

# Fundamentals of Food Biotechnology

Dr. Pramod K. Raghav  
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Editors

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## **PREFACE**

We feel immense pleasure to put forward this book in front of the learners and readers. The book has easy to understand content related to the fundamentals of food and biotechnology. The book has been written keeping in mind those who are the beginners in the area of food technology, food science & technology and food biotechnology. The book begins with the terminology most often used in food technology and biotechnology because it is much important to get familiar with the technical and professional terms used frequently in these disciplines. The book contains the basics of food science & technology including preservation and nutritional importance of the food products so that the learners may get well acquainted with the basics. Further this book has explained the concept of plant tissue culture including the latest plant growing techniques such as hydroponics.

Since in keeping the food safe, microorganisms play an important role so the concept of food microbiology and significance of microbes in food in various aspects has also been explained very effectively by the authors. Biotechnology plays an important role in the environment as well as in managing the food waste hence the principles of environmental biotechnology including the role of biotechnology in waste management has also been elaborated in simple and impressive way with required diagrams and examples. I would like to extend my Sincere thanks to JV'n Mithilesh Garg (Chairperson) and JV'n Vedant Garg (Advisor & CEO), Jayoti Vidyapeeth Women's University, Jaipur, for support, motivation and resources during the writing of this valuable book. Thanks to the entire staff of Department of Food & Biotechnology of the University for their continued support during the writing of this book. I am grateful to all those who directly or indirectly contributed in the completion of this book. The authors will be highly indebted for any type of suggestion or expert opinion so as to further improve the contents of the book.

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## CHAPTER- 1

### TERMINOLOGY IN FOOD & NUTRITION

**Dr. Pramod K. Raghav**

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**Additives:** These are the substances added to food to improve flavour, colour, and texture or to extend the shelf life of food products.

**Adipose Tissue:** This tissue is made up of fat-storing cells, and fat storage begins in the body from these cells.

**Aesthetics:** The appreciation of good looks and taste and the product appeals to the senses.

**Aleurone Layer:** The aleurone layer is a type of cereal endosperm tissue that is lost during processing along with the bran. It contains a lot of protein, fats, vitamins, and minerals.

**Ambient Temperature:** The air temperature of any object or environment where equipment is stored is known as the ambient temperature. The adjective ambient means "relating to the immediate surroundings."

**Amino acids:** Amino acids are molecules that form proteins when they combine. The building blocks of life are amino acids and proteins. Amino acids are left over after proteins are digested or broken down. To help the body, the human body uses amino acids to make proteins.

**Anemia:** Anemia is a condition in which there are insufficient healthy red blood cells to transport oxygen to your body's tissues. Anemia, also known as low haemoglobin, can make a person feel tired and weak. There are numerous types of anaemia, each with its own unique cause.

**Anthocyanins:** Anthocyanins are phenolic pigments that are coloured and water soluble. The pigments have been glycosylated. Fruits and vegetables contain anthocyanins, which are responsible for the color red, purple, and blue colours. Anthocyanins are abundant in berries, currants, grapes, and some tropical fruits.

**Antibacterial:** Antibacterial usually refers to an antibiotic, a type of antimicrobial agent that is primarily used against bacteria; it can either kill or inhibit them.

**Antioxidants:** Antioxidants are synthetic or natural substances that can prevent or postpone certain types of cell damage. Many foods, including fruits and vegetables, contain antioxidants. They can also be purchased as dietary supplements. Beta-carotene is an example of an antioxidant.

**Ascorbic acid:** When the amount of ascorbic acid in the diet is insufficient, ascorbic acid (vitamin C) is used as a dietary supplement. People who eat a limited variety of foods or who

have intestinal malabsorption problems due to cancer or kidney disease are most at risk for ascorbic acid deficiency.

**Atherosclerosis:** The accumulation of fats, cholesterol, and other substances in and on the artery walls is known as atherosclerosis. This buildup is known as plaque. The plaque can narrow the arteries, preventing blood flow.

**Bacteria:** Bacteria are single-celled organisms that are small in size. Bacteria can be found almost anywhere on the planet and are essential to the planet's ecosystems. Some species can survive in extreme temperatures and pressures.

**Basal metabolic rate (BMR):** The amount of energy expended at rest in a neutral environment after the digestive system has been inactive for about 12 hours is known as the basal metabolic rate (BMR). It is the rate at which one's metabolism resumes after "fasting" during sleep.

**Batch Production:** Batch production is a method of producing a large number of identical products at the same time (rather than one at a time). It is up to the manufacturer to determine the size of the batch and how frequently these batches will be produced. Each batch goes through the various stages of processing in tandem.

**Bioavailability:** Bioavailability is the ease with which a substance can be absorbed from the digestive tract and into the bloodstream.

**Blast chill:** Blast chilling is a technique for rapidly cooling food to a low temperature that is relatively safe from bacterial growth.

**Blast freezing:** Blast freezing is the process of rapidly moving cold air across a food product in order to freeze it as quickly as possible.

**Body mass index (BMI):** Body Mass Index (BMI) is calculated by dividing a person's weight in kilogram's (or pounds) by their height in meters squared (or feet)  $BMI = kg/m^2$  or  $lb/ft^2$ .

**Bone Density:** The amount of bone mineral (e.g., calcium) in bone tissue is referred to as bone density or bone mineral density. Bone density peaks at around 30 years of age and declines with age.

**Bran:** Bran is the outer coating or shell of grain that is removed during the manufacturing of white flour. Bran is made up of three layers: the pericarp, the seed coat, and the aleurone layer.

**Brand:** A brand is a name, term, design, symbol, or any other feature that differentiates one seller's good or service from those of other sellers, for example, Birtania Bread.

**C.A.D. :** Computer-aided design e.g. programs used for designing packaging.

**C.A.M.:** Computer-aided manufacture. e.g. using a computer to help control baking temperatures.

**Caffeine:** Caffeine is a naturally occurring chemical that has stimulant properties. It's in coffee, tea, cola, cocoa, and more than 60 other products.

**Calcium:** Calcium is a mineral that is most commonly associated with healthy bones and teeth, but it also plays an important role in blood clotting, muscle contraction, and normal heart rhythms and nerve functions.

**Calories:** A calorie is a type of energy unit. Calories are the energy people get from the food and drink they consume, as well as the energy they use in physical activity. Calories are listed on all food packaging in the nutritional information. A calorie is equal to 4.18 kJ..

**Carbohydrate:** Carbohydrates, also known as carbs, are sugar molecules. Carbohydrates, along with proteins and fats, are one of the three main nutrients found in foods and beverages. Carbohydrates are converted into glucose by your body.

**Glucose:** Glucose, also known as blood sugar, is the primary energy source for your body's cells, tissues, and organs. Rice, bread, cereal, legumes, fruits, and vegetables are all good sources of carbohydrates, as well as important nutrients.

**Carotenoids/carotenes:** Carotenoids are a group of over 750 naturally occurring pigments that are produced by plants, algae, and photosynthetic bacteria (1). Many plants' yellow, orange, and red colours are derived from these vibrantly coloured molecules. Carotenoids are primarily found in fruits and vegetables.

**Catabolism:** Catabolism is a set of metabolic pathways that breaks down molecules into smaller units that are either oxidised to release energy or degraded to release energy. Catabolism is the process by which large molecules are broken down into smaller units.

**Cellulose:** Cellulose is an insoluble fibre that is an important structural component of the primary cell wall of green plants.

**Central obesity:** Central obesity is defined as an abnormal accumulation of fat in the abdomen, most notably visceral fat. Because the portal blood system supplies visceral fat, excess fat in this area can cause the release of fatty deposits into the bloodstream, causing health problems.

**Cholesterol:** Cholesterol is a waxy substance that is found in your bloodstream. Although your body requires cholesterol to build healthy cells, high cholesterol levels can increase your risk of heart disease. High cholesterol can cause fatty deposits in your blood vessels. It is cholesterol.

**Cognition:** Cognition refers to mental functions such as thinking, reasoning, and remembering.

**Complementary proteins:** The concept of complementary proteins is the combination of incomplete protein sources in one meal to consume all essential amino acids. The proteins in one food supplement the proteins in another, supplying any essential amino acids that the other may lack.

**Complete proteins:** Complete proteins are foods that contain all of the essential amino acids in the amounts required by the body and do not require the addition of any other foods.

**Component:** A component is a system element or a machine part. However, a component can also be a factor or an ingredient, such as a readymade dosa batter.

**Consumer:** A purchaser of goods or services.



**Continuous-flow production:** Continuous production is a type of manufacturing system in which the materials being processed are constantly moving.

**Cook-chill:** A cook-chill system is a food preservation technology in which foods are fully cooked (usually at temperatures below 100 degrees Celsius), rapidly chilled, and refrigerated.

**Cook-freeze:** Cooked food that has been quickly frozen and then stored below freezing temperature.

**Cross contamination:** Cross-contamination is the physical movement or transfer of harmful bacteria from one person, object, or location to another. Cross-contamination prevention is essential in the prevention of food-borne illness.

**Danger zone:** Bacteria grow the fastest at temperatures ranging from 40°F to 140°F, doubling in size in as little as 20 minutes. This temperature range is commonly referred to as the Danger Zone (4°C - 60°C).

**Dehydration:** Dehydration occurs when your body uses or loses more fluid than you take in, and your body does not have enough water and other fluids to carry out its normal functions. You will become dehydrated if you do not replenish lost fluids.

**Diabetes:** Diabetes is a long-term health condition that affects how the body converts food into energy. The majority of the food consumed is broken down into sugar (also known as glucose) and released into the bloodstream. When blood sugar levels rise, the pancreas signals the release of insulin.

**Diet:** Diet refers to the food and beverages that we regularly provide or consume.

**Dietary Reference Values DRV's:** Dietary reference values (DRVs) are an umbrella term for a collection of nutrient reference values that includes the average requirement (AR), population reference intake (PRI), adequate intake (AI), and macronutrient reference intake ranges (RI). It is the amount of food and other nutrients required by people of various ages.

**Diuretic:** A diuretic is a substance that increases urine production, thereby increasing water removal from the body. Caffeine is a diuretic that occurs naturally.

**Due diligence:** Due diligence in food refers to being able to demonstrate that your company has taken reasonable steps to prevent food safety violations. This entails performing all necessary checks on every aspect of your food business.

**E numbers:** E numbers are codes for food additives, such as vitamins found naturally in many foods.

**Electrolytes:** Electrolytes are minerals that carry an electric charge in the blood and other bodily fluids. Electrolytes influence how your body works in a variety of ways, including the amount of water in your body. Electrolytes include potassium, sodium, calcium, and magnesium.

**Emulsifiers:** Emulsifiers are minerals in the blood and other body fluids that carry an electric charge. Emulsifiers affect how your body functions in many ways, including: The amount of water in your body. The examples of emulsifiers are potassium, sodium, calcium, and magnesium.

**Endosperm:** Endosperm is the inner part of the grain. It contains carbohydrate, protein and B vitamins.

**Energy balance:** Energy balance is defined as the state achieved when the energy intake equals energy expenditure.

**Energy:** The amount of food energy required to balance energy expenditure in order to maintain body size, body composition, and a level of necessary and desirable physical activity consistent with long-term good health is referred to as energy requirement.

**Enzymes:** Enzymes are proteins that aid in the acceleration of chemical reactions in our bodies. Enzymes are necessary for digestion, liver function, and many other things. Too much or too little of a particular enzyme can be harmful to one's health.

**Essential fatty acids:** Polyunsaturated fatty acids (PUFA), which are important for health but cannot be produced by the body, are referred to as essential fatty acids (EFA) and must be obtained from food sources. There are two families of EFA, omega-3 ( $\omega$ -3) and omega-6 ( $\omega$ -6).

**Fats:** Animal and some plant tissues contain oily compounds called fats. These fats are present in many of the foods we eat. Animal products like milk, eggs, and meat all have fats in them. Olive oil, avocados, and other plant-based meals like almonds also have this property.

