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# Applied Nutrition, Dietetics and Biochemistry for Basic BSc NURSING

*Previously Known as Essentials of Nutrition and Biochemistry for Basic BSc Nursing*



2nd Edition

*As per the Revised INC Syllabus for BSc Nursing*

I Clement

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CHAPTER 2

# Carbohydrates and Energy

CHAPTER OUTLINE

- Carbohydrates
  - Composition—Starches, Sugar and Cellulose
  - Recommended Daily Allowance (RDA)
  - Dietary Sources
  - Functions
- Energy
  - Unit of Energy—Kcal
  - Basal Metabolic Rate (BMR)
  - Factors Affecting BMR

## TERMINOLOGY

- **Sugars:** The term "sugars" describes all mono- and disaccharides. Sugars are found naturally in fruits, vegetables, and milk products, or added to foods and beverages.
- **Basal metabolic rate (BMR):** BMR is a measurement of the level of energy required to maintain the body's vital life functions. Measured when the body is at complete rest.
- **Bioavailability:** Bioavailability is the ease at which a substance can be absorbed from the digestive tract and into the bloodstream. The higher the bioavailability, the greater the absorption.
- **Body mass index (BMI):** BMI is a measure of a person's body size by calculating their weight in relation to their height. BMI = $kg/m_2$
- **Antioxidant:** Antioxidants are chemical substances that help protect against cell damage from free radicals. Well-known antioxidants include vitamin A, vitamin C, vitamin E, carotenoids, and flavonoids.
- **Dietary fiber:** Dietary fiber comes from the thick cell walls of plants. It is an indigestible complex carbohydrate. Fiber is divided into two general categories—water-soluble and water-insoluble
- **Dietary supplements:** A dietary supplement is a product you take to supplement your diet. It contains one or more dietary ingredients (including vitamins; minerals; herbs or other botanicals; amino acids; and other substances). Supplements do not have to go through the testing that drugs do for effectiveness and safety.
- **Nutrient:** Nutrients are chemical compounds in food that are used by the body to function properly and maintain health. Examples include proteins, fats, carbohydrates, vitamins, and minerals.
- **Electrolytes:** Electrolytes are minerals in body fluids. They include sodium, potassium, magnesium, and chloride. When you are dehydrated, your body does not have enough fluid and electrolytes.
- **Digestion:** Digestion is the process the body uses to break down food into nutrients. The body uses the nutrients for energy, growth, and cell repair.
- **Calories:** Calories are a measurement of energy. One calorie is equivalent to 4.18 kJ.
- **Carbohydrate**
- Carbohydrates are the most readily converted energy source. Good sources include rice, bread, cereal, legumes, fruits and vegetables which also provide important nutrients. Additional carbohydrate sources include refined sugars, which do provide instant energy but unfortunately do not offer the nutrients that the more complex sources of carbohydrates do.
- **Catabolism:** Catabolism is the breaking down of a larger molecule into a smaller molecule. For example, the breakdown of carbohydrates to release energy.
- **Cellulose:** Cellulose is an insoluble fiber that makes up the framework of plant cell walls.
- **Energy:** Energy is the fuel we need from food to function and be active. Energy requirements vary depending on your age, body size and physical activity. It is important to monitor your energy consumption as too much energy can lead to weight gain. Fat, protein and carbohydrates all provide energy (known as kilojoules or calories) in the foods we eat. Fats provide more energy per gram than protein or carbohydrates.
- **Energy balance:** Endosperm is the inner part of the grain. It contains carbohydrate, protein and B vitamins.
- **Soluble fiber:** Soluble fiber is beneficial to help lower blood cholesterol levels and, in people with diabetes, helps to control blood sugar. Soluble fiber is found in fruits, vegetables, dried peas, soybeans, lentils, oats, rice and barley.

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- **Insoluble fiber:** Because of its 'bulking properties', insoluble fiber helps keep us 'regular'. Foods containing insoluble fiber include whole grain and whole meal wheat-based breads, cereals and pasta.
- **Resistant starch:** Resistant starch is a type of starch found in plant foods that escapes digestion in the small intestine. Resistant starch may provide similar benefits to other types of fiber, such as helping to prevent constipation. Foods containing resistant starch include firm bananas, roasted chickpeas, boiled long grain white rice, baked beans, cooked and cooled potato, as well as cornflakes.
- **Flavonoids:** Flavonoids are water soluble plant pigments and are a subgroup of the polyphenol group of plant compounds. Flavonoids are believed to function as antioxidants, and are produced by plants to assist in photosynthesis.
- **Fructose:** Fructose is a type of sugar that is found naturally in fruit and honey.
- **Functional foods:** Functional foods are foods that have been manufactured to contain a specific compound to provide a particular health benefit. Also called nutraceuticals or designer foods.
- **Lactase:** Lactase is the enzyme produced in the small intestine that is required to breakdown lactose.
- **Lactose:** Lactose is the sugar found in milk. The body breaks it down to glucose and galactose.
- **Dietary fiber:** A type of carbohydrate that the body cannot easily digest. It occurs naturally in fruits, vegetables, nuts, seeds, beans, and whole grains.
- **Total sugars:** Which include sugars that occur naturally in foods, such as dairy products, as well as added sugars, which are common in baked goods, sweets, and desserts. The body very easily digests and absorbs sugars.
- **Sugar alcohols:** A type of carbohydrate that the body does not fully absorb. They have a sweet taste and fewer calories than sugar. Sugar alcohols are added to foods as reduced-calorie sweeteners, such as in chewing gum, baked goods, and sweets.

## INTRODUCTION

Carbohydrates are macro-nutrient, containing carbon, hydrogen and oxygen. They are primary energy yielder, present in plant foods as well as animal foods. Polyhydroxy aldehyde or ketones group occurs in some sugar units. Glucose is physiologically significant among carbohydrate. Carbohydrates are the chief, cheapest and main source of energy. Carbohydrate normally should provide 50–60% of total caloric requirements.

**Figure 2.1** is depicted the health benefits of carbohydrates.

All the carbohydrates contain carbon, hydrogen and oxygen. All the carbohydrates are changed in the body to simple form called glucose. Carbohydrates are organic compounds composed of carbon, hydrogen and oxygen with the later elements in the ratio of 2:1. The general formula is $C_nH_{2n}O_n$. They are viewed as hydrated carbon atoms.

Carbohydrates, all coming from the process of photosynthesis, represent the major part of organic substance




**Fig. 2.1:** Health benefits of carbohydrates.

on earth, are the most abundant organic components in the major part of fruits, vegetables, legumes and cereal grains, carry out many functions in all living organisms and are the major energy source for humans in Western diet of Mediterranean type. Finally, they provide flavor and texture in many processed foods.

## DEFINITION AND MEANING OF CARBOHYDRATE

Carbohydrates-fiber, starches and sugars—are essential food nutrients that your body turns into glucose to give you the energy to function. Complex carbs in fruits, vegetables and whole-grain products are less likely to spike blood sugar than simple carbs (sugars). Low-carb diets, such as keto can be high in fats.

## CLASSIFICATIONS OF CARBOHYDRATE (FIG. 2.2)

**Chemical classification of carbohydrates:** Carbohydrates, also called Carbs, are defined as aldehydic or ketonic compounds with some number of oxydrilic groups (so polyhydroxy aldehydes or ketones as well). Many of them, but not all, have general formula $(CH_2O)_n$ (only molecules with are considered carbohydrates); some, in addition to carbon (C), oxygen (O) and hydrogen (H), include nitrogen or sulfur. On the basis of the number of forming units, three major classes of carbohydrates can be defined—monosaccharides, oligosaccharides and polysaccharides. The term "saccharide" derives from the Greek word "sakcharon", which means sugar. Carbohydrates are chemically known as saccharides, they are classified according to number of sugar units present in the molecular structure.

