Nutrition

Nutrition is the science of food and the nutrients and other substances contained in food, it is the study of their actions, interactions and balance in relation to health and disease, thus, nutrition is concerned with the digestion, absorption, transport, metabolism and functions performed by the essential nutrients, the macronutrients are proteins, fats and carbohydrates, they form the main bulk of food, micronutrients are vitamins and minerals; they are called micronutrients because they are required in small amounts which may vary from a microgram to several grams, vitamins and minerals do not supply energy but they play an important role in the regulation of the metabolic activity in the body and help in the utilization of proteins, fats and carbohydrates, minerals are also used for the formation of body structure and skeleton

Globally, undernutrition is widespread, leading to impaired growth, defective immune systems, and reduced work capacity, by contrast, in developed countries, there is often excessive food consumption (especially of fat), leading to obesity and to the development of cardiovascular disease and some forms of cancer.

Digestion, absorption of carbohydrate

Dietary carbohydrate is two types:

1. Available or digestible carbohydrate

   The digestible carbohydrates are a major source of food energy, yielding 4 kcal/gm of the energy requirement, in addition, these carbohydrates have protein sparing effect.

2. Unavailable or undigestible carbohydrate.

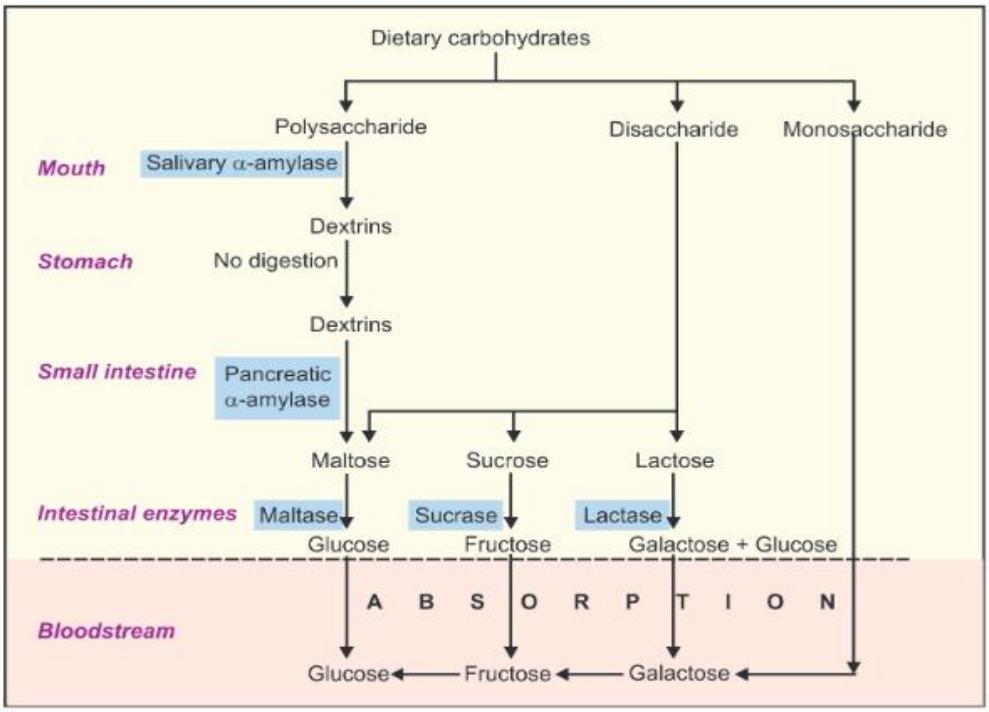
   Unavailable or undigestible carbohydrates provide dietary fiber, fiber is not digested by the digestive enzymes and does not serve as a source of energy, it is however a significant component of the diet.

Dietary fiber is the name given collectively to indigestible carbohydrates present in foods, these carbohydrates consist of cellulose, pectin, gums, and mucilages, the dietary fiber is not digested by the enzyme of the human gastrointestinal tract, where most of the other carbohydrates like starch, sugars are digested and absorbed, plant foods are the only sources of dietary fiber, it is found in vegetables, fruits, and grains, the dietary fibers have a property of holding water and swell like sponge with a concomitant increase in viscosity, thus, fiber adds bulk to the diet and increases transit time in the gut (gastric emptying time) due to high viscosity.

The increase in blood glucose after a test dose of a carbohydrate compared with that after an equivalent amount of glucose is known as the **glycemic index,**

- **g**lucose and galactose have an index of 1.
- lactose, maltose, isomaltose, and trehalose, which give rise compared with these Monosaccharides on hydrolysis.
- fructose and the sugar alcohols are absorbed less rapidly and have a lower glycemic index.