**Fibre:** Fibre is the indigestible component of plant-based meals such as grains, beans, vegetables, fruits, and legumes. It is a form of carbohydrate that supports the health of our digestive systems. There are three different forms of fibre, and each one serves a particular purpose and offers unique health advantages.

**Flavonoids:** Fruits, vegetables, grains, bark, roots, stems, flowers, tea, and wine all contain flavonoids, a class of organic compounds with varying phenolic structures. These all-natural products are well renowned for improving health.

**Flavours:** A flavouring used in food can induce the sensory sense of taste or smell, which is referred to as flavour or flavour.

**Flow diagram:** An organised diagram that depicts a workflow or process is called a flowchart. A flowchart is also sometimes referred to as a process flow diagram and can be thought of as a diagrammatic representation of a production process. The flowchart has boxes of various forms that are connected in a systematic way by arrows.

**Folate (folic acid):** The water-soluble natural vitamin B9 is known as folate, and it can be found in a variety of foods. In the form of folic acid, it is also added to foods and offered as a supplement; this form is actually more readily absorbed than that obtained from dietary sources (85% vs. 50%, respectively).

**Food allergy:** An immune system reaction known as a food allergy happens quickly after consuming a particular meal. A tiny amount of the food that causes allergies can cause signs and symptoms like stomach issues, rashes, or enlarged airways.

**Food aversions:** You have a food aversion if you find it difficult to eat (or even smell) particular meals. Similar to desires, food aversions are fairly prevalent during pregnancy. It's

the reverse of a craving. About 60% of expectant women are thought to suffer dietary aversions.

**Food intolerance:** An individual with a food intolerance has trouble digesting some foods. A food intolerance differs from a food allergy, it is vital to note. People who suffer from digestive system diseases, like irritable bowel syndrome (IBS), are more likely to have food intolerances. Food intolerances often affect the digestive system rather than the immune system, in contrast to meal allergies, which are the result of an immune system response to a particular food.

**Free radicals:** Atoms with unpaired electrons in their outer layers are referred to as free radicals. They are thought to contribute to tissue damage and ageing since they are brought on by pollutants, cigarette smoke, and metabolic by products.

**Fructose:** A monosaccharide is a form of sugar that includes fructose. Fructose contains four calories per gramme, much like other sugars. Because it is largely found naturally in many fruits, fructose is also referred to as "fruit sugar."

**Functional foods:** Foods known as functional foods have potential health benefits above and beyond those of basic nutrition. Functional foods, according to their proponents, encourage optimum health and lower the risk of disease.

**Germ:** The germ, which is a grain's embryo, is a source of protein, healthy fats, minerals, vitamin E, and B vitamins.

**Glucose:** Blood sugar, often known as glucose, is the main sugar found in your blood. It comes from the food you eat and is used as your body's main energy source. Your blood supplies glucose to all of the cells in your body, which then uses it as fuel. Diabetes is a disorder when your blood sugar levels are too high.

**Gluten:** Wheat, rye, spelt, and barley are examples of grains that include the gluten protein family. Wheat is by far the grain that contains gluten that is consumed the most. It makes the dough stickier, helping to produce products like bread.

**Glycaemic index:** The glycaemic index is a ranking system for carb-containing foods (GI). It shows how quickly each food decreases blood sugar (glucose) levels when ingested on its own.

**Glycogen:** When a person is fasting, the blood stream receives glucose from glycogen, a branched polymer of glucose that is mostly stored in the liver and skeletal muscle of the body. Glycogen also delivers glucose to the muscle cells during muscle contraction.

**Goitre:** A goitre, frequently spelled "goitre," is an enlargement of the thyroid gland that manifests as a lump in the front of the neck. The lump will rise and fall as you swallow.  
**Grams:** A measuring unit is the gramme (g). Nutrients including carbohydrates, protein, and fibre are frequently utilised to calculate nutritional values.

**H.A.C.C.P. :** Hazard analysis and critical control point.

**Haemoglobin:** Haemoglobin, a protein found in red blood cells, transports oxygen to your body's organs and tissues while exhaling carbon dioxide back into your lungs. A

haemoglobin test can be used to detect a person's haemoglobin level if they have a low red blood cell count (anemia).

**Hazard:** A hazard is any source that has the potential to harm something or someone, cause damage, or have negative health effects.

**Health claims:** A health claim is any assertion regarding the relationship between nutrition and health.

**Heavy Metals:** A heavy metal is any metallic chemical element that has a relatively high density and is poisonous or hazardous at low concentrations. Heavy metals include substances like mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb).

**High Risk foods:** High risk foods are those that promote bacterial growth and are highly perishable in nature for instance, dairy items, raw fish, cooked meat, and raw meat.

**Hydrogenation:** The chemical process known as hydrogenation, which involves molten hydrogen (H<sub>2</sub>) and another material or element, usually takes place in the presence of a catalyst like nickel, palladium, or platinum. Vegetable oils are routinely solidified using this method in the food business.

**Image board:** a collection of images and illustrations used to convey concepts about a target market or a selection of products.

**Insulin:** The pancreas produces the hormone insulin in response to elevated blood glucose levels. The main function of insulin is to deliver glucose from the bloodstream to the muscles and other tissues.

**Iron:** Iron helps the body produce healthy blood and transports oxygen. Legumes, wholegrain breads and cereals, green leafy vegetables, nuts, seeds, and meat are all sources of iron.

**Isoflavones:** Isoflavones are naturally occurring plant substances that resemble oestrogen in terms of their structural makeup. also referred to as Phytoestrogens.

**Kilojoules (kJ):** The current standard unit of energy measurement is the kilojoule. One gramme of protein or carbohydrates has a caloric content of 17 kJ per gramme, compared to 37 kJ per gramme of fat.

**Lactase:** Lactase is an enzyme. It disintegrates lactose, a sugar found in milk and dairy products. Some people's systems do not produce enough lactase, which prevents them from properly digesting milk and can result in diarrhoea, cramps, and gas. This condition is known as "lactose intolerance." Lactase supplementation can aid in the breakdown of lactose.

**Lactose:** A naturally occurring sugar called lactose can be found in milk and dairy products like cheese and ice cream..

**Legumes:** Any member of the Fabaceae family of plants, including its leaves, stems, and pods, is referred to as a legume. The edible seed of a legume plant is known as a pulse. Peas, lentils, and beans are examples of pulses. As an illustration, a pea pod is a legume, while the pea within is a pulse.

**Logo:** Logo is a simple visual representation that is easy to understand and remember, logos help to symbolise a specific organisation or firm. In most cases, a logo consists either symbols, stylised words, or both.

**Low risk area:** These are areas in commercial kitchens, daily operations, and food processing plants where food is free from contamination

**Lycopene:** Lycopene is a type of organic pigment called a carotenoid. It is connected to beta-carotene and is responsible for the red colour of several fruits and vegetables, including tomatoes. Strong antioxidant lycopene may help shield cells from deterioration.

**M.A.P.:** Modified atmosphere packaging (MAP) is a method of packaging where the gaseous atmosphere surrounding a food product inside a pack is altered. To keep the altered atmosphere at an acceptable level for the food's preservation, packaging materials and formats with the proper level of gas barrier are used.

**Macronutrients :** Protein, fat, and carbs are generally referred to as "macronutrients". You eat the most of these nutrients generally. The body uses the nutritional components of food known as macronutrients for energy as well as to keep its systems and structure in place.

**Metabolic syndrome:** Your risk of developing heart disease, a stroke, and type 2 diabetes is increased if you have metabolic syndrome, a collection of illnesses. These issues include issues with excessive blood sugar, high blood pressure, excess body fat around the waist, and abnormal cholesterol or triglyceride levels.

**Metabolism:** Metabolism is the process by which your body converts what you eat and drink into energy. This intricate process releases the energy your body requires to function by combining calories from food and beverages with oxygen.

**Micrograms:** In the metric system, a microgram or microgramme is a unit of mass equal to one millionth ( $1 \times 10^{-6}$ ) of a gram. Commonly used in nutritional values for nutrients.

**Micronutrients:** Vitamins and minerals that the body needs in extremely small amounts are known as micronutrients. However, they have a crucial impact on a body's health, and a lack of any one of them can result in serious, even life-threatening illnesses.

**Milligrams:** A unit of measurement used frequently when calculating nutritional values for minerals like calcium and iron.

**Minerals:** Our bodies need minerals for optimal growth and development; they can be found in food and the earth. For optimum health, one needs calcium, phosphorus, potassium, sodium, chloride, magnesium, iron, zinc, iodine, chromium, copper, fluoride, and molybdenum.

**Modelling:** To experiment with an idea without actually cooking it. You can model the nutritional value of a food product by using FOODP6.

**Nutrients:** A nutrient is something that an organism uses to live, grow, and reproduce. Animals, plants, fungi, and protists all require dietary nutrient intake.

**One-off production:** Producing one-of-a-kind items, such as a unique product for a single client or a small batch of items in quantities typically lower than those of mass-market goods, is known as one-off production.

**Organoleptic Testing:** The evaluation of a food product's flavour, aroma, appearance, and mouthfeel is known as organoleptic testing. Food products must be organoleptically tested to ensure they meet organizational and consumer criteria.

**Phytoestrogens:** A chemical compound that, when consumed by the body, can have actions similar to those of the hormone oestrogen. Legumes, wholegrain cereals, nuts, seeds, and a variety of vegetables and fruits all naturally contain phytoestrogens.

**Plant based eating:** A chemical that is present in some plants that, when consumed by the body, can have effects similar to those of the hormone oestrogen. Natural phytoestrogens can be found in legumes, whole-grain cereals, nuts, seeds, as well as a variety of vegetables and fruits.

**Plant sterols:** Similar to cholesterol but produced by plants, plant sterols are chemicals. The biggest concentrations of them can be found in seeds, nuts, and vegetable oils. By reducing the amount of cholesterol that can enter the body, plant sterols may aid in lowering cholesterol levels.

**Portion:** A portion for one is the amount of food that satisfies the need for one person

**Potassium:** Potassium is a mineral, which is a necessary component for body. Because it carries a little electrical charge that triggers a variety of cell and neuron activities, it is occasionally referred to as an electrolyte. Potassium can be obtained as a dietary supplement and also available naturally in many foods.

**Product specification:** The exact details needed to make the product.

**Protein:** A protein is a highly complex, naturally occurring substance made up of amino acid residues connected by peptide bonds. All living things are composed of proteins, which also comprise a variety of vital biological elements like hormones, antibodies, and enzymes.

**Prototype:** An original model on which something is patterned

**Quality assurance:** A product or service's compliance with predetermined specifications is determined through a systematic procedure known as quality assurance (QA). QA establishes and maintains standards for creating or producing dependable products.

**Quality control:** A technique or collection of procedures known as quality control (QC) is designed to make sure that a service or product is made in accordance with a specified set of quality criteria or that it satisfies the needs of the client or customer. QC is similar to, but not identical with, quality assurance (QA).

**Recommended daily intake:** The average daily intake level of a particular nutrient that is likely to meet the nutrient requirements of 97-98% of healthy individuals in a particular life stage or gender group.

**Refined:** Refined refers to the process where foods are stripped of their coarse outer layers and many nutritional aspects. For example, wholegrain wheat is refined to produce white flour.

**Repetitive-flow production :** Contrasting batch production, repetitive flow manufacturing is a discrete manufacturing method. Fundamentally, repeated manufacturing aims to reduce



waste by introducing flow onto production lines or cells (overproduction, cycle time, scrap etc.)

**Sensory descriptors:** Food sensory analysis is the use of the human senses to analyse food objectively for qualities like taste, flavour, and texture. It is employed in evaluating the quality of goods, resolving issues, and developing new goods. Actually, these are the terms used to describe flavour, texture, and fragrance.

**Shelf life:** The amount of time a product can be stored before losing its suitability for use or consumption is known as its shelf life. The product's degrading mechanism affects the shelf life.

