

“Issues in Nutrition”.

In Section 1 of this course you will cover these topics:

- What Is Nutrition
- Tools For Healthy Eating
- How The Body Uses The Food And Nutrients You Eat

Topic : What Is Nutrition**Topic Objective:**

At the end of the topic student will be able to understand:

- Minerals
- Protein
- Fiber
- Essential fatty acids
- Fat
- Carbohydrates
- Nutrients
- Nutritional Science
- Poor Diet
- Diet

Definition/Overview:

Nutrition is the science of food, the nutrients in foods and how the body uses those nutrients. It includes the process of ingestion, digestion, absorption, metabolism, transport, storage and excretion of those nutrients. It also includes the environmental, psychological and behavioral aspects of food and eating. The six classes of nutrients include: carbohydrates, fats, proteins, vitamins, minerals and water.

Key Points:**1. Diet**

The diet of an organism refers to what it eats. Dietitians are health professionals who specialize in human nutrition, meal planning, economics, preparation, and so on. They are trained to provide safe, evidence-based dietary advice and management to individuals (in health and disease), as well as to institutions.

2. Poor Diet

Poor diet can have an injurious impact on health, causing deficiency diseases such as scurvy, beriberi, and kwashiorkor; health-threatening conditions like obesity and metabolic syndrome, and such common chronic systemic diseases as cardiovascular disease, diabetes, and osteoporosis.

3. Nutritional Science

Nutritional science investigates the metabolic and physiological responses of the body to diet. With advances in the fields of molecular biology, biochemistry, and genetics, the study of nutrition is increasingly concerned with metabolism and metabolic pathways, the sequences of biochemical steps through which the many substances of living things change from one form to another. The human body contains chemical compounds, such as water, carbohydrates (sugar, starch, and fiber), amino acids (in proteins), fatty acids (in lipids), and nucleic acids (DNA/RNA). These compounds, in turn, consist of elements such as carbon, hydrogen, oxygen, nitrogen, phosphorus, calcium, iron, zinc, magnesium, manganese, and so on. All of these chemical compounds and elements occur in various forms and combinations (e.g. hormones/vitamins, phospholipids, hydroxyapatite), both in the human body and in organisms (e.g. plants, animals) that humans eat.

The human body consists of elements and compounds ingested, digested, absorbed, and circulated through the bloodstream. Except in the unborn fetus, it is the digestive system which carries out the first steps in feeding the cells of the body. In a typical adult, about seven liters of digestive juices enter the lumen of the digestive tract. They break chemical bonds in ingested molecules and modulate their conformations and energy states. Though some molecules are absorbed into the bloodstream unchanged, digestive processes release them

from the matrix of foods in which they occur. Unabsorbed matter is excreted in the feces. Studies of nutritional status must take into account the state of the body before and after experiments, as well as the chemical composition of the diet and the products of excretion. Comparing the food to the waste can help determine the specific compounds and elements absorbed in the body. Their effects may only be discernible after an extended period of time, during which all food and waste must be analyzed. The number of variables involved in such experiments is high, making nutritional studies time-consuming and expensive, which explains why the science of human nutrition is still slowly evolving. In general, eating a wide variety of fresh, whole (unprocessed), foods has proven favourable compared to monotonous diets based on processed foods. In particular, the consumption of whole plant foods slows digestion and provides higher amounts, and a more favourable balance, of essential nutrients per Calorie, resulting in better management of cell growth, maintenance, and mitosis (cell division), as well as better regulation of appetite and blood sugar. Regularly scheduled meals (every few hours) have also proven more wholesome than infrequent, haphazard ones.

4. Nutrients

There are seven major classes of nutrients: carbohydrates, fats, fiber, minerals, protein, vitamins, and water. These nutrient classes can be categorized as either macronutrients (needed in relatively large amounts) or micronutrients (needed in smaller quantities). The macronutrients are carbohydrates, fats, fiber, proteins, and water. The micronutrients are minerals and vitamins. The macronutrients (excluding fiber and water) provide energy, which is measured in Joules or kilocalories (often called "Calories" and written with a capital C to distinguish them from gram calories). Carbohydrates and proteins provide 17 kJ (4 kcal) of energy per gram, while fats provide 37 kJ (9 kcal) per gram. Vitamins, minerals, fiber, and water do not provide energy, but are necessary for other reasons.

Molecules of carbohydrates and fats consist of carbon, hydrogen, and oxygen atoms. Carbohydrates range from simple monosaccharides (glucose, fructose, galactose) to complex polysaccharides (starch). Fats are triglycerides, made of various fatty acid monomers bound to glycerol. Some fatty acids, but not all, are essential in the diet: they cannot be synthesized in the body. Protein molecules contain nitrogen atoms in addition to the elements of carbohydrates and fats. The nitrogen-containing monomers of protein are amino acids, and they include some essential amino acids. They fulfill many roles other than energy metabolism; and when they are used as fuel, getting rid of the nitrogen places a burden on the

kidneys. Other micronutrients include antioxidants and phytochemicals. Most foods contain a mix of some or all of the nutrient classes. Some nutrients are required regularly, while others are needed only occasionally. Poor health can be caused by an imbalance of nutrients, whether an excess or a deficiency.

5. Carbohydrates

A pack of toasted bread is a cheap, high calorie nutrient (usually unbalanced, i.e., deficient in essential minerals and vitamins, because of removal of grain bran) food source with a long shelf-life. Carbohydrates may be classified as monosaccharides, disaccharides, or polysaccharides by the number of monomer (sugar) units they contain. They constitute a large proportion of foods such as rice, noodles, bread, and other grain-based products. Monosaccharides contain one sugar unit, disaccharides two, and polysaccharides three or more. Polysaccharides are often referred to as *complex* carbohydrates because they are long chains of sugar units, whereas monosaccharides and disaccharides are simpler. The difference is important: complex carbohydrates take longer to digest and absorb since their sugar units are processed one-by-one off the ends of the chains. The spike in blood-sugar levels after ingestion of simple sugars is thought to be involved in causing heart and vascular disease. Simple sugars form a greater part of modern diets, leading to more cardiovascular disease in populations. Simple carbohydrates are absorbed quickly, and therefore raise blood-sugar levels more rapidly.

6. Fat

A molecule of fat consists of several fatty acids (containing long chains of carbon and hydrogen atoms), bonded to a glycerol. They are typically found as triglycerides (three fatty acids attached to one glycerol backbone). Fats may be classified as saturated or unsaturated. Saturated fats have all of the carbon atoms in their fatty acid chains bonded to hydrogen atoms, whereas unsaturated fats have some of these carbon atoms double-bonded, so their molecules have relatively few hydrogen atoms. Unsaturated fats may be further classified as monounsaturated (one double-bond) or polyunsaturated (many double-bonds). Trans fats are a type of unsaturated fat with *trans*-isomer fatty acid, typically created in an industrial process called (partial) hydrogenation.

Many studies have shown that unsaturated fats, particularly monounsaturated fats, are best in the human diet. Saturated fats, typically from animal sources, are next, while trans fats are to be avoided. Saturated and trans fats are typically solid at room temperature (such as butter or lard), while unsaturated fats are typically liquids (such as olive oil or flaxseed oil). Trans fats are very rare in nature, but have properties useful in the food processing industry.

7. Essential fatty acids

Most fatty acids are non-essential, meaning the body can produce them as needed. However, in humans at least two fatty acids are essential and must be included in the diet. An appropriate balance of essential fatty acids omega-3 and omega-6 fatty acids is important for health. Both of these "omega" long-chain polyunsaturated fatty acids are substrates for a class of eicosanoids known as prostaglandins, which have roles throughout the human body. They are hormones, in some respects. The omega-3 eicosapentaenoic acid (EPA), which can be made in the human body from the omega-3 essential fatty acid alpha-linolenic acid (LNA), or taken in through marine food sources, serves as a building block for series 3 prostaglandins (e.g. weakly inflammatory PGE₃). The omega-6 dihomo-gamma-linolenic acid (DGLA) serves as a building block for series 1 prostaglandins (e.g. anti-inflammatory PGE₁), whereas arachidonic acid (AA) serves as a building block for series 2 prostaglandins (e.g. pro-inflammatory PGE₂). Both DGLA and AA can be made from the omega-6 linoleic acid (LA) in the human body, or can be taken in directly through food. An appropriately balanced intake of omega-3 and omega-6 partly determines the relative production of different prostaglandins: one reason a balance between omega-3 and omega-6 is important for cardiovascular health. In industrialized societies, people typically consume large amounts of processed vegetable oils, which have reduced amounts of the essential fatty acids along with too much of omega-6 fatty acids relative to omega-3 fatty acids.

The conversion rate of omega-6 DGLA to AA largely determines the production of the prostaglandins PGE₁ and PGE₂. Omega-3 EPA prevents AA from being released from membranes, thereby skewing prostaglandin balance away from pro-inflammatory PGE₂ (made from AA) toward anti-inflammatory PGE₁ (made from DGLA). Moreover, the conversion (desaturation) of DGLA to AA is controlled by the enzyme delta-5-desaturase, which in turn is controlled by hormones such as insulin (up-regulation) and glucagon (down-regulation). The amount and type of carbohydrates consumed, along with some types of amino acid, can influence processes involving insulin, glucagon, and other hormones;

therefore the ratio of omega-3 versus omega-6 has wide effects on general health, and specific effects on immune function and inflammation, and mitosis (i.e. cell division). Good sources of essential fatty acids include most vegetables, nuts, seeds, and marine oils, Some of the best sources are fish, flax seed oils, soy beans, pumpkin seeds, sunflower seeds, and walnuts.

8. Fiber

Fiber is a carbohydrate (or a polysaccharide) that is incompletely absorbed in humans and in some other animals. Like all carbohydrates, when it is metabolized it can produce four Calories (kilocalories) of energy per gram: but in fact it accounts for less than that because of its limited absorption. Dietary fiber consists mainly of cellulose, a large carbohydrate polymer that is indigestible because humans do not have the required enzymes. There are two subcategories: soluble and insoluble fiber. Whole grains, fruits (especially plums, prunes, and figs), and vegetables are rich in dietary fiber. Fiber is important to digestive health and is thought to reduce the risk of colon cancer. It can help in alleviating both constipation and diarrhea. Fiber provides bulk to the intestinal contents, and insoluble fiber stimulates peristalsis: the rhythmic muscular contractions passing along the digestive tract. Some soluble fibers produce a solution of high viscosity: a gel, which slows the movement of food through the intestines. Fiber, especially from whole grains, may help lessen insulin spikes and reduce the risk of diabetes [type 2].

9. Protein

Proteins are the basis of many animal body structures (e.g. muscles, skin, and hair). Each molecule is composed of amino acids, sometimes many thousands, which are characterized by inclusion of nitrogen and sometimes sulphur. The body requires amino acids to produce new proteins (protein retention) and to replace damaged proteins (maintenance). Excess amino acids are discarded, typically in the urine. For all animals, some amino acids are *essential* (an animal cannot produce them internally) and some are *non-essential* (the animal can produce them from other nitrogen-containing compounds). About twenty amino acid are found in the human body, and about ten of these are essential, and therefore must be included in the diet. A diet that contains adequate amounts of amino acids (especially those that are essential) is particularly important when there is greater need: in early development and maturation, pregnancy, lactation, or injury. A *complete* protein source contains all the

essential amino acids; an *incomplete* protein source lacks one or more essential amino acid. It is possible to combine two incomplete protein sources (e.g. rice and beans) to make a complete protein source. Sources of dietary protein include meats, tofu and other soy-products, eggs, grains, legumes, and dairy products such as milk and cheese. A few amino acids from protein can be converted into glucose and used for fuel through a process called gluconeogenesis. The amino acids remaining after such conversion are discarded.

10. Minerals

Dietary minerals are the chemical elements required by living organisms, other than the four elements carbon, hydrogen, nitrogen, and oxygen that are present in common organic molecules. The term "mineral" is archaic, since the intent is to describe simply the less common elements in the diet: heavier than the four just mentioned; including several metals; and often occurring as ions in the body. Some dietitians recommend that these be supplied from foods in which they occur naturally, or at least as complex compounds, or sometimes even from natural inorganic sources (such as calcium carbonate from ground oyster shells). On the other hand, minerals are often artificially added to the diet as supplements, the most famous being iodine in iodized salt.

Topic : Tools For Healthy Eating

Topic Objective:

At the end of the topic student will be able to understand:

- Cultural and psychological factors
- Avoidance of Trans fat
- Healthy Diet

Definition/Overview:

A healthy diet is one that is arrived at with the intent of improving or maintaining optimal health. This usually involves consuming nutrients by eating the appropriate amounts from all of the food groups, including an adequate amount of water. Since human nutrition is complex, a healthy diet may vary widely, and is subject to an individual's genetic makeup, environment, and health. For around 20% of the human population, lack of food and

malnutrition are the main impediments to healthy eating. Conversely, people in developed countries have the opposite problem; they are more concerned about obesity.

Key Points:

1. Healthy Diet

Generally, a healthy diet is said to include:

Sufficient calories to maintain a person's metabolic and activity needs, but not so excessive as to result in fat storage greater than roughly 30% of body mass. For most people the recommended daily allowance of energy is 2,000 calories, but it depends on age, sex, height, and weight. Sufficient quantities of fat, including monounsaturated fat, polyunsaturated fat and saturated fat, with a balance of omega-6 and long-chain omega-3 lipids. The recommended daily allowance of fat is 65-80 grams. Maintenance of a good ratio between carbohydrates and lipids (4:1): four grams of the first for one gram of the second. Avoidance of excessive saturated fat (20grams recommended limit)(although the "evidence" for this claim is forever in debate after the testimony of results provided by the Framingham Heart Study of 1948-1998)

2. Avoidance of Trans fat

Sufficient essential amino acids ("complete protein") to provide cellular replenishment and transport proteins. (All essential amino acids are present in animals. Some plants together give all the essential acids except rice and beans which have limitations.)

Essential micronutrients such as vitamins and certain minerals. Avoiding directly poisonous (e.g. heavy metals) and carcinogenic (e.g. benzene) substances; Avoiding foods contaminated by human pathogens (e.g. e.coli, tapeworm eggs); Avoiding chronic high doses of certain foods that are benign or beneficial in small or occasional doses, such as foods or substances with directly toxic properties at high chronic doses (e.g. ethyl alcohol); foods that may interfere at high doses with other body processes (e.g. refined table salt); foods that may burden or exhaust normal functions (e.g. refined carbohydrates without adequate dietary fiber).

3. Cultural and psychological factors

From a psychological perspective, a new healthy diet may be difficult to achieve for a person with poor eating habits. This may be due to tastes acquired in early adolescence and preferences for fatty foods. It may be easier for such a person to transition to a healthy diet if treats such as chocolate are allowed; sweets may act as mood stabilizers, which could help reinforce correct nutrient intake. It is known that the experiences we have in childhood relating to consumption of food affect our perspective on food consumption in later life. From this, we are able to determine ourselves our limits of how much we will eat, as well as foods we will not eat - which can develop into eating disorders, such as anorexia, bulimia, or orthorexia. This is also true with how we perceive the sizes of the meals or amounts of food we consume daily; people have different interpretations of small and large meals based on upbringing. While plants, vegetables, and fruits are known to help reduce the incidence of chronic disease, the benefits on health posed by plant-based foods, as well as the percentage of which a diet needs to be plant based in order to have health benefits is unknown. Nevertheless, plant-based food diets in society and between nutritionist circles are linked to health and longevity, as well as contributing to lowering cholesterol, weight loss, and in some cases, stress reduction. Indeed, ideas of what counts as "healthy eating" have varied in different times and places, according to scientific advances in the field of nutrition, cultural fashions, religious proscriptions, or personal considerations.

Topic : How The Body Uses The Food And Nutrients You Eat

At the end of the topic student will be able to understand:

- Theoretical Calculation
- Nutrients
- Types of nutrient
- Substances that provide energy
- Substances that support metabolism
- Essential and non-essential nutrients

Definition/Overview:

Energy intake to the body that is not used up is mostly stored as fat in the fat tissue.