- The digestion of polysaccharides like starch by **salivary** and **pancreatic amylases** catalyzes random hydrolysis of (1→4) glycoside bonds, yielding dextrins, then a mixture of glucose, maltose, and isomaltose.
- the disaccharidases: maltase, sucrase lactase (enzyme catalyzing hydrolysis of maltose, sucrose, lactose), lactase is gradually lost through adolescence, leading to lactose intolerance, then lactose remains in the intestinal lumen, where it is a substrate for bacterial fermentation to lactate, resulting in discomfort and diarrhea.
- Glucose and galactose are absorbed by a sodium-dependent process, they are carried by the same active transport (GLT 1), other monosaccharides are absorbed by facillated diffusion, because they are not actively transported.



Flow sheet of digestion of carbohydrates

Digestion, absorption of lipid

Little or no digestion occurs in the mouth or stomach, the major site of lipid digestion is the small intestine, where dietary lipid undergoes its major digestive processes using enzymes secreted by pancreas.

The major lipids in the diet are triacylglycerols and to a lesser extent, phospholipids, these are hydrolyzed and emulsified to very small droplets (micelles) before they can be absorbed, the fat-soluble vitamins (A, D, E, and K) and a variety of other lipids (including cholesterol) are absorbed dissolved in the lipid micelles, hydrolysis of triacylglycerols is initiated by **lingual** and **gastric lipases** and **then to Pancreatic lipase** is secreted into the small intestine, less than 25% of ingested triacylglycerol is completely hydrolyzed to glycerol and fatty acids, in addition bile salts allow the products of digestion, including the fat soluble vitamins pass on to the ileum, where most are absorbed into the **enterohepatic circulation** .All long-chain fatty acids absorbed are converted to triacylglycerol in the mucosal cells secreted as chylomicrons.

Dietary fats are high energy yields 9kcal/gm, besides satisfying metabolic energy needs, there are two essential functions of dietary fat, namely, to provide:

- A vehicle for the absorption of the fat soluble vitamins (A, D, E and K).
- To supply essential fatty acids, linoleic acid and linolenic acid to the body.

Digestion, absorption of protein

Proteins are vital to any living organism, proteins are important constituent of tissues and cells of the body, they form the important component of muscle and other tissues and vital body fluids like.

Protein also form of enzymes and hormones are concerned with wide range of vital metabolic processes in the body, protein as antibodies helps the body to defend against infections also supply essential and nonessential amino acids for the synthesis of protein and nitrogen for the synthesis of several key compounds such as neurotransmitter and heme, thus, proteins are one of the most important nutrient required by the body and should be supplied in the diet.

Any amino acid that humans either cannot synthesize or unable to synthesize in adequate quantity is termed "essential" and rest of the amino acids are called "nonessential" as they can be formed in the body, an essential amino acid must be provided in the diet, an absence of an essential amino acid from the diet impairs protein synthesis, there are eight essential amino acids, which cannot be synthesized in the body:

Table 11.2 : Minimum requirement of essential amino acids

Essential amino acid	*Requirement (mg / kg body weight / per day)*
Phenylalanine	14
Leucine	11
Lysine	9
Valine	14
Isoleucine	10
Threonine	6
Methionine	14
Tryptophan	3

The peptide bond can be hydrolyzed by Proteolytic digestive enzymes (proteases), endopeptidases and exopeptidases hydrolyze peptide bonds between specific amino acids throughout the molecule.
Enzymes hydrolysis large molecules to small fragments, eg, pepsin in the gastric juice and trypsin, chymotrypsin when elastase secreted into the small intestine by the pancreas, free amino acids are absorbed across the intestinal mucosa by sodium-dependent active transport.

Digestion &absorption of vitamin and minerals

Vitamins and minerals are released from food; the availability of vitamins and minerals depends on the type of food, the fat-soluble vitamins (A,E,D,K) are absorbed in the lipid micelles that result from fat digestion; water-soluble vitamins (B, C) and most mineral salts are absorbed from the small intestine either by active transport or by facillated diffusion followed by binding to intracellular binding proteins to achieve concentration upon uptake, vitamin B12 absorption requires a specific transport protein.
Like vitamins, minerals are substances found in food that body needs for growth and health, there are two kinds of minerals, macrominerals and trace minerals, macrominerals are minerals that body needs in larger amounts, they include calcium, phosphorus, magnesium, sodium, potassium, and chloride, also the body needs just small amounts of trace minerals, these include iron, copper, iodine, zinc, fluoride, and selenium shown in Table.

