has various added advantages because of its physiological properties. Some of the physiological properties of dietary fiber along with related effects in body system have been discussed below.

### 2.6.2 Physiological Properties of Fibers

Dietary fiber includes a variety of polysaccharides. About 15-20g /day of dietary fibers is recommended for health. Different physiological properties are:

**Water absorption:** Water absorption contributes to bulk forming laxative effect. It influences the transit time of food mass through the digestive tract and further absorption of nutrients.

**Binding effects:** Binding effect of fibers influences blood lipid levels through their capacity to bind cholesterol and bile salts and prevent their absorption. Excessive dietary fiber has undesirable effect of binding minerals such as iron, zinc or calcium thus preventing needed absorption.

### 2.6.3 Clinical Association Between Dietary Fiber and Various Diseases

Because of diverse physiological function dietary fibers are useful in various diseases. The effects of fibers in various diseases are listed below:

**Table 2.2: Use of dietary fibre during disease condition**

Disease condition	Usefulness of dietary fibre
<b>Diabetes mellitus</b>	<ul style="list-style-type: none"> <li>• Reduces fasting blood sugar level</li> <li>• Reduces glycosuria</li> <li>• Reduces insulin requirements</li> <li>• Increases insulin sensitivity</li> </ul>
<b>Obesity</b>	<ul style="list-style-type: none"> <li>• Increases satiety rate</li> <li>• Reduces energy density</li> <li>• Reduces nutrient bio-availability</li> <li>• Alters hormonal response and thermogenesis</li> </ul>
<b>Coronary heart disease</b>	<ul style="list-style-type: none"> <li>• Inhibits recirculation of bile acids</li> <li>• Reduces triglyceride and cholesterol level</li> </ul>
<b>Colon cancer</b>	<ul style="list-style-type: none"> <li>• Reduces incidence of disease</li> </ul>
<b>Other gastrointestinal disorders</b> like Diverticular disease, Constipation, Hernia, Hemorrhages	<ul style="list-style-type: none"> <li>• Reduces pressure from within the intestinal lumen</li> <li>• Increases diameter of the intestinal lumen, thus allowing intestinal tract to contract more, propelling contents more rapidly and inhibiting segmentation</li> </ul>

#### Check Your Progress 4

1) Dietary fibers are made up of .....

2) What are the physiological properties of fibers?

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3) Name the diseases, which can be managed by the intake of fibers?

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## 2.7 LET US SUM UP

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Primary fuel of our body is carbohydrate, which provides energy. Starches and sugars are the basic fuel forms of carbohydrates. Carbohydrates are called “quick energy” foods, they are our major source of energy. Glucose is a major fuel to provide energy. Other forms of carbohydrates are glycogen for storage, ribose in nucleic acid, galactose in lactose of milk, in certain complex lipids and in combination with protein in glycoprotein and proteoglycans. Special functions of carbohydrates in our body are glycogen reserve, protein sparing function, antiketogenic effect, heat action and in central nervous system.

Hypoglycemia means low blood sugar. Normal blood glucose range is 70-110 mg/100ml. Blood sugar level below 70mg/100ml is the sign of hypoglycemia. Control measures of hypoglycemia include frequent small meals at short intervals, rich in complex carbohydrates and good dietary fiber content with fewer carbohydrates and sugars. Lactose intolerance is due to deficiency of lactase enzyme and can be treated by simply cutting down the milk consumption. Diabetes mellitus is a metabolic disorder with high blood sugar level. Treatment of diabetes includes well-planned food habits and exercise, insulin therapy, self-monitoring of blood glucose level and balance nutrient. Main source of carbohydrates are grains, vegetables and fruits. Small amount of glycogen are present in the meat and seafoods.

Carbohydrates or saccharide (Greek: Sacharon, sugar) means “carbon hydrate”. Carbohydrates are classified as monosaccharide, disaccharides and polysaccharides according to the number of basic unit.

Dietary fibers are made up of polysaccharides. Physiological properties of fibers are water absorption and binding effect. Dietary fibers play important role in management of diseases like diabetes, obesity, coronary heart disease, colon cancer and gastrointestinal problems. Meats are poor source of carbohydrates except those processed products to which sugars or other carbohydrates have been added.

