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Nutrition

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Nutrition

Course Description

Nutrition (BIO533) provides an integrated overview of the physiological requirements and functions of nutrients that are determinants of health and diseases in human populations.

Course Objectives

Upon completion of this course, you will be able to do the following:

- Provide an overview of the major macro and micronutrients relevant to human health.
- Discuss the scientific rationale for defining nutritional requirements in healthy individuals and populations, with reference to specific conditions such as pregnancy, lactation, and older age.
- Recognize the pivotal hubs of water, electrolytes balance and acid base balance.
- Present current evidence for the role of key nutrients in the prevention of chronic diseases.
- Discuss major nutrition-related diseases and Nutritional genomics

Nutrition

Concept of Nutrition

Nutrition is a vital component to overall wellness and health. Diet affects energy, well-being and many disease states. There is a connection between lifetime nutritional habits and the risks of many chronic diseases such as cardio vascular diseases, diabetes, cancer. A well balanced diet can prevent such conditions and improve energy levels and overall health and wellness.

The basis of nutrition is **FOOD**

Definition of terms:

1) Nutrition: is the study of food in relation to health.

2) Food: is any substance when ingested or eaten nourishes the body.

3) Nutrient: is a chemical component needed by the body to provide energy, to build and repair tissues and to regulate life process.

4) Digestion: it is a mechanical and chemical breakdown of food into smaller components.

5) Absorption: it is a process where the nutrients from foods are absorb by the body into the bloodstreams.

6) Metabolism: is a chemical process of transforming foods into other substance to sustain life.

7) Enzymes: an organic catalyst that are protein in nature and are produced by living cells. A catalyst speeds up or slows down chemical reactions without itself undergoing change.

8) Nutritional Status: is the condition of the body resulting from the utilization of essential nutrients.

9) Calorie: fuel potential in a food. One calorie represents the amount of heat required to raise one liter of water one degree Celsius.

10) Malnutrition: It is the condition of the body resulting from a lack of one or more essential nutrients or due to excessive nutrient supply.

Essential Nutrients of the Diet

Essential nutrients of the diet consist of energy sources (carbohydrates, fats, and proteins), essential amino acids, essential fatty acids, vitamins, minerals, water, choline and carnitine. Essential nutrients except arginine cannot be synthesized or can be synthesized in small amount. Arginine can be synthesized by urea cycle.

Component of Food Nutrients

Protein, fat, and carbohydrate are called macronutrients as they are needed in large amounts, and the intake of these three nutrients is larger than that of the other dietary nutrients whereas vitamins and minerals are called micronutrients as these nutrients are needed in lesser amounts.

Minerals can be further subdivided into macrominerals and microminerals. If the daily requirement of minerals is more than 100 mg, they are called macrominerals. If the daily requirement of minerals is less than 100 mg, they are called microminerals or trace elements. Apart from macronutrients and micronutrients, water, choline, and carnitine are considered as essential nutrients.

Water is essential for the survival of all living organisms and takes part in various metabolic processes. The amount of body water depends upon the balance between water intake and water loss. Normal water intake is about 2.4 L/day (includes drinking water/liquid, water from the solid /semisolid food, and water from the oxidation of food) and normal water loss at normal body temperature, which is about 2.4 L/day (through urine, feces, sweat, skin, and lungs).

Excessive loss of water due to gastroenteritis (vomiting and diarrhea) can cause marked lowering of blood pressure, resulting in hypovolemic shock followed by coma and eventually death. On the other hand, high intake of water, especially after administration of antidiuretic hormone (ADH) can cause water intoxication. Swelling of the brain cells can lead to convulsion, coma, and eventually death. In the infants and lactating mothers, the amount of water intake should be adequate.

The infants require more water due to high ratio of surface area to volume. Adequate intake of water for the infants should not be less than 0.7 L /day. The lactating mothers require additional water intake for milk production.

Choline is a lipotropic factor and is synthesized in the body in small amounts, using methyl group donated by methionine (an essential amino acid). Deficiency of choline may result in fatty infiltration of the liver.

Carnitine is synthesized from lysine and methionine and is essential for the oxidation of fatty acids. Carnitine takes part in the transport of fatty acids across the mitochondrial membrane. Due to defective synthesis of carnitine, the body is unable to utilize fatty acids as fuel.

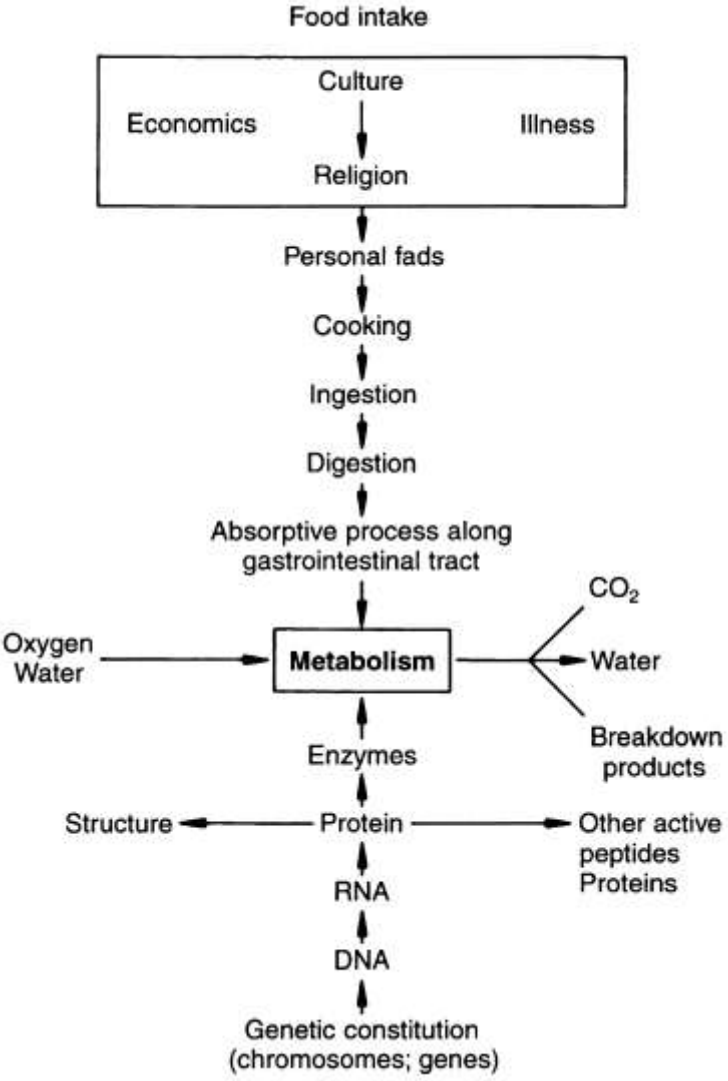
Table 1.1 Macro- and micronutrients

Macronutrients	Micronutrients			
Carbohydrates	Vitamins		Minerals	
Proteins	Fat Soluble Vitamins	Water Soluble Vitamins	Macrominerals (> 100 mg)	Microminerals/ Trace elements (< 100mg)
Fats	Vitamin A	Vitamin B_1	Calcium	Iron
	Vitamin D	Vitamin B_2	Phosphorus	Copper
	Vitamin E	Vitamin B_3	Sodium	Iodine
	Vitamin K	Vitamin B_5	Potassium	Zinc
		Vitamin B_6	Chloride	Fluoride
		Biotin	Magnesium (infants need magnesium <100 mg/day)	Manganese
		Vitamin B_{12}		Selenium
		Folic acid		Molybdenum
		Vitamin C		Cobalt
				Sulfur
				Chromium

Metabolism of Nutrients

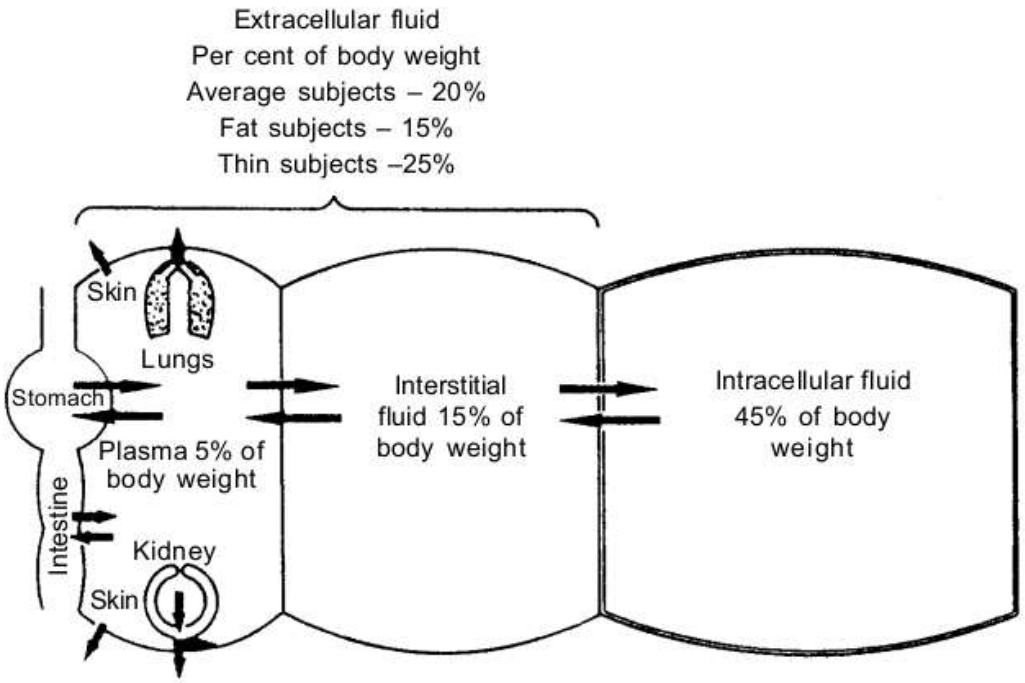
The metabolism of nutrients by enzymes is dictated by the individual's gene structure and the induction of enzymes and, in turn, by species and gender. These distinctions are complex, subtle and only partially understood. The nutrient needs and subsequent metabolism by the individual will be influenced by growth in the young and in pregnancy, and modified by disease, drugs, alcohol and tobacco. As the person ages there are important changes in the effectiveness of the absorption and utilization of the nutrients consumed.

It has been suggested that diet may affect behavior. In some ancient cultures certain foods were thought to have magical qualities capable of giving special powers of strength, courage, health, happiness and well-being. It is possible that some food constituents may affect the synthesis of brain neurotransmitters and thus modify brain functions. It is therefore important to integrate dietary effects on brain chemicals into our wider understanding of human behavior.


Food intake
Culture
Economics
Illness
Religion
Personal fads
Cooking
Ingestion
Digestion
Absorptive process along gastrointestinal tract
CO_2
Oxygen
Water
Metabolism
Water
Breakdown products
Enzymes
Structure
Protein
Other active peptides Proteins
RNA
DNA
Genetic constitution (chromosomes; genes)

Water

Body Composition: Water is the major component of our body. If you weigh 50 kg, 31 kg of that weight is water. Approximately 55 to 70 per cent of the total body weight is made up of water. The percentage of water tends to decrease as a person gets older. Thus infants and children have a much higher content of water than adults. Fat individuals have less water than lean ones. Water is an essential nutrient next only in importance to oxygen. Deprivation of water even for a few days can lead to death.



Water is an essential component of every cell of our body. There is a variation in the water content of various tissues. Metabolically active tissues such as brain, liver, blood and muscles contain more water than bone and fat tissue, which are less active.

For example, blood plasma has 90 per cent, muscle tissue 75–80 per cent and fat tissue 20 per cent water.