### Oligosaccharides

- Oligosaccharides yield 2–10 molecules of monosaccaride on hydrolysis, e.g., disaccharides (maltose, lactose and, sucrose), trisaccharides (raffinose) and tetrasaccharides (stachyose).
- Oligosaccharides are formed by short chains of monosaccharidic units (from 2 to 20) linked one to the next by chemical bounds, called glycosidic bounds.

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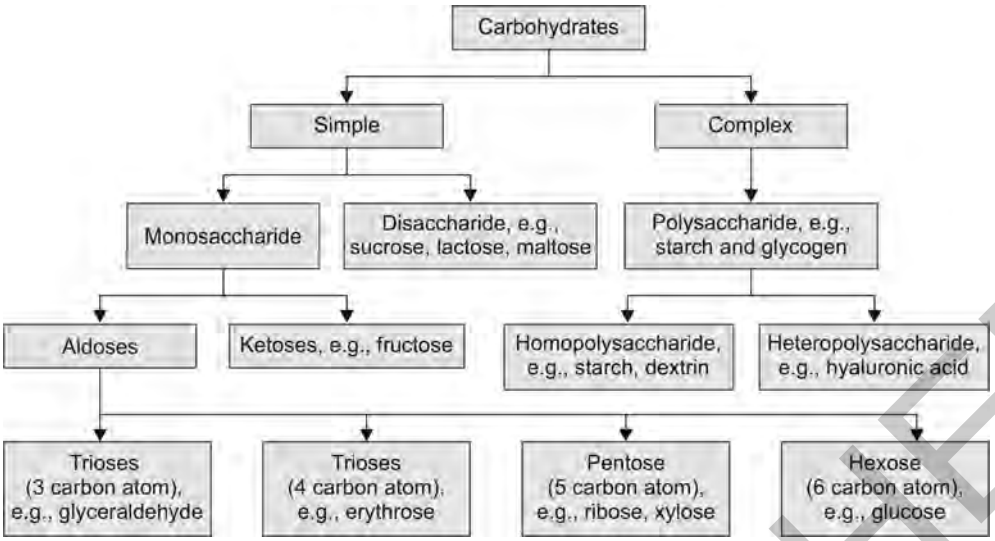


**Fig. 2.2:** Classification of carbohydrates.

- The most abundant oligosaccharides are disaccharides, formed by two monosaccharides, and especially in the human diet the most important are sucrrose (common table sugar), lactose and maltose.
- Within cells many oligosaccharides formed by three or more units do not find themselves as free molecules but linked to other ones, lipids or proteins, to form glycoconjugates.

**Table 2.1** is depicted the classification of oligosaccharides.

### Polysaccharides

- Polysaccharides are polymers consisting of 20 to $10^7$ monosaccharidic units; they differ each other for the monosaccharides recurring in the structure, for the length and the degree of branching of chains or for the type of links between units.
- Whereas in the plant kingdom several types of polysaccharides are present, in vertebrates there are only a small number.
- Polysaccharides are defined homopolysaccharides if they contain only one type of monosaccharide as starch, glycogen and chitin; heteropolysaccharides, instead, contain two or more different kinds (e.g., hyaluronic acid).
- Polysaccharides yield many molecules of monosaccharide on hydrolysis.

**Table 2.1:** Classification of oligosaccharides.

| | *No 'C'* | *Example* | *Type of monosaccharide* |
|---|---|---|---|
| Disaccharides | 2 | Maltose | Glucose + Glucose |
| | | Lactose | Glucose + Galactose |
| | | Lactose | Glucose + Fractose |
| Trisaccharides | 3 | Raffinose | Glu + Fruc + Galactose |
| Tetrasaccharides | 4 | Stachyose | 2 Galactose + Glucose + Fructose |
| Pentasaccharides | | | 3 Galactose + Glucose + Fructose |

1. **Pentosans:** For example, araban, xylan
2. **Hexosans:**
   - Starch, dextrin and glycogen
   - Cellulose, inulin, man

**Complex polysaccharides:** They are not digested by human enzymes, e.g., hemicelluloses, gums, mucilages and pectins.

## CALORIE

The scientific definition of a calorie is a unit of energy, for heat in particular. One calorie is the amount of heat that increases the temperature of 1 kg of water by 1°C, Any food may contain one or more nutrients, but carbohydrates, fats and protein are the nutrients, which gives calories to the body. The caloric value of these nutrients and of any common foods has been determined by burning a known weight of the nutrient or food in an atmosphere of oxygen in what is known as a bomb calorimeter. The caloric values of the nutrients are given in **Table 2.2**.

The following examples of calorie intake are based on US Department of Agriculture (USDA) guidelines: A person's daily calorie intake should be based on age, gender and physical activity level. Men generally need more calories than women and active people need more calories than sedentary (inactive) people.

- Children aged 2 and 8: 1,000–1,400
- Active women aged 14 and 30: 2,400
- Sedentary women aged 14 and 30: 1,800–2,000
- Active men aged 14 and 30: 2,800–3,000
- Sedentary men aged 14 and 30: 2,000–2,600
- Active men and women above 30: 2,200–3,000
- Sedentary men and women 30: 1,800–2,200

**Table 2.2:** Caloric values of the nutrients.

| *Sl. No.* | *Caloric value* | *Kcal/g* |
|---|---|---|
| 1. | Carbohydrate | 4 |
| 2. | Protein | 4 |
| 3. | Fat | 9 |

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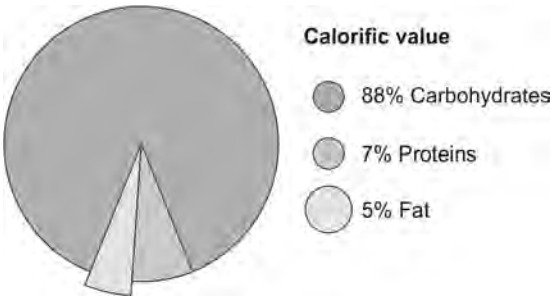


**Fig. 2.3:** Proportion of nutrients.

## Caloric Value

Calories are needed to provide energy so the body functions properly. The number of calories in a food depends on the amount of energy the food provides. The number of calories a person needs depends on age, height, weight, gender, and activity level. People who consume more calories than they burn off in normal daily activity or during exercise are more likely to be overweight. The energy value of a food indicates how much energy the human body can gain through metabolism. The energy value is specified in kilojoules (kJ) per 100 g or 100 mL. In addition, the specification is often in kilocalories (kcal). The total energy value of a food product results from the addition of the energy content of each nutrient components. These are defined as follows:

| | |
|---|---|
| 1 g fat | 37 kJ (9 kcal) |
| 1 g carbohydrates | 17 kJ (4 kcal) |
| 1 g protein | 17 kJ (4 kcal) |
| 1 g alcohol (ethanol) | 29 kJ (7 kcal) |
| 1 g polyhydric alcohols (polyols) | 10 kJ (2.4 kcal) |
| 1 g dietary fiber | 8 kJ (2 kcal) |

For example, fat has a higher calorific value than the same amount of carbohydrates. Calorific value details **Figure 2.3** shows the proportion of nutrients on the calorific value in a small graphic.