**Sodium:** Sodium is an electrolyte that helps maintain acid-base balance of the blood, helps regulate blood pressure and water balance in cells and aids in muscle contraction and nerve impulse transmission.

**Tempeh:** Traditional Indonesian meal called tempe or tempeh is prepared from fermented soybeans. Soybeans are bound into a cake form using a natural culturing and controlled fermentation process. The fermentation method uses a fungus called *Rhizopus oligosporus* or *Rhizopus oryzae*, sometimes referred to as tempeh starter.

**Textured vegetable protein:** Textured or texturized vegetable protein, commonly referred to as textured soy protein, soy meat, or soy chunks, is a by-product of the extraction of soybean oil made from defatted soy flour.

**Tofu:** Tofu is also known as Soy Paneer and is a soft cheese-like food made by coagulating soy milk.

**Tolerance level:** Tolerance level is a term used typically to define the maximum amount of something that can be tolerated. For example: The amount and flexibility allowed when making a product – in terms of weight, colour, size – so that it meets quality standards.

**Traceability:** The capacity to track the movement of a food product and its ingredients through all supply chain steps, both backward and forward, is an example of traceability in the context of food products. The production, processing, and distribution chains of food items and ingredients are tracked and linked through traceability.

**Trend:** The likelihood of something happening. e.g. there is a trend for more single portions.

**Triticale:** The rye (*Secale*) and wheat (*Triticum*) hybrid known as triticale was developed in Scotland and Germany's research labs in the late 19th century. Triticale that is sold commercially is nearly always a second-generation hybrid, which means it was created by crossing two different primary (first-cross) triticales.

**Vegan:** A person who refrains from eating any products originating from animals, such as honey, milk, and gelatin, is known as a vegan.

**Vegetarian:** The practice of not eating meat is known as vegetarianism (red meat, poultry, seafood, insects, and the flesh of any other animal). It might also mean avoiding eating any by-products of animal slaughter.

**Vitamin A:** A class of retinoids known as vitamin A, notably retinol and retinyl esters, are fat-soluble retinoids. Immune system operation, cellular communication, growth and development, and male and female reproduction are all impacted by vitamin A.

**Vitamin B1 (thiamin):** Vitamin B1 is needed for energy metabolism and the proper functioning of the nervous system. Good sources include wholegrains, soybeans, peas, beans, pistachio nuts.

**Vitamin B12:** Vitamin B12 is an essential vitamin required by the body to make red blood cells and DNA. It is also needed to make a protective layer around nerve cells. This vitamin is found naturally in animal products, such as meat, dairy products and eggs.

**Vitamin B2 (riboflavin):** Vitamin B2 is needed for energy metabolism, tissue growth, and maintaining good vision. Good sources include dairy products (milk, cheese, yoghurts), broccoli, spinach, mushrooms and eggs.

**Vitamin B3 (niacin):** Vitamin B3 is needed for energy metabolism, proper digestion, and a healthy nervous system. Good sources include kidney beans, peanuts, mushrooms, milk, cheese, chicken and salmon.

**Vitamin B6 (pyridoxine):** Vitamin B6 is needed for amino acid metabolism, cognitive function and immune function. Good sources include wholegrains, spinach, broccoli, carrots banana and yoghurt.

**Vitamin C:** Vitamin C is an antioxidant vitamin needed for the formation of collagen to hold the cells together and for healthy teeth, gums and blood vessels. It also improves iron absorption and resistance to infection. Fruit and vegetables are good sources of vitamin C.

**Vitamin D:** Vitamin D promotes absorption and use of calcium and phosphate for healthy bones and teeth. The body synthesises vitamin D when our skin is exposed to at least 10-15 minutes sunshine per day. Longer time is required in winter months and in those with darker skin tones. Food sources include fortified milk, cheese, whole eggs, liver, salmon, and fortified margarine.

**Vitamin E:** Vitamin E is a group of eight fat soluble compounds that include four tocopherols and four tocotrienols. Vitamin E deficiency, which is rare and usually due to an underlying problem with digesting dietary fat rather than from a diet low in vitamin E, can cause nerve problems. Food sources of vitamin E include wholegrain products, nuts and seeds, wheatgerm and vegetable oils.

**Vitamin K:** Vitamin K refers to structurally similar, fat-soluble vitamins found in foods and marketed as dietary supplements. The human body requires vitamin K for post-synthesis modification of certain proteins that are required for blood coagulation or for controlling binding of calcium in bones and other tissues.

**Vitamins:** Vitamins are substances that the body needs in minute quantities for growth and health, and they must be consumed daily through diet. Vitamin D, which is produced in the skin when exposed to sunshine, and vitamin K, which can be partially manufactured by gut flora, are the exceptions to this rule.

**Waist circumference:** Waist circumference is a measurement of the size of an individual's waist.

**Waist-to-hip ratio:** Waist-to-hip ratio is measurement of an individual's waist divided by their hip measurement.

**Water:** Water is one of the nutrients that our body requires for health and it makes up 50-70% of our body weight. All cells in the body require it and adequate water intake helps prevent dehydration. 6-8 glasses of water are required each day, more than this may be required during hot weather or for active people.

**Whole foods:** Whole foods are those that have undergone little to no processing and are therefore rich in nutrients. Fruits and vegetables, whole grains, brown rice, nuts, and seeds are a few examples of whole foods.

**Wholegrain:** A whole grain is a grain of any cereal and pseudocereal that contains the endosperm, germ, and bran, Examples include wholegrain wheat and wholegrain (brown) rice.

**Zinc:** Even though the body only requires minute amounts of it, nearly 100 enzymes depend on it to carry out essential chemical reactions. It plays a crucial role in the creation of DNA, cell proliferation, the synthesis of proteins, the repair of damaged tissue, and the maintenance of a strong immune system. Rolled oats, unprocessed bran, rice, muesli, wholegrain breads, and cereals are excellent plant sources of zinc.

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## CHAPTER 2

### TERMINOLOGY IN FOOD BIOTECHNOLOGY AND MICROBIOLOGY

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**Abiotic Stress:** Abiotic stress is the term used to describe the harmful effects that non-living elements have on living things in a given environment. Drought, salt, very low or high temperatures, and other environmental extremes are some of the stressors.

**Acclimatization-** Acclimatization refers to an organism's adjustment to a new environment.

**Active immunity-** Active immunity is a form of acquired immunity in which resistance to a disease is developed via either personal exposure to the illness or vaccination against it.

**Adaptation-** A heritable trait of an individual's phenotype that increases its chances of surviving and reproducing in the current environment is referred to as adaptation in the context of evolution.

**Adjuvant:** An insoluble substance that, when combined with an immunogen, promotes the production and persistence of antibodies.

**Aerobic-** requiring oxygen for development

**Aerobic respiration:** You are only one click away from information and guidance on all facets of microbiology education, including theory and practice.

**Agglutinin-** Agglutinin is a kind of antibody that may bind to and recognize immunological determinants on the surface of bacteria or other cells, causing the cells to cluster together. (Agglutination)

***Agrobacterium tumefaciens*-** Crown gall disease is often produced by the bacterium *Agrobacterium tumefaciens* in a range of plants. This bacterium has produced a plasmid that can be used for plant genetic modification. This plasmid, known as the Ti plasmid, has been altered such that it may introduce foreign DNA into plant cells that are vulnerable to infection while remaining disease-free.

**Alga (algae, plural) -** A single-celled or multi-cellular eukaryotic, photosynthetic organism is an alga (plural: algae).

**Allele-** Any of a gene's several other forms.

**Allogenic-** Species belonging to the same allogenic group but having a distinct genotype.

**Allopolyploid Plants-** Plants with more than two sets of haploid chromosomes acquired from distinct species are known as allopolyploid plants.

**Allopolyploid:** Polyploid created when two species hybridise.

**Allosteric regulation:** Controlling the activity of an enzyme by interacting with a tiny molecule at a location other than the active site area.

**Allotype-** Allotypes follow the simple Mendelian inheritance principles and are the protein products (or the outcome of their activity) of an allele that may be identified as an antigen in another individual of the same species (e.g., immunoglobulins, histocompatibility antigens).

**Alternative splicing-** Alternative splicing is the process of removing introns from eukaryotic pre-mRNAs in different ways, which causes one gene to produce a variety of mRNAs and protein products.

**Alu family-** A distributed family of intermediately repetitive DNA sequences, the alu family, is present in the human genome in roughly 300,000 copies. The sequence is 300 bp in length. The restriction endonuclease AluI, which cleaves it, gave it the name Alu.

**Ames test:** A commonly used test for the detection of potential chemical carcinogens that is based on the mutagenicity of the Salmonella bacteria.

**Amino acid-** A protein's fundamental building component is an amino acid. Polypeptides are the linear chains created when amino acids polymerize and are joined by peptide bonds. All proteins are composed of the twenty typically occurring amino acids. There are twenty common amino acids: valine, alanine, arginine, aspartic acid, cysteine, glutamic acid, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, and valine.

**Amplification-** The process of making more copies of a specific gene or chromosomal sequence is known as amplification. As an alternative to amplifying the sequence, this might also include amplifying the signal to increase detection.

**Anabolic:** The portion of metabolism that is focused on chemical synthesis.

**Anaerobic-** Anaerobic growth occurs without oxygen.

**Aneuploid-** an incomplete chromosomal set or the presence of additional chromosomes results in an aneuploid, which has a chromosome number that is not an exact multiple of the haploid number.

**Aneuploidy-** Aneuploidy is the state in which a cell or an organism has a tiny number of complete chromosomes that have been added or deleted from the anticipated balanced diploid number of chromosomes.

**Annealing-** spontaneous formation of a double helix from two complementary single polynucleotide (RNA, DNA, or RNA plus DNA) strands.

**Antibiotic-** A substance used to treat bacterial illnesses that either kills or prevents the development of germs.

**Antibiotic Chemical compound-** used to treat bacterial infections that is produced as a metabolic byproduct in bacteria or fungus. Antibiotics can be created synthetically or organically utilising microorganisms.

**Antibody-** An antibody is a protein that the body produces in reaction to an antigen (a molecule that is perceived to be foreign). To assist the immune system in eliminating the foreign substance, antibodies attach directly to their target antigen. The body's immune



system creates a Y-shaped protein called antibody that is manufactured by certain white blood cells.

**Anticodon-** A triplet of messenger RNA's triplet complements (complements) a triplet in transfer RNA's nucleotide cases (codon). For instance, the anticodon may be AGC if the codon is UCG.

**Antigen-** A pathogen or other foreign material is an antigen and will cause the body to manufacture antibodies in response.

**Antigen-** A material to which an antibody will particularly attach is called an antigen.

**Antihemophilic factors-** Factor VIII and kidney plasminogen activator are two examples of the family of whole-blood proteins known as antihemophilic factors that start the blood clotting process.

**Antinutrients-** Antinutrients are substances that compete directly with nutrients or else prevent or interfere with their utilization or absorption.

**Anti-oncogene-** An anti-oncogene is a gene that stops the growth of malignant (cancerous) cells; its absence, caused by mutation, causes cancer (eg retinoblastoma).

**Antisense RNA-** A section of RNA-encoding DNA, often one that includes a protein-specific region, is copied, reversed, and placed next to a transcription-control sequence to make antisense RNA. This cassette can be transported to the target cell, causing genetic modification and the synthesis of RNA complementary to that generated from the original, unreversed, DNA segment. The target gene's expression is inhibited as a result of this complementary, or antisense, RNA's ability to bind to the target RNA's complimentary sequences.

**Antiserum-** Blood serum with particular antibodies against an antigen is called an antiserum. Antisera are employed as analytical and preparative reagents for antigens as well as to give passive immunity to numerous illnesses.

**Archaean (archaea, plural)-** An archaean organism is a prokaryotic one-celled organism (plural: archaea).

**Attenuated Weakened;** in the case of vaccinations, manufactured from harmful organisms that have undergone avirulentization therapy.

**Autoimmune disease-** A disorder known as autoimmunity occurs when the body makes antibodies that attack its own tissues.