Key Points:**1. Theoretical Calculation**

Consider the following theoretical calculation. Fat contains about 4,000 kilocalories per pound (37 MJ/kg). If you eat 4,000 kcal more than your body needs, you will put on 0.3 pound of fat (assuming 30% digestion efficiency, or less depending on food conversion inefficiency not included in the "body needs" category). If you burn 4,000 kcal more than you eat, you will lose about a pound of fat (this is close to 100% since even the waste heat counts toward the 4,000 kcal). This assumes that all the weight gained and lost is in the form of fat. In reality, this is a mixture of protein, carbohydrates etc. (in muscle and organ etc). The conversion efficiency of food energy into physical power depends on the form of energy source (type of food) and on the type of physical energy usage (e.g. which muscles are used, whether the muscle is used aerobically or anaerobically). In general, the efficiency of muscles is rather low, and roughly speaking, only about 15% of the food energy is actually converted into mechanical energy. For example, when calculating food energy burnt per unit time gym equipment manufacturers multiply the value of physical power by a factor of eight (assuming 12.5% efficiency). Thus if an exercise bike registers a 150-watt physical power output it might display 17 kcal/min as the rate of food energy burnt per unit time (since $150 \text{ W} \times 8 = 1200 \text{ W} = 17 \text{ kcal/min}$).

2. Nutrients

A nutrient is a chemical that an organism needs to live and grow or a substance used in an organism's metabolism which must be taken in from its environment. Methods for nutrient intake vary, with animals and protists consuming foods that are digested by an internal digestive system, but most plants ingest nutrients directly from the soil through their roots or from the atmosphere. Some plants, like carnivorous plants, externally digesting nutrients from animals, before ingesting them. The effects of nutrients are dose-dependent. Organic nutrients include carbohydrates, fats, proteins (or their building blocks, amino acids), and vitamins. Inorganic chemical compounds such as minerals; water and oxygen may also be

considered nutrients. A nutrient is essential to an organism if it cannot be synthesized by the organism in sufficient quantities and must be obtained from an external source. Nutrients needed in relatively large quantities are called macronutrients and those needed in relatively small quantities are called micronutrients.

3. Types of nutrient

Macronutrients are defined in several different ways.

- The chemical elements humans consume in the largest quantities are carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur.
- The classes of chemical compounds humans consume in the largest quantities and which provide bulk energy are carbohydrates, proteins, and fats. Water and atmospheric oxygen also must be consumed in large quantities, but are not always considered "food" or "nutrients".
- Calcium, salt (sodium and chloride), magnesium, and potassium (along with phosphorus and sulfur) are sometimes added to the list of macronutrients because they are required in large quantities compared to other vitamins and minerals. They are sometimes referred to as the macrominerals.
- The remaining vitamins, minerals, fats or elements, are called micronutrients because they are required in relatively small quantities.

4. Substances that provide energy

- Carbohydrates are compounds made up of sugars. Carbohydrates are classified by their number of sugar units: monosaccharides (such as glucose and fructose), disaccharides (such as sucrose and lactose), oligosaccharides, and polysaccharides (such as starch, glycogen, and cellulose).
- Proteins are organic compounds that consists of the amino acids joined by peptide bonds. The body cannot manufacture some of the amino acids (termed essential amino acids); the diet must supply these. In nutrition, proteins are broken down through digestion by proteases back into free amino acids.
- Fats consist of a glycerin molecule with three fatty acids attached. Fatty acids are unbranched hydrocarbon chains, connected by single bonds alone (saturated fatty acids) or by both double and single bonds (unsaturated fatty acids). Fats are needed to keep cell membranes functioning properly, to insulate body organs against shock, to keep body temperature stable,

and to maintain healthy skin and hair. The body does not manufacture certain fatty acids (termed essential fatty acids) and the diet must supply these. Fat has an energy content of 9 kcal/g (~37.7 kJ/g); proteins and carbohydrates 4 kcal/g (~16.7 kJ/g). Ethanol (grain alcohol) has an energy content of 7 kcal/g (~29.3 kJ/g).

5. Substances that support metabolism

- Dietary minerals are generally trace elements, salts, or ions such as copper and iron. Some of these minerals are essential to human metabolism.
- Vitamins are organic compounds essential to the body. They usually act as coenzymes or cofactors for various proteins in the body.
- Water is an essential nutrient and is the solvent in which all the chemical reactions of life take place.

6. Nutrients and plants

The strip of a green alga (Enteromorpha) along this shore indicates that there is a nearby source of nutrients (probably nitrates or ammonia from a small estuary). The chemical elements consumed in the greatest quantities by plants are carbon, hydrogen, and oxygen. These are present in the environment in the form of water and carbon dioxide; energy is provided by sunlight. Nitrogen, phosphorus, potassium, and sulfur are also needed in relatively large quantities. Together, these are the elemental macronutrients for plants, often represented by the acronym CHNOPS. Usually they are sourced from inorganic (e.g. carbon dioxide, water, nitrate, phosphate, sulfate) or organic (e.g. carbohydrates, lipids, proteins) compounds, although elemental diatomic molecules of nitrogen and (especially) oxygen are often used. Other chemical elements are also necessary to carry out various life processes and build structures; see fertilizer and micronutrient for more information. Some of these are considered macronutrients in certain organisms. The acronym C. HOPKiN'S CaFe Mg (to be used as C. Hopkins coffee mug) is used by some students to remember the list as: Carbon, Hydrogen, Oxygen, Phosphorus, Potassium (K), Nitrogen, Sulfur, Calcium, Iron (Fe), and Magnesium (Mg). Silicon, chloride, sodium, copper, zinc, and molybdenum are sometimes also included, but are in other cases considered micronutrients. Oversupply of plant nutrients in the environment can cause excessive plant and algae growth. Eutrophication, as this process is called, may cause imbalances in population numbers and other nutrients that can be harmful to certain species. For example, an algal bloom can deplete the oxygen available for

fish to breathe. Causes include water pollution from sewage or runoff from farms (carrying excess agricultural fertilizer). Nitrogen and phosphorus are most commonly the limiting factor in growth, and thus the most likely to trigger eutrophication when introduced artificially.

7. Essential and non-essential nutrients

Nutrients are frequently categorized as essential or nonessential. Essential nutrients are unable to be synthesized internally (either at all, or in sufficient quantities), and so must be consumed by an organism from its environment. For humans, these include essential fatty acids, essential amino acids, vitamins, and certain dietary minerals. Oxygen and water are also essential for human survival, but are generally not considered "food" when consumed in isolation. Humans can derive energy from a wide variety of fats, carbohydrates, proteins, and ethanol, and can synthesize other needed amino acids from the essential nutrients. Non-essential nutrients can still have a significant impact on health, whether beneficial or toxic. For example, most dietary fiber is not absorbed by the human digestive tract, but is important in digestion and absorption of otherwise harmful substances. Interest has recently increased in phytochemicals, which include many non-essential nutrients which may have health benefits.

In Section 2 of this course you will cover these topics:

- Carbohydrates: Sugars, Starches, And Fiber
- Lipids: Fats, Oils, Phospholipids, And Sterols
- Proteins And Amino Acids

Topic : Carbohydrates: Sugars, Starches, And Fiber

Topic Objective:

At the end of the topic student will be able to understand:

- Carbohydrates
- Nutrition

- Oligosaccharides and polysaccharides
- Disaccharides
- Use in living organisms
- Conformation
- Monosaccharides
- Classification of Carbohydrates

Definition/Overview:

Carbohydrates (from 'hydrates of carbon') or saccharides (Greek meaning "sugar") are the most abundant of the four major classes of biomolecules, which also include proteins, lipids and nucleic acids. They fill numerous roles in living things, such as the storage and transport of energy (starch, glycogen) and structural components (cellulose in plants, chitin in animals). Additionally, carbohydrates and their derivatives play major roles in the working process of the immune system, fertilization, pathogenesis, blood clotting, and development.

Key Points:

1. Carbohydrates

Chemically, carbohydrates are simple organic compounds that are aldehydes or ketones with many hydroxyl groups added, usually one on each carbon atom that is not part of the aldehyde or ketone functional group. The basic carbohydrate units are called monosaccharides, such as glucose, galactose, and fructose. The general stoichiometric formula of an unmodified monosaccharide is $(CH_2O)_n$, where n is any number of three or greater; however, the use of this word does not follow this exact definition and many molecules with formulae that differ slightly from this are still called carbohydrates, and others that possess formulae agreeing with this general rule are not called carbohydrates (eg formaldehyde). Monosaccharides can be linked together into polysaccharides in almost limitless ways. Many carbohydrates contain one or more modified monosaccharide units that have had one or more groups replaced or removed. For example, deoxyribose, a component of DNA, is a modified version of ribose; chitin is composed of repeating units of N-acetylglucosamine, a nitrogen-containing form of glucose. The names of carbohydrates often end in the suffix -ose.

2. Classification of Carbohydrates

Dietitians and nutritionists commonly classify carbohydrates as simple (monosaccharides and disaccharides) or complex (oligosaccharides and polysaccharides). The term complex carbohydrate was first used in the Senate Select Committee publication Dietary Goals for the United States (1977), where it denoted "fruit, vegetables and whole-grains". Dietary guidelines generally recommend that complex carbohydrates and nutrient-rich simple carbohydrates such as fruit and dairy products make up the bulk of carbohydrate consumption. The USDA's Dietary Guidelines for Americans 2005 dispenses with the simple/complex distinction, instead recommending fiber-rich foods and whole grains.

The glycemic index and glycemic load systems are popular alternative classification methods which rank carbohydrate-rich foods based on their effect on blood glucose levels. The insulin index is a similar, more recent classification method which ranks foods based on their effects on blood insulin levels. This system assumes that high glycemic index foods and low glycemic index foods can be mixed to make the intake of high glycemic foods more acceptable.

3. Monosaccharides

D-glucose is an aldohexose with the formula $(\text{CH}_2\text{O})_6$. The red atoms highlight the aldehyde group, and the blue atoms highlight the asymmetric center furthest from the aldehyde; because this -OH is on the right of the Fischer projection, this is a D sugar.

Monosaccharides are the simplest carbohydrates in that they cannot be hydrolyzed to smaller carbohydrates. The general chemical formula of an unmodified monosaccharide is $(\text{CH}_2\text{O})_n$, where n is any number of three or greater.

3.1. Classification of monosaccharides

The α and β anomers of glucose. Note the position of the anomeric carbon (red or green) relative to the CH_2OH group bound to carbon 5: they are either on the opposite sides (), or the same side (). Monosaccharides are classified according to three different characteristics: the placement of its carbonyl group, the number of carbon atoms it contains, and its

chiralhandedness. If the carbonyl group is an aldehyde, the monosaccharide is an aldose; if the carbonyl group is a ketone, the monosaccharide is a ketose. Monosaccharides with three carbon atoms are called trioses, those with four are called tetroses, five are called pentoses, six are hexoses, and so on. These two systems of classification are often combined. For example, glucose is an aldohexose (a six-carbon aldehyde), ribose is an aldopentose (a five-carbon aldehyde), and fructose is a ketohexose (a six-carbon ketone). Each carbon atom bearing a hydroxyl group (-OH), with the exception of the first and last carbons, are asymmetric, making them stereocenters with two possible configurations each (R or S). Because of this asymmetry, a number of isomers may exist for any given monosaccharide formula. The aldohexose D-glucose, for example, has the formula $(\text{CH}_2\text{O})_6$, of which all but two of its six carbon atoms are stereogenic, making D-glucose one of $2^4 = 16$ possible stereoisomers. In the case of glyceraldehyde, an aldotriose, there is one pair of possible stereoisomers, which are enantiomers and epimers. 1,3-dihydroxyacetone, the ketose corresponding to the aldose glyceraldehyde, is a symmetric molecule with no stereocenters). The assignment of D or L is made according to the orientation of the asymmetric carbon furthest from the carbonyl group: in a standard Fischer projection if the hydroxyl group is on the right the molecule is a D sugar, otherwise it is an L sugar. Because D sugars are biologically far more common, the D is often omitted.

4. Conformation

The aldehyde or ketone group of a straight-chain monosaccharide will react reversibly with a hydroxyl group on a different carbon atom to form a hemiacetal or hemiketal, forming a heterocyclic ring with an oxygen bridge between two carbon atoms. Rings with five and six atoms are called furanose and pyranose forms, respectively, and exist in equilibrium with the straight-chain form. During the conversion from straight-chain form to cyclic form, the carbon atom containing the carbonyl oxygen, called the anomeric carbon, becomes a chiral center with two possible configurations: the oxygen atom may take a position either above or below the plane of the ring. The resulting possible pair of stereoisomers are called anomers. In the α anomer, the -OH substituent on the anomeric carbon rests on the opposite side (trans) of the ring from the CH_2OH side branch. The alternative form, in which the CH_2OH substituent and the anomeric hydroxyl are on the same side of the plane of the ring, is called the β anomer. Because the ring and straight-chain forms readily interconvert, both anomers exist in equilibrium.

5. Use in living organisms

Monosaccharides are the major source of fuel for metabolism, being used both as an energy source (glucose being the most important in nature) and in biosynthesis. When monosaccharides are not needed by cells they are quickly converted into another form, such as polysaccharides.

6. Disaccharides

Two joined monosaccharides are called disaccharides and represent the simplest polysaccharides. Examples include sucrose and lactose. They are composed of two monosaccharide units bound together by a covalent bond known as a glycosidic linkage formed via a dehydration reaction, resulting in the loss of a hydrogen atom from one monosaccharide and a hydroxyl group from the other. The formula of unmodified disaccharides is $C_{12}H_{22}O_{11}$. Although there are numerous kinds of disaccharides, a handful of disaccharides are particularly notable. Sucrose, pictured to the right, is the most abundant disaccharide and the main form in which carbohydrates are transported in plants. It is composed of one D-glucose molecule and one D-fructose molecule. The systematic name for sucrose, O- α -D-glucopyranosyl-(1 \rightarrow 2)-D-fructofuranoside, indicates four things:

- Its monosaccharides: glucose and fructose
- Their ring types: glucose is a pyranose, and fructose is a furanose
- How they are linked together: the oxygen on carbon number 1 (C1) of α -D-glucose is linked to the C2 of D-fructose.
- The -oside suffix indicates that the anomeric carbon of both monosaccharides participates in the glycosidic bond.
- Lactose, a disaccharide composed of one D-galactose molecule and one D-glucose molecule, occurs naturally in milk. The systematic name for lactose is O- β -D-galactopyranosyl-(1 \rightarrow 4)-D-glucopyranose. Other notable disaccharides include maltose (two D-glucoses linked α -1,4) and cellobiose (two D-glucoses linked β -1,4).

7. Oligosaccharides and polysaccharides

Amylose is a linear polymer of glucose mainly linked with α (1 \rightarrow 4) bonds. It can be made of several thousands of glucose units. It is one of the two components of starch, the other being

amylopectin. Oligosaccharides and polysaccharides are composed of longer chains of monosaccharide units bound together by glycosidic bonds. The distinction between the two is based upon the number of monosaccharide units present in the chain. Oligosaccharides typically contain between two and nine monosaccharide units, and polysaccharides contain greater than ten monosaccharide units. Definitions of how large a carbohydrate must be to fall into each category vary according to personal opinion. Examples of oligosaccharides include the disaccharides mentioned above, the trisaccharide raffinose and the tetrasaccharide stachyose. Oligosaccharides are found as a common form of protein posttranslational modification. Such posttranslational modifications include the Lewis and ABO oligosaccharides responsible for blood group incompatibilities, the alpha-Gal epitope responsible for hyperacute rejection in xenotransplantation, and O-GlcNAc modifications. Polysaccharides represent an important class of biological polymers. Their function in living organisms is usually either structure or storage related. Starch is used as a storage polysaccharide in plants, being found in the form of both amylose and the branched amylopectin. In animals, the structurally similar but more densely branched glycogen is used instead. Glycogen's properties allow it to be metabolized more quickly, which suits the active lives of locomotive animals. Cellulose and chitin are examples of structural polysaccharides. Cellulose is used in the cell walls of plants and other organisms, and is claimed to be the most abundant organic molecule on earth. It has a variety of uses including in the paper and textile industry and as a feedstock for the production of rayon (in the viscose process), cellulose acetate, celluloid and nitrocellulose. Chitin has a similar structure to cellulose but has nitrogen containing side branches, increasing its strength. It is found in arthropod exoskeletons and in the cell walls of some fungi. It has a variety of uses, for example in surgical threads. Other polysaccharides include callose or laminarin, xylan, mannan, fucoidan, and galactomannan.