## RECOMMENDED DIETARY ALLOWANCES

The RDA for carbohydrates is set at 130 g per day. That is the minimum amount of glucose (the breakdown product of carbohydrate) needed by the brain. Carbohydrate intake is typically higher to meet calorie needs. In a healthy diet, the acceptable range for carbohydrates is set at 45 to 65% of total calories. Carbohydrate from of sugar added to processed foods should not exceed 10% of total calories. Carbohydrate in the form of dietary fiber should measure at least 25 g a day. As carbohydrate is utilized as main source of energy, at least 40% of the total energy in the food should come from carbohydrates. In our country, 60–80% of a day's energy needs are met from carbohydrates in the form of starch furnished by cereals and pulses. In developed countries, only 30–40% of days energy needs are met from carbohydrates.

- The body has a specific need for carbohydrates as a source of energy for the brain and other tissue cells, for synthesis of lactose of milk (lactating women) and galactose and other sugars present in the cerebrosides, mucopolysaccharides, etc.
- Carbohydrate is essential for the oxidation of fat and for the synthesis of certain non-essential amino acids.
- The carbohydrate calories should be at least 40% in well-balanced diets. The level of carbohydrates calories in the diet will also depend on the availability of fat and the economic conditions of the people as fat is about twice as costly as cereals on equicalorie basis in the developing countries and per caput production of fat per day is low (10–15 g).
- The optimal levels of carbohydrates in the diet, taking into physiological needs for proteins and fats.

| *Sl. No.* | *Age group* | *Optimal level calories as per cent of total calories* |
|---|---|---|
| 1. | Adults | 50–70 |
| 2. | Expectant and nursing mothers | 40–60 |
| 3. | Infants (1–12 months) | 40–50 |
| 4. | Pre-school children (1–5 years) | 40–60 |
| 5. | Older children and adolescents | 50–70 |

The RDA daily value percentage listed on food labels can give you a general idea of what percentage the carbohydrates in a single serving of the food will contribute to your overall daily intake. This information is based on a 2,000-calorie diet, which is average for adult males. Women may need slightly less, and as you age, caloric needs continue to decrease. The Recommended Daily Allowances, or RDA, are a part of a larger nutrition system called the Dietary Reference Intake, or DRI, determined by the Institute of Medicine. Because the exact number of carbohydrates needed each day varies from person to person, the DRI is given as a percentage of total daily caloric intakes. Carbohydrates contribute four calories per gram; the USDA recommends that between 45 and 65% of your total caloric intake should come from carbohydrates. Based on a 2,000-calorie diet, this would equate to between 225 and 325 g of carbohydrates daily.

**DRIs actually include four different reference values:**

1. The **RDA**, which is the daily intake of a nutrient sufficient to meet the needs of almost all healthy people in an age and gender group.
2. The **AI**, or **Adequate Intake**, which is used if the RDA cannot be established. This is based on looking at how much of a nutrient healthy people actually eat.
3. The **UL** is the **Tolerable Upper Intake Level**, or the amount of a nutrient that a healthy person can eat without any risk of toxicity.
4. The **EAR**, or **Estimated Average Requirement**, is the amount of a nutrient that is estimated to meet the requirement of half of all healthy individuals in the population.

Of these four reference values, the **RDA, AI** and **UL** are of most use to individuals who want to know a safe and healthy level of nutrient intake. The **EAR** is mainly of use to people who are planning diets for large population groups, or developing new foods.

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Estimated amounts of calories needed to maintain energy balance for various gender and age groups at three different levels of physical activity. The estimates are rounded to the nearest 200 calories and were determined using the Institute of Medicine equation.

| | | Activity level | | |
|---|---|---|---|---|
| *Gender* | *Age (years)* | *Sedentary* | *Moderately active* | *Active* |
| Child | 2–3 | 1,000 | 1,000–1,400 | 1,000–1,400 |
| Female | 4–8 | 1,200 | 1,400–1,600 | 1,400–1,800 |
| | 9–13 | 1,600 | 1,600–2,000 | 1,800–2,200 |
| | 14–18 | 1,800 | 2,000 | 2,400 |
| | 19–30 | 2,000 | 2,000–2,200 | 2,400 |
| | 31–50 | 1,800 | 2,000 | 2,200 |
| | 51+ | 1,600 | 1,800 | 2,000–2,200 |
| Male | 4–8 | 1,400 | 1,400–1,600 | 1,600–2,000 |
| | 9–13 | 1,800 | 1,800–2,200 | 2,000–2,600 |
| | 14–18 | 2,200 | 2,400–2,800 | 2,800–3,200 |
| | 19–30 | 2,400 | 2,600–2,800 | 3,000 |
| | 31–50 | 2,200 | 2,400–2,600 | 2,800–3,000 |
| | 51+ | 2,000 | 2,200–2,400 | 2,400–2,800 |

1. These levels are based on Estimated Energy Requirements (EER) from the Institute of Medicine Dietary Reference Intakes macronutrients report, 2002, calculated by gender, age, and activity level for reference-sized individuals. "Reference size," as determined by IOM, is based on median height and weight for ages up to age 18 years of age and median height and weight for that height to give a BMI of 21.5 for adult females and 22.5 for adult males.
   **Table 2.3** is depicted the sources of carbohydrate.
2. Sedentary means a lifestyle that includes only the light physical activity associated with typical day-to-day life.
3. Moderately active means a lifestyle that includes physical activity equivalent to walking about 1.5 to 3 miles per day at 3 to 4 miles per hour, in addition to the light physical activity associated with typical day-to-day life
4. Active means a lifestyle that includes physical activity equivalent to walking more than 3 miles per day at 3 to 4 miles per hour, in addition to the light physical activity associated with typical day-to-day life.
5. The calorie ranges shown are to accommodate needs of different ages within the group. For children and adolescents, more calories are needed at older ages. For adults, fewer calories are needed at older ages.

**Table 2.3:** Sources of carbohydrate.

| *Sl. No.* | *Age group* | *Optimal level of carbohydrate calories as % of total calories* |
|---|---|---|
| 1. | Adults | 50–70% |
| 2. | Expectant and nursing mothers | 40–60% |
| 3. | Infants (1–12 month) | 40–50% |
| 4. | Preschool children (1–5 years) | 40–60% |
| 5. | Older children and adolescents | 50–70% |

The food groups in the USDA Food Guide are grains; vegetables; fruits; milk, yogurt, and cheese; and meat, poultry, fish, dry beans, eggs, and nuts. Food groups in the DASH Eating Plan are grains and grain products; vegetables; fruits; low-fat or fat-free dairy; meat, poultry, and fish; and nuts, seeds, and dry beans.

The body needs energy to maintain body temperature for metabolic processes to support growth, for functioning of the internal organs, such as heart, kidney, lungs, etc and for physical activity. Energy needs are influenced by factors such as body size, age, climate, extent of physical activity and altered physiological status such as pregnancy and lactation.

**Energy allowance for infants:**

| *Age* | *Kcal/Kg* |
|---|---|
| 3 months | 120 |
| 3–5 months | 115 |
| 6–8 months | 110 |
| 9–11 months | 105 |
| Average during 1st year | 112 |

Recommendation of energy intake of infants is based on breast milk intake. These allowances would form guidelines in feeding children who do not get sufficient breast milk. Usually the breast milk would be sufficient to meet the calorie recommendation up to 5–6 months and later require supplementation with other food stuffs besides milk in order to fulfill not calories but also other nutritional requirements.

| *Age group* | *Body weight (kg)* | *Energy allowance (kcal)* |
|---|---|---|
| 1–3 years | 12.03 | 1220 |
| 4–6 years | 18.87 | 1720 |

The allowances for calories are based on ideal body weight and not on actual body weights.