**Autoimmunity-** The condition known as autoimmune disease occurs when the body develops an immunological reaction against one of its own tissues or organs.

**Autosome-** Any chromosome that is not a sex chromosome is an autosome.

**Avirulent-** means not able to spread illness.

**B lymphocytes (B-cells) -** A type of lymphocytes known as B lymphocytes (B-cells) are discharged from the bone marrow and create antibodies.

**Bacillus subtilis-** A bacterium called Bacillus subtilis is frequently employed as a host in recombinant DNA research. Because of its capacity to produce proteins, it is significant.

**Bacillus thuringiensis (Bt)-** A naturally occurring microbe called *Bacillus thuringiensis* (Bt) creates a toxin protein that exclusively kills species with alkaline stomachs, such as insect larvae. As this toxin protein has been utilised for years for biological control when it is administered as a component of the entire deceased organism. To develop plants insect-tolerant, the genetic material encoding the toxin protein was located and transferred into the plants.

**Bactericide:** A substance that eliminates bacteria. It is likewise known as biocide or germicide.

**Bacteriophage-** A bacteria-killing virus called a bacteriophage. It's also known as a phage.

**Bacterium (bacteria, plural)-** A prokaryotic, single-celled creature is referred to as a bacterium (bacteria, plural). Bacterium is single-cell creatures having a very basic cell structure. Some species produce their own sustenance solely from inorganic building blocks, while others are parasites on other living things or feed exclusively on decomposing waste.

**Base** One of the four chemical building blocks that, in the sequence they appear, represent the various amino acids on the DNA molecule. Adenine (A), cytosine (C), guanine (G), and thymine are the four bases (T). Uracil (U) takes the place of thymine in RNA.

**Base pair:** A pair of two bases that connect two strands of a nucleic acid molecule. Adenine and thymine (DNA) or uracil (RNA) and guanine and cytosine (RNA) are the only two base pairings that are often used.

**Batch processing-** Growth in a closed system with a fixed quantity of nutritional medium. In bioprocessing, certain amounts of live organisms and nutritional material are added to a bioreactor and then removed after the process is complete. Compare with continuous processing.

**Binary fission-** A kind of asexual reproduction called binary fission produces two identically DNA-matched daughter cells after cell division.

**Bioassay:** The process of determining a compound's potency by seeing how it affects animals, tissues, or organisms. Typically, this is done in comparison to a reference preparation.

**Biocatalyst-** In bioprocessing, a biocatalyst is an enzyme that initiates or accelerates a biochemical reaction.

**Biochemical:** A live organism's response to a chemical interaction.

**Biochip-** A biochip is an electronic device that creates a semiconductor using organic molecules with biological origins or connections.

**Biocide-** A biocide is a substance that can destroy practically any kind of cell.

**Bioconversion-** A biocatalyst is used in bioconversion, which is the chemical reformation of basic materials.

**Biodegradable:** Able to decompose by the activity of microorganisms, often in the environment and under environmental circumstances.

**Biogas:** A gas created when organic matter breaks down anaerobically (without oxygen).

**Bioinformatics-** Bioinformatics is a field that deals with the creation and application of computer tools for the storage, analysis, and interpretation of biological data.

**Biological response modulator:** A chemical that changes how cells grow or work. It includes hormones and substances that have an impact on the immunological and neurological systems.

**Biological oxygen demand (BOD)-** The quantity of oxygen consumed for development by organisms in water containing organic matter while they are breaking down that substance is known as the biological oxygen demand (BOD).

**Biomass-** Total biological matter in a specific region is referred to as biomass. Using cellulose, a renewable resource, to produce compounds that may be used to generate energy or as substitute feedstock's for the chemical industry to lessen reliance on nonrenewable fossil fuels is known as biotechnology.

**Bioprocess-** A bioprocess is a method that uses live cells or parts of them to create the final product that is sought.

**Bioreactor-** A bioprocessing vessel is called a bioreactor.

**Bioremediation-** Utilizing microorganisms to degrade harmful or undesired compounds is known as bioremediation.

**Biosynthesis-** Biosynthesis is the process through which a living thing creates a chemical.

**Biosynthetic** referring to the process through which living things create complex molecules from simpler ones.

**Biotechnology-** Biotechnology is the process of creating things using biological methods. Both entire organisms (like yeast and bacteria) and natural chemicals (like enzymes) derived from living things can be used in production.

**Biotechnology-** The use of organisms, cells, sections of them, and molecular equivalents for various purposes through the combination of natural sciences and technical sciences, notably recombinant DNA technology and genetic engineering, is known as biotechnology.

**Biotic Stress-** Stress caused by living things that might harm plants, such as bacteria, fungus, viruses, and pests. Check out abiotic stress.

**Bovine somatotropin**, commonly known as bovine growth hormone, is a hormone that the pituitary gland of cows secretes. It has been used to boost milk output in dairy cattle by increasing their feed efficiency.

**Budding-** A kind of asexual reproduction called budding occurs when a cell's parent produces an extension. After that, it often pinches off to become a distinct, independent cell.

**Callus-** A callus is a collection of undifferentiated plant cells that, in some species, can be stimulated to develop into the entire plant.

**Calvin Cycle-** The Calvin Cycle is a set of biochemical activities that take place during photosynthesis and produce glucose from carbon dioxide.

**Capsid-**The protein covering a virus is called a capsid.

**Carcinogen-** an agent that causes cancer.

The portion of metabolism that is catabolic and focused on degradation processes.

**Catalyst-**A catalyst is a substance (such as an enzyme or a metallic complex) that speeds up a process but does not alter the substance itself.

**Cell culture** is the growth of a group of cells, often of a single genotype, in a lab setting.

**Cell Cycle-** The phrase "cell cycle" refers to the sequence of meticulously timed events that a cell must go through before it may divide into two daughter cells.

**Cell fusion** *See* Fusion.

**Cell line:** A group of cells that constantly divide and expand outside of a live body.

**Cell** - The smallest unit of life is the cell.

**Cell** - The smallest structural component of living things, the cell has the capacity to develop and procreate on its own.

**Cell-mediated immunity-** Immunity that is acquired and is mediated by cells mostly by T lymphocytes. Early thymus development is essential for the healthy growth and operation of cell-mediated immunity.

**Chemostat Growth chamber** that continuously adds new nutrient media while eliminating used culture to maintain a bacterial or other cell culture at a set volume and rate of growth.

**Chimera** a person made up of cells from several genotypes, such as an animal, plant, or lower multicellular creature. For instance, chimaeras are created by grafting a portion of an embryo from one species onto an embryo from either the same species or a different species.

**Chlorophyll** is a green photosynthetic pigment that is often present in chloroplasts, or organelles.

**Chloroplast** a photosynthetic organelle in eukaryotic cells that contains chlorophyll and can use light energy.

**Chromosome** a lengthy continuous DNA fragment that contains genetic data.

**Chromosomes** subcellular structures that carry an organism's genetic information. Cellular elements that resemble threads and hold DNA and proteins. The chromosomes contain the genes.

**Cilium (cilia, plural) (cilia, plural)** a small, hair-like structure that beats regularly on the surface of some microbes or cells in order to either release trapped substances from the body, such as in the lungs, or to cause a free-living microorganism to move.

**Cistron** a segment of chromosomal DNA that is similar to a gene and serves as the smallest functional unit of heredity.

**Clone-** A set of genes, cells, or organisms that have a common ancestry are said to be clones. The members of the clone are genetically identical to the parent or nearly so since there is no mixing of genetic material (as in sexual reproduction).

**A codon** is a group of three nucleotides that, during the synthesis of proteins, designates an amino acid or sends a signal to halt or resume protein synthesis (translation).

**Coenzyme** an organic substance required for the activity of an enzyme. Coenzymes can be either firmly or loosely linked to the enzyme protein molecule and are smaller than the enzymes themselves.

**Cofactor** a non-protein molecule necessary for the activity of certain enzymes. Coenzymes or metallic ions are examples of cofactors.

**Colony-promoting elements** a class of lymphokines that stimulates the development and proliferation of white blood cells from the bone marrow's progenitor cell types.

**Comparative Genomics**- comparing genome function and structure across species to better understand biological mechanisms and evolutionary processes.

**Complementarity**- The interaction between the nucleotide bases on two different strands of DNA or RNA is known as complementarity. The strands are said to as "complementary" when the bases are appropriately paired, such as guanine and cytosine in DNA and adenine and thymine in RNA.

**Complementary DNA (cDNA)**- Reverse transcription is a method used to create complementary DNA (cDNA) from an expressed messenger RNA. This kind of DNA is utilised for cloning or as a DNA probe in DNA hybridization investigations to identify certain genes.

**Composition Analysis**- Determine the concentration of a component in a plant using composition analysis. Proteins, lipids, carbs, minerals, vitamins, amino acids, fatty acids, and antinutrients are among the substances that are frequently measured.

**Conjugation** is the sexual reproduction of bacteria in which the genetic material of the cells in contact is exchanged in only one direction.

**Continuous processing** is a type of bioprocessing in which fresh materials are continually supplied and waste products are continuously removed at a rate that keeps the volume of the mixture at a predetermined level and typically preserves the combination's composition as well. See also chemostat and batch processing.

**Conventional breeding** is the process of breeding plants by carefully transferring pollen from one plant to another, then selecting offspring through several generations for a desired phenotype. In order to create more variety in the donor material, this procedure has also frequently involved irradiating or genetically modifying plants or seeds.

**Coumarins** are crystalline esters with a white vanilla aroma that are employed as an anticoagulant, a flavouring, and in perfumes. Compound:  $C_9H_6O_2$ .

**Crossing over**- stepping over between two paired chromosomes, a gene exchange.

**Culture cultivation** of live organisms in a prepared environment; verb: to grow in a prepared environment.

**Culture medium**- Any nutrition system used to grow bacteria or other organisms artificially; often consists of a complicated blend of organic and inorganic components.

**Cyt** a designation for a cell or cell plasm.

**Cytogenetics** study of the cell and its components connected to heredity, particularly the study of chromosomes in their "condensed" form, which they experience when not reproducing.

**Cytokines-** Intercellular signals called cytokines, which are often proteins or glycoproteins, are in charge of controlling cellular growth and function.

**Cytoplasm** Cellular components that surround the nucleus and are found inside the cell membrane.

**Cytotoxic** may lead to cell death A cytotoxic chemical often has a more nuanced effect than a biocide.

**Decomposer** is the term used to describe certain fungus and soil bacteria that convert waste from dead plants and animals into simpler compounds known as nutrients.

**Defensin** a protein from cow that is naturally protective. It could work against shipping fever, a virus that affects cattle when they are being transported and costs an estimated \$250 million year in damages.

**DNA** is the molecule that houses the genetic material for the majority of living systems. Adenine, Cytosine, Guanine, and Thymine are the four bases that make up the DNA molecule. These bases are organised in two interconnected strands to create a double helix.

**Diagnostic** a tool for diagnosing an illness or other medical issue. DNA probes and monoclonal antibodies are both beneficial diagnostic tools.

**Diet** An individual's or an animal's usual intake of a certain amount of food or feed.

**Differentiation** the biochemical and structural processes that take place as an organism grows, causing cells to specialise in their shape and function.

**Diploid** a cell that possesses two full sets of chromosomes.

**DNA** Deoxyribonucleic acid: the genetic data repository found within most viruses and living cells.

**DNA test** a molecule that has been marked with a radioactive isotope, dye, or enzyme and is used to identify a specific nucleotide sequence or gene on a DNA or RNA molecule. This molecule is often a nucleic acid.

**DNA** Check out deoxyribonucleic acid.

The order of base pairs in a DNA molecule can be determined using DNA sequencing technologies.

**Dose-Response Assessment-** establishing a connection between the amount of exposure (dose) to a chemical, biological, or physical agent and the seriousness and/or frequency of the unfavourable health consequences that are a result (response).

**Double helix** a phrase frequently used to describe how the DNA molecule is set up. Two helix strands of nucleotides—a sugar, phosphate, and base—that are connected across by a certain pairing of the bases make up the helix.