8. Nutrition

- Grain products: rich sources of complex and simple carbohydrates
- Carbohydrates require less water to digest than proteins or fats and are the most common source of energy. Proteins and fat are vital building components for body tissue and cells and are also a source of energy for the body.
- Carbohydrates are not essential nutrients: the body can obtain all its energy from protein and fats. The brain cannot burn fat and needs glucose for energy, but the body can make this

glucose from protein. Carbohydrates contain 3.75 and proteins 4 kilocalories per gram, respectively, while fats contain 9 kilocalories and alcohol contains 7 kilocalories per gram.

- Foods that are high in carbohydrates include breads, pastas, beans, potatoes, bran, rice and cereals.
- Based on evidence for risk of heart disease and obesity, the Institute of Medicine recommends that American and Canadian adults get between 40-65% of dietary energy from carbohydrates. The Food and Agriculture Organization and World Health Organization jointly recommend that national dietary guidelines set a goal of 55-75% of total energy from carbohydrates, but only 10% should be from Free sugars (their definition of simple carbohydrates).

9. Classification

Dietitians and nutritionists commonly classify carbohydrates as simple (monosaccharides and disaccharides) or complex (oligosaccharides and polysaccharides). The term complex carbohydrate was first used in the Senate Select Committee publication Dietary Goals for the United States (1977), where it denoted "fruit, vegetables and whole-grains". Dietary guidelines generally recommend that complex carbohydrates and nutrient-rich simple carbohydrates such as fruit and dairy products make up the bulk of carbohydrate consumption. The USDA's Dietary Guidelines for Americans 2005 dispenses with the simple/complex distinction, instead recommending fiber-rich foods and whole grains.

The glycemic index and glycemic load systems are popular alternative classification methods which rank carbohydrate-rich foods based on their effect on blood glucose levels. The insulin index is a similar, more recent classification method which ranks foods based on their effects on blood insulin levels. This system assumes that high glycemic index foods and low glycemic index foods can be mixed to make the intake of high glycemic foods more acceptable.

Topic : Lipids: Fats, Oils, Phospholipids, And Sterols**Topic Objective:**

At the end of the topic student will be able to understand:

- Nutrition and health
- Other functions
- Signaling
- Energy storage and metabolism
- Membranes
- Biological Functions
- Categories of Lipids

Definition/Overview:

Lipids are broadly defined as any fat-soluble (lipophilic), naturally-occurring molecule, such as fats, oils, waxes, cholesterol, sterols, fat-soluble vitamins (such as vitamins A, D, E and K), monoglycerides, diglycerides, phospholipids, and others. The main biological functions of lipids include energy storage, acting as structural components of cell membranes, and participating as important signaling molecules.

Key Points:

Although the term lipid is sometimes used as a synonym for fats, fats are a subgroup of lipids called triglycerides and should not be confused with the term fatty acid. Lipids also encompass molecules such as fatty acids and their derivatives (including tri-, di-, and monoglycerides and phospholipids), as well as other sterol-containing metabolites such as cholesterol. The emulsion test is a crude method for determining the presence or absence of lipids in a given sample. Lipids are a diverse group of compounds that have many key biological functions, such as acting as structural components of cell membranes, serving as energy storage sources and participating in signaling pathways. Lipids may be broadly defined as hydrophobic or amphiphilic small molecules that originate entirely or in part from two distinct types of biochemical subunits or "building blocks": ketoacyl and isoprene groups. Using this approach, lipids may be divided into eight categories : fatty acyls,

glycerolipids, glycerophospholipids, sphingolipids, saccharolipids and polyketides (derived from condensation of ketoacyl subunits); and sterol lipids and prenol lipids (derived from condensation of isoprene subunits).

1. Categories of Lipids

1.1. Fatty Acyls

Fatty acyls (including fatty acids) are a diverse group of molecules synthesized by chain-elongation of an acetyl-CoA primer with malonyl-CoA or methylmalonyl-CoA groups. The fatty acyl structure represents the major lipid building block of complex lipids and therefore is one of the most fundamental categories of biological lipids. The carbon chain may be saturated or unsaturated, and may be attached to functional groups containing oxygen, halogens, nitrogen and sulfur. Examples of biologically interesting fatty acyls are the eicosanoids which are in turn derived from arachidonic acid which include prostaglandins, leukotrienes, and thromboxanes. Other major lipid classes in the fatty acyl category are the fatty esters and fatty amides. Fatty esters include important biochemical intermediates such as wax esters, fatty acyl thioester coenzyme A derivatives, fatty acyl thioester ACP derivatives and fatty acyl carnitines. The fatty amides include N-acyl ethanolamines such as anandamide.

1.2. Glycerolipids

Glycerolipids are composed mainly of mono-, di- and tri-substituted glycerols, the most well-known being the fatty acid esters of glycerol (triacylglycerols), also known as triglycerides. These comprise the bulk of storage fat in animal tissues. Additional subclasses are represented by glycosylglycerols, which are characterized by the presence of one or more sugar residues attached to glycerol via a glycosidic linkage. Examples of structures in this category are the digalactosyldiacylglycerols found in plant membranes and seminolipid from mammalian spermatazoa.

1.3. Glycerophospholipids

Glycerophospholipids, also referred to as phospholipids, are ubiquitous in nature and are key components of the lipid bilayer of cells, as well as being involved in metabolism and signaling. Glycerophospholipids may be subdivided into distinct classes, based on the nature of the polar headgroup at the sn-3 position of the glycerol backbone in eukaryotes and eubacteria or the sn-1 position in the case of archaeobacteria. Examples of glycerophospholipids found in biological membranes are phosphatidylcholine (also known as PC or GPCho, and lecithin), phosphatidylethanolamine (PE or GPEtn) and phosphatidylserine (PS or GP Ser). In addition to serving as a primary component of cellular membranes and binding sites for intra- and intercellular proteins, some glycerophospholipids in eukaryotic cells, such as phosphatidylinositols and phosphatidic acids are either precursors of, or are themselves, membrane-derived second messengers. Typically one or both of these hydroxyl groups are acylated with long-chain fatty acids, but there are also alkyl-linked and 1Z-alkenyl-linked (plasmalogen) glycerophospholipids, as well as dialkylether variants in prokaryotes.

1.4. Sphingolipids

Sphingolipids are a complex family of compounds that share a common structural feature, a sphingoid base backbone that is synthesized de novo from serine and a long-chain fatty acyl CoA, then converted into ceramides, phosphosphingolipids, glycosphingolipids and other species. The major sphingoid base of mammals is commonly referred to as sphingosine. Ceramides (N-acyl-sphingoid bases) are a major subclass of sphingoid base derivatives with an amide-linked fatty acid. The fatty acids are typically saturated or mono-unsaturated with chain lengths from 14 to 26 carbon atoms. The major phosphosphingolipids of mammals are sphingomyelins (ceramide phosphocholines), whereas insects contain mainly ceramide phosphoethanolamines and fungi have phytoceramide phosphoinositols and mannose containing headgroups. The Glycosphingolipids are a diverse family of molecules composed of one or more sugar residues linked via a glycosidic bond to the sphingoid base. Examples of these are the simple and complex glycosphingolipids such as cerebroside and gangliosides.

1.5. Sterol lipids

Sterol lipids, such as cholesterol and its derivatives are an important component of membrane lipids, along with the glycerophospholipids and sphingomyelins. The steroids, which also contain the same fused four-ring core structure, have different biological roles as hormones and signaling molecules. The C18 steroids include the estrogen family whereas the C19 steroids comprise the androgens such as testosterone and androsterone. The C21 subclass includes the progestogens as well as the glucocorticoids and mineralocorticoids. The secosteroids, comprising various forms of vitamin D, are characterized by cleavage of the B ring of the core structure. Other examples of sterols are the bile acids and their conjugates, which in mammals are oxidized derivatives of cholesterol and are synthesized in the liver.

1.6. Prenol lipids

Prenol lipids are synthesized from the 5-carbon precursors isopentenyl diphosphate and dimethylallyl diphosphate that are produced mainly via the mevalonic acid (MVA) pathway. The simple isoprenoids (linear alcohols, diphosphates, etc.) are formed by the successive addition of C5 units, and are classified according to number of these terpene units. Structures containing greater than 40 carbons are known as polyterpenes. Carotenoids are important simple isoprenoids that function as anti-oxidants and as precursors of vitamin A. Another biologically important class of molecules is exemplified by the quinones and hydroquinones, which contain an isoprenoid tail attached to a quinonoid core of non-isoprenoid origin. Vitamin E and vitamin K, as well as the ubiquinones, are examples of this class. Bacteria synthesize polyprenols (called bactoprenols) in which the terminal isoprenoid unit attached to oxygen remains unsaturated, whereas in animal polyprenols (dolichols) the terminal isoprenoid is reduced.

1.7. Saccharolipids

Saccharolipids describe compounds in which fatty acids are linked directly to a sugar backbone, forming structures that are compatible with membrane bilayers. In the saccharolipids, a sugar substitutes for the glycerol backbone that is present in glycerolipids and glycerophospholipids. The most familiar saccharolipids are the acylated glucosamine precursors of the Lipid A component of the

lipopolysaccharides in Gram-negative bacteria. Typical lipid A molecules are disaccharides of glucosamine, which are derivatized with as many as seven fatty-acylchains. The minimal lipopolysaccharide required for growth in *E. coli* is Kdo₂-Lipid A, a hexa-acylateddisaccharide of glucosamine that is glycosylated with two 3-deoxy-D-manno-octulosonic acid (Kdo) residues.

1.8. Polyketides

Polyketides are synthesized by polymerization of acetyl and propionyl subunits by classic enzymes as well as iterative and multimodular enzymes that share mechanistic features with the fatty acid synthases. They comprise a very large number of secondary metabolites and natural products from animal, plant, bacterial, fungal and marine sources, and have great structural diversity. Many polyketides are cyclic molecules whose backbones are often further modified by glycosylation, methylation, hydroxylation, oxidation, and/or other processes. Many commonly used anti-microbial, anti-parasitic, and anti-cancer agents are polyketides or polyketide derivatives, such as erythromycins, tetracyclines, avermectins, and antitumor epothilones.

2. Membranes

The glycerophospholipids are the main structural component of biological membranes, such as the cellular plasma membrane and the intracellular membranes of organelles. In animal cells the plasma membrane physically separates the intracellular components from the extracellular environment. All eukaryotic cells are compartmentalized into membrane-bound organelles which carry out different functions. These glycerophospholipids are amphipathic molecules that contain a glycerol core linked to two fatty acid-derived "tails" by ester or, more rarely, ether linkages and to one "head" group by a phosphate ester linkage. While glycerophospholipids are the major component of biological membranes, other non-glyceride lipid components such as sphingomyelin and sterols (mainly cholesterol in animal cell membranes) are also found in biological membranes. In plants and algae, the galactosyldiacylglycerols, and sulfoquinovosyldiacylglycerol, which lack a phosphate group, are important components of membranes of chloroplasts and related organelles and are the most abundant lipids in photosynthetic tissues, including those of higher plants, algae and certain bacteria.

A biological membrane is a form of lipid bilayer, as is a liposome. The formation of lipid bilayers is an energetically-preferred process when the glycerophospholipids described above are in an aqueous environment. In an aqueous system, the polar heads of lipids orientate towards the polar, aqueous environment, while the hydrophobic tails minimise their contact with water. The lipophilic tails of lipids (U) tend to cluster together, forming a lipid bilayer (1) or a micelle (2). Other aggregations are also observed and form part of the polymorphism of amphiphile(lipid) behaviour. The polar heads (P) face the aqueous environment, curving away from the water. Phase behaviour is a complicated area within biophysics and is the subject of current academic research. Micelles and bilayers form in the polar medium by a process known as the hydrophobic effect. When dissolving a lipophilic or amphiphilic substance in a polar environment, the polar molecules (i.e. water in an aqueous solution) become more ordered around the dissolved lipophilic substance, since the polar molecules cannot form hydrogen bonds to the lipophilic areas of the amphiphile. So in an aqueous environment the water molecules form an ordered "clathrate" cage around the dissolved lipophilic molecule.

3. Energy storage and metabolism

Triacylglycerols, stored in adipose tissue, are a major form of energy storage in animals. Animals use triglycerides for energy storage because of its high caloric content (9 KCal/g), whereas plants, which do not require energy for movement, can afford to store food for energy in a less compact but more easily accessible form, such as starch (carbohydrate). Triglycerides and phospholipids are broken down into free fatty acids by the action of lipases. Beta oxidation is the process by which fatty acids, in the form of acyl-CoA molecules, are broken down in the mitochondria and/or in peroxisomes to generate acetyl-CoA. The acetyl CoA is then ultimately converted into ATP, CO₂, and H₂O using the citric acid cycle and the electron transport chain. Conversely, fatty acid biosynthesis (Lipogenesis) takes place in the cytoplasm, using acetyl-CoA (derived from carbohydrates, amino acids or fatty acids) as the precursor. The fatty acids may be subsequently converted to triacylglycerols that are packaged in lipoproteins (VLDL's) and secreted from the liver.

4. Signaling

In recent years, evidence has emerged showing that lipid signaling is a vital part of the cell signaling. Lipid signaling may occur via activation of GPCR's or nuclear receptors, and

members of several different lipid categories have been identified as signaling molecules and cellular messengers. These include sphingosine-1-phosphate, a sphingolipid derived from ceramide that is a potent messenger molecule involved in regulating calcium mobilization, cell growth, apoptosis; diacylglycerol (DAG) and the phosphatidylinositol phosphates (PIPs), involved in calcium-mediated activation of protein kinase C; the prostaglandins, arachidonic acid-derived fatty acids involved in inflammation and immunity; the steroid hormones such as estrogen, testosterone and cortisol, which modulate a host of functions such as reproduction, metabolism and blood pressure; and the oxysterols such as 25-hydroxy-cholesterol that are Liver X receptor (LXR) agonists.

5. Other functions

The "fat-soluble" vitamins (A, D, E and K) which are isoprene-based lipids are essential nutrients stored in the liver and fatty tissues. These have a diverse range of functions discussed elsewhere. Acyl-carnitines are involved in the transport and metabolism of fatty acids in and out of mitochondria, where they undergo beta oxidation. Polyprenols and their phosphorylated derivatives also play important transport roles, in this case the transport of oligosaccharides across membranes. Polyprenol phosphate sugars and polyprenol diphosphate sugars function in extra-cytoplasmic glycosylation reactions, in extra-cellular polysaccharide biosynthesis (for instance peptidoglycan polymerization in bacteria), and in eukaryotic protein N-glycosylation. Cardiolipins are a subclass of glycerophospholipids containing four acyl chains and three glycerol groups that are particularly abundant in the inner mitochondrial membrane. They are believed to activate enzymes involved with oxidative phosphorylation.

6. Nutrition and health

Lipids play diverse and important roles in nutrition and health. Many lipids are absolutely essential for life. However, there is also considerable awareness that abnormal levels of certain lipids, particularly cholesterol (in hypercholesterolemia) and trans fatty acids, are risk factors for heart disease amongst others.

Humans have a requirement for certain essential fatty acids, such as linoleic acid (an omega-6 fatty acid) and alpha-linolenic acid (an omega-3 fatty acid) in the diet because they cannot be synthesized from simple precursors in the diet. Both of these fatty acids are 18-carbon

polyunsaturated fatty acids differing in the number and position of the double bonds. Most vegetable oils are rich in linoleic acid (safflower, sunflower, and corn oils). Alpha-linolenic acid is found in the green leaves of plants, and in selected seeds, nuts and legumes (flax, canola, walnuts and soy). Fish oils are particularly rich in the longer-chain omega-6 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Most of the lipid found in food is in the form of triacylglycerols, cholesterol and phospholipids. Most of the saturated fatty acids (as triacylglycerols) in the diet are incorporated into adipose tissue stores, because the absence of double bonds allows a higher energy yield per carbon than is obtained from oxidation of unsaturated fatty acids. The longer chain fatty acids are incorporated into cell membranes as phospholipids regardless of degree of saturation. Since dietary fatty acids are exchanged with membrane fatty acids, dietary fat composition is reflected in membrane lipid composition. Thus dietary fatty acids can influence cell function through effects on membrane properties. Dietary fat provides an average energy intake which is approximately twice that of carbohydrate or protein. A minimum amount of dietary fat is necessary to facilitate absorption of fat-soluble vitamins (A, D, E and K) and carotenoids. A minimal amount of body fat is also necessary to provide insulation that prevents heat loss and protects vital organs from shock due to ordinary activities. High fat intake contributes to increased risk of obesity, diabetes and atherosclerosis. Atherosclerosis is the primary cause of coronary and cardiovascular diseases and is primary due to the buildup of plaque on the inside walls of arteries. Plaque is made up of cholesterol-rich low density lipoproteins (LDL), macrophages, smooth muscle cells, platelets, and other substances. In North America and most other western countries, atherosclerosis is the leading cause of illness and death, almost doubling the number of deaths from cancers. Despite significant medical advances, coronary artery disease and atherosclerotic stroke are responsible for more deaths than all other causes combined. A substantial amount of scientific evidence supports the impact of dietary fatty acids on cardiovascular health. Saturated fats have a profound hypercholesterolemic (increase blood cholesterol levels) effect and tend to increase plasma LDL. They are found predominantly in animal products (butter, cheese and meat) but coconut oil and palm oil are common vegetable sources. Intake of monounsaturated fats in oils such as olive oil is thought to be preferable to consumption of polyunsaturated fats in oils such as corn oil because the monounsaturated fats apparently do not lower high-density-lipoprotein (HDL) cholesterol levels. Keeping cholesterol in the normal range not only helps prevent heart attacks and strokes but may also prevent the progression of atherosclerosis. "Statins" are a class of drugs

that lowers the level of cholesterol in the blood by inhibiting the enzyme HMG-CoA reductase. This is a key enzyme involved in the biosynthesis of cholesterol in the liver.