Water holds innumerable body components in solution or suspension. Therefore, it is more appropriate to refer to these as fluids. The fluids, which exist inside the cells, are called intracellular fluids, which form about 55 per cent of water in the body. The rest is found as extracellular fluid (outside the cells). Blood, lymph circulation and interstitial fluid (fluid between cells or tissues) are part of extracellular fluid.

The fluid balance is maintained between the compartments as also between blood and interstitial fluid; kidneys are the final regulators of fluid balance.

Functions :

Water serves as a building material for each cell of the body. Water is a universal solvent and is able to dissolve all the products of digestion. Further as it is a constituent of all body fluids, it helps in the transport of the porducts of digestion to the appropriate organs.

For example, blood, which contains 90 per cent water, carries carbon dioxide to the lungs, nutrients to the cells and waste nitrogenous material and salt to the kidneys. Urine which contains 97 per cent water has all the waste material dissolved in it and the body is thus able to excrete soluble waste products of metabolism. Water is needed for many chemical reactions to occur in the body. For example, the breakdown of sugar to simpler substances needs the presence of water.

Water acts as a lubricant preventing friction between moving parts of the body. The body temperature is regulated through the evaporation of water from the skin and lungs.

Water Balance

The body normally maintains a water balance precisely, i.e., the amount of water ingested is equal to the water excreted or lost from the body. This water balance is maintained even though the fluid intake may vary widely from day-to-day. How exactly this regulatory mechanism works is not known; but certain regions of the hypothalmus are believed to regulate the intake. The water excretion is controlled by hormones.

Sources:

The water we drink as such is the main source from which maximum water is obtained by the human body. In addition to this, the intake of all beverages and liquid foods that contain water, contribute water to the system. Certain metabolic reactions carried on inside the body also release water and this is another source of water.

Requirement:

About 1 ml of water is needed per 1 kcal energy intake; thus about 2000 ml water is necessary when energy intake is 2000 kcal. Infants who have a large body surface area, in proportion to body weight, need 1.5 ml water/1 kcal energy intake.

The amount of water needed by an individual will depend on many factors such as the environmental temperature, humidity, occupation and the diet. In general, apart from water obtained in the food, an individual may need to drink about 1.5 to 2 litres of water per day. An athlete or a player, playing a strenuous game such as football or hockey, may lose several litres of water and dissolved salts during the game and would need replacement early. On the other hand, a sedentary individual would need much less water.

Dehydration:

When intake of water and other fluids is less than the body needs, dehydration occurs. Dehydration is a serious medical problem, which needs prompt attention and remedial action. Dehydration results from excessive loss of water due to vomiting and/or diarrhoea. Infants who have a high body water content and high water requirement get dehydrated very quickly, when they suffer from diarrhoea. If the loss of water and electrolytes is not promptly made up by feeding beverages such as oral rehydration solution, coconut water, weak tea, lemon sherbet, etc., the infant may not survive.

Vomitting due to either gastrointestinal disturbances or any other cause can lead to appreciable loss of fluid from the body. Excessive perspiration due to strenuous exercise, while playing games such as hockey, football can result in losses of many litres of water. Protracted fevers can lead to appreciable loss of water due to perspiration. In all such instances where there is loss of water, it is important to replace the water and soluble salts lost quickly to maintain body composition.

Any loss more than 10 per cent of fluid from the body can be serious. Progressively, deprivation of water can cause poor absorption of food, delayed elimination of wastes, elevation of body temperature, failure of the circulatory system and malfunctioning of the renal system.

Oedema

It is accumulation of excess fluid in the tissues. It occurs when the sodium content in the extracellular fluid increases due to the inability of the kidneys to excrete sodium. Water is retained with the excess sodium, resulting in oedema. In protracted protein deficiency, the tissues are unable to ensure water balance, and the oedema, which follows, is called nutritional oedema. Other conditions, which lead to oedema, are kidney disease, cirrhosis of the liver and heart ailment.

Electrolytes

Chemical compounds, which break up into their constituent ions, when dissolved in water, are known as electrolytes, because each carries an electric charge. The positively charged electrolyte is known as a cation and the negatively charged one as an anion. In an electrolyte solution, the total number of cations are exactly equal to the total anions. Electrolytes are necessary to regulate the water and acid-base balance in the body.

Sodium is the principal cation and chloride the anion in blood plasma. The other cations are potassium, calcium and magnesium; other anions are bicarbonate, phosphate, sulphate, protein and organic acids.

In contrast, inside the cell, the main cation is potassium and the main anion is phosphate. There is a strict maintenance of concentration of electrolytes in the fluids inside and outside the cell in a healthy person. Thus sodium stays mainly outside the

cell and potassium inside the cell. Any change in the level of electrolytes in the blood plasma is an early warning of disorder in the body.

Sodium

Sodium is an essential nutrient, which participates along with other minerals in many regulatory functions.

Functions:

The regulatory functions of sodium include normal muscle contraction, maintenance of normal osmotic pressure, water balance and cell permeability, and transmission of nerve impulses and regulation of acid-base balance. It facilitates the absorption of sugars and amino acids, through the sodium pump.

The adult body contains about 85 g sodium; halt of it is in the extracellular fluid, about two-fifths in the bone and about a tenth in the intracellular fluid.

Food Sources:

The main source of sodium in the diet is salt. It is used as a preservative in a variety of pickles. It is also used in processed foods, snack foods such as potato wafers and other savory foods.

Other sodium compounds used in food preparation include baking soda, baking powder, monosodium glutamate (MSG).

The typical diet contains about 500 mg sodium, when no salt or sodium containing salts are added during preparation. Most of this sodium is present in animal foods such as milk and meats. Most of the plant foods, with a few exceptions are low in sodium.

Utilisation:

About 95 per cent of sodium intake is absorbed. The sodium not utilised is excreted in the urine. Actually the sodium content of the body is regulated by the kidneys.

Requirement:

Dietary deficiency of sodium does not occur in normal circumstances, as common salt is a very cheap ingredient.

Sodium, which is available from common salt (sodium chloride) in the diet, helps to maintain the fluid and acid-base balance of the body. People, who do rigorous exercises or who work in hot places such as furnaces or mines, lose salt from the body in perspiration and urine, and so need an extra intake of salt. Similarly, during the hot weather, when one perspires profusely, extra amount of salt is indicated in the diet. Deficiency of salt in the diet may cause cramps of muscles, headache, tiredness or

sickness. Salt may need to be restricted in diets of persons suffering from kidney or heart malfunction.

Potassium

Potassium is primarily present in the intracellular fluid (about 12.6 g/per kg), so that the body is able to conserve it.

Functions:

Like sodium, potassium helps to maintain the normal osmotic pressure of the body fluids and the acid-base balance of the body. It is also involved in muscle contraction and transmission of nerve stimuli. It acts as an activator of several enzyme reactions in metabolism.

Food Sources:

Potassium is widely distributed in foods. Meat, fish and poultry are good sources. Fruits such as bananas, oranges, lemons and vegetables like potatoes, carrots, leafy vegetables and whole-grain cereals are also good sources of potassium.

Requirement and Utilisation:

About 3 to 7 g per day as potassium chloride, which is the intake in ordinary diet, appears to be adequate. About 90 per cent of ingested potassium is absorbed from the intestine, the rest is excreted in urine.

Deficiency and Related Problems:

Normally dietary deficiency of potassium does not occur.

But persons, who take diuretics for weight reduction, may lose excessive amounts and need to consume potassium rich foods to make up the loss. Severe vomiting, diarrhoea, diabetic acidosis may increase losses and thus precipitate a deficiency. The symptoms are the same as diarrhoea and need to be corrected promptly to avoid a fatal crisis.

Abnormal elevation of blood plasma potassium known as hyperkalemia occurs in severe dehydration and kidney failure, which needs immediate action. Rehydration fluids rich in sodium, potassium and glucose/sucrose help to reverse the situation and pave the way to recovery.

Acid-base Balance

pH:

The concentration of hydrogen ions in a solution is referred to by the symbol pH. It is the measure of acidity or alkalinity of the solution. Neutral pH, which is the pH of water, is 7.0. The pH below 7.0 denotes acidity which increases with decrease in the pH. The alkalinity on the other hand, increases with increase in the pH.

The pH of body fluids is maintained in the narrow range between 7.35 and 7.45 , which is slightly alkaline. The maintenance of pH in this narrow range is known as acid-base balance.

Reactions of Foods:

The foods which contain sizeable amounts of sulphur, chloride and phosphorus, metabolize to form anions in excess of cations. Such foods are potentially acid producing foods. Acid producing foods include cheese, legumes, cereal foods, coconut, eggs and flesh foods.

The foods which produce excess cations on metabolism are termed alkali producing foods. These foods contain excess cations such as calcium, sodium, potassium and magnesium. Fruits, vegetables, milk, groundnuts, etc., are alkali producing foods.

It is important to note that the sour tasting fruits (citrus and other fruits) are alkali producing foods. So the taste of the food is not related to its metabolic reaction.

The third group of foods which are low in mineral elements are termed neutral foods. These include sugar, starch, tapioca, oils, butter and other cooking fats.

Regulation of Acid-base Balance :

Mineral elements act as buffer salts, which prevent change in the pH. In the body the carbonate and the sodium phosphate buffer systems are important in pH regulation. Proteins, which hydrolyze to form amino acids, containing an alkaline (NH_2) an acidic (COOH) group, are also good buffers.

Carbonic acid is the main acid produced in metabolism, which is exhaled by the lungs as carbon dioxide and water vapour. Breathing rapidly and deeply helps us to bring down the increased carbon dioxide content of the blood. This is the basis of for the recommendations for exercises, which make us breathe rapidly and cleanse the blood.

Yoga, which teaches us to breathe deeply, ensures that oxygen reaches all the cells. Thus it helps the process of oxidation, which releases the carbon dioxide to be exhaled.

The kidneys are able to excrete very acidic urine, when excess acid is produced in the body, thus preventing changes in blood pH. The kidneys act as the last regulators of acid-base balance.

Disturbances in Acid-base Balance:

If the pH of body fluids drops below pH 7.3, it is called acidosis. When diabetes is not controlled, the patients suffer from acidosis and excrete large amounts of ketones.

In severe starvation, the body fat reserves are metabolised in the absence of carbohydrate and acidosis occurs. In renal failure, acidosis occurs, as the kidneys are not able to get rid of excess acid.

If the pH increases above 7.5., it is called alkalosis. Any condition which leads to loss of stomach acid, results in alkalosis. Severe vomiting is one such condition. Another is excessive intake of antacids such as sodium bicarbonate. Third is loss of hydrogen ions due to renal malfunction. Any change in pH needs immediate action to avoid disturbance in the metabolism and restore normalcy.

Carbohydrates

Carbohydrate is the major food stuff consumed by humans in most of the countries. As stated earlier carbohydrates contributes to 50-60% of body energy requirement. Principle carbohydrates present in diet are polysaccharides like starch, dextrins, glycogen and trace of inulin. Cereals, legumes, potatoes, sweet potato, bananas, meat and garlic present in food are sources for polysaccharides.

Starch is the dominant carbohydrate in the diet and it is cheapest source of energy. In

low income groups it contributes to 75-80% calories. However in high income group it may contributes to 40% calories. Starches of different origin are not digested equally. The digestibility of starch depends on amylopectin content. Starches of cereals are digested rapidly due to high amylopectin whereas starches of legumes are digested slowly due to low amylopectin content. The rate of digestibility of different starches is of importance to diabetic patients. Amylase inhibitors present in some foods also affect starch digestibility.