## **Downstream processing**

Delivery of drugs the method used to give a patient a medication that has been created. Oral administration or intravenous perfusion has been the conventional approaches. The development of new techniques includes administering a transdermal patch through the skin or an aerosol spray with a unique formulation over the nasal membrane.

**Electrophoresis**- In a gel (or liquid), ion-conducting media, various types of molecules may be separated using the electrophoresis technique based on how differently they travel in an electrical field.

**Endonuclease** an enzyme that fragments nucleic acids into different lengths by breaking them at specified internal bonding points. Observe exonuclease.

**Enterotoxins** Toxins that harm the intestinal mucosal cells.

**Enzyme** a protein catalyst that speeds up particular chemical or metabolic processes required for cell division and development. vs. catalyst

**Enzyme** a protein that promotes biological reactions by accelerating their cellular occurrence.

**Epitope** a location on a macromolecule's surface where an antibody can attach itself. A protein epitope could only include a few amino acid residues, while a polysaccharide epitope might only have a few sugar residues. "Immunological determinant" is a synonym.

**Erythropoietin (EPO)**, also known as erythropoietin, is a protein that increases the formation of red blood cells. Clinically, it helps in the treatment of some anaemias.

**Escherichia coli (E. coli)** is a bacteria that most vertebrates have in their digestive tracts. This organism has been the subject of a significant amount of research utilising recombinant DNA methods because its genetic makeup has been so well described.

**Eukaryote**- A cell or creature that has a real nucleus and a distinct membrane enclosing it. All living things are eukaryotic, with the exception of bacteria, archebacteria, viruses, and blue-green algae.

**Eukaryote**- An creature with a genuine membrane-bound nucleus and membrane-bound organelles is referred to as a eukaryote.

**Event**- the name given to a plant and its descendants that have a particular DNA insertion. Such events will be distinguished from other events by the particular location where the added DNA is integrated.

**Exon**- The region of a gene that codes for a protein and is translated into messenger RNA (in eukaryotic cells).

**Exposure Assessment** -the evaluation, either qualitatively or quantitatively, of potential exposure to biological, chemical, and physical substances coming from various sources.

**Expressed sequence tags (ESTs)** - tags for expressed sequences (ESTs) A distinct DNA sequence produced from a cDNA library is called an expressed sequence tag (EST) (therefore from a sequence which has been transcribed in some tissue or at some stage of development). By using a variety of genetic mapping techniques, it is possible to map an EST to a specific gene locus in the genome, identifying that gene locus.

**Expression-** manifestation of a trait that is determined by a gene in genetics. For instance, a person might possess the gene for a genetic disease without really having the illness. The gene is present but not expressed in this instance. The phrase is frequently used to refer to the creation of a protein by a gene that has been introduced into a new host organism in molecular biology and industrial biotechnology.

**Extremophile-** a bacterium that lives in conditions where other creatures would perish.

**Factor VIII-** is a large, intricate protein used to treat haemophilia and to help blood clot.

**Feedstock-** is the term for the primary component in chemical or biological reactions.

**Fermentation-** The anaerobic process of fermentation involves the growth of microbes to produce a range of chemical or medicinal substances. In enormous tanks known as fermentors, microbes are often cultured under precise circumstances in the presence of nutrients.

**Fermentation** the process through which bacteria break down complex chemical components like carbohydrates into simpler ones, often under anaerobic circumstances (with no oxygen present). This produces energy.

**Flagellum (flagella, plural) (flagella, plural)** a long, thin appendage that some organisms, including bacteria and protoctists, have on their surfaces and that gives them the ability to move.

**Food poisoning-** Foodborne illness any disease brought on by consuming food tainted with harmful bacteria.

**Food spoilage-** changes in the food's flavour, aroma, and other properties as a result of microbial proliferation, which leads to decomposition and spoilage.

**Frameshift-** erroneous triplets of bases are read as codons due to the insertion or deletion of one or more nucleotide bases.

**Fructan** is a specific fructose polymer that is found in several fruits.

**Functional foods** are described as "any food or food component that may deliver a health benefit beyond the typical nutrients it provides" by the Institute of Medicine's Food and Nutrition Board.

**Functional Genomics** -Genes and Functions the creation and use of technologies to describe the mechanisms by which genes and the things they produce work and interact with one another and the environment.

**Fungus (fungi, plural)-** A eukaryotic, non-photosynthetic, spore-forming organism is a fungus (fungi, plural). They include both simple single-celled creatures and more sophisticated multicellular ones.

**Fusion** joining of two cells' membranes, resulting in the formation of a new, fused cell that has at least part of the nuclear components of both of its parent cells. used to create hybrid ovaries.

**Fusion protein-** a protein that has a polypeptide chain made of two or more different proteins. A gene created using recombinant DNA techniques from the parts of genes encoding two or more proteins is used to produce a fusion protein.

**Gas chromatography** is an analytical technique that separates substances based on how differently they pass through a (coated) capillary as an inert gas stream at a high temperature. This method is appropriate for the analysis of volatile substances or substances that are stable at higher temperatures but can become volatile through derivatization processes.

**Gel electrophoresis** is an analytical technique that uses an electric field to separate big macromolecules (such as proteins and DNA) via a gel. Charge and molecule size, for instance, may affect separation. Separate bands at various locations on the gel may be seen to represent separated biomolecules.

**Gene** a chromosomal tract that contains the regulatory and sequence data required to control the production of a protein or RNA product. See also Operator; Regulatory, structural, and suppressor mechanisms.

**Gene** situated on a chromosome, the fundamental unit of heredity. A gene is a segment of DNA that houses the instructions necessary to produce a particular protein.

**Expression of Genes** the process by which a gene gets turned on at a certain time and location to create a functional offspring.

**The Gene Machine** A computer-controlled solid-state chemistry device for progressively mixing chemically activated precursors of deoxyribonucleotides (bases) to create oligodeoxyribonucleotides in the right order.

**Gene mapping-** Finding the relative positions of genes on a chromosome is known as gene mapping.

**Gene pool:** The total amount of genetic material present in a population.

**Gene sequencing-** Finding the bases in a DNA strand's nucleotide sequence is known as gene sequencing.

**Gene silencing** is a technique that typically entails the expression in a cell of an mRNA with a nucleotide sequence that is complementary to or identical to the protein that is being silenced.

**Gene therapy-** replacement of a damaged gene in an organism is known as gene therapy. The working gene is isolated and then inserted into cells using recombinant DNA techniques. In humans, more than 300 single gene genetic diseases have been discovered. The majority of these are amenable to gene therapy.

**Gene Transfer-** When referring to the transfer of a gene to an organism using biotechnology instruments, the term "gene transfer" is used.

**Generation time-** The amount of time it takes for a population of microbes to double in size.

**Genetic code:** The method by which living things preserve their genetic information. The code creates the amino acids that make up proteins using sets of three nucleotide bases known as codons.

**Genetic engineering** is a technique that modifies the genetic code of live cells to enable the production of new molecules.

A **genetic map** is a diagram that displays the locations of genetic markers along a chromosome's length in relation to one another or in terms of their absolute distances from one another (physical map).

**Genetic screening** - the application of a particular biological test to check for inherited illnesses or other disorders. Testing can be done post-natally to identify carriers of inherited diseases as well as during pregnancy to look for metabolic and congenital problems in the developing foetus.

**Genome** a cell's full genetic makeup, which consists of every chromosome present in each nucleus of a specific species.

**Genomics** is the branch of science that examines the genomes, or the full genetic code, of living things. This frequently involves analysing DNA sequence information and identifying genes.

**Genotype** genetic composition of a person or group. Compare phenotype.

**Germ cell** sexually active cell (sperm or egg). also known as a sex cell or a gamete.

**Germicide** Look up bactericide.

**Germplasm**- the complete genetic diversity present in a group of organisms, as exemplified by the germ cells or seeds.

**Global warming**- a rise in atmospheric temperature brought on by an increase in greenhouse gas emissions, which trap more heat in the atmosphere and warm the planet.

**Glycoalkaloid** - toxic glycoalkaloids Solanaceae plants contain steroid-like substances, most notably "solanine," which is found in potato tubers.

**Golden Rice**- Scientists from Germany and Switzerland revealed the creation of a genetically modified rice crop in 1999. This crop produces beta-carotene, which the body uses to synthesise vitamin A. This more nutrient-dense rice was created to help those with vitamin A deficiency.

**Photosynthesis** is a mechanism used by green plants, algae, and some bacteria known as cyanobacteria to make their own sustenance. They can be discovered at the top of the food chain.

**Growth hormone** is a protein that the pituitary gland makes and is involved in cell growth (also known as somatotropin). Clinically, human growth hormone is used to treat dwarfism. Animal growth hormones can be used to increase milk production and produce leaner meat varieties.

**Haploid** a cell with one chromosomal set, or half the normal number of chromosomes. The sex cells are haploid. Compare Diploid.

**Hapten**- Small molecule known as a hapten that, when chemically bound to a protein, functions as an immunogen and induces the production of antibodies both against the two-molecule complex and the hapten itself.

**Hemagglutination-** clumping (agglutination) of red blood cells, caused, for instance, by virus particles or antibody molecules.

**Hereditary-** Capable of transmitting genetic data from parent cells to offspring.

**Heterozygote-** A heterozygote possesses a distinct allelic form of the gene on each of the two homologous chromosomes with regard to a particular gene at a designated chromosomal location.

**The histocompatibility protein** an antigen that renders grafted tissue from animals with genotypes differing from the host animal's inedible.

**Histocompatibility** tissue grafting is possible due to the immunologic similarity of the tissues, which prevents tissue rejection.

**Homologous** corresponding to or similar in origin, place, or structure.

**Homozygote** A homozygote is a person who carries the same allelic type of a gene on both of two homologous chromosomes at a specific chromosomal site.

**Hormone** A substance that communicates instructions to activate or stop specific physiological processes by acting as a messenger or stimulatory signal. One type of cell produces the hormones, which are subsequently released to control the activity of other cell types.

**Host** a cell or organism that is used to produce cloned molecules, grow viruses, plasmids, or other types of foreign DNA.

**Host-vector system-** When introducing foreign DNA into a cell, the host-vector system combines DNA-receiving cells (the host) with a DNA-transporting material (the vector).

**Humoral immunity-** Immunity brought on by circulating antibodies in plasma protein is known as humoral immunity.

**Hybrid:** Children of two parents that have at least one genetic difference (trait). A DNA-RNA or heteroduplex molecule is also possible.

**Hybridization-** creation of children, or hybrids, from parents with different genetic backgrounds. By breeding two different types together, the procedure can be utilised to create hybrid plants or hybridomas (hybrid cells formed by fusing two unlike cells, used in producing monoclonal antibodies). Additionally, the joining of complementary DNA or RNA strands is referred to by this phrase.

**Hybridoma-** A hybridoma is a cell that results from the fusion of two unrelated cells. Hybridomas are created by uniting an immortal cell (a cell that divides indefinitely) with an antibody-producing cell in monoclonal antibody technology. See also Myeloma; monoclonal antibody.

**Hypha,** often known as hyphae, is the fundamental component of filamentous fungi.

**Immune serum-** Antibody-containing blood serum is known as immune serum.

**Immune system-** The collection of cells, biological substances (such antibodies), and cellular processes known as the immune system function as a unit to give resistance to disease.

**Immunity:** The inability to contract a disease or be toxic by antigenic substances. Additional terms to consider are Active, Cell-mediated, Humoral, Natural Active, Natural Passive, and Passive.

**Immunoassay:** A method of drug identification based on the use of antibodies.

**Immunodiagnostics** the measurement of a material using particular antibodies. This device can be used to detect the presence of foreign substances and infectious diseases in a variety of human and animal fluids (blood, urine, etc.) It is being researched as a means to find tumour cells inside the body.

**Immunofluorescence-** Uses fluorescently-labeled antibodies as a method of identifying antigenic material. Applying UV light rays and observing the visible light that results from that process allows one to see the specific binding of the antibody and antigen under a microscope.