**Energy allowances for adults:** Recommendation for adults is made on a "Reference man" and "Reference women" who belong to the age group 20–39 years and weighing 55 kg and 45 kg respectively.

**Energy allowances for women performing moderate activity:**

| *Category* | *Energy allowance (kcal)* |
|---|---|
| Women (Normal) | 2200 |
| Pregnancy | 2500 |
| Lactation (1st 6 months) | 2750 |
| 6–12 months | 2600 |

During pregnancy additional energy is needed to support the growth of the fetus, placenta and maternal tissues as well as to meet the increased metabolic rate. 300 extra calories is provided during pregnancy. Extra energy is provided during lactation for encouraging optimum secretion of milk. During the 1st 6 months, the quantity of milk produced by the mother is more and an extra allowance of 550 kcal is made during this period. Since women continue to lactate beyond 6 months, with reduced milk output up to one year, an extra allowance of 400 kcal/day recommended for periods from 6–12 months.

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## SOURCES OF CARBOHYDRATE (FIG. 2.4 AND TABLE 2.4)

Carbohydrates are broken down into three main categories—starches and starchy vegetables, fruits and dairy products. The USDA recommends that at least half of the starches and grains included in your diet be whole grains, such as bran, whole-wheat breads and pastas, brown rice and oatmeal. Other complex carbohydrates recommended include fruits and vegetables and low-fat or fat-free dairy products. On average, each serving provides between 12 and 15 g of carbohydrate, and a serving may be made up of a slice of bread, 1/3 cup of rice or pasta, a cup of milk or a small piece of fresh fruit.

Carbohydrates are classified as simple or complex. The classification depends on the chemical structure of the food, and how quickly the sugar is digested and absorbed. Simple carbohydrates have one (single) or two (double) sugars. Complex carbohydrates have three or more sugars. Examples of single sugars from foods include: Fructose (found in fruits), Galactose (found in milk products).

**Double sugars** include: Lactose (found in dairy), maltose (found in certain vegetables and in beer), sucrose (table sugar), honey is also a double sugar. But unlike table sugar, it contains a small amount of vitamins and minerals. (Note: Honey should not be given to children younger than 1 year old.) Complex carbohydrates often referred to as "starchy" foods, include—legumes, starchy vegetables, whole-grain breads and cereals. Simple carbohydrates that contain vitamins and minerals occur naturally in—fruits, milk and milk products, vegetables.

Simple carbohydrates are also found in processed and refined sugars, such as—candy, regular (nondiet) carbonated beverages, such as soda, syrups, table sugar. Refined sugars provide calories, but lack vitamins, minerals, and fiber. Such simple sugars are often called "empty calories" and can lead to weight gain. Also, many refined foods, such as white flour, sugar, and white rice, lack B vitamins and other important nutrients unless they are marked "enriched." It is healthiest to get carbohydrates, vitamins, and other nutrients in as natural a form as possible—for example, from fruit instead of table sugar.

**Table 2.5** is depicted the food groups suggested by ICMR (2011).

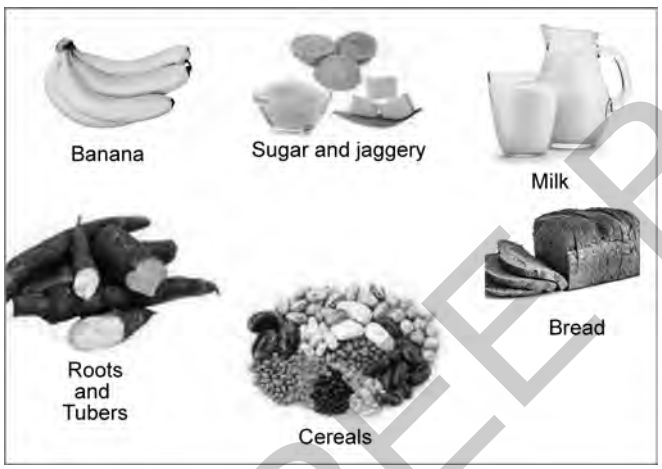


**Fig. 2.4:** Food sources of carbohydrates.

**Table 2.4:** Sources of carbohydrate.

| *Sl. No.* | *Source* | *Percentage* |
|---|---|---|
| 1. | Arrowroot powder | 83% |
| 2. | Sago | 87% |
| 3. | Syrup, jelly, jam | 65–85% |
| 4. | Rice | 79% |
| 5. | Barley, dates dried | 75% |
| 6. | Mango powder | 64% |
| 7. | Ragi | 72% |
| 8. | Tapioca | 38% |
| 9. | Jaggery | 90% |
| 10. | Bread | 55% |
| 11. | Honey | 79% |

**Table 2.5:** Food Groups Suggested by ICMR (2011).

| *Nutrient content of food groups* | *Nutrients* |
|---|---|
| **Cereals, millets and pulses:** | |
| Rice, wheat, ragi, bajra, maize, jowar, barley, rice flakes, wheat flour, breakfast cereals | Energy, protein, invisible fat, vitamin B1, vitamin B2, folic acid, iron, fiber |
| *Pulses and Legumes:* Bengal gram, black gram, green gram, red gram, lentil (whole as well as dhal), cowpea, peas, rajmah, soya bean, beans | Energy, protein, invisible fat, vitamin B1, vitamin B2, folic acid, calcium, iron, fiber |
| **Milk and animal products:** | |
| Milk, curd, skimmed milk, cheese, chicken, liver, fish, egg, meat | Protein, fat, vitamin B1, vitamin B2, calcium, iron |
| **Vegetables and fruits:** | |
| *Fruits:* mango, guava, tomato, papaya, orange, sweet lime, water melon | Carotenoids, vitamin C, fiber, invisible fat, vitamin B2, folic acid, Iron |
| *Green leafy vegetables:* Amaranth, spinach, gogu, drumstick leaves, coriander leaves, fenugreek leaves | Carotenoids, vitamin B2, folic acid, calcium, iron, fiber |
| *Other vegetables:* Carrots, brinjal, ladies finger, beans, capsicum, onion, drumstick, cauliflower | Carotenoids, folic acid, calcium, fiber |
| **Oils, fats and nuts:** | |
| *Fats:* Butter ghee, hydrogenated fat, cooking oils, such as groundnut, mustard, sunflower | Energy, fat, essential fatty acids |
| *Sugar:* Jaggery and cane-sugar | Energy |
| Almonds, walnuts and gingelly seeds | Protein, ω-3 fatty acids |

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## FUNCTIONS OF CARBOHYDRATE