Topic : Proteins And Amino Acids

Topic Objective:

At the end of the topic student will be able to understand:

- Nutritional importance
- Uses in technology
- Nonstandard amino acids
- Hydrophilic and hydrophobic amino acids
- Zwitterions
- Reactions
- Isomerism
- General structure
- Non-protein functions
- Polypeptide
- Amino Acids

Definition/Overview:

In chemistry, an amino acid is a molecule containing both amine and carboxyl functional groups. In biochemistry, this term refers to alpha-amino acids with the general formula $H_2NCH(R)COOH$, where R is an organic substituent. In the alpha amino acids, the amino and carboxylate groups are attached to the same carbon, which is called the α carbon. The various alpha amino acids differ in which side chain (R group) is attached to their alpha carbon. They can vary in size from just a hydrogen atom in glycine through a methyl group in alanine to a large heterocyclic group in tryptophan.

Alpha-amino acids are the building blocks of proteins. Amino acids combine in a condensation reaction that releases water and the new "amino acid residue" that is held together by a peptide bond. Proteins are defined by their unique sequence of amino acid residues; this sequence is the primary structure of the protein. Just as the letters of the

alphabet can be combined to form an almost endless variety of words, amino acids can be linked in varying sequences to form a vast variety of proteins.

Key Points:

1. Amino Acids

Beyond the amino acids that are found in all forms of life, many non-natural amino acids have vital roles in technology and industry. For example, the chelating agents EDTA and nitrilotriacetic acid are alpha amino acids that are important in the chemical industry.

Twenty standard amino acids are used by cells in protein biosynthesis, and these are specified by the general genetic code. These 20 amino acids are biosynthesized from other molecules, but organisms differ in which ones they can synthesize and which ones must be provided in their diet. The ones that cannot be synthesized by an organism are called essential amino acids.

2. Polypeptide

A polypeptide is a chain of amino acids. Amino acids are the basic structural building units of proteins. They form short polymer chains called peptides or longer chains called either polypeptides or proteins. The process of such formation from an mRNA template is known as translation, which is part of protein biosynthesis. Twenty amino acids are encoded by the standard genetic code and are called proteinogenic or standard amino acids. Other amino acids contained in proteins are usually formed by post-translational modification, which is modification after translation in protein synthesis. These modifications are often essential for the function or regulation of a protein; for example, the carboxylation of glutamate allows for better binding of calcium cations, and the hydroxylation of proline is critical for maintaining connective tissues and responding to oxygen starvation. Such modifications can also determine the localization of the protein, e.g., the addition of long hydrophobic groups can cause a protein to bind to a phospholipid membrane.

3. Non-protein functions

The 20 standard amino acids are either used to synthesize proteins and other biomolecules or oxidized to urea and carbon dioxide as a source of energy. The oxidation pathway starts with

the removal of the amino group by a transaminase, the amino group is then fed into the urea cycle. The other product of transamination is a keto acid that enters the citric acid cycle. Glucogenic amino acids can also be converted into glucose, through gluconeogenesis. Hundreds of types of non-protein amino acids have been found in nature and they have multiple functions in living organisms. Microorganisms and plants can produce uncommon amino acids. In microbes, examples include 2-aminoisobutyric acid and lanthionine, which is a sulfide-bridged alanine dimer. Both these amino acids are both found in peptidic antibiotics such as alamethicin. While in plants, 1-aminocyclopropane-1-carboxylic acid is a small disubstituted cyclic amino acid that is a key intermediate in the production of the plant hormone ethylene.

In humans, non-protein amino acids also have important roles, such as the neurotransmitter gamma-aminobutyric acid. Many amino acids are used to synthesize other molecules, for example:

- Tryptophan is a precursor of the neurotransmitter serotonin.
- Glycine is a precursor of porphyrins such as heme.
- Arginine is a precursor of nitric oxide.
- Carnitine is used in lipid transport within the cell.
- Ornithine and S-adenosylmethionine are precursors of polyamines.
- Homocysteine is an intermediate in S-adenosylmethionine recycling.
- Hydroxyproline, hydroxylysine, and sarcosine are also non-protein amino acids. The thyroid hormones are also alpha-amino acids. Some amino acids have even been detected in meteorites, especially in a type known as carbonaceous chondrites. This observation has prompted the suggestion that life may have arrived on earth from an extraterrestrial source.

4. General structure

In the structure shown at the right, R represents a side chain specific to each amino acid. The central carbon atom, called C α , is a chiral central carbon atom (with the exception of glycine) to which the two termini and the R-group are attached. Amino acids are usually classified by the properties of the side chain into four groups. The side chain can make them behave like a weak acid, a weak base, a hydrophilic if they are polar, and hydrophobic if they are nonpolar. The chemical structures of the 20 standard amino acids, along with their chemical properties, are catalogued in the list of standard amino acids.

The phrase "branched-chain amino acids" or BCAA is sometimes used to refer to the amino acids having aliphatic side chains that are non-linear; these are leucine, isoleucine, and valine. Proline is the only proteinogenic amino acid whose side group links to the α -amino group and, thus, is also the only proteinogenic amino acid containing a secondary amine at this position. Proline has sometimes been termed an imino acid, but this is not correct in the current nomenclature.

5. Isomerism

Most amino acids can exist in either of two optical isomers, called D and L. The L-amino acids represent the vast majority of amino acids found in proteins. D-amino acids are found in some proteins produced by exotic sea-dwelling organisms, such as cone snails. They are also abundant components of the peptidoglycan cell walls of bacteria. The L and D conventions for amino acid configuration do not refer to the optical activity of the amino acid itself, but rather to the optical activity of the isomer of glyceraldehyde having the same stereochemistry as the amino acid. S-glyceraldehyde is levorotary, and R-glyceraldehyde is dexterorotary, and so S-amino acids are called L-amino acids even if they are not levorotary, and R-amino acids are likewise called D-amino acids even if they are not dexterorotary. There are two exceptions to these general rules of amino acid isomerism. Firstly, glycine, where R = H, no isomerism is possible because the α -carbon bears two identical groups (hydrogen). Secondly, in cysteine, the L = S and D = R assignment is reversed to L = R and D = S. Cysteine is structured in the same way as the other amino acids but the sulfur atom alters the interpretation of the Cahn-Ingold-Prelog priority rule.

6. Reactions

As amino acids have both a primary amine group and a primary carboxyl group, these chemicals can undergo most of the reactions associated with these functional groups. These include nucleophilic addition, amide bond formation and imine formation for the amine group and esterification, amide bond formation and decarboxylation for the carboxylic acid group. The multiple side chains of amino acids can also undergo chemical reactions. The types of these reactions are determined by the groups on these side chains and are discussed in the articles dealing with each specific type of amino acid.

Peptide bond formation

As both the amine and carboxylic acid groups of amino acids can react to form amide bonds, one amino acid molecule can react with another and become joined through an amide linkage. This polymerization of amino acids is what creates proteins. This condensation reaction yields the newly formed peptide bond and a molecule of water. In cells, this reaction does not occur directly; instead the amino acid is first activated by attachment to a transfer RNA molecule through an ester bond. This aminoacyl-tRNA is produced in an ATP-dependent reaction carried out by an aminoacyl tRNA synthetase. This aminoacyl-tRNA is then a substrate for the ribosome, which catalyzes the attack of the amino group of the elongating protein chain on the ester bond. As a result of this mechanism, all proteins made by ribosomes are synthesized starting at their N-terminus and moving towards their C-terminus. However, not all peptide bonds are formed in this way. In a few cases, peptides are synthesized by specific enzymes. For example, the tripeptide glutathione is an essential part of the defenses of cells against oxidative stress. This peptide is synthesized in two steps from free amino acids. In the first step gamma-glutamylcysteine synthetase condenses cysteine and glutamic acid through a peptide bond formed between the side-chain carboxyl of the glutamate (the gamma carbon of this side chain) and the amino group of the cysteine. This dipeptide is then condensed with glycine by glutathione synthetase to form glutathione. In chemistry, peptides are synthesized by a variety of reactions. One of the most used in solid-phase peptide synthesis, which uses the aromatic oxime derivatives of amino acids as activated units. These are added in sequence onto the growing peptide chain, which is attached to a solid resin support.

7. Zwitterions

As amino acids have both the active groups of an amine and a carboxylic acid they can be considered both acid and base. At a certain pH known as the isoelectric point, the amine group has a positive charge (is protonated) and the acid group a negative charge (is deprotonated). The exact value is specific to each different amino acid. This ion is known as a zwitterion, which comes from the German word Zwitter meaning "hybrid". A zwitterion can be extracted from the solution as a white crystalline structure with a very high melting point, due to its dipolar nature. Near-neutral physiological pH allows most free amino acids to exist as zwitterions.

8. Hydrophilic and hydrophobic amino acids

Depending on the polarity of the side chain, amino acids vary in their hydrophilic or hydrophobic character. These properties are important in protein structure and protein-protein interactions. The importance of the physical properties of the side chains comes from the influence this has on the amino acid residues' interactions with other structures, both within a single protein and between proteins. The distribution of hydrophilic and hydrophobic amino acids determines the tertiary structure of the protein, and their physical location on the outside structure of the proteins influences their quaternary structure. For example, soluble proteins have surfaces rich with polar amino acids like serine and threonine, while integral membrane proteins tend to have outer ring of hydrophobic amino acids that anchors them into the lipid bilayer, and proteins anchored to the membrane have a hydrophobic end that locks into the membrane. Similarly, proteins that have to bind to positively-charged molecules have surfaces rich with negatively charged amino acids like glutamate and aspartate, while proteins binding to negatively-charged molecules have surfaces rich with positively charged chains like lysine and arginine. Recently a new scale of hydrophobicity based on the free energy of hydrophobic association has been proposed.

Hydrophilic and hydrophobic interactions of the proteins do not have to rely only on the sidechains of amino acids themselves. By various posttranslational modifications other chains can be attached to the proteins, forming hydrophobic lipoproteins or hydrophilic glycoproteins.

Amino Acid	3- Letter	1- Letter	Side chain polarity	Side chain acidity or basicity of neutral species	Hydropathy index
Alanine	Ala	A	nonpolar	neutral	1.8
Arginine	Arg	R	polar	basic (strongly)	-4.5
Asparagine	Asn	N	polar	neutral	-3.5
Aspartic acid	Asp	D	polar	acidic	-3.5
Cysteine	Cys	C	polar	neutral	2.5
Glutamic acid	Glu	E	polar	acidic	-3.5
Glutamine	Gln	Q	polar	neutral	-3.5
Glycine	Gly	G	nonpolar	neutral	-0.4

Histidine	His	H	polar	basic (weakly)	-3.2
Isoleucine	Ile	I	nonpolar	neutral	4.5
Leucine	Leu	L	nonpolar	neutral	3.8
Lysine	Lys	K	polar	basic	-3.9
Methionine	Met	M	nonpolar	neutral	1.9
Phenylalanine	Phe	F	nonpolar	neutral	2.8
Proline	Pro	P	nonpolar	neutral	-1.6
Serine	Ser	S	polar	neutral	-0.8
Threonine	Thr	T	polar	neutral	-0.7
Tryptophan	Trp	W	nonpolar	neutral	-0.9
Tyrosine	Tyr	Y	polar	neutral	-1.3
Valine	Val	V	nonpolar	neutral	4.2
Asparagine or aspartic acid	Asx	B			
Glutamine or glutamic acid	Glx	Z			
Leucine or Isoleucine	Xle	J			
Unspecified or unknown amino acid	Xaa	X			

[Table 1: standard amino acid abbreviations and side chain properties]

In addition to the normal amino acid codes, placeholders were used historically in cases where chemical or crystallographic analysis of a peptide or protein could not completely establish the identity of a certain residue in a structure. The ones they could not resolve between are these pairs of amino-acids: Ambiguous Amino Acids

Unk is sometimes used instead of Xaa, but is less standard.

9. Nonstandard amino acids

Aside from the twenty standard amino acids, there are a vast number of "non-standard" amino acids. Two of these can be specified by the genetic code, but are rather rare in

proteins. Selenocysteine is incorporated into some proteins at a UGA codon, which is normally a stop codon. Pyrrolysine is used by some methanogenic archaeal enzymes that they use to produce methane. It is coded for with the codon UAG.

Examples of nonstandard amino acids that are not found in proteins include lanthionine, 2-aminoisobutyric acid, dehydroalanine and the neurotransmitter gamma-aminobutyric acid. Nonstandard amino acids often occur as intermediates in the metabolic pathways for standard amino acids for example ornithine and citrulline occur in the urea cycle, part of amino acid catabolism. Nonstandard amino acids are usually formed through modifications to standard amino acids. For example, homocysteine is formed through the transsulfuration pathway or by the demethylation of methionine via the intermediate metabolite S-adenosyl methionine, while dopamine is synthesized from L-DOPA, and hydroxyproline is made by a posttranslational modification of proline.

10. Uses in technology

Amino acid derivative	Use in industry
Aspartame (aspartyl-phenylalanine-1-methyl ester)	Low-calorie artificial sweetener
5-HTP (5-hydroxytryptophan)	Treatment for depression and the neurological problems of phenylketonuria.
L-DOPA (L-dihydroxyphenylalanine)	Treatment for Parkinsonism.
Monosodium glutamate	Food additive that enhances flavor. Confers the taste umami.

[Table 2]

11. Nutritional importance

Of the 20 standard proteinogenic amino acids, 8 are called essential amino acids because the human body cannot synthesize them from other compounds at the level needed for normal growth, so they must be obtained from food. However, the situation is a little more complicated since cysteine, tyrosine, histidine and arginine are semiessential amino acids in children, because the metabolic pathways that synthesize these amino acids are not fully

developed. The amounts required also depend on the age and health of the individual, so it is hard to make general statements about the dietary requirement for some amino acids.

Essential	Nonessential
Isoleucine	Alanine
Leucine	Asparagine
Lysine	Aspartate
Methionine	Cysteine*
Phenylalanine	Glutamate
Threonine	Glutamine*
Tryptophan	Glycine*
Valine	Proline*
Arginine*	Serine*
Histidine*	Tyrosine*

[Table 3: Essential only in certain cases]

Several common mnemonics have evolved for remembering the ten amino acids often described as essential. PVT TIM HALL ("Private Tim Hall") uses the first letter of each of these amino acids. Another mnemonic that frequently occurs in student practice materials beneath "AH TV TILL Past Midnight", is "These ten valuable amino acids have long preserved life in man"

In Section 3 of this course you will cover these topics:

- Vitamins
- Minerals And Water
- Alchoho

Topic : Vitamins

Topic Objective:

At the end of the topic student will be able to understand:

- List of vitamins
- Fat-soluble
- Water-soluble
- In humans
- History
- Vitamins

Definition/Overview:

A vitamin is an organic compound required as a nutrient in tiny amounts by an organism. A compound is called a vitamin when it cannot be synthesized in sufficient quantities by an organism, and must be obtained from the diet. Thus, the term is conditional both on the circumstances and the particular organism. For example, ascorbic acid functions as vitamin C for some animals but not others, and vitamins D and K are required in the human diet only in certain circumstances.