Disaccharides lactose, sucrose and maltose are also present in food. Milk and other dairy products are lactose source in the food. Lactose is the major carbohydrate for infants. It contributes to 35-45% of infants energy requirement. Sucrose is present in candies, sweets, honey, syrups, jams, jellies and jaggery. Some fruits also contain sucrose. Sucrose supplies empty calories. In developing countries sucrose consumption is low where as it is high in developed countries. Excess sucrose is found to raise plasma cholesterol and triglyceride level. Hence sucrose content in the diet should be below 50-70 gm per day.

Recommended dietary allowance

Since carbohydrate is synthesized in the body no recommended dietary allowance for

carbohydrate. But absence of carbohydrate in the diet for few days leads to keto acidosis and loss of muscle protein. So minimum 100 gm of carbohydrate must present in diet to avoid keto acidosis and wasting of muscle protein.

Lipids

Dietary fat furnishes about 30-40% of body energy requirement. Apart from energy dietary fat provides essential fatty acids, vitamins and cholesterol. In advanced countries dietary fat furnish 40-50% of body energy. However in poor countries it may contribute to 15% of energy requirement. For quick energy high fat intake is essential for dynamic people.

Dietary fat reduces bulkyness of diet. It improves palatability of food and give satiety.

Sources of fat in the diet are vegetable oils like peanut oil, safflower oil, cotton seed oil, coconut oil, soybean oil, palm oil, corn oil and sunflower oil. Other sources for fat in diet are butter, cheese, ghee, eggs and chicken fat, beef, cereals, pulses, nuts and

other vegetables also contain fats. Cholesterol is present in most of animal fats. Cholesterol rich diet is not good for health

Recommended dietary allowance

Minimum requirement for fat is very low and not yet clearly known. However an ideal diet must contain about 30-50 gm of fat and 5 gm of essential fatty acids. In pregnancy and lactation diet should contain more essential fatty acids.

Proteins

Main function of dietary protein is to provide essential amino acids required for the synthesis of body proteins and other nitrogenous substances. Therefore diet must contain adequate amount of protein to replace essential amino acids and nitrogen lost through normal protein turnover and maintain nitrogen balance. Dietary protein contributes to 10-15% of body energy requirement. In low income groups it may be less.

Nitrogen Balance

Since protein is the main source of nitrogen in body the dietary protein must make up

nitrogen lost from body to maintain nitrogen balance. If an individual's total nitrogen content of the urine and feces equals the amount of dietary nitrogen then the individual is said to be in nitrogen balance or equilibrium

$$\text{Fecal nitrogen (N)} + \text{Urinary nitrogen (N)} = \text{Dietary nitrogen (N)}$$

$$\text{N output} = \text{N intake}$$

i.e.,

$$\frac{\text{N intake}}{\text{Noutput}} = 1$$

In other words if the ratio of nitrogen intake to nitrogen output is one then the individual is in nitrogen balance or equilibrium. Intestinal flora influences nitrogen balance of an individual.

Positive nitrogen balance

If the ratio of N intake to N output is greater than one then it is called as positive nitrogen balance or if the N output is less than N intake then the individual is in positive nitrogen balance. In the positive nitrogen balance most of dietary nitrogen is retained in the body and less is eliminated from body. More over in positive nitrogen balance the tissue protein content increases due to increased protein synthesis. Usually it occurs during growth, pregnancy, lactation and postoperative recovery.

Negative nitrogen balance

If the nitrogen output is more than the N intake then the individual is in negative nitrogen balance or if the ratio of N intake to N output is less than one then the individual is in negative nitrogen balance. In the negative nitrogen balance nitrogen lost is not replaced by dietary nitrogen. It occurs in malnutrition and other wasting diseases where there is tissue breakdown like starvation, uncontrolled diabetes mellitus and cancer. Menstruating women may have transient negative nitrogen balance if proper replacement for nitrogen lost is not possible. Physical exercise trainee may also have transient negative nitrogen balance because of atrophy of muscle.

Protein minimum

It is the minimum amount of dietary protein required to maintain nitrogen balance. It is 1 gm/kg body weight per day.

However protein requirement also depends on the (a) Protein quality (b) Carbohydrate and fat contents (c) Physical activity.

Protein quality

Essential amino acid content determines quality of a protein. An ideal or a good quality protein is the one which has amino acid composition of body protein synthesized at any given time. Further an ideal protein must meet essential amino acid requirement. Unfortunately ideal proteins or good quality proteins are limited.

Limiting amino acid

Proteins of different foods have different proportions of essential amino acids. Some of them may contain required amounts of essential amino acid and few of them may not have adequate amounts of one or more of essential amino acids. An essential amino acid of a protein which is present much below requirement is called as **limiting amino acid.**

Examples.

(a) Tryptophan is the limiting amino acid in maize, bengal gram and red gram proteins.

(b) Lysine is the limiting amino acid in wheat protein.

(c) Methionine is the limiting amino acid in peanut protein.

Effect of limiting amino acid on protein utilization

When tissue proteins are synthesized all the essential amino acids must be present in proper proportions in tissues. If one essential amino acid is absent in tissues due to lack of dietary supply protein synthesis decreases and nitrogen balance is not maintained.

Protein Supplementation

One way of improving quality of dietary protein with limiting amino acid is by adding another protein containing the missing amino acid. This is termed as protein supplementation. For example cereal proteins are limiting in lysine whereas milk proteins are good source of this amino acid. Thus milk protein effectively supplement cereal proteins. Protein supplementation has important role in preparation of vegetarian balanced diet. Supplementation of wheat bread with lysine is commonly done.

Complementary proteins and mutual supplementation of proteins

Complementary proteins are poor quality proteins as such due to limiting amino acids. But they are complementary in limiting essential amino acid composition i.e., a limiting essential amino acid in one protein is present in excess amounts in another protein and vice versa. So they supplement each other and make good quality protein in diet. This is known as **mutual supplementation** of proteins. For example wheat proteins and red gram proteins are complementary proteins and as such both are low quality proteins due to limiting amino acid.

Wheat protein is limiting in lysine but good source of tryptophan whereas red gram is

limiting in tryptophan but a good source of lysine. When they are mixed they make up good quality protein in diet by supplementing one another i.e., wheat protein effectively supplement pulse protein and vice versa .

Carbohydrate and fat content

If diet contains sufficient amounts of carbohydrate and fat then use of protein for energy production is reduced. Hence protein requirement in diet is minimum. In contrast if the diet contains inadequate amounts of carbohydrates and fats then use of protein for energy production is more. This increases protein requirement in diet.

Physical activity

Protein requirement increases with increases in physical activity due to retention of nitrogen or increased muscle protein in the body.

Recommended dietary allowance for protein and amino acids

For adults daily intake of 55-80 gm (1 gm/kg body weight) of protein has been recommended. Extra amounts are required by pregnant and lactating women. Minimal daily amino acid requirement of adult male are methionine (16.3 mg/kg), threonine (7 mg/kg), tryptophan (4 mg/kg), valine (11 mg/kg), isoleucine (10 mg/kg), leucine (16 mg/kg), lysine (11 mg/kg) and phenyl alanine (16.4 mg/kg).

Methods to assess protein quality

Few biological methods are available to assess protein quality.

1. Nitrogen balance

If a protein is unable to maintain nitrogen balance then it is a poor quality protein. However nitrogen balance does not indicate anything about digestibility, essential amino acid content and assimilation of products of digestion. Usually good quality protein maintain nitrogen balance if taken in adequate amounts.

2. Biological value (BV)

The biological value of a protein measures the quantity of dietary protein used by animal for growth and maintenance of body function. It is defined as percentage of absorbed nitrogen that is retained by the body.

$$\text{Biological value (BV)} = \frac{\text{N retained}}{\text{N absorbed}} \times 100$$

Biological value of protein may also indicates essential amino acid content, digestibility of protein and availability of digested products for absorption.

3. Net protein utilization (NPU)

Biological value of protein does not cover nitrogen lost in digestion. In net protein utilization, it is included. It is defined as percentage of dietary nitrogen that is retained in the body.

$$\text{Net protein utilization} = \frac{\text{N retained}}{\text{N intake}} \times 100$$

4. Protein efficiency ratio (PER)

It is a better index of protein quality than biological value. It is defined as weight gain per weight of protein eaten

$$\text{PER} = \frac{\text{Weight gain (gm)}}{\text{Weight of dietary protein (gm)}}$$

Depending on BV, NPV and PER values proteins can be divided into:

(a) Good quality proteins.

Animal proteins are good quality proteins because they have high BV, NPU and PER values. They are egg, milk and meat proteins.

(b) Low quality proteins.

Plant proteins are low quality proteins because they have low BV, NPU and PER values. They are rice, wheat, bengal gram and groundnut proteins. The plant proteins have low values because they are not digested (absorbed) completely due to several factors.

Vitamins

Vitamins are organic compounds that perform specific metabolic functions in the body. The body does not synthesize most vitamins and must get them from food. Unlike carbohydrates, lipids, and proteins, vitamins do not produce energy. However, they are necessary for many of the metabolic processes that produce energy. People who do not eat the proper amounts of vitamins can get vitamin deficiencies that cause illness and disease.

Vitamins are classified into two categories based on the substances they dissolve in. **Fat-soluble vitamins** can be stored by the body when they are not used. These vitamins are essential for good health but not needed every day.

Fat-soluble vitamins include A, D, E, and K. These vitamins are necessary for the development and maintenance of certain body tissues, including those in the eyes (vitamin A), bones (vitamin D), and muscles; for the coagulation of blood (vitamin K); for synthesizing certain enzymes, and for absorbing other essential nutrients such as calcium (vitamin D).

Water-soluble vitamins pass directly into the bloodstream. The body has limited ability to store these vitamins and must get them daily from food. Water-soluble vitamins include C (ascorbic acid), B1 (thiamine), B2 (riboflavin), B3 (niacin), B6 (pyroxidine), B12 (cobalamin), pantothenic acid, and folic acid.

These vitamins are often classified by their functions. **Energy-releasing vitamins** that enable the body to use macronutrients include B1 (thiamine), B2 (riboflavin), B3 (niacin or nicotinic acid), biotin, and pantothenic acid. **Hematopoietic (red blood cell synthesizing) vitamins** that help the body make new red blood cells include folic acid and B12 (cobalamin). **Co-enzyme vitamins** that help the body break down amino acids, produce enzymes, and synthesize new proteins include B6 (pyroxidine), which helps metabolize protein, and others. **Skin- and bone-building vitamins** that help form collagen, an important component of skin, bone, and connective tissues include C (ascorbic acid).

Food Groups and Balanced Diet

Food groups can be divided into **six categories**. Each food group is a prerequisite for the maintenance of vitality of health. **Proteins** of high biologic value are obtained from egg, fish, meat, poultry, milk, and milk products. Cereals, legumes, and pulses contain maximum amount of **carbohydrate** and dietary **fibers** and have low **fat** content. Vegetables including green leafy vegetables provide **minerals**, **vitamins** especially vitamin A, and less amount of fat. Fruits are rich sources of vitamins, containing low sodium and low fat.

Balanced diet is one of the major determinants of health. It provides optimal energy and nutrition for optimal growth and development. Excess of any food group should be avoided. Dietary fibers, antioxidants, and foods of low glycemic index should be included. Balanced diet should be constructed to meet the energy requirement of an individual as well as the need for all macro and micronutrients. Dietary fibers and antioxidants should be included. Food of low glycemic index should be selected, and excess of any food group should be avoided.

The amount of balanced diet increases proportionately with moderate and heavy activities.