**Immunogen-** anything that can cause an immunological reaction, particularly the creation of certain antibodies. An antigen is an immunogen that interacts with the evoked antibody.

**Immunoglobulin-** a collective term for proteins that serve as antibodies. These proteins are divided into five categories as a result of their structure-related differences: IgG is made up of immunoglobulins M, A, D, and E.

**Immunology-** the examination of all phenomena connected to the body's reaction to an antigenic challenge (i.e., immunity, sensitivity, and allergy).

**Immuno modulators** - a broad category of proteins that strengthen the immune system. There are numerous cell growth factors that quicken the development of particular cells necessary for establishing an immune response in the body. These proteins are being researched for potential applications in cancer treatments.

**Immunotoxins-** monoclonal antibodies with a protein toxin molecule that are specific. A tumour cell is the target of the monoclonal antibody, and the toxin is intended to destroy that cell when the antibody binds to it. The term "magic bullets" has also been applied to immunotoxins.

**In vitro-** performed in a test tube or another piece of lab equipment.

**In vivo-** within a live thing.

**Inbred Progeny-** Produced via inbreeding are Inbred Progeny.

**Inducer** a chemical or molecule that accelerates the production of enzymes, typically by inhibiting the activity of the appropriate repressor.

**Inflammation** a tissue's response to irritability, harm, or infection. It is a helpful procedure because it eliminates or confines the pathogen in a restricted space, allowing the healing process to start.

**Inserted DNA** is a section of DNA that has been inserted using recombinant DNA techniques into a chromosome, plasmid, or other vector.



**Interferon-** Important lymphokine proteins from the interferon A class for the immune response. Interferon comes in three main varieties: alpha (leukocyte), beta (fibroblast), and gamma (immune). Inhibiting viral infections and perhaps being anti-cancer, interferons.

**Interleukin-** is a class of lymphokine whose function in the immune system is the subject of in-depth research. Interleukin has been classified into two categories. When there is inflammation, the macrophage-derived interleukin 1 (IL-1) is produced, which increases the production of other lymphokines, including interleukin 2. (IL-2). T lymphocyte maturation and cell division are controlled by IL-2.

**Backcrossing** between two plant populations results in introgressed hybrids, which introduce new genes into a wild population.

**Intron-** In eukaryotic cells, an intron is a segment of DNA that is part of a gene but does not encode a protein. The presence of introns separates the gene's coding sequence into chunks known as exons. Also see Exon and Splicing.

**Inulins-** A fructose polymer called inulin is found in several plants' tubers and rhizomes.  $(C_6H_{10}O_5)_n$  is the formula.

**Invertase activity** is an enzyme that hydrolyzes sucrose into glucose and fructose and is found in yeast and animal intestinal fluid.

**Isoenzyme (isozyme)-** A particular enzyme can exist in a number of different forms, including isoenzyme (isozyme). Although the forms' physical characteristics may vary, they both serve as biocatalysts.

**Isoflavones** Are water-soluble compounds, also known as phytoestrogens, that are present in many plants. They get their name from the fact that they have effects on mammals that resemble those of oestrogen. Genistein and daizen, two of the most well studied natural isoflavones, are present in soy products and the herb red clover.

**Isogenic** identical in genotype.

**plasminogen activator of the kidney-** a substance that is a precursor to the blood-clotting enzyme urokinase.

**Knock-out-** a method for defining a gene's function by inactivating a specific gene, mainly in mouse genetics.

**Lectins-** Proteins that agglutinate are typically taken from plants.

**Leukocyte-** A vital part of the body's immune system, a white blood cell is a colourless cell found in the blood, lymph, and tissues.

**Library-** DNA fragments that have been cloned. a group of genomes or complementary DNA sequences from a certain organism that have been cloned in a vector and developed in the right host (e.g., bacteria, yeast).

An enzyme called a **ligase** is used to connect DNA or RNA fragments. They are known correspondingly as DNA ligase and RNA ligase.

**Linkage group-** A chromosome is a collection of recognised gene loci. As many homologous chromosomal pairs as there are, there are linkage groups.

**Linkage map-** a chromosomal locus abstract map based on recombinant frequencies.

**Linkage:** When two genes are physically close to one another on a chromosome, they are more likely to be inherited together.

**Linker-** a piece of restriction-site-containing DNA that can be utilised to link DNA strands.

**Lipoproteins** are a group of serum proteins that move cholesterol and fats through the bloodstream.

**Liquid chromatography,** which separates materials depending on how differently they travel through a liquid stream. For instance, in column chromatography, the dissolved substances may bind to a column of solid material with different affinities differentially from the liquid and then be released, being carried from the column into the liquid at various speeds by the liquid through the column liquid, providing a basis for separation.

**Locus(Plural loci)-** location of a gene, DNA marker, or genetic marker on a chromosome is referred to as a locus (plural loci).

**Lymphatic system-** the body, a network of tiny tubes known as the lymphatic system connects lymph nodes to transfer lymph fluid.

**Lymphocyte-** The blood, lymph nodes, and organs all include lymphatic tissue, which is a form of leukocyte. In the bone marrow, lymphocytes are continuously produced and develop into cells that produce antibodies. B and T lymphocytes are also mentioned.

**Lymphokines** are a group of soluble proteins made by white blood cells that are thought to play a part in the immune response but whose exact function is still unclear.

**Lymphoma-** Cancer that affects the lymphatic system is called lymphoma.

**Lysis-** are broken apart during lysis.

**Lysis-** A cell physically rupturing is known as lysis.

**Lysozyme-** an enzyme that breaks down certain bacteria's cells and is found in things like tears, saliva, egg whites, and various plant tissues.

**Macronutrient-** any element necessary in significant quantities for normal growth and development, such as carbon, hydrogen, or oxygen.

**Macrophage-** An assortment of white blood cells that are formed in blood vessels and loose connective tissues and are capable of ingesting dead cells and tissue. They also contribute to the production of interleukin 1. Macrophages also eliminate tumour cells when exposed to the lymphokine "macrophage-activating factor."

**Macrophage-activating factor-** a substance that encourages macrophages to go for and consume cancer cells.

**Marker:** A chromosome or chromosomal segment is followed by any genetic element (locus, allele, DNA sequence, or chromosomal characteristic) that can be easily recognised by phenotypic, cytological, or molecular methods during genetic analysis.

**Mass Spectrometry-** Analysis method known as mass spectrometry uses the mass-dependent behavior of ionized compounds or their fragments in response to the application of a

magnetic or electric field in a vacuum to ionise, eventually fragment, accelerate, and detect substances in a compartment.

**Medium-** a substance that is either liquid or solid (gel) and contains the nutrients necessary for cell growth.

**Meiosis** is a form of cell division in which the daughter cells have half as many chromosomes as the parent cells. Meiosis produces sex cells.

**Memory cells** are cells that are created as a regular element of the immune system. These cells retain memory of a particular antigen and are in charge of the prompt immune response, or antibody production, in response to recurrent infections caused by that specific antigen.

**Messenger RNA (mRNA)-** A ribosome receives instructions from messenger RNA (mRNA), a kind of nucleic acid, for the synthesis of a certain protein.

**Metabolism-** All biochemical processes that an organism uses to stay alive are referred to as metabolism.

**Metabolite-** A material produced by or involved in metabolism is referred to as a metabolite.

**Metabolomics:** "Open-ended" analytical methods that produce profiles of the chemical compounds in a biological sample known as metabolites. Commonly, variations between profiles of several (groups of) samples are identified, and the corresponding metabolites' identities are clarified. These methods are indiscriminate, as opposed to targeted analysis, in that they don't necessitate knowledge of every substance that is present.

**Methanogen** Micro-organism that creates Metabolomics. Microorganism that creates methane is recognized as a **Methanogen**.

**Microarrays** allow for the parallel study of intricate biochemical samples. They are microscopic, organised arrays of nucleic acids, proteins, small compounds, organisms, or other objects. Microarrays come in a wide variety of biological and manufacturing system configurations. All oligonucleotide-based array types are collectively referred to as "oligonucleotide arrays" or "oligonucleotide-based arrays," respectively. The two most popular ones are genomic and cDNA arrays. cDNA array: A microarray that can be probed with total messenger RNA from a cell or tissue to detect changes in gene expression in comparison to a control sample. It is made up of a grid of nucleic acid molecules with known composition that are connected to a solid substrate.

**Microorganisms** that are hazardous to particular plants or insects make up microbial pesticides and herbicides. These microorganisms may be superior to their chemical equivalents for some pest control applications due to their low toxicity and restricted host range.

**Microbiology** is the study of viruses and living things that can only be seen under a microscope.

**Micronutrients** are substances that are necessary for proper growth and development but only in trace levels, such as vitamins or trace elements.

**Micro-organism (microbe)-** A tiny living entity is referred to as a microorganism. Bacteria, archaea, protozoa, algae, fungi, and viruses are included in this group.

**Microorganism-** Any organism that can only be observed under a microscope is referred to as a microorganism. also known as a microorganism.

**Mitochondria-**The cellular organelles known as mitochondria are found in eukaryotic species and allow for aerobic respiration, which produces the energy needed to power cellular operations. There are only a few genes and a modest amount of DNA in each mitochondrion (approximately 50).

**Mitosis** is a form of cell division in which the daughter cells have the same number of chromosomes as the parent cells.

**Molecular Biology-** Biology at the molecular level is the subject of molecular biology.

**Molecular genetics** is the study of how genes work to regulate biological processes.

**Monoclonal antibody:** An extremely focused, purified antibody that only identifies one antigen and is generated from one clone of cells.

**Mould-** A filamentous fungus with many cells.

**mRNA-** Messenger RNA.

**Hereditary traits** can be multigenic if they are determined by many genes.

**Mutagen-** A chemical that causes mutations is a mutagen.

**Mutant:** A cell that exhibits novel traits as a result of a DNA alteration.

**Mutation:** An undetected error during DNA replication that results in a structural alteration in the DNA sequence.

**Mutation-** Breeding genetic changes brought on by natural occurrences or the application of mutagens. Genes with stable mutations are handed down to progeny; those with unstable mutations are not.

**Muton-** The smallest component of a chromosome, referred known as a "muton," can change, leading to a mutation or a mutant organism.

**Mycelium-** a fungal hyphal network with branches.

**Myeloma-** a specific kind of tumour cell that can produce hybridomas when treated with monoclonal antibodies.

**Nanoscience-** the examination of events and the handling of substances at the atomic, molecular, and macromolecular scales, where characteristics are very different from those at a larger scale.

**Nanotechnology-** the creation and use of structures, devices, and systems by precise control of size and shape at the nanometer scale.

**Natural active immunity-** immunity that develops with the onset of a disease.

**NK (natural killer) cells-** a leukocyte kind that targets virus- or cancer-infected cells without first coming into contact with the antigen. Interferon is known to enhance NK cell activation.

**Natural passive immunity-** immunity given to the foetus or infant by the mother.

**Nitrogen fixation-** The biological process of nitrogen fixation, which is typically linked to plants, involves some bacteria converting atmospheric nitrogen to ammonia, which then creates a nutrient necessary for growth.

**Normal body flora-** Microbes that have adapted to living on the body are typically present and hardly ever cause illness in people with normal body flora.

**Nuclease** is an enzyme that disassembles nucleic acids into their individual nucleotides by cleaving chemical bonds. also see exonuclease

**Nucleic acid-** Large molecules consisting of nucleotide bases known as nucleic acid are typically present in the cytoplasm and/or nucleus of cells. Nucleic acids come in two varieties: DNA and RNA.

**Nucleotides-**The components of nucleic acids are called nucleotides. Sugar, phosphate, and one of four nitrogen bases make up each nucleotide.

**Nucleus-** In eukaryotic cells, the nucleus is the primary organelle that houses the majority of the chromosomes. Other organelles, most notably the mitochondria and chloroplasts, contain trace amounts of DNA from the chromosomal material.