Key Points:

1. Vitamins

Vitamins are classified by their biological and chemical activity, not their structure. Thus, each "vitamin" actually refers to a number of vitamers, which form a set of distinct chemical compounds that show the biological activity of a particular vitamin. Such a set of chemicals are grouped under an alphabetized vitamin "generic descriptor" title, such as "vitamin A," which (for example) includes retinal, retinol, and many carotenoids.

Vitamins are often inter-convertible in the body. The term vitamin does not include other essential nutrients such as dietary minerals, essential fatty acids, or essential amino acids, nor does it encompass the large number of other nutrients that promote health but are otherwise required less often. Vitamins have diverse biochemical functions, including function as hormones (e.g. vitamin D), antioxidants (e.g. vitamin E), and mediators of cell signaling and regulators of cell and tissue growth and differentiation (e.g. vitamin A). The largest number of vitamins (e.g. B complex vitamins) function as precursors for enzyme cofactor biomolecules (coenzymes), that help act as catalysts and substrates in metabolism. When acting as part of a catalyst, vitamins are bound to enzymes and are called prosthetic groups. For example, biotin is part of enzymes involved in making fatty acids. Vitamins also act as

coenzymes to carry chemical groups between enzymes. For example, folic acid carries various forms of carbon group methyl, formyl and methylene - in the cell. Although these roles in assisting enzyme reactions are vitamins' best-known function, the other vitamin functions are equally important. Until the 1900s, vitamins were obtained solely through food intake, and changes in diet (which, for example, could occur during a particular growing season) can alter the types and amounts of vitamins ingested. Vitamins have been produced as commodity chemicals and made widely available as inexpensive pills for several decades, allowing supplementation of the dietary intake.

2. History

The value of eating a certain food to maintain health was recognized long before vitamins were identified. The ancient Egyptians knew that feeding a patient liver would help cure night blindness, an illness now known to be caused by a vitamin A deficiency. , however this was first discovered by Hippocrates the father of modern medicine in Ancient Greece. The advancement of ocean voyage during the Renaissance resulted in prolonged periods without access to fresh fruits and vegetables, and made illnesses from vitamin deficiency common among ship's crew.

In 1749, the Scottish surgeon James Lind discovered that citrus foods helped prevent scurvy, a particularly deadly disease in which collagen is not properly formed, causing poor wound healing, bleeding of the gums, severe pain, and death. In 1753, Lind published his Treatise on the Scurvy, which recommended using lemons and limes to avoid scurvy, which was adopted by the British Royal Navy. This led to the nickname Limey for sailors of that organization. Lind's discovery, however, was not widely accepted by individuals in the Royal Navy's Arctic expeditions in the 19th century, where it was widely believed that scurvy could be prevented by practicing good hygiene, regular exercise, and by maintaining the morale of the crew while on board, rather than by a diet of fresh food. As a result, Arctic expeditions continued to be plagued by scurvy and other deficiency diseases. In the early 20th century, when Robert Falcon Scott made his two expeditions to the Antarctic, the prevailing medical theory was that scurvy was caused by "tainted" canned food. In 1881, Russian surgeon Nikolai Lunin studied the effects of scurvy while at the University of Tartu in present-day Estonia. He fed mice an artificial mixture of all the separate constituents of milk known at

that time, namely the proteins, fats, carbohydrates, and salts. The mice that received only the individual constituents died, while the mice fed by milk itself developed normally. He made a conclusion that "a natural food such as milk must therefore contain, besides these known principal ingredients, small quantities of unknown substances essential to life." However, his conclusions were rejected by other researchers when they were unable to reproduce his results. One difference was that he had used table sugar (sucrose), while other researchers had used milk sugar (lactose) that still contained small amounts of vitamin B.

The discovery of vitamins and their sources		
Year of discovery	Vitamin	Source
1909	Vitamin A (Retinol)	Cod liver oil
1912	Vitamin B ₁ (Thiamine)	Rice bran
1912	Vitamin C (Ascorbic acid)	Lemons
1918	Vitamin D (Calciferol)	Cod liver oil
1920	Vitamin B ₂ (Riboflavin)	Eggs
1922	Vitamin E (Tocopherol)	Wheat germ oil, Cosmetic and Liver
1926	Vitamin B ₁₂ (Cyanocobalamin)	Liver
1929	Vitamin K (Phylloquinone)	Alfalfa
1931	Vitamin B ₅ (Pantothenic acid)	Liver
1931	Vitamin B ₇ (Biotin)	Liver
1934	Vitamin B ₆ (Pyridoxine)	Rice bran
1936	Vitamin B ₃ (Niacin)	Liver
1941	Vitamin B ₉ (Folic acid)	Liver

[Table 1]

In east Asia, where polished white rice was the common staple food of the middle class, beriberi resulting from lack of vitamin B1 was endemic. In 1884, Takaki Kanehiro, a British trained medical doctor of the Japanese Navy, observed that beriberi was endemic among low-ranking crew who often ate nothing but rice, but not among crews of Western navies and officers who consumed a Western-style diet. Kanehiro initially believed that lack of protein was the chief cause of beriberi. With the support of the Japanese navy, he experimented using crews of two battleships; one crew was fed only white rice, while the other was fed a diet of

meat, fish, barley, rice, and beans. The group that ate only white rice documented 161 crew members with beriberi and 25 deaths, while the latter group had only 14 cases of beriberi and no deaths. This convinced Kanehiro and the Japanese Navy that diet was the cause of beriberi. This was confirmed in 1897, when Christiaan Eijkman discovered that feeding unpolished rice instead of the polished variety to chickens helped to prevent beriberi in the chickens. The following year, Frederick Hopkins postulated that some foods contained "accessory factors" in addition to proteins, carbohydrates, fats, et cetera that were necessary for the functions of the human body. Hopkins was awarded the 1929 Nobel Prize for Physiology or Medicine with Christiaan Eijkman for their discovery of several vitamins. In 1910, Japanese scientist Umetaro Suzuki succeeded in extracting a water-soluble complex of micronutrients from rice bran and named it aberic acid. He published this discovery in a Japanese scientific journal.

When the article was translated into German, the translation failed to state that it was a newly discovered nutrient, a claim made in the original Japanese article, and hence his discovery failed to gain publicity. Polish biochemist Kazimierz Funk isolated the same complex of micronutrients and proposed the complex be named "Vitamine" (a portmanteau of "vital amine") in 1912. The name soon became synonymous with Hopkins' "accessory factors", and by the time it was shown that not all vitamins were amines, the word was already ubiquitous. In 1920, Jack Cecil Drummond proposed that the final "e" be dropped to deemphasize the "amine" reference after the discovery that vitamin C had no amine component. Throughout the early 1900s, the use of deprivation studies allowed scientists to isolate and identify a number of vitamins. Initially, lipid from fish oil was used to cure rickets in rats, and the fat-soluble nutrient was called "antirachitic A". Thus, the first "vitamin" bioactivity ever isolated, which cured rickets, was initially called "vitamin A", although confusingly the bioactivity of this compound is now called vitamin D. What we now call "vitamin A" was identified in fish oil as a separate factor that was inactivated by ultraviolet light. In 1931, Albert Szent-Gyrgyi and a fellow researcher Joseph Svribely determined that "hexuronic acid" was actually vitamin C and noted its anti-scorbutic activity. In 1937, Szent-Gyrgyi was awarded the Nobel Prize for his discovery. In 1943 Edward Adelbert Doisy and Henrik Dam were awarded the Nobel Prize for their discovery of vitamin K and its chemical structure.

3. In humans

Vitamins are classified as either water-soluble or fat soluble. In humans there are 13 vitamins: 4 fat-soluble (A, D, E and K) and 9 water-soluble (8 B vitamins and vitamin C).

4. Water-soluble

Water-soluble vitamins dissolve easily in water, and in general, are readily excreted from the body, to the degree that urinary output is a strong predictor of vitamin consumption. Because they are not readily stored, consistent daily intake is important. Many types of water-soluble vitamins are synthesized by bacteria.

5. Fat-soluble

Fat-soluble vitamins are absorbed through the intestinal tract with the help of lipids (fats). Because they are more likely to accumulate in the body, they are more likely to lead to hypervitaminosis than are water-soluble vitamins. Fat-soluble vitamin regulation is of particular significance in cystic fibrosis.

6. List of vitamins

Each vitamin is typically used in multiple reactions and, therefore, most have multiple functions.

Vitamin generic descriptor or name	Vitamin chemical name(s) (list not complete)	Solubility	Recommended dietary allowances (male, age 1970)	Deficiency disease	Upper Intake Level (UL/day)	Overdose disease
Vitamin A	Retinoids (retinol, retinoids and carotenoids)	Fat	900 g	Night-blindness and Keratomalacia	3,000 g	Hypervitaminosis A
Vitamin B ₁	Thiamine	Water	1.2 mg	Beriberi, Wernicke-	N/D	Rare hypersensitivity

				Korsakoff syndrome		e reactions resembling anaphylactic shock-- injection only; Drowsiness
Vitamin B₂	Riboflavin	Water	1.3 mg	Ariboflavinosis	N/D	?
Vitamin B₃	Niacin, niacinamide	Water	16.0 mg	Pellagra	35.0 mg	Liver damage (doses > 2g/day) and other problems
Vitamin B₅	Pantothenic acid	Water	5.0 mg	Paresthesia	N/D	?
Vitamin B₆	Pyridoxine, pyridoxamine, pyridoxal	Water	1.3-1.7 mg	Anemia	100 mg	Impairment of proprioception, nerve damage (doses > 100 mg/day)
Vitamin B₇	Biotin	Water	30.0 g	Dermatitis, enteritis	N/D	?
Vitamin B₉	Folic acid, folinic acid	Water	400 g	Deficiency during pregnancy is associated with birth defects, such as neural tube	1,000 g	Possible decrease in seizure threshold

				defects		
Vitamin B₁₂	Cyanocobalam in, hydroxycobalam in, methylcobalam in	Water	2.4 g	Megaloblastic anemia	N/D	No known toxicity
Vitamin C	Ascorbic acid	Water	90.0 mg	Scurvy	2,000 mg	Vitamin C megadosage
Vitamin D	Ergocalciferol, cholecalciferol	Fat	5.0 g-10 g	Rickets and Osteomalacia	50 g	Hypervitaminosis D
Vitamin E	Tocopherols, tocotrienols	Fat	15.0 mg	Deficiency is very rare; mild hemolytic anemia in newborn infants.	1,000 mg	Increased congestive heart failure seen in one large randomized study.
Vitamin K	phylloquinone, menaquinones	Fat	120 g	Bleeding diathesis	N/D	Increases coagulation in patients taking warfarin.

[Table 2]

Topic : Minerals And Water**Topic Objective:**

At the end of the topic student will be able to understand:

- Nickel present in urease
- Trace minerals
- Sodium electrolyte
- Chloride
- Macrominerals
- Mineral

Definition/Overview:

Dietary minerals are the chemical elements required by living organisms, other than the four elements carbon, hydrogen, nitrogen, and oxygen which are present in common organic molecules.

About 70% of the non-fat mass of the human body is made of water. To function properly, the body requires between one and seven liters of water per day to avoid dehydration; the precise amount depends on the level of activity, temperature, humidity, and other factors. With physical exertion and heat exposure, water loss will increase and daily fluid needs may increase as well.

Key Points:**1. Mineral**

The term "mineral" is archaic, since the intent of the definition is to describe ions, not chemical compounds or actual minerals. Some dietitians recommend that these heavier elements should be supplied by ingesting specific foods (that are enriched in the element(s) of interest), compounds, and sometimes including even minerals, such as calcium carbonate. Sometimes these "minerals" come from natural sources such as ground oyster shells. Sometimes minerals are added to the diet separately from food, such as mineral supplements, the most famous being iodine in "iodized salt."

2. Macrominerals

A variety of elements are required to support the biochemical processes, many play a role as electrolytes or in a structural role. In Human nutrition, the dietary bulk "mineral elements" (RDA > 200 mg/day) are in alphabetical order (parenthetical comments on folk medicine

perspective): Calcium (for muscle and digestive system health, builds bone, neutralizes acidity, clears toxins, helps blood stream)

3. Chloride

Magnesium required for processing ATP and related reactions (health, builds bone, causes strong peristalsis, increases flexibility, increases alkalinity) Phosphorus required component of bones and energy processing and many other functions (bone mineralization) Potassium required electrolyte (heart and nerves health)

4. Sodium electrolyte

Sulfur for three essential amino acids and many proteins and cofactors (skin, hair, nails, liver, and pancreas health)

5. Trace minerals

A variety of elements are required in trace amounts, unusually because they play a role in catalysis in enzymes. Some trace mineral elements (RDA < 200 mg/day) are (alphabetical order):

- Cobalt required for biosynthesis of vitamin B12 family of coenzymes
- Copper required component of many redox enzymes, including cytochrome c oxidase
- Chromium required for sugar metabolism
- Iodine required for the biosynthesis of thyroxin
- Iron required for many proteins and enzymes, notably hemoglobin
- Manganese (processing of oxygen)
- Molybdenum required for xanthineoxidase and related oxidases

6. Nickel present in urease

Selenium required for peroxidase (antioxidant proteins)

Vanadium (There is no established RDA for vanadium. No specific biochemical function has been identified for it in humans, although vanadium is found in lower organisms.)

Zinc required for several enzymes such as carboxypeptidase, liver alcohol dehydrogenase, carbonic anhydrase. Zinc is pervasive. Iodine is required in larger quantities than the other trace minerals in this list and is sometimes classified with the bulk minerals. Sodium is not generally found in dietary supplements, despite being needed in large quantities, because the ion is very common in food.

It is not clear how much water intake is needed by healthy people, although some experts assert that 810 glasses of water (approximately 2 liters) daily is the minimum to maintain proper hydration. The notion that a person should consume eight glasses of water per day cannot be traced back to a scientific source. The effect of water on weight loss and constipation is also still unknown. Original recommendation for water intake in 1945 by the Food and Nutrition Board of the National Research Council read: "An ordinary standard for diverse persons is 1 milliliter for each calorie of food. Most of this quantity is contained in prepared foods." The latest dietary reference intake report by the United States National Research Council in general recommended (including food sources): 2.7 liters of water total for women and 3.7 liters for men. Specifically, pregnant and breastfeeding women need additional fluids to stay hydrated. According to the Institute of Medicine who recommend that, on average, women consume 2.2 litres and men 3.0 litres this is recommended to be 2.4 litres (approx. 9 cups) for pregnant women and 3 litres (approx. 12.5 cups) for breastfeeding women since an especially large amount of fluid is lost during nursing. For those who have healthy kidneys, it is rather difficult to drink too much water, but (especially in warm humid weather and while exercising) it is dangerous to drink too little. People can drink far more water than necessary while exercising, however, putting them at risk of water intoxication, which can be fatal.

Normally, about 20 percent of water intake comes from food, while the rest comes from drinking water and beverages (caffeinated included). Water is excreted from the body in multiple forms; through urine and feces, through sweating, and by exhalation of water vapor in the breath.

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multiple forms; through urine and feces, through sweating, and by exhalation of water vapor in the breath.

Topic : Alcohol

Topic Objective:

At the end of the topic student will be able to understand:

- Toxicity
- Oxidation of primary alcohols to carboxylic acids
- TEMPO
- Oxidation of alcohols to aldehydes and ketones
- Oxidation
- Esterification
- Dehydration
- Nucleophilic substitution
- Deprotonation
- Reactions
- Laboratory synthesis
- Endogenous
- Production
- Applications
- Physical and chemical properties
- Etymology
- Examples of alcohols & their names
- Systematic names
- Nomenclature
- Alcohol

Definition/Overview:

In chemistry, an alcohol is any organic compound in which a hydroxyl group (-OH) is bound to a carbon atom of an alkyl or substituted alkyl group. The general formula for a simple acyclic alcohol is $C_nH_{2n+1}OH$. The word alcohol was introduced into the English language circa 1543 from the Arabic: *al- u l*". In layman's terms, it usually refers to ethanol, also known as grain alcohol or (older) spirits of wine, or to any alcoholic beverage. Ethanol is a colorless, volatile liquid with a mild odor which can be obtained by the fermentation of sugars. (Industrially, it is more commonly obtained by ethylene hydration the reaction of ethylene with water in the presence of phosphoric acid.) Ethanol is the most widely used depressant in the world, and has been for thousands of years. This sense underlies the term alcoholism (addiction to alcohol).

Other alcohols are usually described with a clarifying adjective, as in isopropyl alcohol (propan-2-ol) or wood alcohol (methyl alcohol, or methanol). The suffix -ol appears in the "official" IUPAC chemical name of all alcohols.