Main aim of a balanced diet is to:

1. Prevent or slow age-related decline of physiological functions of the body (Maintain growth and development, and functions of brain and nervous system).
2. Slow the progression of degenerative diseases.
3. Improve longevity.
4. Improve immunity.
5. Maintain vitality of health.

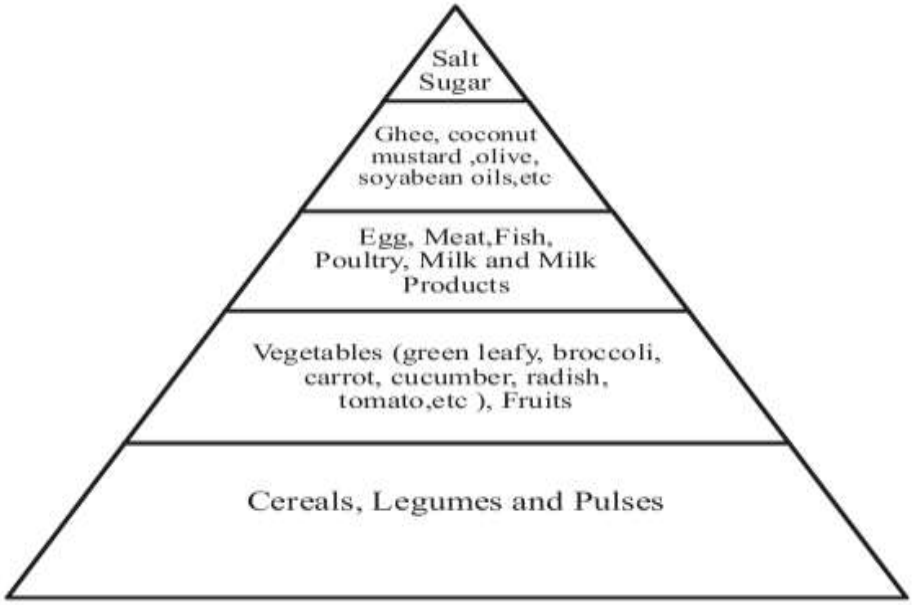
Foods to be avoided while constructing a balanced diet:

1. Sugar, sweet, biscuit, jam, and chocolate.
2. Foods fried in unhealthy trans-fat. Acrylamide found in a variety of fried foods is neurotoxic.
3. Cholesterol-rich food and food containing high saturated fat.
4. High amount of salt intake, processed foods, and reined flour.
5. Excessive intake of sugar in combination with a hypercaloric diet will increase fat deposition, particularly in the liver. It may induce fatty liver.

Table (2) Balanced diet (g/day) at different age groups having sedentary life, and during pregnancy and lactation

	School children		Adolescents		Adults		Elderly person	Pregnancy and lactation
	Boys	Girls	Boys	Girls	Boys	Girls		
Cereals	150	140	340	300	340	300	250	340
Mixed pulses and legumes	60	50	70	60	70	60	50	70
Leafy green vegetables	50	50	50	50	50	50	50	50
Other vegetables including roots and tubers	100	100	120	120	120	120	120	120
Fruits	120	120	120	120	120	120	120	130
Skimmed milk	250	250	250	250	250	250	250	300
Milk products (except butter and ghee)/egg without yolk/fish/poultry without visible fat	30	30	40	40	50	40	40	50
Fats and oils	20	20	25	25	30	25	20	25
Sugar	20	20	20	20	20	20	15	20

Food Pyramid



A **food pyramid** is a representation of the optimal number of servings to be eaten each day from each of the basic food groups. The first pyramid was published in Sweden in 1974.The 1992 pyramid introduced by the United States Department of Agriculture (USDA) was called the "Food Guide Pyramid" or "Eating Right Pyramid". It was updated in 2005 to "MyPyramid", and then it was replaced by "My Plate" in 2011.

My Plate:

My Plate is the current nutrition guide published by the United States Department of Agriculture, depicting a place setting with a plate and glass divided into five food groups.

Nutritional requirements of different age groups

1. Infants (0–1 Year)

The term nutrition is derived from the Latin word "Nutrire," which means to breast-feed and nurse. Mother's milk is sterile and contains IgA, lactoferrin, and lactoper - oxidase. Lactoferrin is a glycoprotein, having antimicrobial activity.

Lactoperoxidase catalyzes reactions, resulting in oxidized products that are antimicrobial. Low pH of mother's milk inhibits the growth of pathogens. Thus, mother's milk protects the infants from infection. Mother's milk also protects against allergens and reduces the chances of allergic reactions in infants. Mortality rate of infants is reduced. Mother's milk contains lactalbumin, which is easily digestible compared to casein present in cow's milk.

Mother's milk contains high amount of docosahexaenoic acid (DHA), which improves cognitive functions as well as development of the brain in the infants and children. Longer

breast-feeding duration is associated with better cognitive and motor development

in children aged 2–3 years (Bernard et al. 2013). Breast milk provides 8.3% linoleic

acid. It also, provides high amount of vitamin A, vitamin C, nicotinic acid, thiamin, and pyridoxine. Breast-feeding is an important birth control device. Suckling relex through the hypothalamus stimulates the secretion of prolactin from the anterior pituitary. Prolactin stimulates the formation of milk and simultaneously inhibits the actions of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) on the ovaries. As a result, ovulation is inhibited.

Breast-feeding stimulates the maternal behavior. Lactating mother must avoid caffeine, alcohol, and as far as possible antibiotics, since they are secreted into the mother's milk and could be harmful to the infant.

Weaning is the transition period of introducing the liquid and semi -solid diet to the infant other than the breast milk from 6 months to 1 year. Weaning foods should contain adequate amount of macronutrients and micronutrients, for the growth and development of the infants. The newborn infants need a prophylactic dose of vitamin K to prevent hemorrhagic disease. Flours of germinating cereals should be preferred as they contain high amount of amylase.

2. Preschool Children (1–6 Years)

Adequate protein intake is needed, since kwashiorkor generally occurs in the children after 1 year of age if their diet consists mainly of carbohydrate. High-energy intake is necessary for growth and activity. Oral dose of vitamin A should be given below the age of 5 years to prevent blindness. Additional amount of calcium, phosphorus and vitamin D is needed as rickets occurs mostly between the age of 1 and 3 years. Excess

fat, salt, and sugar should be avoided from the beginning to decrease the desire to eat these nutrients. The habit of eating a balanced diet should be initiated from the age of 5–6 years. Soluble dietary fibers and plenty of fluid should be started to prevent constipation and diverticular disease (a pouch or sac formed at the weak point of the intestinal tract).

3. Schoolchildren (6–12 Years)

Continuous growth of the body demands an increased calorie intake. All the nutrients according to the RDA should be taken. Nutrients in excess of the RDA are not recommended. Special care should be considered for bone formation. Balanced diet is to be followed. Dietary fibers, plenty of fluids, and fruits are to be consumed. Regular exercise must be encouraged. Excess salt, sugar, saturated, and trans fat should be avoided. Fluoridated toothpaste is recommended to prevent dental caries.

Flavored milk is a palatable choice of schoolchildren. Flavored milk contains nutrients like plain milk and meets the requirements of proteins, carbohydrates, essential fatty acids, calcium, potassium, phosphorus, folate, ascorbic acid, and vitamins (B1, B2, B3, B6, B12). Desire to drink flavored milk and having an excessive amount of sugar and chocolate can lead to childhood /adult obesity due to high-energy intake. The disadvantage is that flavored milk, containing added sugar and chocolates, has been associated with obesity and lower nutrient density of children's diet. It may lead to dental caries/dental erosion later in childhood.

4. Adolescents (8–13 Years in Girls and 9–14 Years in Boys)

Rapid growth of the body in adolescence needs adequate nutrients. Protein requirement is more in adolescents (about 1.5 g/kg/day) compared with adults (about 0.8 g/kg/day) for the maturation of reproductive organs and for the repair of old tissues. Calcium and vitamin D are needed for building bone density. Dietary fibers, plenty of fluids, and fruits should be consumed.

5. Adults (21–59 Years)

Nutritional needs are essential to slow age-related progressive decline of physiological and cognitive functions. Adult females require more iron to compensate the loss of blood during menstruation. Daily exercise and active daily living will minimize the progression of lifestyle-related diseases or disorders like type 2 diabetes, hypertension, obesity, and atherosclerosis. Minimize saturated and trans fat (<10% of total energy), cholesterol-rich diet (<250 mg/day), and salt intake (<4 g/day). Smoking must be avoided as it increases the synthesis of cholesterol and causes constriction of coronary artery, leading to myocardial infarction. Extra calcium and vitamin D are needed to prevent osteomalacia. Fruits, vegetables, and dietary fibers should be regularly consumed.

6. Elderly People (60 Years and Above)

Low protein intake due to anorexia causes depletion of protein store with aging. Elderly people may suffer from edema and lower resistance to infection if protein intake is not adequate. Positive nitrogen balance should be maintained. Extra vitamin D and calcium are needed to prevent osteoporosis and fractures. Antioxidants are needed to decrease oxidative stress. Regular walking or non-strenuous exercise is essential to slow the progress of aging. Exercise improves muscle mass, strength, and balance. Maintenance of balance and equilibrium is difficult in old age, probably due to cerebellar dysfunction. Saturated fat, trans fat, and cholesterol-rich diet must be restricted to prevent atherosclerosis. Soluble dietary fibers with plenty of fluid should be taken to prevent constipation and diverticular disease. Apart from the RDA, certain nutrients may be required in increased amounts due to defective absorption, for example, vitamin B12 and iron are required to prevent anemia, and zinc is required for wound healing.

Tobacco smoking must be avoided, since it produces ROS. It increases metabolic rate and aggravates insomnia. Alcohol consumption must be avoided to prevent loss of cognitive function.

7. Pregnant Women

Additional requirement of nutrients (more than all age groups) must be considered in pregnant women for the benefit of fetus. The nutritional requirements of the pregnant women for "feeding two" are more than those of non-pregnant women. Adequate nutrition during pregnancy accounts for the fetal brain development as it stimulates neuron proliferation and myelination. Malnutrition in the mother will impair brain development of the infant.

Sufficient energy is needed for the development of the fetus and placenta and for the secretion of breast milk. Extra 250 calories /day is essential during last 3 months. Adequate folate intake is required to prevent abnormal fetal development. Zinc supplementation during pregnancy leads to a significant decrease in preterm births without affecting infant birth weight. Adequate amount of essential fatty acids is essential for the fetal brain development.

Sufficient amount of vitamin C is needed for the absorption of iron. Adequate vitamin D and calcium are needed for building bone density. Carbohydrate intake should not be less than 100 g /day as it will lead to ketosis. High-caloric intake due to increased consumption of fat and carbohydrate with adequate protein in pregnancy may result in neonatal adiposity

Alcohol consumption during pregnancy must be avoided, since it may cause abnormal fetal development and prenatal death. Maternal smoking may cause miscarriage and fetal death. Pregnant women are susceptible to ketosis due to insulin resistance,

increased lipolysis, and free fatty acids (FFA). They suffer from hyperlipidemia and ketoacidosis after short period of fasting (even after 1 day fasting) and vomiting.

8. Lactating Mother

Nutritional requirements in the lactating mothers are higher than all age groups and pregnant women. Adequate fluid intake and nutrients are required for the production of milk. Undernourished mother produces less quantity of milk. Smoking, alcohol, and few contraindicated medications should be avoided during lactation.