Minerals and their actions

Calcium	• Needed for forming bones and teeth
Chloride	• Needed for keeping the right amounts of water in the different parts of your body
Copper	• Helps protect cells from damage
Fluoride	• Needed for forming bones and teeth
Iodine	• Needed for thyroid gland function
Iron	• Helps red blood cells deliver oxygen to body tissues

Magnesium	• Needed for forming bones and teeth
Phosphorus	• Needed for forming bones and teeth
Potassium	• Needed for keeping the right amounts of water in the different parts of your body
Selenium	• Helps protect cells from damage
Sodium	• Needed for keeping the right amounts of water in the different parts of your body
Zinc	• Needed for wound healing and helps your body fight off illnesses and infections

Although iron deficiency is a common problem, about 10% of the population are genetically at risk of iron overload **(hemochromatosis),** once the **ferritin** in the cell is saturated with iron, no more can enter, iron can only leave the mucosal cell if there is **transferrin** in plasma to bind to, once transferrin is saturated with iron, any that has accumulated in the mucosal cells will be lost, as a result of this mucosal barrier, only about 10% of dietary iron is normally absorbed and only 1–5% from many plant foods, inorganic iron is absorbed only in the Fe2+ (reduced) state, the iron (Fe2+) entering the mucosal cells by absorption is oxidized to ferric form (Fe3+) by the enzyme ferroxidase. ceruloplasmin which possesses ferroxidase activity, iron is stored in liver, spleen and bone marrow in the form of ferritin.

Energy balance

After the provision of water, the body's first requirement is for metabolic fuels fats, carbohydrates, and proteins, if Food intake in excess of energy expenditure leads to obesity, while intake less than expenditure leads to emaciation and wasting, both obesity and severe under nutrition are associated with increased mortality.

Body Mass Index: defined as weight in kilograms divided by height in meters squared, is commonly used as a way of expressing relative obesity to height, desirable range is between 20 and 25:

$$\mathrm{BMI} = \frac{\mathrm{mass_{kg}}}{\mathrm{height^2_m}}$$

Basal Metabolic Rate (BMR):

Defines as is the minimal rate of energy expenditure at rest under controlled conditions of thermal neutrality, the decrease in BMR with increasing age is due to muscle tissue replacement by adipose tissue, which is metabolically much less active, similarly, women have a significantly lower BMR than do men of the same body weight because women's bodies have proportionately more adipose tissue than men, the BMR is the energy expenditure necessary to maintain basic physiologic functions, such as the activity of the heart, respiration, conduction of nerve impulses, ion transport across membranes, reabsorption in the kidney, metabolic activity such as synthesis of macromolecules.

Factors affecting BMR

1. Surface area: The BMR is directly proportional to the surface area, surface area is related to weight and height.
2. Sex: men have marginally higher (about 5%) BMR than women, this is due to the higher proportion of lean muscle mass in men.
3. Age: in infants and growing children, BMR is higher, in adults, BMR decreases at the rate of about 2 % per decade of life.
4. Hormones: thyroid hormones (T3 and T4) have a stimulatory effect on the metabolism of the body and, therefore BMR is raised in hyperthyroidism and reduced in hypothyroidism.

6-Starvation: during the period's starvation, a decrease up to 50% has been reported, this may be an adaptation by the body.

Nitrogen Balance

Dietary protein is almost exclusive source of nitrogen to the body, therefore, the term nitrogen balance truly represents the protein utilization and its loss from the body, although nucleic acids also contain nitrogen, protein is the major dietary source of nitrogen and measurement of total nitrogen intake gives a good estimate of protein.

- Nitrogen balance is determined by comparing the intake of nitrogen (chiefly by proteins) and the excretion of nitrogen (mostly undigested protein in feces; urea and ammonia in urine).
- Normal healthy adult is in a nitrogen equilibrium since the daily dietary intake (l) is equal to the loss through urine (U), feces (F) and sweat (S): **I=U+F+S**

The difference between intake and output of nitrogenous compounds is known as **nitrogen balance, t**hree states can be defined:

Nitrogen equilibrium: in normal adults, nitrogen intake = nitrogen excretion, the subject is said to be in nitrogen equilibrium or balance.

Positive nitrogen balance: in this, nitrogen intake > nitrogen excretion, i.e. intake of nitrogen is more than excretion, it shows that nitrogen is retained in the body, which means that protein is laid down, this occurs in growing infants and pregnant women.

Negative nitrogen balance: in this, nitrogen intake < nitrogen excretion, this occurs during serious illness and major injury and trauma, in advanced cancer, if the situation is prolonged, it will ultimately lead to death.