Key Points:**1. Alcohol**

There are three major subsets of alcohols: primary (1), secondary (2) and tertiary (3), based upon the number of carbon atoms the C-OH group's carbon (shown in red) is bonded to. Ethanol is a simple 'primary' alcohol. The simplest secondary alcohol is isopropyl alcohol (propan-2-ol), and a simple tertiary alcohol is tert-butyl alcohol (2-methylpropan-2-ol). The phenols with parent compound phenol have a hydroxyl group (attached to a benzene ring) just like alcohols, but differ sufficiently in properties as to warrant a separate treatment. Carbohydrates (sugars) and sugar alcohols are an important class of compounds containing multiple alcohol functional groups. For example, sucrose (common sugar) contains eight hydroxyl groups per molecule and sorbitol has six. Most of the attributes of these polyols, from nomenclature, to occurrence, use and toxicity, are sufficiently different from simple aliphatic alcohols as to require a separate treatment.

The simplest and most commonly used alcohols are methanol and ethanol. Methanol was formerly obtained by the distillation of wood and called "wood alcohol." It is now a cheap

commodity, the chemical product of carbon monoxide reacting with hydrogen under high pressure. Methanol is intoxicating but not directly poisonous. It is toxic by its breakdown (toxication) by the enzyme alcohol dehydrogenase in the liver by forming formic acid and formaldehyde which cause permanent blindness by destruction of the optic nerve. Apart from its familiar role in alcoholic beverages, ethanol is also used as a highly controlled industrial solvent and raw material. To avoid the high taxes on ethanol for consumption, additives are added to make it unpalatable (such as denatonium benzoate "Bitrex") or poisonous (such as methanol). Ethanol in this form is known generally as denatured alcohol; when methanol is used, it may be referred to as methylated spirits ("Meths") or "surgical spirits".

2. Nomenclature

Two other alcohols whose uses are relatively widespread (though not so much as those of methanol and ethanol) are propanol and butanol. Like ethanol, they can be produced by fermentation processes. (However, the fermenting agent is a bacterium, *Clostridium acetobutylicum*, that feeds on cellulose, not sugars like the *Saccharomyces* yeast that produces ethanol.)

3. Systematic names

In the IUPAC system, the name of the alkane chain loses the terminal "e" and adds "ol", e.g. "methanol" and "ethanol". When necessary, the position of the hydroxyl group is indicated by a number between the alkane name and the "ol": propan-1-ol for $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$, propan-2-ol for $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$. Sometimes, the position number is written before the IUPAC name: 1-propanol and 2-propanol. If a higher priority group is present (such as an aldehyde, ketone or carboxylic acid), then it is necessary to use the prefix "hydroxy", for example: 1-hydroxy-2-propanone ($\text{CH}_3\text{COCH}_2\text{OH}$).

Some examples of simple alcohols and how to name them:

4. Examples of alcohols & their names

Common names for alcohols usually takes name of the corresponding alkyl group and add the word "alcohol", e.g. methyl alcohol, ethyl alcohol or tert-butyl alcohol. Propyl alcohol may

be n-propylalcohol or isopropyl alcohol depending on whether the hydroxyl group is bonded to the 1st or 2nd carbon on the propane chain. Isopropyl alcohol is also occasionally called sec-propyl alcohol. As mentioned above alcohols are classified as primary (1), secondary (2) or tertiary (3), and common names often indicate this in the alkyl group prefix. For example $(\text{CH}_3)_3\text{COH}$ is a tertiary alcohol is commonly known as tert-butyl alcohol. This would be named 2-methylpropan-2-ol under IUPAC rules, indicating a propane chain with methyl and hydroxyl groups both attached to the middle (#2) carbon. Primary alcohol (1)- Have general formulas RCH_2OH Secondary alcohol (2)- Have general formulas $\text{RR}'\text{CHOH}$ Tertiary alcohol (3)- Have general formulas $\text{RR}'\text{RCOH}$ Hydrogen bond strength order: $1 > 2 > 3$ Boiling point order: $1 > 2 > 3$ Acidity order: $1 > 2 > 3$

5. Etymology

The word alcohol appears in English in the 16th century, loaned via French from medical Latin, ultimately from the Arabic *al-kuhl*. *al* is Arabic for the definitive article, the in English. *kuhl* was the name given to the very fine powder, produced by the sublimation of the natural mineral stibnite to form antimony sulfide Sb_2S_3 (hence the essence or "spirit" of the substance), which was used as an antiseptic and eyeliner.

The introduction of the word to European terminology in alchemy dates to the 12th century, by Latin translations of works of Rhazes (865-925), who described the art of distillation. Bartholomew Traheron in his 1543 translation of John of Vigo introduces the word as a term used by "barbarous" (Moorish) authors for "fine powder":

William Johnson in his 1657 *Lexicon Chymicum* glosses the word as *antimonium sive stibium*. By extension, the word came to refer to any fluid obtained by distillation, including "alcohol of wine", the distilled essence of wine. Libavius in *Alchymia* (1594) has *vinialcohol vel vinum alcalisatum*. Johnson (1657) glosses *alcohol vini* as *quando omnis superfluitas vini a vino separatur, ita ut accensum ardeat donec totum consumatur, nihilque fæcum aut phlegmatis in fundo remaneat*. The word's meaning became restricted to "spirit of wine" (ethanol) in the 18th century, and was again extended to the family of substances so called in modern chemistry from 1850. The current Arabic name for alcohol is *al-kuhl*, re-introduced from western usage, while the Classical Arabic word is *al-awl* (e.g. *sura 37:47*), literally "spirit" (the word *al-awl* is also the origin of the English word "ghoul", and the name of the star *Algol*).

6. Physical and chemical properties

The hydroxyl group generally makes the alcohol molecule polar. Those groups can form hydrogen bonds to one another and to other compounds. This hydrogen bonding means that alcohols can be used as protic solvents. Two opposing solubility trends in alcohols are: the tendency of the polar OH to promote solubility in water, and of the carbon chain to resist it. Thus, methanol, ethanol, and propanol are miscible in water because the hydroxyl group wins out over the short carbon chain. Butanol, with a four-carbon chain, is moderately soluble because of a balance between the two trends. Alcohols of five or more carbons (Pentanol and higher) are effectively insoluble in water because of the hydrocarbon chain's dominance. All simple alcohols are miscible in organic solvents.

Because of hydrogen bonding, alcohols tend to have higher boiling points than comparable hydrocarbons and ethers. The boiling point of the alcohol ethanol is 78.29 °C, compared to 69 °C for the hydrocarbon Hexane (a common constituent of gasoline), and 34.6 °C for Diethyl ether. Alcohols, like water, can show either acidic or basic properties at the O-H group. With a pKa of around 16-19 they are generally slightly weaker acids than water, but they are still able to react with strong bases such as sodium hydride or reactive metals such as sodium. The salts that result are called alkoxides, with the general formula RO⁻ M⁺. Meanwhile the oxygen atom has lone pairs of nonbonded electrons that render it weakly basic in the presence of strong acids such as sulfuric acid. For example, with methanol:

Alcohols can also undergo oxidation to give aldehydes, ketones or carboxylic acids, or they can be dehydrated to alkenes. They can react to form ester compounds, and they can (if activated first) undergo nucleophilic substitution reactions. The lone pairs of electrons on the oxygen of the hydroxyl group also makes alcohols nucleophiles.

7. Applications

Alcohols can be used as a beverage (ethanol only), as fuel and for many scientific, medical, and industrial utilities. Ethanol in the form of alcoholic beverages has been consumed by humans since pre-historic times. A 50% v/v solution of ethylene glycol in water is commonly used as an antifreeze. Some alcohols, mainly ethanol and methanol, can be used as an Alcohol fuel. Fuel performance can be increased in forced induction internal combustion engines by injecting alcohol into the air intake after the turbocharger or supercharger has

pressurized the air. This cools the pressurized air, providing a denser air charge, which allows for more fuel, and therefore more power. Alcohols have applications in industry and science as reagents or solvents. Because of its low toxicity and ability to dissolve non-polar substances, ethanol can be used as a solvent in medical drugs, perfumes, and vegetable essences such as vanilla. In organic synthesis, alcohols serve as versatile intermediates. Ethanol can be used as an antiseptic to disinfect the skin before injections are given, often along with iodine. Ethanol-based soaps are becoming common in restaurants and are convenient because they do not require drying due to the volatility of the compound. Alcohol is also used as a preservative for specimens.

8. Production

Industrially alcohols are produced in several ways:

- By fermentation using glucose produced from sugar from the hydrolysis of starch, in the presence of yeast and temperature of less than 37°C to produce ethanol. For instance the conversion of invertase to glucose and fructose or the conversion of glucose to zymase and ethanol.
- By direct hydration using ethylene (ethylene hydration or other alkenes from cracking of fractions of distilled crude oil. It usually uses a catalyst of phosphoric acid under high temperature and pressure of 50-120.
- Methanol is produced from synthesis gas, where carbon monoxide and 2 equivalents of hydrogen gas are combined to produce methanol using a copper, zinc oxide and aluminium oxide catalyst at 250°C and a pressure of 50-100 atm.

9. Endogenous

It is inevitable that all humans always have some amount of alcohol in their bodies at all times, even if they never drink alcoholic beverages in their lives. This is because of a process called endogenous ethanol production. Many of the bacteria in the intestines use alcohol fermentation as a form of respiration. This metabolic method produces alcohol as a waste product, in the same way that metabolism results in the formation of carbon dioxide and water. Thus, human bodies always contain some quantity of alcohol produced by these benign bacteria.

10. Laboratory synthesis

Several methods exist for the preparation of alcohols in the laboratory.

Primary alkyl halides react with aqueous NaOH or KOH mainly to primary alcohols in nucleophilic aliphatic substitution. (Secondary and especially tertiary alkyl halides will give the elimination (alkene) product instead). Aldehydes or ketones are reduced with sodium borohydride or lithium aluminiumhydride (after an acidic workup). Another reduction by aluminiumisopropylates is the Meerwein-Ponndorf-Verley reduction.

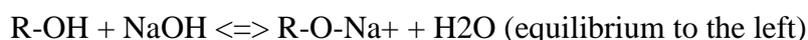
Alkenes engage in an acid catalysed hydration reaction using concentrated sulfuric acid as a catalyst which gives usually secondary or tertiary alcohols. The hydroboration-oxidation and oxymercuration-reduction of alkenes are more reliable in organic synthesis. Alkenes react with NBS and water in halohydrin formation reaction Grignard reagents react with carbonyl groups to secondary and tertiary alcohols. Related reactions are the Barbier reaction and the Nozaki-Hiyama reaction. Noyori asymmetric hydrogenation is the asymmetric reduction of α -keto-esters Amines can be converted to diazonium salts which are then hydrolyzed. The formation of a secondary alcohol via reduction and hydration is shown:

11. Deprotonation

Alcohols can behave as weak acids, undergoing deprotonation. The deprotonation reaction to produce an alkoxide salt is either performed with a strong base such as sodium hydride or n-butyllithium, or with sodium or potassium metal.



Water is similar in pKa to many alcohols, so with sodium hydroxide there is an equilibrium set up which usually lies to the left:



It should be noted, though, that the bases used to deprotonate alcohols are strong themselves. The bases used and the alkoxides created are both highly moisture sensitive chemical reagents. The acidity of alcohols is also affected by the overall stability of the alkoxide ion. Electron-withdrawing groups attached to the carbon containing the hydroxyl group will serve to stabilize the alkoxide when formed, thus resulting in greater acidity. On the other hand, the presence of an electron-donating group will result in a less stable alkoxide ion formed. This will result in a scenario whereby the unstable alkoxide ion formed will tend to accept a proton to reform the original alcohol. With alkyl halides, alkoxides give rise to ethers in the Williamson ether synthesis.

12. Nucleophilic substitution

The OH group is not a good leaving group in nucleophilic substitution reactions, so neutral alcohols do not react in such reactions. However, if the oxygen is first protonated to give $R-OH_2^+$, the leaving group (water) is much more stable, and the nucleophilic substitution can take place. For instance, tertiary alcohols react with hydrochloric acid to produce tertiary alkyl halides, where the hydroxyl group is replaced by a chlorine atom by unimolecular nucleophilic substitution. If primary or secondary alcohols are to be reacted with hydrochloric acid, an activator such as zinc chloride is needed. Alternatively, the conversion may be performed directly using thionyl chloride.

Alcohols may likewise be converted to alkyl bromides using hydrobromic acid or phosphorus tribromide, for example:



In the Barton-McCombie deoxygenation an alcohol is deoxygenated to an alkane with tributyltin hydride or a trimethylborane-water complex in a radical substitution reaction.

13. Dehydration

Alcohols are themselves nucleophilic, so $R-OH_2^+$ can react with ROH to produce ethers and water in a dehydration reaction, although this reaction is rarely used except in the manufacture of diethyl ether. More useful is the E1 elimination reaction of alcohols to

produce alkenes. The reaction generally obeys Zaitsev's Rule, which states that the most stable (usually the most substituted) alkene is formed. Tertiary alcohols eliminate easily at just above room temperature, but primary alcohols require a higher temperature.

This is a diagram of acid catalysed dehydration of ethanol to produce ethene:

14. Esterification

To form an ester from an alcohol and a carboxylic acid the reaction, known as Fischer esterification, is usually performed at reflux with a catalyst of concentrated sulfuric acid:



In order to drive the equilibrium to the right and produce a good yield of ester, water is usually removed, either by an excess of H_2SO_4 or by using a Dean-Stark apparatus. Esters may also be prepared by reaction of the alcohol with an acid chloride in the presence of a base such as pyridine. Other types of ester are prepared similarly- for example tosyl (tosylate) esters are made by reaction of the alcohol with p-toluenesulfonylchloride in pyridine.

15. Oxidation

Primary alcohols ($\text{R-CH}_2\text{-OH}$) can be oxidized either to aldehydes (R-CHO) or to carboxylic acids ($\text{R-CO}_2\text{H}$), while the oxidation of secondary alcohols ($\text{R}_1\text{R}_2\text{CH-OH}$) normally terminates at the ketone ($\text{R}_1\text{R}_2\text{C=O}$) stage. Tertiary alcohols ($\text{R}_1\text{R}_2\text{R}_3\text{-OH}$) are resistant to oxidation.

The direct oxidation of primary alcohols to carboxylic acids normally proceeds via the corresponding aldehyde, which is transformed via an aldehydehydrate (R-CH(OH)_2) by reaction with water before it can be further oxidized to the carboxylic acid.

Often it is possible to interrupt the oxidation of a primary alcohol at the aldehyde level by performing the reaction in absence of water, so that no aldehyde hydrate can be formed.

Reagents useful for the transformation of primary alcohols to aldehydes are normally also suitable for the oxidation of secondary alcohols to ketones. These include:

Chromium-based reagents, such as Collins reagent (CrO_3Py_2), PDC or PCC.

Activated DMSO, resulting from reaction of DMSO with electrophiles, such as oxalyl chloride (Swernoxidation), a carbodiimide (Pfitzner-Moffattoxidation) or the complex SO_3Py (Parikh-Doeringoxidation). Hypervalent iodine compounds, such as Dess-Martin periodinane or 2-Iodoxybenzoic acid.

- Catalytic TPAP in presence of excess of NMO (Ley oxidation).
- Catalytic TEMPO in presence of excess bleach (NaOCl) (Anellis oxidation).

16. Oxidation of alcohols to aldehydes and ketones

Allylic and benzylic alcohols can be oxidized in presence of other alcohols using certain selective oxidants such as manganese dioxide (MnO_2).

Reagents useful for the oxidation of secondary alcohols to ketones, but normally inefficient for oxidation of primary alcohols to aldehydes, include chromium trioxide (CrO_3) in a mixture of sulfuric acid and acetone (Jones oxidation) and certain ketones, such as cyclohexanone, in the presence of aluminium isopropoxide (Oppenauer oxidation). The direct oxidation of primary alcohols to carboxylic acids can be carried out using:

- Potassium permanganate (KMnO_4).
- Jones oxidation.
- PDC in DMF.
- Heyns oxidation.
- Ruthenium tetroxide (RuO_4).

17. Oxidation of primary alcohols to carboxylic acids

Alcohols possessing two hydroxy groups located on adjacent carbons that is, 1,2-diols suffer oxidative cleavage at a carbon-carbon bond with some oxidants such as sodium periodate (NaIO_4) or lead tetraacetate ($\text{Pb}(\text{OAc})_4$), resulting in generation of two carbonyl groups.