Energy Derived from Food

The metabolism of food converts about 40% of the energy of food to adenosine triphosphate (ATP) and 60% of energy is dissipated as heat. Heat cannot be utilized for the energy and increases body temperature. The energy content of food is measured from the heat released by the total combustion of food in a calorimeter and is calculated in kilocalorie (kcal), i.e., equal to 1000 calories per gram. A calorie (equal to 4.185 J) is the amount of heat that raises the temperature of 1 g of water from 14.5 to 15.5 °C. Energy derived from the macronutrients ("Energy nutrients") in kcal /g is 9 for fats, 4 for carbohydrates, and 4 for proteins.

The food provides energy, which is essential to power all the body functions. Normal health depends on the supply of optimal energy. Energy supply from the food is utilized for the storage of energy, internal heat production, and external work.

Metabolic Rate

Energy supply is reduced by energy expenditure of basal metabolic rate (BMR).The BMR is defined as the minimum energy expenditure necessary to carry on the basic physiologic functions of the body and the vital life processes of the body (heart rate, respiratory rate, etc.) and to maintain metabolic functions of the tissues when a person is at rest and is awake. The BMR is thus called "metabolic cost of living." The measurement of BMR is taken at least 12 h after a meal in a room at a comfortable thermoneutral temperature (about 25 °C). The subject must be at complete physical and mental rest (standardized conditions). One liter of oxygen consumption used to oxidize food releases 4.82 kcal.

Oxygen consumption (milliliter per unit time) is measured by a spirometer (oxygen-filled chamber with a device to absorb carbon dioxide) and is corrected to standard temperature and pressure.

Metabolic rate = liters of oxygen consumption per unit time × 4.82 kcal.

An adequate diet must have an energy value sufficient to provide the requirement of basal metabolism. The BMR of men (about 60 kg) is about 1800 kcal/ day and for women (about 50 kg) is about 1400 kcal/ day.

Ingested food increases the metabolic rate due to specific dynamic action (SDA) of the food. The SDA is also called "thermic effect of feeding". The SDA of a food is the energy expenditure due to digestion and absorption.

The SDA contributes to about 10% of total energy expenditure. The SDA of the food is exerted mainly by protein food. An amount of protein sufficient to provide 100 kcal increases the metabolic rate of about 30 kcal.

Determination of food energy values using Bomb calorimeter

Bomb calorimeter consist of steel chamber fitted with O2 under high pressure. A fixed amount of food sample is placed in the chamber. An electrical discharge is used to initiate combustion of food sample. Energy (heat) is released into surrounding which is carried away by water flowing outside the chamber. Energy output of food sample is calculated from difference between the temperature of out-going and incoming water.

Energy values obtained with bomb calorimeter for carbohydrates, fats and proteins are given below.

1 gm of carbohydrate	4.1 C or 4.1 Kcal
1 gm of fat	9.45 C or 9.45 Kcal
1 gm of protein	5.65 C or 5.65 Kcal

Energy values for other food stuffs like bread, milk, vegetables etc., may be obtained similarly.

Physiological calorific values of foods (Animal calorimetry)

Calorific values obtained with bomb calorimeter do not reflect in vivo values because in bomb calorimeter food is completely oxidized to CO2 and H2O where as in body a fraction of food is lost in digestion and nitrogen of protein is eliminated as urea. Furthermore bomb calorimeter is nonliving object. Hence to get clear picture of energy output of food in the body methods involving humans are needed. Direct and indirect calorimetric methods are used to determine energy production (expenditure) in humans when a particular food is oxidized in the body.

Direct Calorimetry

In the direct calorimetry energy production of an individual is measured by estimating his body's heat production. The individual is placed in an insulated chamber then his heat production when a particular food is oxidized in the body is measured directly by recording amount of heat transferred to water circulating through the chamber. The O2 in take, CO2 output and nitrogen in urine and feces are also measured.

The calorific values obtained for different foods are given below Table (3).

Food stuff	Energy value
Carbohydrates (1 g)	4 C
Fats (1 gm)	9 C
Proteins (1 gm)	4 C
Cooked rice (1 Kg)	290 C
Milk (1 L)	700 C
Bread (1 Kg)	2630 C
Sugar (1 Kg)	4100 C
Cake (1 Kg)	4000 C

The figures obtained for carbohydrates, fats and proteins are slightly less than those obtained with bomb calorimeter due to loss of food (little) in digestion and protein nitrogen as urea.

Indirect Calorimetry

Since oxidation of food in the body is associated with O2 consumption and CO2 release in indirect Calorimetry energy production of an individual when a particular food is oxidized in the body is measured by estimating O2 consumed and CO2 released.

Respiratory quotient

It is the ratio of the volume of CO2 produced to the volume of O2 consumed when particular food is oxidized in the body.

$$\text{Respiratory quotient (R.Q.)} = \frac{\text{Volume of } CO_2 \text{ produced}}{\text{Volume of } O_2 \text{ consumed}}$$

R.Q. for carbohydrate, fat and protein are 1, 0.7 and 0.8 respectively on mixed diet R.Q. is 0.85.

Medical Importance

1. It indicates type of food being oxidized in the body.

2. In diabetes mellitus and starvation R.Q. decreases.

Energy Requirements of an individual

Energy requirement of an individual is made up of several components. They are

(1) Basal metabolic rate

(2) Specific dynamic action of food

(3) Various activities. However, for women pregnancy and lactation are additional components of energy requirement.

Basal metabolic rate

It is the energy expenditure (heat output) of an individual in post absorptive state for the last 12 hours lying at complete physical and mental or emotional rest and having normal temperature. Measurements of BMR have been made on humans using indirect calorimeter.

The Harris-Benedict BMR Equation:

BMR = Men (10 × weight in kg) + (6.25 × height in cm) – (5 × age in years) + 5

= Women (10 × weight in kg) + (6.25 × height in cm) – (5 × age in years)– 161

FACTORS AFFECTING BMR

Many factors influence BMR

1. Age. BMR decreases with age. Children have high BMR than adults, old people has low BMR than adults.

2. Surface area. BMR is directly proportional to body surface area. Larger the surface area higher the BMR.

3. Sex. BMR is high in males than females.

4. Environment. In cold BMR is high whereas in warm climate BMR is low.

5. **Physiological conditions** like pregnancy and lactation increases BMR whereas sleep decreases BMR.

6. **Exercise**. Muscular exercise increases BMR.

Medical Importance

1. In fever BMR increases. For every 1°C rise in body temperature BMR increases by 10%.

2. In hyper thyroidism BMR increases up to 80-90%.

3. BMR increases in conditions like Cushings syndrome, cancer, emphysema and hyperactivity of pituitary. Drugs like salicylates and amphetamines increase BMR.

4. BMR decreases in starvation, hypothyroidism, Addisons disease and nephrotic syndrome.

Estimating energy requirements for adults

Energy requirements and the dietary intake needed to meet these requirements may change from day to day. These definitions are estimates of the appropriate energy for a particular group of people. Energy requirements are measured in calories and are determined by multiplying the BMR by an activity multiplier. The BMR is one of the most important determinants of energy requirements. It is calculated using age, gender, height, and weight.

Table (4) shows the BMR for males and females of various ages and weight.

Age (years)	Kcal/day
Males	
18–30	15.1 x weight (kg) + 692
30–60	11.5 x weight (kg) + 873
> 60	11.7 x weight (kg) + 588
Females	
18–30	14.7 x weight (kg) + 496
30–60	8.7 x weight (kg) + 829
> 60	10.5 x weight (kg) + 596

Table (5) shows multiples of BMR used to determine the average daily energy requirements of adults based on their physical activity. Activities are classified as light (e.g., the work of an office clerk), moderate (e.g., the work of a subsistence farmer), and heavy (e.g., the work of a laborer).

	Light	Moderate	Heavy
Male	1.55	1.78	2.10
Female	1.56	1.64	1.82

The equation for determining estimated energy requirements based on activity is

(kcal/day = BMR x activity factor)

As an example, to determine the estimated daily energy required by a healthy 35-year-old man who weighs 70 kg and does heavy activity, we would multiply 2.10 x BMR, or 2.10 x (11.5 x 70 kg + 873). This would give us 3,524 kcal/day.

Energy Balance

Energy balance depends on the balance between energy intake and energy expenditure. Energy balance is **negative** when the energy expenditure is more than the energy content of ingested food. Because of negative energy balance, endogenous stores of fat, glycogen, and protein are catabolized, resulting in loss of body weight. Energy balance is **positive** when the energy expenditure is less than the energy content of ingested food. Because of positive energy balance, energy is stored that results in gain of body weight. However, under physiologic condition, food intake is regulated to the point where energy intake equals the energy expenditure (energy homeostasis). Body weight depends on the balance between energy intake and energy expenditure. Food intake increases after illness or starvation until the individual regains the lost weight. Food intake decreases after overfeeding for days until the individual loses body weight to the control level.

RDA of Energy Intake

RDA of energy intake depends on age, gender, body weight, and physical activity. The RDA of energy intake indicates the average dietary intake that is essential to maintain energy homeostasis. The RDA for energy intake (kcal /day) for schoolchildren (boys 10–12 years, weight 34.3 kg) is about 2190 whereas for men (sedentary work, weight 60 kg) is about 2320. Energy intake increases proportionately with moderate and heavy activities. Energy intake of adult women is lesser compared to adult men due to high-fat content of the body. Obesity in women begins at puberty. Pregnant women require an additional energy for the development of fetus, placenta, and maternal tissues.

Respiratory Quotient

The RQ is the ratio of the volume of CO_2 production to the volume of O_2 consumption per unit time.

1. RQ for Carbohydrate

$$\underset{(\text{Glucose})}{C_6H_{12}O_6} + 6O_2 \rightarrow 6CO_2 + 6H_2O, \quad RQ = 6/6 = 1.0$$

2. RQ for Fat

$$\underset{(\text{Palmitic acid})}{CH_3(CH_2)_{14}COOH} + 23O_2 \rightarrow 16CO_2 + 16H_2O, \quad RQ = 16/23 = 0.7$$

($\text{more } O_2 \text{ is required for the formation of } H_2O$)

3. RQ for Protein

As protein is not simply oxidized to CO2 and H2O, determination of RQ of protein is a complex process. Generally the RQ value of protein is around 0.82. The amount of oxidation of carbohydrate, fat, and protein can be determined from the RQ and the

urinary nitrogen excretion (metabolism of about 6.3 g of protein produces 1.0 g of urinary nitrogen).

The RQ is reduced under the following conditions:

1. Diabetes mellitus due to increased utilization of fat, which is secondary to decreased utilization of carbohydrate.
2. High-fat diet.
3. Increased oxidation of ketone bodies.

Nutritional Requirements and RDA

Nutritional requirements are the minimum amount of nutrients that are essential for physio-biochemical functions of the body. RDA is the average daily amount of a nutrient required by the body. The RDA reflects the standard of good nutrition and ensures nutritional requirement of the individual. The RDA maintains energy homeostasis. The RDA of nutrients varies with different age groups, gender, body weight, and during pregnancy and lactation. The tolerable upper intake level (UL) is the maximum average daily intake of nutrients of an individual. UL may not cause health hazard. Above UL, the individual may have adverse health effects.

Various diets lacking in one nutrient or the other can significantly affect the RDA, for example,

1. Diets poor in vitamin C will impair the absorption of iron.

2. Protein synthesis will be impaired, even if there is a lack of a single essential amino acid in the diet.

3. Prolonged consumption of raw eggs can cause biotin deficiency.

4.Chronic alcoholics will suffer from deficiencies of vitamins B1 and B6

DIETARY REFERENCE INTAKES

Committees of U.S. and Canadian experts organized by the Food and Nutrition Board of the National Academy of Sciences have compiled Dietary Reference Intakes (DRI)—estimates of the amounts of nutrients required to prevent deficiencies and maintain optimal health and growth. The DRIs replace and expand on the Recommended Dietary Allowances (RDA), which have been published with periodic revisions since 1941. Unlike the RDA, the DRI establish upper limits on the consumption of some nutrients, and incorporate the role of nutrients in life-long health, going beyond deficiency diseases. Both the DRI and the RDA refer to long-term average daily nutrient intakes, because it is not necessary to consume the full RDA every day.