**Nutraceuticals** are described as "any substance that may be considered a food or part of a food that delivers medicinal or health advantages, including the prevention and treatment of disease" and were first used by the Foundation for Innovation in Medicine in 1991.

**Nutritionally Improved:** Increasing the amount, ratio, and/or bioavailability of key macro- and micronutrients as well as other substances for which there is strong clinical and epidemiological evidence that they are limiting in diets and play a vital role in maintaining optimal health.

**Oncogene-** Any member of a family of cellular DNA sequences known as an oncogene has the capacity to change into a malignant form. The four categories of viral and non-viral oncogenes are nuclear proteins, protein kinases, GTPases, and growth factors.

**Oncogenic**—causes cancer

**Oncology-**Tumor study is known as oncology.

**An open reading frame** is a nucleotide sequence that starts with the start codon (AUG), continues in register with the codons that code for amino acids, and then ends with the stop codon.

**Operator-** A repressor protein binds to the operator region of the chromosome, which is close to the sequences encoding the gene product, to stop transcription.

**Operon:** A group of genes that produce the enzymes required for the production of a chemical. An operator gene and a repressor gene regulate an operon.

**Opsonin-** Antibody called opsonin makes bacteria and other antigenic material vulnerable to phagocyte eradication.

**Organelle:** A membrane-enclosed cell structure with a specific purpose.

**Organic compound-** An organic compound is one that contains carbon.

**Organolectic:** Capable of detecting sensory stimuli like flavour.

**Passive immunity-** Immunity obtained from obtaining premade antibodies is known as passive immunity.

**Pathogen-**An organism that causes disease is a pathogen.

**Pathogen:** An organism that causes disease.

**Peptide:** A group of two or more amino acids connected by a peptide bond.

**Phagocyte-**A white blood cell known as a phagocyte is capable of engulfing and destroying viruses, bacteria, and other invaders through the process of phagocytosis.

**Phenotype-** Observable traits that are the outcome of the interplay between an organism's genetic makeup and its environment are called phenotypes.

**Photosynthesis** is a process used by plants, algae, and a kind of bacterium called cyanobacteria to fix carbon dioxide into organic compounds by capturing solar energy.

**Photosynthesis** is the process through which plants transform light energy into chemical energy, which is then utilised to sustain the biological functions of the plants.

**Phytate (Phytic Acid)-** In addition to lowering the bioavailability of phosphorous itself, phytate (phytic acid), a phosphorus-containing molecule found in the outer husks of cereal grains, interacts with minerals and prevents their absorption.

**Phytochemicals-** Small molecules only found in plants and plant products are known as phytochemicals.

**Plasma:** The fluid portion of blood (noncellular).

**Plasmapheresis** is a method for removing beneficial components from blood.

**Plasmid-** DNA molecules with a circular structure that are found in yeast and bacteria. Every time a bacteria splits, plasmids replicate independently and are passed on to the daughter cells. Plasmid vectors are frequently used to clone DNA fragments.

**Polyclonal-** derived from many cell types.

**Polymer-** a lengthy molecule with repeating parts.

**Polymerase chain reaction (PCR)**

**Polymerase-** a collective noun for the enzymes responsible for synthesising nucleic acids.

**Polypeptide-** a lengthy amino acid chain connected by peptide bonds.

**Post-transcriptional Modification-** After being created by the translation of messenger RNA, protein molecules go through a sequence of processes in a cell before being biochemically altered. Before a protein is created in its final functional form, it may go through a complicated series of changes in several cellular compartments.

**Primary producer-**Plants and services are the primary producers. (Adapted from: Joint IUFOST/IUNS Committee on Food, Nutrition, and Biotechnology, 1989; European Federation of Biotechnology).

**Profiling** is the process of creating random patterns of the compounds present in a sample using analytical methods including functional genomics, proteomics, and metabolomics. It is not necessary to know the names of the chemicals that the pattern can identify.

**Prokaryote:** An organism with a straightforward cell structure devoid of organelles or a membrane-bound nucleus.

**Promoter:** A DNA segment that regulates gene expression and is situated close to or even entirely within nucleotide sequences that code for proteins. Promoters are necessary for RNA polymerase to bind and begin transcription.

**Protease K** is an enzyme that effectively breaks down proteins.

**Protein A** is an antibody-specific protein produced by the bacteria *Staphylococcus aureus*. In the purification of monoclonal antibodies, it is helpful.

folded long-chain amino acid molecule known as a **Protein A**. Every protein serves a unique purpose. The structure, operation, and regulation of an organism's cell or cells, tissues, and organs depend on proteins.

**Proteins** – The genome of an organism encodes proteins, which are biological effector molecules. One or more polypeptide chains of amino acid subunits make up a protein.

**Proteomics** the creation and implementation of methods for examining the interactions between the protein byproducts of the genome to ascertain the biological activities.

**Protoplast** the cellular substance that is still present after the cell wall has been eliminated. a plant cell that has undergone mechanical or enzymatic cell wall removal. The main tissues of the majority of plant organs and plant cells grown in culture can both be used to create protoplasts.

**Protozoan (protozoa, plural) (protozoa, plural)**- a single-celled, eukaryotic creature that rarely has chlorophyll.

**Pseudopodium (pseudopodium, plural) (pseudopodium, plural)** a momentary expansion of an amoeboid cell's cytoplasm. Both feeding and motility make use of it.

**Pure culture**- only one species of bacterium can develop in vitro.

**Recombinant DNA (rDNA)** is DNA that has been created by joining DNA segments from two or more different genomic regions or sources.

**Recombinant DNA** is DNA created by fusing DNA from many types of organisms. any DNA molecule created by connecting DNA strands from several origins (not necessarily different organisms). Additionally, this might be a DNA strand that was synthesised in the lab by joining particular DNA segments from other organic species or by supplementing an already existing DNA strand with a particular segment.

**Recombinant DNA technology**, in particular the use of restriction enzymes that cleave DNA at specified locations, allows for the manipulation of DNA molecule sections that may then be put into plasmids or other vectors and cloned in the proper host organism (e. g. a bacterial or yeast cell).

**Recycling** is a continuous process that releases vital substances into the environment so they can later be utilised.

**Regeneration** is a laboratory process for creating a new plant from a collection of existing ones.

A **regulatory gene** is one that regulates the activity of other genes involved in protein synthesis.

**Regulatory Sequence-** A DNA region to which particular proteins bind to activate or repress the expression of a gene is known as a regulatory sequence.

**Regulon** a protein that has an impact on growth, such as a heat-shock protein.

**Replication** is the act of making an exact duplicate of anything, such as a DNA strand.

**Replicon:** A section of DNA (such as a chromosome or plasmid) that has the ability to replicate on its own

**Repressor:** A protein that attaches to an operator next to a structural gene and prevents the gene's transcription.

**Reproductive Cloning:** Cellular level procedures used to create organisms with identical genomes to those of already existing organisms.

**Restriction enzyme-** enzyme known as a restriction enzyme recognises a certain DNA nucleotide sequence, typically one that is symmetrical, and cuts the DNA inside or close to the identified sequence.

**Retrovirus:** An animal virus that produces further viral particles by combining with the DNA of the host cell through the action of the enzyme reverse transcriptase, which transforms viral RNA into DNA.

**RIA (Radioimmunoassay)-** A diagnostic procedure called RIA (Radioimmunoassay) uses antibodies to find small quantities of chemicals. These tests are helpful for studying how medications interact with receptors in biomedical research.

**Ribonucleic acid (RNA)-** Similar to DNA, ribonucleic acid (RNA) is a molecule that primarily serves to interpret the instructions for protein synthesis carried by genes. See also transfer RNA and messenger RNA.

**Ribosome:** A cellular component that is involved in protein synthesis and contains both protein and RNA

**Ribozyme-** Any RNA molecule with catalytic activity that serves as a biological catalyst is known as a ribozyme. Based on risk identification, risk characterization, and exposure assessment, one may determine the consequences on a specific population.

**RNA (Ribonucleic Acid)**

**Scale-up** the changeover from small-scale to large-scale industrial manufacturing.

**Secondary Metabolites-** Additional Metabolites Chemical compounds that are present in a biological organism but are not required for the basic cellular processes. The primary



metabolites of photosynthesis, respiration, etc. are modified to produce secondary metabolites.

**Selective medium-** discerning medium nutrient substance designed to promote the growth of some organisms while restraining the growth of others.

**Sequence Homology-** the quantifiable resemblance of two nucleotide or amino acid sequences, or their degree of identity or similarity.

**Serology** study of the interactions between the antibodies and antigens in blood serum.

**Single-cell protein-** large-scale cultivation of microorganisms' cells or protein extracts for use as protein supplements. An ideal amino acid balance for feeding is anticipated in single cell protein.

**Somatic cells-** somatotype cells additional cells outside sex or germ cells.

**Analysis/Hybridization of the South (Southern Blotting)**

**Splicing-** the process of removing introns and combining exons in RNA to create a continuous coding sequence.

**Sporangium (sporagia plural) (sporagia plural)** a spore-carrying sac that grows from a fungus's fruiting body.

**Spore** - organism's latent stage is known as a spore in general. Spores allow for reproduction, dissemination, and survival in challenging circumstances. There are numerous varieties that can be created sexually or asexually.

**Stem Cell-** a cell that, depending on the environmental cues it receives, has the capacity to differentiate into a range of distinct cell types.

**Stilbenes** - Trans-1,2-diphenylethene is a stilbene, a colourless or slightly yellow crystalline unsaturated hydrocarbon used in the production of colours.  $C_6H_5CH:CHC_6H_5$  is the formula.

**Strain A-** Pure-breeding lineage, typically of bacteria, viruses, or haploid creatures, is known as strain A.

**Stringent response-** Prokaryotes have a translational control mechanism called the stringent response that inhibits the production of tRNA and rRNA when the cells are starved of amino acids.

**Structural gene-** Gene called a structural gene codes for a protein, such as an enzyme in plants. The safety evaluation conducted in this method does not suggest the new product is absolutely safe; rather, it concentrates on evaluating the safety of any variations that have been detected so that the new product's safety may be compared to that of its conventional counterpart.

**Suppressor gene-** A gene known as a suppressor gene can counteract the effects of a mutation in another gene.

**Synteny-** All the loci on a single chromosome are said to be syntenic, or syntenic (literally on the same ribbon).

**Syntenic test:** A test that examines concordance (the co-occurrence of markers) in hybrid cell lines to determine whether two loci are syntenic (belong to the same linkage group).

**Tannins** are a group of yellowish or brownish solid chemicals that are present in many plants and are employed as astringents, mordants, and tanning agents. Tannins are derived from gallic acid, which has the chemical formula about  $C_{76}H_{52}O_{46}$ .

Following the fermentation or bioconversion stage, the product goes through several processing steps, including separation, purification, and packaging.

**Ti Plasmid:** A plasmid that contains the gene or genes that cause plant tumour formation when they are transferred from *A. tumefaciens* to plant cells.

**Tissue culture** is the in vitro development of tissue-isolated cells in nutritional medium.

**Tissue plasminogen activator (tPA)-** Blood clots can be broken up by a protein called tissue plasminogen activator (tPA), which is produced in the body in minute levels.

**A toxin** is a toxic substance that some microbes create.

**Toxin-** Any chemical that is poisonous to other living things is a toxin.

**Transcription-** A gene's expression to produce a complementary messenger RNA molecule is called transcription. creation of any type of RNA using a DNA template, including messenger RNA.

**Transcriptome-** The total amount of messenger RNA expressed in a cell or tissue at any one time is known as the transcriptome.

**Transduction** is the process by which genetic material is transferred from one cell to another using a virus or phage vector.

**Transfection** is the process of infecting a cell with a virus's nucleic acid, which causes the infection to replicate completely.

**Transformation-** altering an organism's genetic makeup by incorporating outside DNA.

**Transgene-** a gene that has been inserted into the genome of another organism from another source.

**Transgenic organism-** an entity created when foreign genetic material is inserted into an organism's germ cells. Transgenic organisms are frequently created using recombinant DNA technology.