Carbohydrates perform the following functions **(Box 2.1).**

- **Yield energy:** Yield energy—principle function of carbohydrates is to serve as a major source of energy for the body. Each gram of carbohydrate yields 4 kcal of energy regardless of its source. In Indian diets, 60–80% of energy is derived from carbohydrate.
- **Glucose maintenance:** Glucose maintenance is indispensable for the maintenance of the functional integrity of the nervous tissue and is the sole source of energy for the proper functioning of the brain. Prolonged lack of glucose may cause irreversible damage to the brain.
- **Protein sparing action:** Carbohydrates exert a protein sparing action. If sufficient amounts of carbohydrates are not available in the diet, the body will convert protein to glucose in order to supply energy. Hence to spare proteins for tissue building, carbohydrates must be supplied in optimum amounts in the diet. This is called the protein sparing action of carbohydrates.
- **Fat metabolism:** Carbohydrates are essential to maintain normal fat metabolism. Insufficient carbohydrates in the diet results in larger amounts of fat being used for energy than the body are equipped to handle. This leads to accumulation of acidic intermediate products called ketone bodies.
- **Synthesis of body substances:** Carbohydrates aid in the synthesis of non-essential amino acids, glycoproteins (which function as antibodies) and glycolipids (which form a part of cell membrane in body tissues especially brain and nervous system). Lactose remains in the intestine longer than other disaccharides and thus encourages growth of beneficial bacteria.
- **Precursors of nucleic acid:** Carbohydrates and products derived from them, serve as precursors of compounds, such as nucleic acids, connective tissue matrix and galactosides of nervous tissue.
- **Detoxification function:** Glucuronic acid, a metabolite of glucose serves as a detoxifying agent. It combines with harmful substances containing alcohol or phenolic group converting them to harmless compounds, which are later excreted.
- **Roughage of the diet:** Insoluble fibers known as composite carbohydrates can absorb water and give bulk to the intestinal contents, which aids in the elimination of waste products by stimulating peristaltic movements of the gastrointestinal tract.
- **Other roles:** Carbohydrate has a variety of functions in the animal and human body. It plays crucial role in biological system they are:
  - 1 g of carbohydrate provides 4 kcal on oxidation.
  - Protein sparing action helps to regulate protein metabolism. When carbohydrate and fat is adequate amount in the diet, major protein is used for tissues building.
  - Ketone body from fat metabolism is prevented when carbohydrate is sufficient.

**Box 2.1:** Functions of carbohydrates in the human body.

- Carbohydrate oxidation provides energy
- Carbohydrate storage, in the form of glycogen, provides a short-term energy reserve
- Carbohydrates supply carbon atoms for the synthesis of other biochemical substances (proteins, lipids, and nucleic acids)
- Carbohydrates form part of the structural framework of DNA and RNA molecules
- Carbohydrates linked to lipids are structural components of cell membranes
- Carbohydrates linked to proteins function in a variety of cell-cell and cell-molecule recognition processes

| *Name of the polysaccharide* | *Composition* | *Occurrence* | *Function* |
|---|---|---|---|
| Starch | Polymer of glucose containing a straight chain of glucose molecules and a branched chain of glucose molecules | In several plant species as main storage carbohydrate | Storage of reserve food |
| Glycogen | Polymer of glucose | Animals (eq. of starch | Storage of reserve food |
| Callose | Polymer of glucose | Different regions of plant, in sieve tubes of phloem | Formed often as a response to wounds |
| Insulin | Polymer of fructose | In roots and tubers | Storage of reserve food |
| Cellulose | Polymer of glucose | Plant cell wall | Cell wall matrix |
| Hemicellulose | Polymer of pentoses and sugar acids | Plant cell wall | Cell wall matrix |

- Pentose carbon-5 sugar is utilized in formation of DNA and RNA.
- It supplies fuel to brain tissues, otherwise irreversible damage occurs.
- If carbohydrate exceeds the normal requirement, fat synthesis in adipose tissue.
- Lactose in gastrointestinal tract promotes the growth of bacteria, which is responsible for the synthesis of B-complex vitamins.
- Complex polysaccharides cellulose and hemicellulose contribute bulk to the stool.
- Carbohydrate in well-balanced diet keeps the blood sugar level within normal limits

## DIGESTION AND ABSORPTION OF CARBOHYDRATE

**Digestion:**

- The first stage of digestion of carbohydrate takes place in the mouth. Chewing breaks up food and exposes starch

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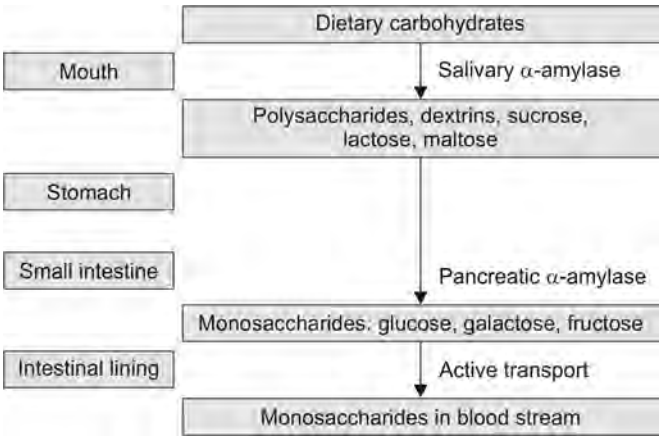


**Fig. 2.5:** Digestion of carbohydrate.

and sugars to the action of enzymes. Saliva contains salivary amylase (ptyalin).

- It converts starch to maltose, but time limits the action of salivary amylase, because as food enters the stomach, the acid present in the stomach blocks the action of salivary amylase.
- In the stomach, the acid causes hydrolysis of sucrose. In the small intestine, pancreatic amylase and intestinal amylase digest starch up to the stage of maltose.
- Starch salivary, pancreatic maltose + Isomaltose and intestinal amylase
- Glycogen is also broken by these enzymes to disaccharides. Enzymes maltase, sucrase and lactase present in the brush borders of the columnar cells of small intestine convert disaccharides to monosaccharides.
  **Maltase:** Maltose glucose + Glucose
  **Lactase:** Lactose glucose + Galactose
  **Sucrase:** Sucrose glucose + Fructose
- Cellulose and other polysaccharides are not digested by enzymes, so undigested material passes to large intestine forming bulk, which contributes to feces.
- The end products of carbohydrate digestion are monosaccharides—glucose, galactose and fructose. They are absorbed by process of active absorption by the mucosa of the small intestine.

**Figure 2.5** is depicted the digestion of carbohydrate.

### Metabolism

Metabolism occurs inside the various cells of the body. There are two types of metabolism—anabolism (building up) and catabolism (breaking down).

1. The major carbohydrate anabolic path ways are conversion of glucose into glycogen (glycogenesis) is tale place in the liver and muscles.
2. The conversion of glucose into fat (lipogenesis) in the liver and adipose tissue.
3. Carbohydrates follow two major catabolic pathways:
   a. The breakdown of glucose releasing energy (glycolysis) and converting it into usable energy (ATP) and the converting into of glycogen glucose (glycogenolysis).
   b. After digestion and absorption of glucose into the blood stream it is utilized directly by the tissues for energy. When the absorbed glucose exceeds the body's need for energy, it is stored as glycogen in the liver and muscle and excess glucose is converted to triglycerides and stored as fat in adipose tissue.

### Glucose Formation from Non-carbohydrate Sources

- Glucose can be formed the metabolism of protein and from the glycerol of fat. It has been estimated that the glycerol present in 100 g of fat can give rise to 50–60 g glucose.
- Lactate which is formed from glucose can be reconverted into glucose in the liver.

## REGULATION OF BLOOD SUGAR

- Blood circulates glucose continuously to each and every cell of the body as a source of energy and for the synthesis of a number of substances.
- In fasting state blood sugar level is 60–85 mg/100 mL of blood. Soon after a meal it raises to 140–150 mg/100 mL.
- If the body is in a good carbohydrate metabolic pathway this concentration will fall down to a normal blood sugar level of 60–85 mg/100 mL.
- The liver very efficiently maintains the normal blood sugar level. The liver is the only organ in our body, which can either supply glucose to the circulation or to remove the excess sugar from blood.
- If the blood sugar concentration is high this condition is known as hyperglycemia. Hypoglycemia occurs when the blood sugar level is below normal level. This occurs in certain abnormalities of liver function or when insulin is produced in excessive amount by the pancreas.