A. Definition of the DRI

The DRI consist of four dietary reference standards for the intake of nutrients designated for specific age groups, physiologic states, and gender.

1. Estimated Average Requirement (EAR): The EAR is the average daily nutrient intake level estimated to meet the requirement of one half of the healthy individuals in a particular life stage and gender group. It is useful in estimating the actual requirements in groups and individuals.

2. Recommended Dietary Allowance (RDA): The RDA is the average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97–98%)

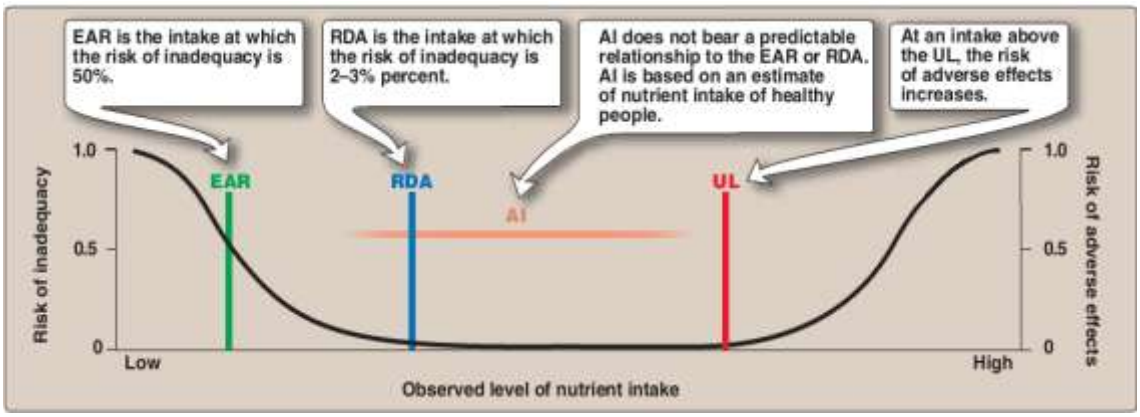
the individuals in a life stage and gender group. The RDA is not the minimal requirement for healthy individuals; rather, it is intentionally set to provide a mar-gin of safety for most individuals. The EAR serves as the foundation for setting the RDA. If the standard deviation (SD) of the EAR is available and the requirement for the nutrient is normally distributed, the RDA is set at 2 SDs above the EAR, that is, RDA = EAR+ $2SD_{EAR}$.

3. Adequate Intake (AI): The AI is set instead of an RDA if sufficient scientific evidence is not available to calculate an EAR or RDA.

The AI is based on estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate. For example, the AI for young infants, for whom human milk is the recommended sole source of food for the first 4-6 months, is based on the estimated daily mean nutrient intake supplied by human milk for healthy, full-term infants who are exclusively breast-fed.

4. Tolerable Upper Intake Level (UL): The UL is the highest average daily nutrient intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects may increase. The UL is not intended to be a recommended level of intake. The UL are useful because of the increased availability of fortified foods and the increased use of dietary supplements. The UL applies to chronic daily use. For some nutrients, there may be insufficient data on which to develop a UL.

B. Using the DRI: Most nutrients have a set of DRI. Usually a nutrient has an EAR and a corresponding RDA. Most are set by age and gender, and may be influenced by special factors, such as pregnancy and lactation in women. When the data are not sufficient to estimate an EAR (or an RDA), then an AI is designated. The AI is judged by experts to meet the needs of all healthy individuals in a group, but is based on less data than an EAR and RDA. Intakes below the EAR need to be improved because the probability of adequacy is 50% or less. Intakes between the EAR and RDA likely need to be improved because the probability of adequacy is less than 98%, and intakes at or above the RDA can be considered adequate. Intake above the AI can be considered adequate. Intakes between the UL and the RDA can be considered to have no risk for adverse effects.



Body Mass Index and Autonomic Function

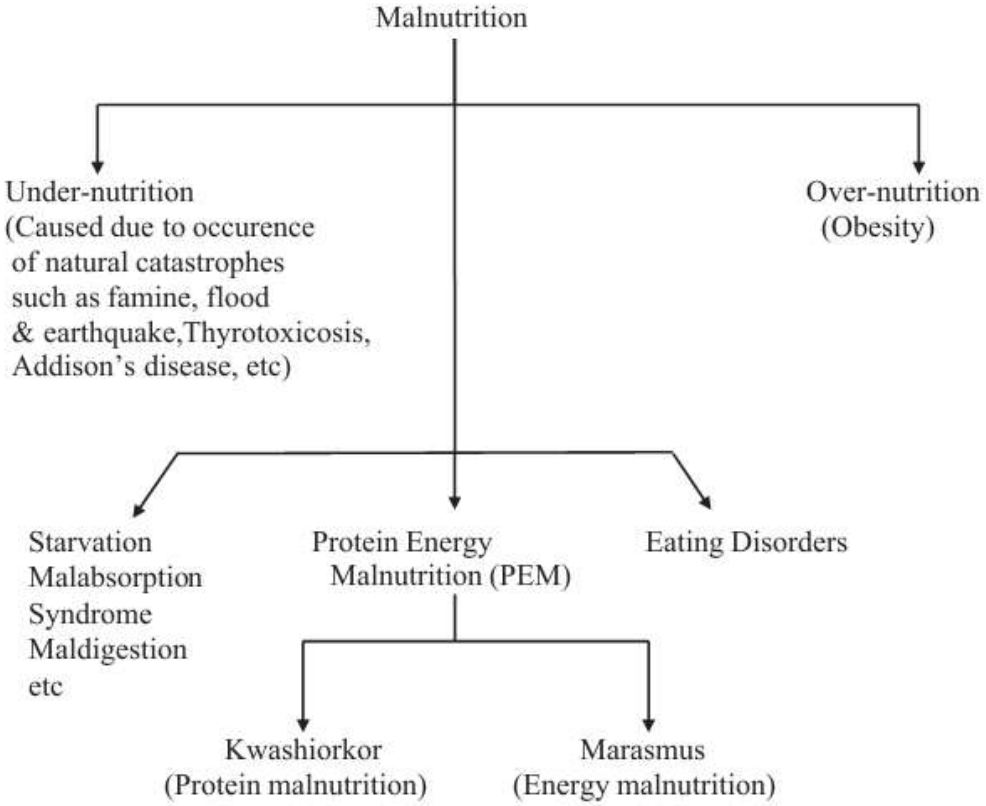
Measurement of body mass index (BMI) will determine whether the individual is suffering from malnutrition, under-nutrition, and obesity.

BMI is measured from weight in kg (W) and height in meters (H).

BMI = W/H^2

BMI of a normal healthy individual is 18.5–24.9 kg /m^2. Overweight is considered when BMI is 25–30 kg /m^2. Obesity is considered when BMI is more than 30 kg/m^2. Under-nutrition is considered if BMI is less than 18 kg/m^2. Severe obesity should be considered if BMI > 40 kg /m^2. Under-nutrition can be considered also, if the body weight is less than 90% of ideal height.

Nutritional deficiencies and disorders



Kwashiorkor

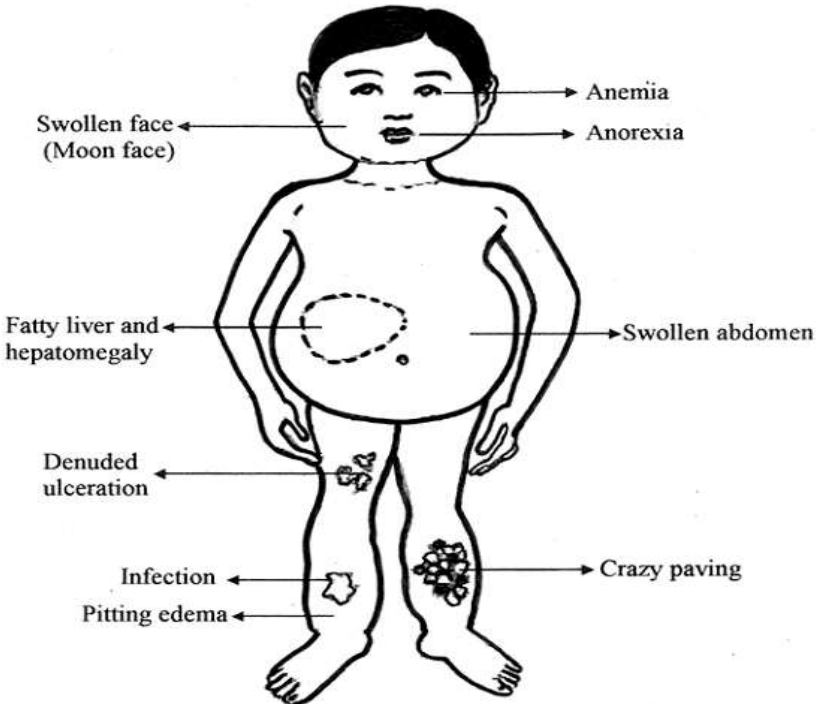
It is caused by inadequate intake of protein in the presence of adequate intake of calories. It is frequently seen in infants and children after weaning, i.e., about 1 year of age, when their diet consists of mainly carbohydrate. Protein deficiency occurs due to consumption of staple diets consisting of cereals and tubers only. The child is deprived of breast-feeding and is fed a starchy diet. Cicely Williams introduced the term kwashiorkor meaning "sickness the older child gets when the next child is born," after studies on the Ga tribe of Ghana.

Characteristic features

- The hallmarks are hypoalbuminemia and edema. The hypoalbuminemia reflects the inadequate supply of amino acids derived from the protein, thus impairing the synthesis of albumin and other proteins. Plasma albumin is below 2.5 g /dL.
- Fatty liver and moderate enlargement of liver (hepatomegaly).
  Causes
  i. Synthesis of plasma protein by the liver is decreased. This, in turn, impairs the export of triglycerides and other lipids from the liver, resulting in fatty liver.
  ii. Low level of epinephrine as epinephrine is synthesized from phenylalanine. Because of lower level of epinephrine, fat is not mobilized from the liver.
  iii. Impaired protein synthesis in the liver along with sufficient dietary carbohydrate ensures lipid synthesis, leading to the accumulation of triacylglycerides in the liver.
- Antibodies are highly specific proteins. The immune system is impaired. Individuals are very susceptible to infections.
- Swollen abdomen and swollen face (moon face) due to edema. Lower limb also shows edema.
- Anorexia, i.e., loss of appetite, occurs due to fatty liver, which causes further restriction of food intake. Anorexia causes malnutrition
- Loss of emotions or apathy is the characteristic feature.
- Growth retardation is present. It is due to deficiency of protein and associated deficiencies of zinc, phosphorus, and sulfur. Inflammation due to immune dysfunction causes reduced secretion of insulin-like growth factor (IGF-1), which in part may cause growth retardation.
- Muscles undergo wasting. Proteins are the major component of muscle. Milestones like crawling and walking are delayed. Impaired muscle strength and fatigue predispose to falls or accidents.
- Dermatitis causes skin cracks and leads to denuded areas of ulceration. Due to dermatitis, the skin resembles "crazy paving" (type of paving made up of irregular shaped slabs of stone or concrete).

- Anemia is due to low hemoglobin and transferrin.