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## 2.8 KEY WORDS

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<b>Carbohydrates</b>	:	Carbohydrates or saccharides (Greek: Sacharon, sugar) means "carbon hydrate" which is $(CH_2O)_n$ where $n > 3$ .
<b>Disaccharides</b>	:	Sugars composed of two saccharide units.
<b>Fasting hypoglycemia</b>	:	Occurs after extended period without food or from poor eating habits.
<b>Galactosemia</b>	:	It is the accumulation of galactose in blood.
<b>Glucose tolerance factor</b>	:	It stimulates the action of insulin.
<b>Hyperglycemia</b>	:	Hyperglycemia refers to an elevated glucose level than normal in blood.
<b>Hypoglycemia</b>	:	Hypoglycemia is the condition when glucose level is below normal in blood.
<b>Lactose intolerance</b>	:	A condition that results in abdominal cramps, nausea, bloating or diarrhea when milk is consumed.
<b>Obesity</b>	:	Clinical term for excess body weight.
<b>Oral hypoglycemic agents:</b>	:	Drugs act to lower the elevated blood glucose by stimulating pancreas to produce more endogenous insulin.
<b>Polysaccharides</b>	:	Made up of many simple sugars.

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## 2.9 SOME USEFUL BOOKS

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Williams, S.R. (1990). *Essential of Nutrition and diet therapy*. Times Mirror/Mosby College Publishing.

Williams, E.R. and Caliedo, M.A. (1984). *Nutrition: Principles, Issues and Applications*. McGraw-Hill book company, New York.

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## 2.10 ANSWERS TO CHECK YOUR PROGRESS

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### Check Your Progress 1

- 1) Carbohydrates are known as 'quick energy' foods because they provide energy due to rapid breakdown in the body.
- 2) 50-60 per cent of energy is provided by carbohydrates for normal functioning of body.
- 3) Starch and glycogen are two stored forms of carbohydrates.
- 4) Carbohydrates are the major component of our diet because (a) these are widely available (b) easily grown plants such as grains, vegetables and fruits (c) Carbohydrates are relatively low in cost d) they may be stored easily. Carbohydrate rich foods can be kept in dry storage for relatively longer period without spoilage.
- 5) Special functions of carbohydrates in our body are glycogen reserve, protein sparing function, antiketogenic effect, heart action and in central nervous system.

- 6) (i) **Antiketogenic effect:** High amount of carbohydrate in diet provides sufficient amount of energy. Due to which, there is inhibition of lipid catabolism. The formation of ketone from lipids was inhibited.
- (ii) **Protein sparing function:** The presence of sufficient carbohydrates prevents the conversion of protein to its components which fulfil the energy needs so that the proteins are used in the body for its basic structural purpose of tissue building.
- 7) Glycogen is the emergency source of contractile energy of cardiac muscle.
- 8) Glucose is required for functional integrity of nerve tissue.

#### Check Your Progress 2

- 1) Main source of carbohydrates are grains, vegetables and fruits. Small amount of glycogen are present in the meat and seafoods.
- 2) Carbohydrates or saccharides (Greek: Sacharon, sugar) means "carbon hydrate" which is  $(CH_2O)_n$  where  $n > 3$ .
- 3) One.
- 4) Aldehyde.

#### Check Your Progress 3

- 1) Normal level of blood sugar is 70-110 mg/ 100ml and below 70 mg/100ml in hypoglycemia.
- 2) Diseases associated with carbohydrates are hypoglycemia, lactose intolerance, diabetes mellitus and galactosemia.
- 3) The symptoms of hypoglycemia are nervousness, anxiety, hunger, palpitations and headache.
- 4) Diabetes is a metabolic disorder. The cause is the lack of available insulin, the pancreatic hormone.
- 5) Diagnosis of diabetes can be done by different methods: (i) Estimation of sugar in urine (glycosuria), (ii) Elevation of blood sugar (hyperglycemia), (iii) Glucose tolerance test, (iv) Glycosylated Hemoglobin A<sub>1c</sub>.
- 6) Diabetes can be controlled by well-planned food habits and exercise, insulin therapy, self monitoring of blood glucose level and nutrient balance.

#### Check Your Progress 4

- 1) Polysaccharides.
- 2) Physiological properties of fibers are water absorption and binding effect.
- 3) Dietary fibers play an important role in management of diseases like diabetes, obesity, coronary heart disease, colon cancer and gastrointestinal disorders.