### Glucose Tolerance Test (Fig. 2.6)

Glucose tolerance test (GTT) is done to detect the abnormalities of carbohydrate metabolism.

**Indications:** 1. Hypoglycemia, 2. Diabetes mellitus, 3. Adrenocortical diseases.




**Fig. 2.6:** Glucose tolerance test.

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**Preparation of the patient**

- At least 2 weeks of good health is desirable in the patient prior to the test. Patient with inadequate dietary intake may show high curve than normal.
- They should receive a high carbohydrate diet for at least 3 days prior to the test and then the patient should fast 8 to 12 hours.
- On the previous day of the test, approximately 12 hours prior to the test, the patient is given evening meal. Thereafter no food is allowed until the test is over.
- On the day of test, the patient should not have even black coffee or tea and should not smoke.
- Undue exercise and mental stress should be avoided and the patient should relax for 30 minutes before the test is started.

## General Instructions

- The GTT test curve shows abnormal in thyroid diseases, adrenal insufficiency, hyper functioning of the adrenal cortex, excess insulin due to pancreatic tumors, physical and mental stress.
- The abnormal GTT curve also seen in patients receiving diuretics, glucocorticoids, estrogens, oral-contraceptives, etc.
- Patient should be monitored for hypoglycemic reactions, such as profuse. Sweating and dizziness, a drop in blood sugar much below normal and must be watched.
- The glucose (dextrose) could be given intravenously at the dose of 0.2 g/kg body weight, as 50% glucose solution. intravenous administration of glucose given for patients with decreased absorption of sugar from the intestine.
- The GTT test should not be performed on patients with intital fasting blood sugar of over 200 mg/dL.
- The delayed return (beyond 2 hours) of blood glucose to a fasting (if normal) level indicates abnormal glucose tolerance.

**Factors affecting GTT test:**

- **Coffee and tea:** These substances alter the body's response to carbohydrate.
- **Stress control:** Because epinephrine and cortisone that are released will raise the blood sugar.

**What the numbers mean in tests for diabetes:** Each test to detect diabetes and prediabetes uses a different measurement. Usually, the same test needs to be repeated on a second day to diagnose diabetes. Your doctor may also use a second test method to confirm that you have diabetes. This table does not apply to pregnant women. Glucose values are in milligrams per deciliter, or mg/dL.

| *Diagnosis* | *A1C* | *Fasting plasma glucose (FPG)* | *Oral glucose tolerance test (OGTT)* | *Random plasma glucose test (RPG)* |
|---|---|---|---|---|
| Normal | Below 5.7% | 99 or below | 139 or below | |
| Prediabetes | 5.7% to 6.4% | 100 to 125 | 140 to 199 | |
| Diabetes | 6.5% or above | 126 or above | 200 or above | 200 or above |

***Soruce:*** American Diabetes Association.

## Procedure

**On the day of the test:**

- Obtain the fasting blood and urine specimen and label them with time.
- Administer 100 g of glucose by mouth, diluted in lemon juice.
- Obtain blood and urine specimens at half, 1, 2 and 3 hours after giving the glucose.
- The patient may encouraged to drink water to promote urine excretion at the required times.

## Interpretation

**In normal person:**

- In a normal individual the fasting blood sugar will be 55 to 110 mg/dL.
- In first hour, the maximum blood sugar level reached after the oral glucose intake. It blood sugar level will be 140 to 180 mg/dL (usually not more than 160 mg/dL).
- The blood sugar level returns to normal fasting limits after I hour or at least by 2 hours.
- There is usually no sugar in any of the urine specimens in normal persons.

**In diabetic mellitus:**

- In the post-oral glucose period, the blood sugar level is rises to a peak much higher than 160 mg/dL.
- Sometimes it may reach high as 400 mg/dL and does not return to normal by the second or third hour.
- All the specimens of urine will contain glucose.

## Deficienies of Carbohydrate

Low level of glucose (40 mg% or below) in the blood is called hypoglycemia. This is not common in healthy individual. Diabetic people may get this condition on poor or irregular treatment. The signs and symptoms of diabetes are tiredness, convulsions, dizziness, tingling, faintness, headache, firmness, tachycardia, palpation, confusion, slurred speech, staggering gait, lack of coordination and coma.

**Figure 2.7** is depicted the main symptoms of diabetes.

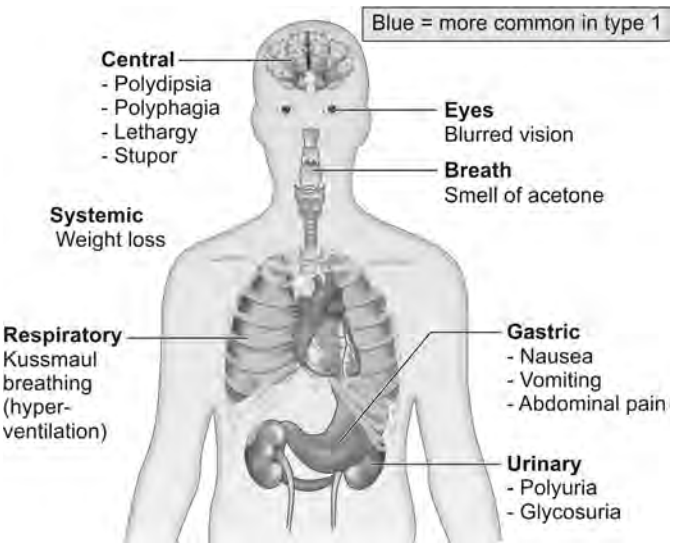


**Fig. 2.7:** Main symptoms of diabetes.

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**Diabetes mellitus:**

- Diabetes mellitus is a chronic disease in which blood glucose level is raised above 180 mg/dL of blood and glucose is excreted in urine.
- The disease is primarily due to the insufficient production of the hormone, insulin by the beta-cells of the islets of langerhans of the pancreas.
- The two types of diabetes are referred to as type 1 and type 2. Former names for these conditions were insulin-dependent and non-insulin-dependent diabetes, or juvenile onset and adult onset diabetes.
- Symptoms of diabetes include increased urine output, thirst, hunger, and fatigue.
- Diabetes is diagnosed by blood sugar (glucose) testing. The major complications of diabetes are both acute and chronic.

**Acute complications:** Dangerously elevated blood sugar (hyperglycemia) or abnormally low blood sugar (hypoglycemia) due to diabetes medications

**Chronic complications:** Disease of the blood vessels (both small and large) that can damage the feet, eyes, kidneys, nerves, and heart. Diabetes treatment depends on the type and severity of the diabetes. Type 1 diabetes is treated with insulin, exercise, and a diabetic diet. Type 2 diabetes is first treated with weight reduction, a diabetic diet, and exercise. When these measures fail to control the elevated blood sugars, oral medications are used. If oral medications are still insufficient, insulin and other injectable medications are considered.