Illustration of the features of kwashiorkor



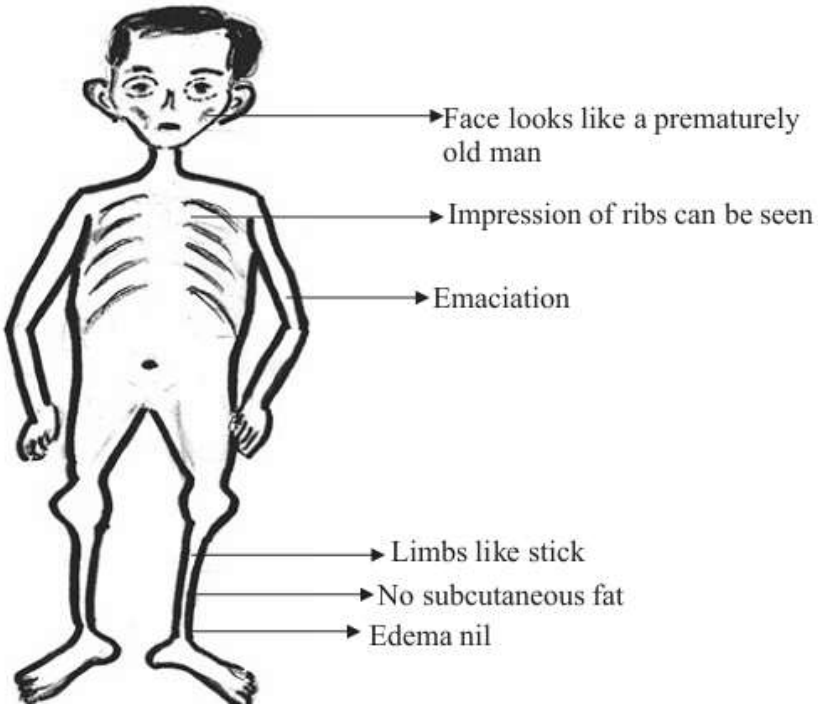
Marasmus

Marasmus is a condition caused by generalized starvation. It is due to severe and prolonged restriction of all foods. Thus, it is a calorie-deficient malnutrition (due to energy-deficient diets). It occurs below 1 year of age. This is a disease of infants of poor mothers in developing countries.

Characteristic features

1) The infant is very thin with no subcutaneous fat. Marked reduction of body weight compared with length. Weight is reduced below 60% of the standard.
2) The combination of low insulin and high cortisol greatly favors the catabolism of muscle. Thus, the muscle wasting is greater in marasmus than in kwashiorkor. Extreme muscle wasting known as emaciation is the characteristic feature of marasmus. The limbs look like sticks or broomsticks.
3) Lowering of BMR.
4) Poor hygiene leads to gastroenteritis (diarrhea and vomiting). Persistent diarrhea and vomiting will aggravate marasmus. Diarrhea may be due to lactose mal-absorption.

Illustration of the features of marasmus



Differences between kwashiorkor and marasmus

	Kwashiorkor	Marasmus
1. Age of onset	1–5 years	Below 1 year
2. Deficiency of	Protein	Calorie
3. Cause	Starchy diet after weaning	Early weaning
4. Edema	Present	Absent
5. Hypoalbuminemia	Severe	Mild
6. Fatty liver and hepatomegaly	Present	Absent
7. Level of insulin	Maintained	Low
8. Level of cortisol	Normal	High
9. Muscle wasting	Mild	Severe
10. Body weight as % of standard	60–80	<60

Mal-absorption Syndrome

The digestion and absorption of food in the small intestine is essential for the maintenance of normal health. Macronutrients and micronutrients are absorbed from the intestine. Malnutrition occurs due to deficient nutrient absorption. Nutrient absorption (arbitrarily upper 40% of small intestine is duodenum and jejunum and lower 60% is the ileum)

- Iron, fat-soluble vitamins, water-soluble vitamins except vitamin B12, fats (after hydrolysis), and calcium are absorbed mainly from upper small intestine.
- Sugars and amino acids are mainly absorbed from mid small intestine.
- Vitamin B12, bile salts, and water are absorbed mainly from lower small intestine.
- Water and electrolytes are absorbed from colon.

Common causes of mal-absorption syndrome

- Due to deficiency of bile salt, for example, cirrhosis.
- Massive intestinal resection by surgery (more than 50% of small intestine) due to malignant tumor or bypass surgery causes inadequate absorptive surface. Resection decreases the surface area for absorption as well as decreases the brush border enzyme activity.
- Mal-digestion due to diseases of the pancreas.
- Inflammatory disease of the small intestine (especially, Crohn's disease).
- Mucosal diseases due to infections (giardiasis and tropical sprue), causing mal-digestion.
- Mutations in SGlT (sodium glucose cotransporter) genes cause glucose-galactose mal-absorption.

Effects of Mal-absorption Syndrome

i. Intestinal mal-absorption of nutrients will cause malnutrition or deficiencies of iron, vitamin B12, folate, etc.
ii. Defective absorption of amino acids causes kwashiorkor.
iii. Due to mal-absorption, the amount of fat in the stool is increased and causes steatorrhea.

Over-nutrition and Obesity

Obesity is a state of excessive deposition of adipose tissue mass in the body. Adipose tissue is composed of lipid-storing adipose cells. Excess of energy intake in food over energy expenditure is the fundamental cause of obesity. In other words, intake of excess amount of calorie-rich food and insufficient exercise causes obesity.

Hyperplasia (increase in number) and hypertrophy (increase in size) of adipocytes are responsible for the development of obesity.

Obesity occurs at all ages, but is more prevalent in middle age. The fat content of adult women is more than that of adult men. Obesity in women begins at puberty and continues during pregnancy and at menopause.

Causes

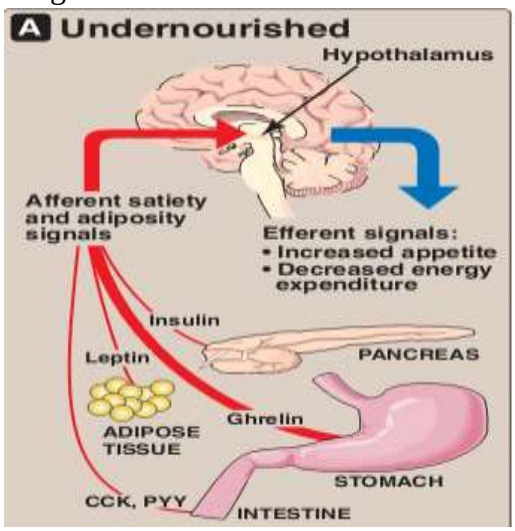
There is no one cause for excess weight, but poor diet and inactivity appear to be leading factors. Genetic, physiological, metabolic, biochemical, and psycho-logical factors can also contribute to it. Energy imbalance is a significant cause of overweight. People eat more than they need. Excess weight can accumulate during and after middle age because people reduce their level of activity and metabolism slows with age. Consequently, weight accumulates unless calorie intake is reduced. **Hypothyroidism** is a possible, but rare, cause of obesity. In this condition, the basal metabolic rate (BMR) is low, thereby reducing the number of calories needed for energy. Unless corrected with medication, this condition can result in excess weight.

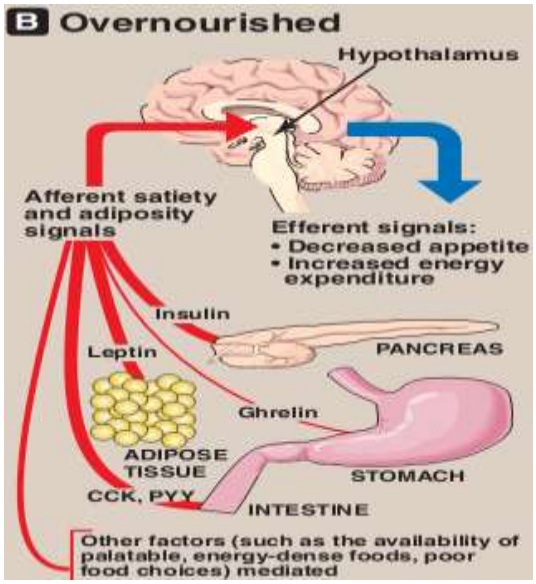
There are two popular theories about weight loss: the fat cell theory and the set-point theory. According to the **fat cell theory,** obesity develops when the size of fat cells increases. When their size decreases, as during a reducing diet, the individual is driven to eat in order for the fat cells to regain their former size. Therefore, it is difficult to lose weight and keep it off.

According to the **set-point theory,** everyone has a set point or natural weight at which the body is so comfortable that it does not allow for deviation. This is said to be the reason why some people cannot lose weight below a “set point” or why, if they do, they quickly regain to that “set point.” The only way to lower a set point is through exercising three to five times a week.

Molecules That Influence Obesity

The cause of obesity can be summarized in a deceptively simple statement of the first law of thermodynamics: Obesity results when energy intake exceeds energy expenditure. However, the mechanism underlying this imbalance involves a complex interaction of biochemical, neurologic, environmental, and psychologic factors. The basic neural and humoral pathways that regulate appetite, energy expenditure, and body weight involve systems that regulate short-term food intake (meal to meal), and signals for the long-term (day to day, week to week, year to year) regulation of body weight.





A. Long-term signals.

1. Leptin:

Leptin is an adipocyte hormone that is secreted in proportion to the size of fat stores. When we consume fewer calories than we need, body fat declines and leptin production from the fat cell decreases. The body adapts by minimizing energy utilization (decreasing activity) and increasing appetite, closing the feedback loop that regulates body weight. Unfortunately, in many individuals, the leptin system may be better at preventing weight loss than pre-venting weight gain. Although a meal or overeating increases leptin and this should, in theory, also dampen appetite and prevent over-consumption of calories, other cues that stimulate appetite can apparently overcome the leptin system in many individuals.

2. **Insulin**:

Obese individuals are also hyperinsulinemic. Like leptin, insulin acts on hypothalamic neurons to dampen appetite.

B. Short-term signals.

Short-term signals from the gastrointestinal tract control hunger and satiety, which affect the size and number of meals over a time course of minutes to hours. In the absence of food intake (between meals), the stomach produces ghrelin, an orexigenic (appetite-stimulating) hormone that drives hunger. During a meal, as food is consumed, gut hormones, including cholecystokinin (CCK) and peptide YY (PYY), among others, through actions on the gastric emptying and neural signals to the hypothalamus, cause satiety and meals are terminated. Within the hypothalamus, neuropeptides such as NPY and α -melanocyte stimulating hormone (α -MSH), and neuro-transmitters such as serotonin and dopamine are important in regulating hunger and satiety. Long-term and short-term signals interact, as leptin can affect the sensitivity of hypothalamic neurons to short-term signals such as CCK. Thus, there are many and complex regulatory loops that control the size and number of meals in relationship to the status of body fat stores.

Nutrient Drug Interaction

Diet and drugs are both necessary to treat and cure diseases. But some drugs may have adverse effect on the utilization of some nutrients. So it is necessary to understand their relationship and maximize their utility by judicious planning.

Interaction between diet and drugs is significant in:

(a) Those who need long term drug therapy.

(b) Those who are malnourished.

(c) Those suffering from chronic diseases.

(d) Those who have undergone surgery.

(e) Those who are obese

(f) High-risk segments of population

High Risk Segments of Population

These include developing fetus, infants (especially premature ones), pregnant women, chronically ill persons and elderly persons.

In late pregnancy increased concentrations of the transport protein for most drugs results in drug concentration in the fetus.

Young children (including infants) have high requirements of nutrients per kg body weight; hence drugs that decrease absorption or increase excretion of a nutrient affects them adversely.