19. Toxicity

Alcohols often have an odor described as 'biting' that 'hangs' in the nasal passages. Ethanol in the form of alcoholic beverages has been consumed by humans since pre-historic times, for a variety of hygienic, dietary, medicinal, religious, and recreational reasons. The consumption of large doses results in drunkenness or intoxication (which may lead to a hangover as the effect wears off) and, depending on the dose and regularity of use, can cause acute respiratory failure or death and with chronic use has medical repercussions. Because alcohol impairs judgment, it can often be a catalyst for reckless or irresponsible behavior. The LD50 of ethanol in rats is 10,300 mg/kg. Other alcohols are substantially more poisonous than ethanol, partly because they take much longer to be metabolized, and often their metabolism produces even more toxic substances. Methanol, or wood alcohol, for instance, is oxidized by alcohol dehydrogenase enzymes in the liver to the poisonous formaldehyde, which can cause blindness or death. An effective treatment to prevent formaldehyde toxicity after methanol ingestion is to administer ethanol. Alcohol dehydrogenase has a higher affinity for ethanol, thus preventing methanol from binding and acting as a substrate. Any remaining methanol will then have time to be excreted through the kidneys. Remaining formaldehyde will be converted to formic acid and excreted.

In Section 4 of this course you will cover these topics:

- Weight Management And Disordered Eating
- Nutrition And Fitness
- Food Safety And Technology

Topic : Weight Management And Disordered Eating

Topic Objective:

At the end of the topic student will be able to understand:

- Biological
- Environmental

- Disordered Eating

Definition/Overview:

An eating disorder is a compulsion to eat, or avoid eating, that negatively affects both one's physical and mental health. Eating disorders are all encompassing. They affect every part of the person's life. According to the authors of *Surviving an Eating Disorder*, "feelings about work, school, relationships, day-to-day activities and one's experience of emotional well being are determined by what has or has not been eaten or by a number on a scale." Anorexia nervosa and bulimia nervosa are the most common eating disorders generally recognized by medical classification schemes, with a significant diagnostic overlap between the two. Together, they affect an estimated 5-7% of females in the United States during their lifetimes. There is a third type of eating disorder currently being investigated and defined - Binge Eating Disorder. This is a chronic condition that occurs when an individual consumes huge amounts of food during a brief period of time and feels totally out of control and unable to stop their eating. It can lead to serious health conditions such as morbid obesity, diabetes, hypertension, and cardiovascular disease. ANAD, or the National Association of Anorexia Nervosa and Associated Disorders is a non profit organization aimed at fighting these disorders. They work primarily in areas such as research, educating the public and running a hotline which is dedicated to referring those afflicted by disorders to support groups, therapists, or inpatient/outpatient clinics.

Key Points:

1. Disordered Eating

Many people believe that eating disorders occur only among young white females, but this is not the case. While eating disorders do mainly affect women between the ages of 12 and 35, other groups are also at risk of developing eating disorders. Eating disorders affect all ethnic and racial groups and while the specific nature of the problem and the risk factors may vary, no population is exempt. Younger and younger children seem to be at risk of developing eating disorders. While most children who develop eating disorders are between 11 and 13, studies have shown that 80% of 3rd through 6th graders are dissatisfied with their bodies or their weight and by age 9 somewhere between 30 and 40% of girls have already been on a diet. Between ages 10 and 16, the statistic jumps to 80%. Many eating disorder experts

attribute this behavior to the effects of cultural expectations. Stress is also considered to be a factor in the development of eating disorders. According to Abigail Natanshon, a psychotherapist specializing in eating disorders, children as young as 5 show signs of stress related eating disorders. This includes compulsively exercising and running to burn off calories. Natanshon notes that as children reach puberty younger and younger, they are less equipped to understand the changes in their bodies. They understand the message of the media to be "thin" and try to fit in without comprehending the effects on their bodies. While eating disorders affect younger and younger children, not only girls but also boys suffer from eating disorders. Boys who participate in sports where weight is an issue and often boys who experience issues regarding sexual identity are at risk of developing eating disorders Causes

2. Environmental

The media may be a significant influence on eating disorders through its impact on values, norms, and image standards accepted by modern society. Both society's exposure to media and eating disorders have grown immensely over the past decade. Researchers and clinicians are concerned about the relationship between these two phenomena and finding ways to reduce the negative influence thin-ideal media has on women's body perception and susceptibility to eating disorders. The dieting industry makes billions of dollars each year by consumers continually buying products in an effort to be the ideal weight. Hollywood displays an unrealistic standard of beauty that makes the public feel incredibly inadequate and dissatisfied and forces people to strive for an unattainable appearance. This takes an enormous toll on one's self-esteem and can easily lead to dieting behaviors, disordered eating, body shame, and ultimately an eating disorder.

3. Biological

Patients with severe obsessive compulsive disorder, depression or bulimia patients were all found to have abnormally low serotonin levels. Neurotransmitters such as serotonin, dopamine and norepinephrine are secreted by the intestines and central nervous system during digestion. Researchers have also found low cholecystokinin levels in bulimics. Cholecystokinin is a hormone that causes one to feel full and decreases eating. Low levels of this hormone are likely to cause a lack of satiety feedback when eating, which can lead to overeating. Another explanation researchers found for overeating is abnormalities in the neuromodulator peptides, neuropeptide Y and peptide YY. Both of these peptides increase

eating and work with another peptide called leptin. Leptin is released by fat cells and is known to decrease eating. Research found the majority of people who overate produced normal amounts of leptin but they might have complications with the blood-brain barrier preventing an optimal amount to reach the brain. Cortisol is a hormone released by the adrenal cortex which promotes blood sugar and increases metabolism. High levels of cortisol were found in people with eating disorders. This imbalance may be caused by a problem in or around the hypothalamus. A study in London at Maudsley Hospital found that anorexics were found to have a large variation of serotonin receptors and a high level of serotonin. Many of these chemicals and hormones are associated with the hypothalamus in the brain. Damage to the hypothalamus can result in abnormalities in temperature regulation, eating, drinking, sexual behavior, fighting, and activity level. While scientists have determined that there are possible biochemical or biological causes leading to eating disorders because certain chemicals which control hunger, appetite or digestions are out of balance, experts such as Dr. Edward J. Cumella, executive director of the Remuda Treatment Programs, states that there are three components to eating disorders: 1. The genetic component; 2. The unique environmental factors, such as personal experiences; and 3) The shared environmental factors, such as culture. According to Dr. Cumella, "Some people are born with a predisposition to having an eating disorder and there are genetic markers that can push a person in the direction of anorexia or bulimia...but it does not guarantee that a person will automatically suffer from an eating disorder. The environment - a person's life experience - still has to pull the trigger."

Topic : Nutrition And Fitness

Topic Objective:

At the end of the topic student will be able to understand:

- Carbohydrates
- Water and salts
- Protein
- Sports nutrition
- Nutrition
- Physical Fitness

Definition/Overview:

Fitness may mean: The state of being physically active on a regular basis to maintain good physical condition.

Key Points:**1. Physical Fitness**

Physical fitness is used in two close meanings: general fitness (a state of health and well-being) and specific fitness (a task-oriented definition based on the ability to perform specific aspects of sports or occupations). Physical fitness is the capacity of the heart, blood vessels, lungs, and muscles to function at optimum efficiency. In previous years, fitness was defined as the capacity to carry out the days activities without undue fatigue. Automation increased leisure time, and changes in lifestyles following the industrial revolution meant this criterion was no longer sufficient. Optimum efficiency is the key. Physical fitness is now defined as the bodys ability to function efficiently and effectively in work and leisure activities, to be healthy, to resist hypokinetic diseases, and to meet emergency situations. Fitness can also be divided into five categories aerobic fitness, muscular strength, muscular endurance, flexibility, and body composition.

2. Nutrition

Nutrition (also called nourishment or aliment) is the provision, to cells and organisms, of the materials necessary (in the form of food) to support life. Many common health problems can be prevented or alleviated with good nutrition. The diet of an organism refers to what it eats. Dietitians are health professionals who specialize in human nutrition, meal planning, economics, preparation, and so on. They are trained to provide safe, evidence-based dietary advice and management to individuals (in health and disease), as well as to institutions. Poor diet can have an injurious impact on health, causing deficiency diseases such as scurvy, beriberi, and kwashiorkor; health-threatening conditions like obesity and metabolic syndrome, and such common chronic systemic diseases as cardiovascular disease, diabetes, and osteoporosis.

3. Sports nutrition

4. Protein

Protein milkshakes, made from protein powder (center) and milk (left), are a common bodybuilding supplement. Protein is an important component of every cell in the body. Hair and nails are mostly made of protein. The body uses protein to build and repair tissues. Also protein is used to make enzymes, hormones, and other body chemicals. Protein is an important building block of bones, muscles, cartilage, skin, and blood.

The protein requirement for each individual differs, as do opinions about whether and to what extent physically active people require more protein. The 2005 Recommended Dietary Allowances (RDA), aimed at the general healthy adult population, provide for an intake of 0.8 grams of protein per kilogram of body weight, with the review panel stating that "no additional dietary protein is suggested for healthy adults undertaking resistance or endurance exercise". Conversely, Di Pasquale (2008), citing recent studies, recommends a minimum protein intake of 2.2 g/kg "for anyone involved in competitive or intense recreational sports who wants to maximize lean body mass but does not wish to gain weight".

5. Water and salts

Water is one of the most important nutrients in the sports diet. It helps eliminate food waste products in the body, regulates body temperature during activity and helps with digestion. Maintaining hydration during periods of physical exertion is key to peak performance. While drinking too much water during activities can lead to physical discomfort, dehydration in excess of 2% of body mass (by weight) markedly hinders athletic performance. Additional carbohydrates and protein before, during, and after exercise increase time to exhaustion as well as speed recovery. Dosage is based on work performed, lean body mass, and environmental factors, especially ambient temperature and humidity.

6. Carbohydrates

The main fuel used by the body during exercise is carbohydrates, which is stored in muscle as glycogen form of sugar. During exercise, muscle glycogen reserves can be used up,

especially when activities last longer than 90 min. Because the amount of glycogen stored in the body is limited, it is important for athletes to replace glycogen by consuming a diet high in carbohydrates. Meeting energy needs can help improve performance during the sport, as well as improve overall strength and endurance.

There are different kinds of carbohydrates simple or refined, and unrefined. A typical American consumes about 50% of their carbohydrates as simple sugars, which are added to foods as opposed to sugars that come naturally in fruits and vegetables. These simple sugars come in large amounts in sodas and fast food. Over the course of a year, the average American consumes 54 gallons of soft drinks, which contain the highest amount of added sugars. Even though carbohydrates are necessary for humans to function, they are not all equally healthful. When machinery has been used to remove bits of high fiber, the carbohydrates are refined. These are the carbohydrates found in white bread and fast food

Topic : Food Safety And Technology

Topic Objective:

At the end of the topic student will be able to understand:

- GURT technology
- Food safety
- Regulatory agencies
- United Kingdom
- Australia
- United States
- Federal-level regulation
- State and local regulation
- European Union

Definition/Overview:

Food safety is a scientific discipline describing the handling, preparation, and storage of food in ways that prevent foodborne illness. This includes a number of routines that should be followed to avoid potentially severe health hazards. Food can transmit disease from person to

person as well as serve as a growth medium for bacteria that can cause food poisoning.

Debates on genetic food safety include such issues as impact of genetically modified food on health of further generations and genetic pollution of environment, which can destroy natural biological diversity. In developed countries there are intricate standards for food preparation, whereas in lesser developed countries the main issue is simply the availability of adequate safe water, which is usually a critical item.

Key Points:

1. GURT technology

There is a concern that V-GURT plants could cross-pollinate with non-genetically modified plants, either in the wild or on the fields of farmers who do not adopt the technology. Though the V-GURT plants are supposed to produce sterile seeds, there is concern that this trait will not be expressed in the first generation of a small percentage of these plants, but be expressed in later generations. This does not seem to be much of a problem in the wild, as a sterile plant would naturally be selected out of a population within one generation of trait expression. As with all Genetically Modified crops the food safety of GURT technology would need to be assessed when and if a commercial release of a GURT containing crop was proposed.

Initially developed by the US Department of Agriculture and multinational seed companies, suicide seeds have not been commercialized anywhere in the world due to an avalanche of opposition from farmers, indigenous peoples, civil society and some governments. In 2000, the United Nations Convention on Biological Diversity recommended a de facto moratorium on field-testing and commercial sale of Terminator seeds; the moratorium was re-affirmed in 2006. India and Brazil have already passed national laws to prohibit the technology.

1.1 Possible advantages

Where effective intellectual property protection systems don't exist or are not enforced, GURTs could be an alternative to stimulate plant developing activities by biotech firms. Non-viable seeds produced on V-GURT plants will reduce the propagation of volunteer plants. Volunteer plants can become an economic problem for larger-scale mechanized farming systems that incorporate crop rotation. Under warm, wet harvest conditions non V-GURT grain can sprout, which lowers the quality of grain produced. It is

speculated[weasel words] that this problem would not occur with the use of V-GURT grain varieties. Use of V-GURT technology could prevent escape of transgenes into wild relatives and prevent any impact on biodiversity. Crops modified to produce non-food products could be armed with GURT technology to prevent accidental transmission of these traits into crops destined for foods.

1.2. Possible disadvantages

There is a concern that V-GURT plants could cross-pollinate with non-genetically modified plants, either in the wild or on the fields of farmers who do not adopt the technology. Though the V-GURT plants are supposed to produce sterile seeds, there is concern that this trait will not be expressed in the first generation of a small percentage of these plants, but be expressed in later generations. This does not seem to be much of a problem in the wild, as a sterile plant would naturally be selected out of a population within one generation of trait expression. As with all genetically modified crops, the food safety of GURT technology would need to be assessed if a commercial release of a GURT containing crop were proposed. Initially developed by the US Department of Agriculture and multinational seed companies, suicide seeds have not been commercialized anywhere in the world due to an avalanche of opposition from farmers, indigenous peoples, civil society and some governments. In 2000, the United Nations Convention on Biological Diversity recommended a de facto moratorium on field-testing and commercial sale of Terminator seeds; the moratorium was re-affirmed in 2006. India and Brazil have already passed national laws to prohibit the technology.

2. Food safety

Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent foodborne illness. This includes a number of routines that should be followed to avoid potentially severe health hazards. Food can transmit disease from person to person as well as serve as a growth medium for bacteria that can cause food poisoning. Debates on genetic food safety include such issues as impact of genetically modified food on health of further generations and genetic pollution of environment, which can destroy natural

biological diversity. In developed countries there are intricate standards for food preparation, whereas in lesser developed countries the main issue is simply the availability of adequate safe water, which is usually a critical item.

3. United Kingdom

The UK Food Standards Agency is the body responsible for food safety policy and legislation, with enforcement carried out by 'Food Authorities' which are the local authorities and, in respect of imports, port health authorities. The Agency provides guidance and information to food businesses as well as enforcement bodies, and mounts publicity campaigns aimed at informing the public about food safety. The official control of food is governed by criminal law, with the main primary legislation in the form of the Food Safety Act 1990. There is a raft of subordinate regulations, many of which implement European Union directives and regulations, prescribing requirements for hygiene, limits for contaminants, controls over the use of additives, and labelling requirements, together with other matters related such as food quality and authenticity.

Regulatory control by food authorities is based on inspection of premises supplemented by sampling of food for analysis by public analysts (chemical analysis for contaminants etc) and food examiners (microbiological examination for bacteria).

4. Australia

Australian Food Authority is working toward ensuring that all food businesses implement food safety systems to ensure food is safe to consume in a bid to halt the increasing incidence of food poisoning, this includes basic food safety training for at least one person in each business. Smart business operators know that basic food safety training improves the bottom line, staff take more pride in their work; there is less waste; and customers can have more confidence in the food they consume. Food Safety training in units of competence from a relevant training package, must be delivered by a Registered Training Organization (RTO) to enable staff to be issued with a nationally-recognised unit of competency code on their certificate. Generally this training can be completed in less than one day. Training options are available to suit the needs of everyone. Training may be carried out in-house for a group, in a public class, via correspondence or online. (To find Food Safety Training available search Google or contact the local Health Department) Basic Food Safety Training includes:

- Understanding the hazards associated with the main types of food and the conditions to prevent the growth of bacteria which can cause food poisoning
- The problems associated with product packaging such as leaks in vacuum packs, damage to packaging or pest infestation, as well as problems and diseases spread by pests.
- Safe Food handling. This includes safe procedures for each process such as receiving, re-packing, food storage, preparation and cooking, cooling and re-heating, displaying products, handling products when serving customers, packaging, cleaning and sanitizing, pest control, transport and delivery. Also the causes of cross contamination.
- Catering for customers who are particularly at risk of food-borne illness, including allergies and intolerance.
- Correct cleaning and sanitizing procedures, cleaning products and their correct use, and the storage of cleaning items such as brushes, mops and cloths.
- Personal hygiene, hand washing, illness, and protective clothing.