**Complications linked to badly controlled diabetes:**

- **Eye complications**—glaucoma, cataracts, diabetic retinopathy, and some others.
- **Foot complications**—neuropathy, ulcers, and sometimes gangrene which may require that the foot be amputated
- **Skin complications**—people with diabetes are more susceptible to skin infections and skin disorders
- **Heart problems**—such as ischemic heart disease, when the blood supply to the heart muscle is diminished
- **Hypertension**—common in people with diabetes, which can raise the risk of kidney disease, eye problems, heart attack and stroke
- **Mental health**—uncontrolled diabetes raises the risk of suffering from depression, anxiety and some other mental disorders
- **Hearing loss**—diabetes patients have a higher risk of developing hearing problems
- **Gum disease**—there is a much higher prevalence of gum disease among diabetes patients
- **Gastroparesis**—the muscles of the stomach stop working properly
- **Ketoacidosis**—a combination of ketosis and acidosis; accumulation of ketone bodies and acidity in the blood.
- **Neuropathy**—diabetic neuropathy is a type of nerve damage which can lead to several different problems.
- **HHNS (Hyperosmolar Hyperglycemic Nonketotic Syndrome)**—blood glucose levels shoot up too high, and there are no ketones present in the blood or urine. It is an emergency condition.
- **Nephropathy**—uncontrolled blood pressure can lead to kidney disease
- **PAD (peripheral arterial disease)**—symptoms may include pain in the leg, tingling and sometimes problems walking properly
- **Stroke**—if blood pressure, cholesterol levels, and blood glucose levels are not controlled, the risk of stroke increases significantly
- **Erectile dysfunction**—male impotence
- **Infections**—people with badly controlled diabetes are much more susceptible to infections
- **Healing of wounds**—cuts and lesions take much longer to heal

**Figure 2.8** is depicted the complications of diabetes and **Figure 2.9** is depicted the major complications of diabetes.

## Energy

Energy is defined as the capacity for doing work. It is the heat produced in the body, which is utilized for performing the involuntary and voluntary activities, to maintain body temperature to synthesize new body constituents.

### *Definitions*

- **Unit:** The standard quantity (constant quality), used for comparison is called unit.
- **Measurement:** Measurement is the comparison of an unknown quantity with a known standard quantity (constant quantity) or unit.
- **GCS system:** This system is generally adopted for smaller measurement of mass, length and time. In this system, C stands for centimeter (length), G-stands for gram (mass), and S-stands for seconds (time).
- **MKS system:** In this system, M-stands for meter (length); K-stands for kilogram (mass) and S-stands for second (time). This system is generally adopted for longer measurements.

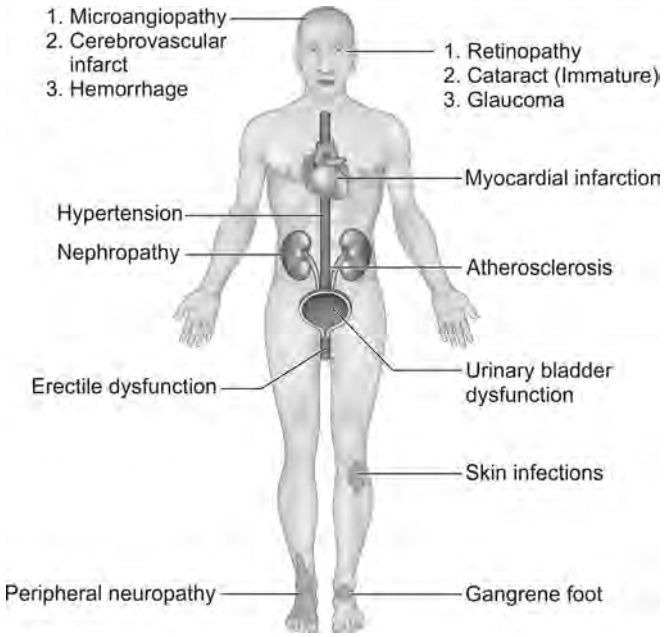


**Fig. 2.8:** Complications of diabetes.

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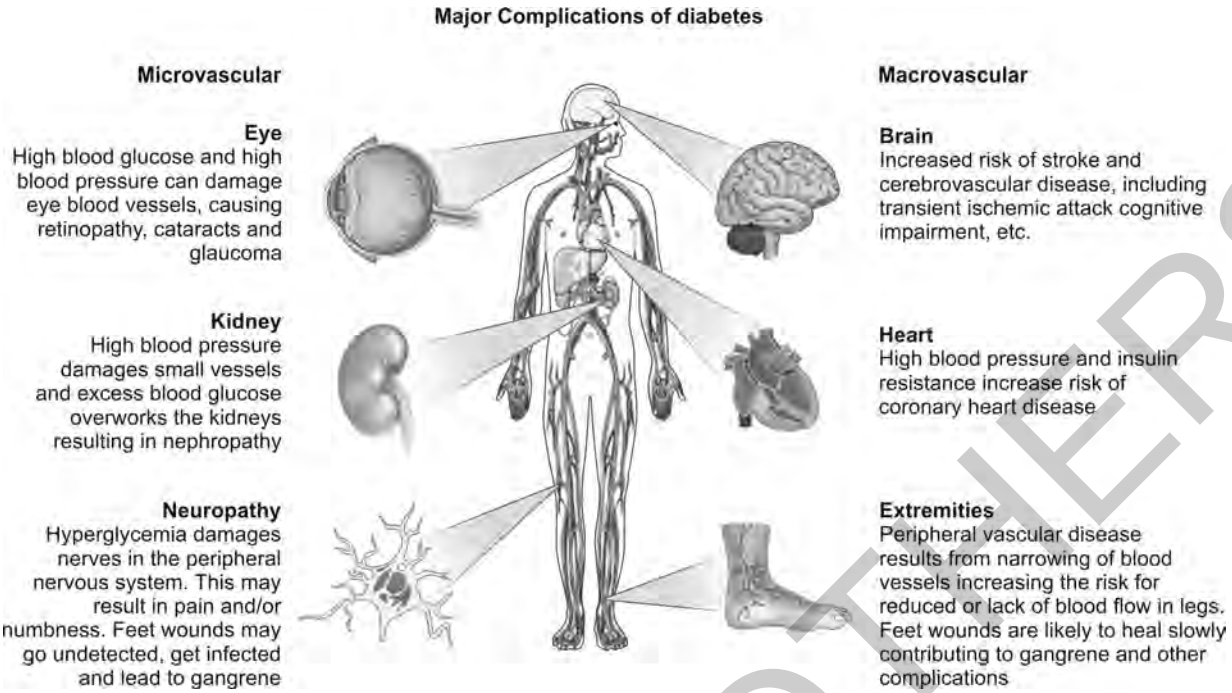


**Fig. 2.9:** Major complications of diabetes.

- **SI system:** It is standard international system, in this system the units of mass, length and time are same, as that of MKS system.
- **Fundamental unit:** A unit which is indepentable of any other unit, or which can neither be changed nor related to any other fundamental unit, is a fundamental unit.
- **Basal metabolic rate (BMR):** The minimal rate of energy expenditure compatible with life. It is measured in the supine position under standard conditions of rest, fasting, immobility, thermoneutrality and mental relaxation. Depending on its use, the rate is usually expressed per minute, per hour or per 24 hours.
- **Body mass index (BMI):** The indicator of weight adequacy in relation to height of older children, adolescents and adults. It is calculated as weight (in kilograms) divided by height (in meters), squared. The acceptable range for adults is 18.5 to 24.9, and for children it varies with age.
- **Doubly labeled water (DLW) technique:** A method used to measure the average total energy expenditure of free-living individuals over several days (usually 10 to 14), based on the disappearance of a dose of water enriched with the stable isotopes $^{2}H$ and $^{18}O$.
- **Energy requirement (ER):** The amount of food energy needed to balance energy expenditure in order to maintain body size, body composition and a level of necessary and desirable physical activity, and to allow optimal growth and development of children, deposition of tissues during pregnancy, and secretion of milk during lactation, consistent with long-term good health. For healthy, well-nourished adults, it is equivalent to total energy expenditure. There are additional energy needs to support growth in children and in women during pregnancy, and for milk production during lactation.
- **Heart rate monitoring (HRM):** A method to measure the daily energy expenditure of free-living individuals, based on the relationship of heart rate and oxygen consumption and on minute-by-minute monitoring of heart rate.
- **Total energy expenditure (TEE):** The energy spent, on average, in a 24-hour period by an individual or a group of individuals. By definition, it reflects the average amount of energy spent in a typical day, but it is not the exact amount of energy spent each and every day.
- **Physical activity level (PAL):** TEE for 24 hours expressed as a multiple of BMR, and calculated as TEE/BMR for 24 hours. In adult men and non-pregnant, non-lactating women, BMR times PAL is equal to TEE or the daily energy requirement.
- **Physical activity ratio (PAR):** The energy cost of an activity per unit of time (usually a minute or an hour) expressed as a multiple of BMR. It is calculated as energy spent in an activity/BMR, for the selected time unit.