Many elderly persons suffer from chronic diseases and have to take several drugs for prolonged periods. Their food intake is often inadequate. They may take wrong drugs at times. Thus this segment of elderly need special assistance to avoid adverse nutrient drug interaction.

Some commonly used drugs include analgesics (pain killers), cough, cold, sinus and allergy drugs, digestive aids, antacids, sleep aids (sedatives), appetite suppressants, diuretics, antibiotics etc.

Many of these drugs are available without prescription. In addition, health enthusiasts take vitamin and mineral pills in the belief, if a little is good, a higher amount may be better for health. These create a scenario for an undesirable nutrient-drug interaction.

Nutrient Absorption

Most nutrients and drugs are absorbed in the small intestine. Hence it is the major site for nutrient-drug intervention. The absorption of nutrients may be adversely affected by drugs, if the transit time is altered.

Laxatives tend to reduce nutrient absorption by reducing the transit time. If the pH of stomach contents is increased due to drugs (e.g. antacids), the absorption of iron, calcium, zinc and folates is reduced.

Fat and fat-soluble vitamins are poorly absorbed, when drugs are taken to reduce cholesterol by the patient; neomycin (an antibiotic) has the same effect.

High doses of antacids (aluminium or magnesium hydroxide) can cause phosphate depletion, leading to muscle weakness, loss of appetite (anorexia) and even congestive heart failure. Diuretics (thiazide and furosemide) can cause sodium, potassium and magnesium depletion leading to loss of appetite and muscle weakness.

Drug Absorption

A drug is a chemical, which interacts with the metabolic process in the body to bring about a desirable effect. Drug action can occur only after it is dissolved, carried to the target site and absorbed. About 75 per cent of oral drugs will generally be absorbed in 1 to 3 hours.

The metabolism of many drugs and a variety of foreign compounds is carried out by the mixed-function-oxidase system (MFOS). Almost all nutrients are components of the MFO system. These include proteins, lipids, B-complex vitamins (nicotinic acid, riboflavin and pantothenic acid), fat soluble vitamins (A and E) and minerals (iron, copper, calcium, zinc and magnesium).

When food enters the stomach, the gastric pH is lowered by dilution and stomach emptying is delayed. These factors may reduce the absorption rate and hence the effectiveness of the drugs. In view of this, it is advisable to take pain relievers (analgesics), fever reducing drugs (antipyretics), anti-infective for acute infections and antihistamines on an empty stomach for rapid recovery. Aspirin and antibiotics are also better absorbed in a fasting state.

Effect of Drugs on Food Intake

Food intake is affected by drugs taken by the patient. The effects can include decrease or increase in appetite and taste, nausea and vomiting. For example, antacids, caffeine, cough medicines, antihistamines can decrease appetite.

Drugs taken to reduce weight are intended to reduce appetite. But their effectiveness is reduced rapidly. Hence their utility in weight reduction regimen is limited.

Antibiotics and many chemotherapy agents (for cancer) may cause diarrhea or vomiting and thus reduce food intake. Some drugs may be a source of nutrients which may not be appropriate for some patients. For example, cough medications may contain sugar; antibiotics and antacids may contain sodium.

Nutrient Metabolism

Some drugs used as anticonvulsants may cause calcium loss and folate deficiency. Calcium loss may lead to osteomalacia on prolonged use of anticonvulsants. Hence the need for nutrient supplements with these drugs. In contrast, the effectiveness of some drugs such as levadopa and coumarin is reduced due to vitamin supplements (pyridoxine and vitamin K) respectively.

Some drugs block enzymatic action involved in DNA synthesis and thus lead to the death of a cell. This is the principle used in the chemotherapy of cancer. Two common antivitamins, used as drugs, are the folate antagonists, methotrexate (MRX) (used in the treatment of leukemia and rheumatoid arthritis) and pyrimethamine (used in the treatment of malaria and ocular toxoplasmosis).

These drugs displace folic acid from the related enzyme and the unbound folic acid is excreted. In the absence of folic acid, DNA synthesis is inhibited, cell synthesis stops and the cell dies. Isoniazid, which is used in the long-term treatment of TB, forms a complex with the B-vitamin, pyridoxine, which may lead to its deficiency in some patients.

Anticoagulants used in treatment are intentional vitamin K antagonists. The acidity of the gastrointestinal tract also affects drug disposition. A more acidic environment reduces the availability of penicillin and isoniazid but increases the absorption of tetracyclines. Food decreases, delays or enhances the absorption of some antibiotics.

Nutritional genomics

Nutrigenomics is the application of genomics in the field of nutrition research, enabling associations between specific nutrients and genetic factors, e.g. the way in which food or food ingredients influence gene expression.

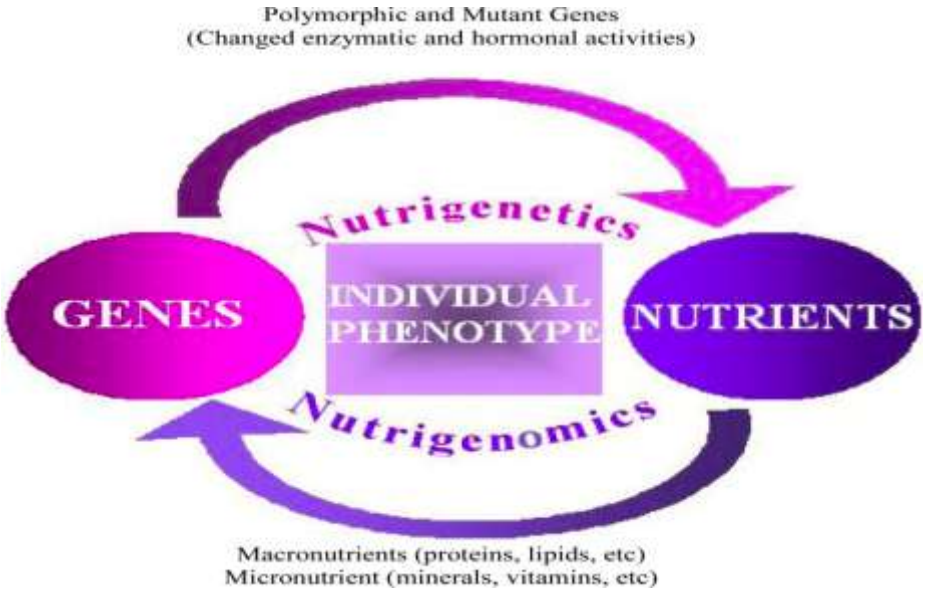
Nutrigenomics facilitate the greater understanding of how nutrition affects metabolic pathways and how this process goes away in diet-related diseases. It is an attempt to study the genome-wide influences of nutrition and aims to identify the genes that influence the risk of diet-related diseases on a genome-wide scale, and to understand the mechanisms that underlie these genetic predispositions.

Nutrigenomics will also identify the genes involved in physiological responses to diet and the genes in which small changes, called polymorphisms, may have significant nutritional consequences and the influence of environmental factors on gene expression.

Nutrigenetics

Nutrigenetics is the tool that helps to reveal the association between the genetic makeup of a particular person with the diet. It also gives an idea why and how a person reacts or responds differently by a particular food ingredient. These individual differences may be at the level of single nucleotide polymorphisms rather than at the gene level. It is envisaged that nutrigenetics may lead to individualized dietary advice.

These two approaches secure a vital role to understand the effects of diet on individual persons and eventually nutrigenomics will lead to evidence-based dietary intervention strategies for restoring health and fitness and for preventing diet-related disease.



Gene Diet Disease Interaction

Nutrigenetic diseases

Human diseases like monogenic diseases are known to be associated with genes and slight modifications in the dietary intake can prevent some monogenetic diseases e.g., high protein food as well as food containing amino acid phenylalanine should be avoided in case of phenylketonuria (PKU).

Patients having galactosemia (lack of a liver enzyme to digest galactose) should avoid diets which contain lactose or galactose, while in case of lactose intolerance (shortage of the enzyme lactase) patients should avoid milk and milk products.

Nutrigenomics diseases

Nutrients are considered to be the most significant environmental stimuli and Genomes are exposed to various types of environmental stimuli, including nutrition. Therefore, the genetic expressions are highly dependent and regulated by, nutrients and phytochemicals present in food.

Unbalanced diets can change nutrient-gene interactions; thereby can increase the possibility of occurrence of chronic diseases. Either direct or indirect dietary chemical can alter genomic expressions. Nutrient imbalances may lead to aging, alcoholism/ substance abuse, behavioral disorders, cancer, cardiovascular disease (CVD), chronic fatigue, deafness, diabetes, immune disorders, macular degeneration, multiple sclerosis, neurological disorders, osteoporosis, Parkinson's disease and stroke.

Diseases that are known to involve in the interactions between multiple genetic and environmental factors include many cancers, diabetes, heart disease, obesity and some psychiatric disorders. Therefore, both areas (nutrigenomics & nutrigenetics) aim to disclose genome-diet interactions; although their approaches and immediate goals are distinct.

Nutrigenomics will reveal the most favorable diet to choose from nutritional alternatives available, whereas nutrigenetics will provide information that will be useful for identifying the optimal diet for particular subject i.e. personalized nutrition.

The following principles of nutritional genomics serve as a conceptual basis for understanding the focus and promise of this emerging field:

1. Unbalanced diets are risk factors for developing disease.

2. Gene expression and / or genome structure can be altered or changed by dietary chemicals.

3. The extent to which diet influences the balance between healthy and disease condition may depend on an individual's genetic makeup.

4. Some diet-regulated genes are likely to play a role in the onset, incidence, progression, and/or severity of chronic diseases.

Nutrigenomics - Direct Link to Single Nucleotide Polymorphisms (SNPS)

Single nucleotide polymorphisms (SNPs) are the most common genetic variations known as polymorphism. Although at the gene sequence level, humans are having 99.9 % identical genomic sequences. Remaining 0.1 % variations in genomic sequence responsible for differences like phenotypic differences (height, weight etc.) and individual's susceptibility to disease conditions and health status.

Genetic polymorphisms influence absorption as well as metabolism of dietary components. Epigenetic variations can bring changes in DNA methylation pattern and thus affects overall genetic expression.

Many dietary components affect post translational events and many account for at least part of the variation. The example of phenylketonuria there is direct link of nutrition to genetic level one more example is available that direct link nutrition with SNPs.

Regarding SNP's, the relationship between folate and the gene MTHFR – 5, 10-methylenetetrahydrofolate reductase. MTHFR is required for supplying 5-MTHF, which is essential for remethylation of homocysteine for production of methionine.

Methionine is crucial for many metabolic pathways including neurotransmitters production and genetic expression regulation. Folate is essential to the efficient functioning of MTHFR. When thymine replaces cytosine at base pair 677 in MTHFR gene, it leads to two forms of the protein: the wild type (C), which functions normally, and the thermal-labile version (T), which has a significantly reduced activity.

Individuals with two copies of the wildtype gene (CC) or one copy of each (CT) will have normal folate metabolism. Those persons with unstable version of both copies (TT) and low folate intake will have higher plasma homocysteine levels, which increases their risk of cardiovascular disease and premature cognitive disturbances.

If supplemented with folic acid or increased folate intake, these individuals can restore their normal methionine levels through metabolising homocysteine. SNP analysis provides a great tool for investigating the role of nutrition in disease and health status at molecular stage and its deliberation in metabolic and epidemiological studies can throw a light to define optimal diets.

Each genomic sequence is a recipe for a specific protein or group of proteins that regulates biological functions and some SNPs change the recipe for the gene that could result either a different quantity of the protein is produced or the structure is altered.

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