People responsible for serving unsafe food can be liable for heavy fines under this new legislation, consumers are pleased that industry will be forced to take food safety seriously.

5. United States

According to the FDA, 48 of 56 states and territories, representing 79% of the U.S. population, have adopted food codes patterned after one of the five versions of the Food Code, beginning with the 1993 edition.

In the United States, federal regulations governing food safety are fragmented and complicated, according to a February 2007 report from the Government Accountability Office. There are 15 agencies sharing oversight responsibilities in the food safety system, although the two primary agencies are the U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS), which is responsible for the safety of meat, poultry, and processed egg products, and the Food and Drug Administration (FDA), which is responsible for virtually all other foods.

6. Federal-level regulation

The Food and Drug Administration publishes the Food Code, a model set of guidelines and procedures that assists food control jurisdictions by providing a scientifically sound technical

and legal basis for regulating the retail and food service industries, including restaurants, grocery stores and institutional foodservice providers such as nursing homes. Regulatory agencies at all levels of government in the United States use the FDA Food Code to develop or update food safety rules in their jurisdictions that are consistent with national food regulatory policy.

7. State and local regulation

A number of U.S. states have their own meat inspection programs that substitute for USDA inspection for meats that are sold only in-state. Certain state programs have been criticized for undue leniency to bad practices. However, other state food safety programs supplement, rather than replace, Federal inspections, generally with the goal of increasing consumer confidence in the state's produce. For example, state health departments have a role in investigating outbreaks of food-borne disease bacteria, as in the case of the 2006 outbreak of *Escherichia coli* O157:H7 (bad *E. coli* bacteria) from processed spinach. Health departments also promote better food processing practices to eliminate these threats. In addition to the US Food and Drug Administration, several states that are major producers of fresh fruits and vegetables (including California, Arizona and Florida) have their own state programs to test produce for pesticide residues. Restaurants and other retail food establishments fall under state law and are regulated by state or local health departments. Typically these regulations require official inspections of specific design features, best food-handling practices, and certification of food handlers. In some places a letter grade or numerical score must be prominently posted following each inspection. In some localities inspection deficiencies and remedial action are posted on the Internet.

8. European Union

The parliament of the European Union (EU) makes legislation in the form of directives and regulations, many of which are mandatory for member states and which therefore must be incorporated into individual countries' national legislation. As a very large organisation that exists to remove barriers to trade between member states, and into which individual member states have only a proportional influence, the outcome is often seen as an excessively bureaucratic 'one size fits all' approach. However, in relation to food safety the tendency to err on the side of maximum protection for the consumer may be seen as a positive benefit. The EU parliament is informed on food safety matters by the European Food Safety

Authority. Individual member states may also have other legislation and controls in respect of food safety, provided that they do not prevent trade with other states, and can differ considerably in their internal structures and approaches to the regulatory control of food safety.

In Section 5 of this course you will cover these topics:

- Eating Throughout The Lifecycle: Pregnancy, Breastfeeding, And Infants
- Eating Throughout The Lifecycle: Toddlers Through Later Years
- Hunger At Home And Abroad

Topic : Eating Throughout The Lifecycle: Pregnancy, Breastfeeding, And Infants

Topic Objective:

At the end of the topic student will be able to understand:

- Breastfeeding
- Nutrition during pregnancy
- Nutrition And Pregnancy

Definition/Overview:

Nutrition and pregnancy refers to the nutrient intake, and dietary planning that is undertaken before, during and after pregnancy. All dietary advice relating to pregnancy-related nutrition is noted by Mary E. Barasi as one of the major factors in determining the future well-being of a child conceived, some factors of a diet are even noted to reduce childhood morbidity and mortality due to helping the supply of nutrients to the mother.

Key Points:

1. Nutrition And Pregnancy

In a precursory study into the link between nutrition and pregnancy in 1950 women who consumed minimal amounts over the eight week period had a higher mortality or disorder rate concerning their offspring than women who ate regularly, because children born to well-

fed mothers had less restriction within the womb. Not only have physical disorders been linked with ill-nutrition before and during pregnancy, but neurological disorders and handicaps are a risk that is run by mothers who are mal-nourished, a condition which can also lead to the child becoming more susceptible to later degenerative disease(s).

The following sections refer to the pertinence of nutrition throughout pregnancy, and are thoroughly researched enough to be usable for mothers or couples planning on conceiving.

2. Nutrition during pregnancy

As it is known, the embryo at conception, and in the subsequent weeks afterwards is the time when it is at its most vulnerable, as it is the time when the organs and systems develop within. The energy used to create these systems comes from the energy and nutrients in the mother's circulation, and around the lining of the womb, such is the reason why correct nutrient intake during pregnancy is so important. During the early stages of pregnancy, the placenta is not formed yet, so there is no mechanism to protect the embryo from the deficiencies which may be inherent in the mother's circulation, so it is critical that the correct amount of nutrients and energy are consumed. One problem that was found in trials with pregnant women is that deficiencies in folic acid contributed towards neural tube deflection; women who had 4 mg of folic acid in their systems due to supplementing 3 months before childbirth significantly reduced the risk of NTD within the fetus. This is now advocated by the UK department of health, recommending 400 g per day of folic acid. Intake of retinol, in extreme cases, has been linked to birth defects and abnormalities. However, regular intake of retinol is not seen as dangerous. It is noted that a 100 g serving of liver may contain a large amount of retinol, so it is best that it is not eaten daily during pregnancy, something which is also the same with alcohol intake in binge drinking. Excessive amounts of alcohol have been proven to cause Fetal alcohol syndrome. The World Health Organization recommends that alcohol should be avoided entirely during pregnancy, given the relatively unknown effects of even small amounts of alcohol during pregnancy. A study published in the British medical journal The Lancet demonstrated that those who had been well-fed soon after they were born earned almost 50% more in average salary than those who had not. The study was performed by giving a high-nutrition supplement to some infants and a lower-nutrition supplement to others, with only the researchers knowing which infants received which supplements. The infants that received the high-nutrition supplement had higher average salaries, proving that infant nutrition affects cognitive development independent of other factors such as class or

parental income. Breastfeeding (or nursing) is the feeding of an infant or young child with breast milk directly from human breasts rather than from a baby bottle or other container. Babies have a sucking reflex that enables them to suck and swallow milk. Most mothers can breastfeed for six months or more, without the addition of infant formula or solid food.

3. Breastfeeding

Human breast milk is best for human babies. There are few exceptions, such as when the mother is taking certain drugs or is infected with tuberculosis or HIV. Breastfeeding promotes health, helps to prevent disease and reduces health care and feeding costs. In both developing and developed countries, artificial feeding is associated with more deaths from diarrhoea in infants. Experts agree that breastfeeding is beneficial, but may disagree about the length of breastfeeding that is most beneficial, and about the risks of using artificial formulas. Both the World Health Organization (WHO) and the American Academy of Pediatrics (AAP) recommend exclusive breastfeeding for the first six months of life and then breastfeeding up to two years or more (WHO) or at least one year of breastfeeding in total (AAP). Exclusive breastfeeding for the first six months of life "provides continuing protection against diarrhea and respiratory tract infection" that is more common in babies fed formula. The WHO and AAP both stress the value of breastfeeding for mothers and children. While recognizing the superiority of breastfeeding, regulating authorities also work to minimize the risks of artificial feeding.

According to a WHO 2001 report, alternatives to breastfeeding include:

- expressed breast milk from an infant's own mother
- breast milk from a healthy wet-nurse or a human-milk bank
- a breast-milk substitute fed with a cup, which is a safer method than a feeding bottle and teat.

The acceptability of breastfeeding in public varies by culture and country. In Western culture, though most approve of breastfeeding, some mothers may be reluctant to do so out of fear of public opinion.

Topic : Eating Throughout The Lifecycle: Toddlers Through Later Years

Topic Objective:

At the end of the topic student will be able to understand:

- Traditional diet
- Religious and cultural dietary choices
- Diet and life outcome
- Individual dietary choices
- Diets for weight management
- Eating disorders
- Toddlers Chart

Definition/Overview:

In nutrition, the diet is the sum of food consumed by a person or other organism. Dietary habits are the habitual decisions an individual or culture makes when choosing what foods to eat. Although humans are omnivores, each culture holds some food preferences and some food taboos. Individual dietary choices may be more or less healthy. Proper nutrition requires the proper ingestion and equally important, the absorption of vitamins, minerals, and fuel in the form of carbohydrates, proteins, and fats. Dietary habits and choices play a significant role in health and mortality, and can also define cultures and play a role in religion.

Key Points:

1. Traditional diet

"Traditional diet" is the diet of native populations such as the Native Americans, Khoisanor Australian Aborigines. Traditional diets vary with availability of local resources, such as fish in coastal towns or grains in farming towns, as well as with cultural and religious customs and taboos. In some cases, the crops and domestic animals that characterize a traditional diet have been replaced by modern high-yield crops, and are no longer available. The slow food movement attempts to counter this trend and to preserve traditional diets.

2. Religious and cultural dietary choices

Some cultures and religions have restrictions concerning what foods are acceptable in their diet. For example, only Kosher foods are permitted by Judaism, and Halal foods by Islam.

3. Diet and life outcome

A study published in the British medical journal *The Lancet* demonstrated that those who had been well-fed soon after they were born earned almost 50% more in average salary than those who had not. The study was performed by giving a high-nutrition supplement to some infants and a lower-nutrition supplement to others, with only the researchers knowing which infants received which supplements. The infants that received the high-nutrition supplement had higher average salaries, proving that infant nutrition affects cognitive development independent of other factors such as class or parental income.

4. Individual dietary choices

Many individuals choose to limit what foods they eat for reasons of health, morality, environmental impact, or other factors. Additionally, many people choose to forgo food from animal sources to varying degrees. Properly planned vegetarian and vegan diets have been found to completely satisfy nutritional needs in every stage of life, and significantly reduce risks of major diseases.

5. Diets for weight management

A particular diet may be chosen to seek weight gain, weight loss, sports training, cardiovascular health, and avoidance of cancers, food allergies and for other reasons. Changing a subject's dietary intake, or "going on a diet", can change the energy balance and increase or decrease the amount of fat stored by the body. Some foods are specifically recommended, or even altered, for conformity to the requirements of a particular diet. These diets are often recommended in conjunction with exercise.

6. Eating disorders

An eating disorder is a mental disorder that interferes with normal food consumption. Eating disorders often affect people with a negative body image.

7. Toddlers Chart

Age	Physical	Mental	Emotional
12-14 months	<p>walk alone well.</p> <p>Drink from a cup (poorly).</p> <p>Turn pages in a book (a few at a time).</p> <p>Play ball by rolling or tossing it.</p>	<p>Uses one or two syllable words such as "ball" or "cookie"</p> <p>Can follow a simple command with an associated gesture, such as: bringing a cup to you when you point at it and say "Please bring me the cup".</p>	<p>Use gestures or words to convey objects, such as: Pointing at a book, raising arms to be picked up, or saying "cup".</p> <p>Mimic actions such as covering eyes while playing Peekaboo.</p>
15-18 months	<p>Hold a crayon well enough to scribble.</p> <p>Lift cup up to mouth for drinking.</p> <p>Climb onto furniture.</p> <p>Uses 1020 words.</p> <p>May be able to follow a command without a gesture.</p> <p>Stack two blocks.</p>	<p>Address others with greetings.</p> <p>Mimic parental activities such as cleaning up or talking on a telephone.</p>	
19-24 months	<p>Feed self with a spoon.</p> <p>Run.</p> <p>Climb into a small chair.</p> <p>Walk up steps.</p> <p>Helps with dressing:</p> <p>Likes to dress and undress self.</p>	<p>Speaks 2050 words;</p> <p>understands many more</p> <p>Stack six blocks</p> <p>Understands non-physical relationships such as turning on lights or pushing buttons.</p> <p>Sorting toys.</p> <p>Searching for hidden objects.</p> <p>Problem solving through experimentation.</p>	<p>Wants to be independent at times. Will throw a tantrum or possibly say no.</p> <p>Mimics social behavior such as hugging a teddy bear or feeding a doll.</p> <p>Self recognition.</p> <p>Self reference.</p> <p>Displays attachment.</p> <p>Separation anxiety.</p>

			Can play turn-taking games. <input type="checkbox"/> Beginning be ready for toilet learning
2536 months	Advanced mobility and climbing skills. Increased dexterity with small objects, puzzles. Able to dress oneself.	Speaking in sentences. Ability to be independent to primary care giver. Easily learns new words, places and people's names. Anticipates routines. Toilet learning continues Plays with toys in imaginative ways. Attempts to sing in-time with songs.	Knows boys from girls. Shows preferences, such as clothes and entertainment. Knows how to play different games.

[Table 1]

Topic : Hunger At Home And Abroad**Topic Objective:**

At the end of the topic student will be able to understand:

- Behavioral response
- Biological mechanisms
- Hunger pangs
- Biological mechanisms
- Hunger pains

Definition/Overview:

Hunger is a feeling experienced usually followed by a desire to eat. The often unpleasant feeling originates in the hypothalamus and is released through receptors in the liver. Although an average nourished individual can survive weeks without food intake, the sensation of hunger typically begins after a couple of hours without eating and is generally considered quite uncomfortable. The sensation of hunger can often be alleviated and even mitigated entirely with the consumption of food.

Key Points:**1. Hunger pains**

When hunger contractions occur in the stomach, these are called hunger pangs. Hunger pangs usually do not begin until 12 to 24 hours after the last ingestion of food, in starvation. A single hunger contraction lasts about 30 seconds, and pangs continue for around 30-45 minutes, then hunger subsides for around 30-150 minutes. Individual contractions are separated at first, but are almost continuous after a certain amount of time. Emotional states (anger, joy etc.) may inhibit hunger contractions. Levels of hunger are increased by lower blood sugar levels, and are higher in diabetics. They reach their greatest intensity in 3 to 4 days and may weaken in the succeeding days, though hunger never disappears. Hunger contractions are most intense in young, healthy people who have high degrees of gastrointestinal tonus. Periods between contractions increase with old age.

2. Biological mechanisms

The fluctuation of leptin and ghrelin hormone levels results in the motivation of an organism to consume food. When an organism eats, adipocytes trigger the release of leptin into the body. Increasing levels of leptin results in a reduction of one's motivation to eat. After hours of non-consumption, leptin levels drop significantly. These low levels of leptin cause the release of secondary hormone, ghrelin, which in turn reinitiates the feeling of hunger. Some studies have suggested that an increased production of grehlin may enhance desire towards perceptive food cues, while an increase in stress may also influence the hormone's production. These findings support why hunger can prevail under stressful situations.

3. Behavioral response

Hunger appears to increase activity and movement in many animals - for example, an experiment on spiders showed increased activity and predation in starved spiders, resulting in larger weight gain. This pattern is seen in many animals, including humans while sleeping. It even occurs in rats with their cerebral cortex or stomachs completely removed. Increased activity on hamster wheels occurred when rats were deprived not only of food, but also water or B vitamins such as thiamine. This response may increase the animal's chance of finding food, though it has also been speculated the reaction relieves pressure on the home population.

4. Hunger pangs

When hunger contractions start to occur in the stomach, these are commonly referred to as hunger pangs (less commonly as hunger pains). Hunger pangs usually do not begin until 12 to 24 hours after the last ingestion of food. A single hunger contraction lasts about 30 seconds, and pangs continue for around 30-45 minutes, then hunger subsides for around 30-150 minutes. Individual contractions are separated at first, but are almost continuous after a certain amount of time. Emotional states (anger, joy etc.) may inhibit hunger contractions. Levels of hunger are increased by lower blood sugar levels, and are higher in diabetics. They reach their greatest intensity in 3 to 4 days and may weaken in the succeeding days, though hunger never disappears. Hunger contractions are most intense in young, healthy people who have high degrees of gastrointestinal tonus. Periods between contractions increase with old age.