## UNITS OF ENERGY

The words "power" and "energy" are often used interchangeably. While energy in the ability to do work, power is the rate at which energy is transferred, used, or transformed. Energy is defined as the capacity of a system to perform work. Suppose a body having mass M kg moving with a linear velocity of v meter/sec so its energy is in the form of kinetic energy which is equal to KE = 21 $mv^2$. SI unit of energy is Joule. CGS unit of energy is erg.

**Example of a unit of energy:** A related unit is the Watt, which is a unit of power (energy per unit time). Power units can be converted to energy units through multiplication by seconds [s], hours, [h], or years [yr]. For example, 1 kWh [kilowatt hour]

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= 3.6 MJ [mega Joule]. The energy value of food is expressed in terms of kilocalories (kcal or C). A kilocalorie is defined as the amount of heat required to raise the temperature of 1 kg of water by 10°C. In the metric system, the international unit, which is kilojoules, is used instead of kilocalories. Kilojoules energy is expended when 1 kg of mass is moved by 1 meter using a force of a Newton.

- 1 Calorie = 4.184 Joule
- 1 kcal or C = 4.184 kjoule
- 1,000 kcal or C = 4.184 MJoule
- 1 MJoule = 239 kcal

**Joule (J):** This is the basic energy unit of the metric system, or in a later more comprehensive formulation, the International System of Units (SI). It is ultimately defined in terms of the meter, kilogram, and second.

**Calorie (cal):** Historically the calorie was defined in terms of the heating of water. Thus, in a traditional definition, one calorie is the amount of heat required to raise the temperature of 1 gram of water by 1°C, from 14.5°C to 15.5°C. (This is sometimes referred to as the 15°C calorie, and differs slightly from the "calorie" measured for other temperature intervals.) More recently the calorie has been defined in terms of the joule; the equivalence between the calorie and joule is historically known as the mechanical equivalent of heat.

## Energy Requirements of Different Categories of People

An adequate, healthy diet must satisfy human needs for energy and all essential nutrients. Furthermore, dietary energy needs and recommendations cannot be considered in isolation of other nutrients in the diet, as the lack of one will influence the others. Thus, the following definitions are based on the assumption that requirements for energy will be fulfilled through the consumption of a diet that satisfies all nutrient needs.

**Energy requirement** is the amount of food energy needed to balance energy expenditure in order to maintain body size, body composition and a level of necessary and desirable physical activity consistent with long-term good health. This includes the energy needed for the optimal growth and development of children, for the deposition of tissues during pregnancy, and for the secretion of milk during lactation consistent with the good health of mother and child.

| *Scenario* | *Physical activity level* |
|---|---|
| Sedentary | Light physical activity associated with daily living, 1976–2003 |
| Moderately active | Walking 2.4 to 4.8 km/d in addition to light physical activity associated with daily living, 1976–2003 |
| Active | Walking >3.8 km/d in addition to light physical activity associated with daily living, 1976–2003 |
| Moderate → sedentary | Progressing from moderate physical activity level in 1976 to sedentary physical activity level in 2003 |

**The recommended level of dietary energy intake** for a population group is the mean energy requirement of the healthy, well-nourished individuals who constitute that group. Based on these definitions, a main objective for the assessment of energy requirements is the prescription of dietary energy intakes that are compatible with long-term good health. Therefore, the levels of energy intake recommended by this expert consultation are based on estimates of the requirements of healthy, well-nourished individuals. It is recognized that some populations have particular public health characteristics that are part of their usual, "normal" life. Foremost among these are population groups in many developing countries where there are numerous infants and children who suffer from mild to moderate degrees of malnutrition and who experience frequent episodes of infectious diseases, mostly diarrhoeal and respiratory infections. Special considerations are made in this report for such sub-populations.

**Daily energy requirements and daily energy intakes:** Energy requirements and recommended levels of intake are often referred to as daily requirements or recommended daily intakes. These terms are used as a matter of convention and convenience, indicating that the requirement represents an average of energy needs over a certain number of days, and that the recommended energy intake is the amount of energy that should be ingested as a daily average over a certain period of time. There is no implication that exactly this amount of energy must be consumed every day, nor that the requirement and recommended intake are constant, day after day. Neither is there any biological basis for defining the number of days over which the requirement or intake must be averaged. As a matter of convenience, taking into account that physical activity and eating habits may vary on some days of the week, periods of seven days are often used when estimating the average daily energy expenditure and recommended daily intake.

**Energy requirements of children:** Although children of all ages grow rapidly, their energy needs vary. For example, the amount of energy needed—on a per kilogram (pound) basis—by an 18-year-old teenager is much lower than that of an 18-month-old toddler. Babies double their body weight over a few months, whereas older children and adolescents may double their weight over five to ten years.

| *Age* | *Boys per day* | *Girls per day* |
|---|---|---|
| **0–3 months** | 545 calories | 515 calories |
| **4–6 months** | 690 calories | 645 calories |
| **7–9 months** | 825 calories | 765 calories |
| **10–12 months** | 920 calories | 865 calories |
| **1–3 years** | 1230 calories | 1165 calories |
| **4–6 years** | 1715 calories | 1545 calories |
| **7–10 years** | 1970 calories | 1740 calories |
| **11–14 years** | 2220 calories | 1845 calories |
| **15–18 years** | 2755 calories | 2110 calories |

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# Applied Nutrition, Dietetics and Biochemistry
## for Basic BSc NURSING

**Highlights of the Book**

- This textbook has been written as per Indian Nursing Council (INC) new syllabus and explains the basic principles of biochemistry, nutrition and dietetics and their application to health and disease.
- It has 23 chapters presenting core information to introduce basic concepts and thereby apply the acquired knowledge in nursing practice.
- This book helps for the nursing students to acquire knowledge of the normal biochemical composition and functioning of human body, its alterations in disease conditions and to apply this knowledge in the practice of nursing.
- This text is comprehensively updated to meet the constantly changing health needs of people.
- This book has been framed carefully in simple language with adequate tables, diagrams, chemical structures and clinical aspects for easy understanding of the basic nutrition and biochemistry.
- The content has been reorganized and significant changes have been made during the development of the text to include addition of a new section on biochemistry and recent updates in the nutrition section as per the revised syllabus outlined by the Indian Nursing Council.
- This book can be used by students and teachers of biochemistry, nutrition, dietetics, nursing, medicine, and other health sciences.
- Chapter-end summaries for quick review and self-assessment (review questions) section as per university examination pattern.

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