**Transgenic Plant-** A viable plant that has one or more foreign genes in its germ line is referred to as a transgenic plant.

**Translation** is the process through which a messenger RNA molecule's information is utilised to control the production of a protein.

**Trypsin Inhibitors-** If not rendered inactive by heating or other processing techniques, trypsin is inhibited by antinutrient proteins found in plants like soybeans.

**Vaccine** a substance used to impart immunity against the disease that the substance's antigen, which is made up of whole disease-causing organisms (dead or weakened) or sections of such

organisms, causes. Natural, synthetic, or recombinant DNA technology-derived vaccine preparations are all possible.

**Vaccine-** a special medication that is administered to both people and animals in order to bolster defences against a specific illness and stop the spread of infectious diseases.

**Vector-** the substance that introduces new DNA into a cell, such as a virus or plasmid.

**Viral envelope-** a spikey covering for the capsid, or protein coat, of the virus.

**Virion** a basic viral component made of of genomic material and a protein shell.

**Virology** research on viruses

**Virulence-** ability to spread sickness or infection.

**Virus-** a microscopic organism with genetic material but no capacity for self-reproduction. It must infiltrate another cell and utilise some of that cell's reproductive apparatus in order to duplicate.

**Virus-** an infectious agent whose growth and replication are reliant on the host cell's cellular infrastructure.

**Wild type-** a type of organism that is most typical in nature.

**Yeast** is the collective name for single-celled fungi that budding for reproduction. Some yeasts are useful in brewing and baking because they can ferment carbohydrates (starches and sugars).

One-celled fungus called **yeast**.

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## CHAPTER 3

### BASICS IN FOOD SCIENCE AND TECHNOLOGY

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This chapter gives a general introduction to food, including information on its components (carbohydrates, protein, fats, vitamins, and minerals), as well as a clear description of each based on how it serves its purpose in the field of food technology. This chapter offers in-depth information about food and their behavior towards processing technology together with a review of food composition, sources, and relevance of food to human health in order to emphasize the perspective of the foundations of food science and technology.

#### **1.1 Food**

According to Somati et al. (2007), food is anything consumed that satisfies the body's needs for energy, body construction, regulation, and protection. Any substance that can deliver one or more of the following when swallowed qualifies as food.

- Substances that the body may employ to produce heat, motion, or other sorts of energy.
- Materials for regeneration, growth, repair, and reproduction.
- Materials required to control the development and maintenance of activities.

Therefore, food can be considered as a source of energy for the body that needs to support everyday activities and manufacture essential substances, which has a direct impact on the human body and its functionality. As a result, it is believed that the main factor affecting human health and happiness is the composition or contents of food.

Based on consumption habits, food has been divided into a number of categories. One of the classifications separates them into the following basic seven categories: fats and sugars; cereals, grains, and products; vegetables and fruits; pulses and legumes; milk and meat products; and oils, fats, nuts, and oilseeds. Another classification separates them into the following basic four categories: oils, fats, nuts, and oilseeds (butter or fortified margarine; green and yellow vegetables; bread flour and cereals; meat, poultry, fish and eggs).

#### **1.2 Food Science**

Food science is described as "the discipline concerned with the basic chemical, physical, biological, and biophysical properties of foods and their components, as well as changes resulting from handling, preservation, processing, storing, distribution, and food preparation" (Bender 2006). So, based on basic principles, food science is an applied science that unifies various fields of study and incorporates concepts from them, including biochemistry, physics, microbiology, bioengineering, and nutrition. When food science was young, people had a rudimentary grasp of the composition and purposes of food.

There was little information on a variety of subjects, including the effects of food on the human body, the concept of a balanced diet, the function of specific nutrients in health and illness, food preparation and preservation, fortification, enrichment, quality, safety, and microbiology. However, as the study of food science developed, the emphasis moved to the mechanisation of food factories and production lines. Managing and standardising production variables like temperature, humidity, water level, evenness of size, etc. became easy as a result. To satisfy the needs of disadvantaged populations, extraction and fortification techniques were developed to alter the nutritional worth of food. To make managing, keeping, and transporting food easier, rigid and flexible packaging materials were concurrently created.

The creation and invention of new non-thermal food processing methods has transformed the field of food science and technology. As a consequence, contemporary consumers are more conscious of the ingredients, quality, safety, and wholesomeness of food as well as the connection between nutrition and health and illness.

### **1.3 Food Technology**

The application of information produced by food science in the selection, shipping, processing, preservation, packing, marketing, and dissemination of food, as well as its effect on safe, nutritious, and healthy food intake, is described as food technology. The application of science and technology to the treatment, preparation, storage, and dissemination of food, on the other hand, is described as "food technology" (Bender 2006). Food technology, in practise, is concerned with the large-scale production and preservation of numerous food products based on food science, as well as the development and analysis of food items on an industrial scale, which has been critical in reducing postharvest losses while also adding value to raw food materials.

### **1.4 Food Technologists and Scientists**

Food scientists are in charge of implementing fundamental food processing principles using technology-based knowledge, and they are expected to: have a thorough understanding of food, its components and nature, functionality and nutritional value, processing and preservation, fortification and analysis; develop palatable, wholesome, and affordable food products; work to produce allergen-free foods, novel and functional foods; and concentrate on fortification. By merging national standards, food scientists are tasked with ensuring the purity and safety of food while also fostering international trade.

### **1.5 Food Constituents**

The main sources of food constituents, which are essentially bio-chemicals that come together to create a particular food and are found in varying amounts and configurations in food systems, are plants and animals. These components give food its distinct flavour, texture, structure, colour, and nutritional value. Even though two foods may contain comparable amounts of one or more components, they may have entirely distinct physicochemical and organoleptic characteristics. Understanding the fundamental elements of food is necessary to comprehend the structure and composition of food.

## **1.6 Nutrients and Non-nutrients**

The body needs sufficient quantities of water, protein, fats, carbohydrates, minerals, and vitamins in order to develop, reproduce, and live a typical, healthy life (Somati et al. 2007). A food's forty important nutrients are the building blocks for thousands of other compounds needed for development and bodily processes. Technically speaking, some food ingredients are categorised as non-nutrients, or pure food ingredients without a nutritious purpose. They might be poisons, healthy substances like fibre, or chemicals that make food more palatable or have pharmacological meaning. Examples include flavours, acids, phytates, tannins, phenolics, and other similar dietary ingredients. Energy generation follows alcohol metabolism as a non-nutrient process because it harms the body and goes against the meaning of nutrition. Alcohol affects organ efficacy, self-healing capacity, and bodily development despite having a high energy density (7Kcal/g).

### **1.6.1 Nutrients Functions**

Food is a mixture of different ingredients that, based on their nature, serve different purposes in the body. The four primary purposes of food nutrients are energy generation, body construction, regulating bodily activities, and maintaining health. Each of the functions, including the production of energy, the development and maintenance of the body, the regulation of the body's functions, and the end aim of maintaining health, typically involves one or more food components. The following paragraphs provide a summary of the major discussion of all tasks.

#### **1.6.1.1. Energy Provision**

The main source of energy for the bodies of both humans and animals is food, which is created through the process of governed metabolism. The body uses this energy to fuel functions in the brain and other organs and cells. The most significant and essential sources of energy in the diet are foods rich in macronutrients (fats, carbohydrates, proteins, and alcohol), which are quantified in calories or kilocalories (Kcal), or the amount of energy needed to increase the temperature of 1 kilogram of water by 1°C. 3.75, 4, or 9 kilocalories are produced by one gram of carbs, protein, fat, or alcohol, accordingly.

Energy-producing foods include grains, legumes, nuts, seeds, roots, tubers, meat, seafood, unadulterated carbs (sugar and starch), and fats or oils. Most meals not only give you energy but also nutrition (vitamins and minerals). High protein cereals and legumes are excellent providers of vitamins and minerals. Pure carbs only provide energy; in contrast, the lipids in such meals are rich in fat-soluble vitamins.

Foods high in dietary fibre provide the least amount of energy while still giving nutritional advantages, whereas foods high in fat and oils are typically energy dense. Vegetables, fruits, and grain flour are all sources of dietary fibre.

#### **1.6.1.2. Growth and Development of Body**

Body components like teeth, skin, bone, and musculature all contain protein. So meals high in protein are crucial for fitness. More than 80% of the dry weight of the musculature is made up of proteins, and a diet deficient in them can cause stunted development. In early children and teenagers, a diet high in protein plays a significant role in the formation of muscles and other bodily systems, resulting in linear growth.

There are 20 distinct amino acids that make up proteins. Like collagen protein, which has a robust and flexible helical structure and supports the bodily structure, each protein has a distinct pattern of amino acids that defines its particular purpose. Proteins with great biological worth, including all of the necessary amino acids in a regulated ratio for human tissue synthesis, are abundant in milk, eggs, meat, and seafood. Furthermore, despite the high protein content of legumes, oilseeds, and nuts, not all of the necessary amino acids required by the human body may be present in these foods.

Proteins and minerals both play a role in developing muscle. For instance, fluorine is a crucial component of dental enamel, and calcium and phosphorous are essential and significant constituents of bones. Among other things, foods high in minerals include milk and dairy products, eggs, poultry, seafood, and green leafy veggies.

Cellular components known as lipids are crucial for weightlifting. The body uses fat as insulation to keep its essential systems safe from harm. Similarly, fatty acids not only serve as the structural foundation of the brain but also help to cover the synapses with myelin. Therefore, eating fat is linked to a reduced incidence of melancholy.

#### **1.6.1.3. Regulation of body processes**

Dietary components play a critical role in safeguarding and preserving the body's endocrine system. The capacity of an organism or system to maintain its parameters within a typical range of numbers is known as homeostasis. The pH, blood pressure, glucose content, and body temperature are among the bodily processes that are regulated by vitamins and minerals.

#### **1.6.1.4. Health Maintenance**

Foods deemed to offer health advantages above and beyond those of fundamental nutrition by reducing the chance of specific illnesses and conditions are referred to as functional or nutraceutical foods. Phyto-chemicals are an essential element inherently present in plants, completing such tasks as natural antioxidants and antimicrobials. Some examples of phyto-chemicals include green leafy veggies, coloured fruits, legumes, whole cereals, and seasonings.

Foods strong in phytochemicals may reduce the chance of chronic cardiovascular illnesses, diabetes, some cancers, and high blood pressure that are linked to ageing. Additionally, they act as synergistic agents to facilitate effective nutritional uptake. Chemicals called antioxidants prevent free radical activity, which could otherwise harm cells and cause cancer.



## **1.6.2 Nutrients Classification**

The six main types of nutrition are water, lipids, proteins, vitamins, minerals, and proteins. These are further split into the following four groups:

- a) Macro and micro nutrients,
- b) Essential and non-essential nutrients,
- c) Energy generating and non-energy generating nutrients,
- d) Organic and inorganic nutrients.

### **1.6.2.1. Macro and micro- nutrients**

As macronutrients, which the body needs in significant amounts everyday in grams, nutrients are categorised according to their quantity or volume. Examples of macronutrients include fluids, proteins, lipids, and carbohydrates. Protein, fats, and water serve as the body's building blocks while fats, carbohydrates, and protein provide energy for the body to develop and heal itself. However, the body only requires lesser quantities of micronutrients—measured in milligrams or micrograms—daily. Despite the fact that these nutrients are needed in lesser amounts, their significance cannot be exaggerated. Serious repercussions for the human body can result from nutritional deficiencies in these substances. Minerals and vitamins are micronutrients.

### **1.6.2.2. Essential and non-essential nutrients**

According to the requirement for nutritional consumption, nutrients are divided into essential and non-essential categories. The body is unable to produce enough essential nutrients, so they must be consumed through food. Vitamins, minerals, amino acids (proline, threonine, valine, isoleucine, leucine, lysine, histidine, arginine, and methionine), and fatty acids are all related to important nutrients (linoleic acid, alpha linolenic acid).

The body can make enough of the non-essential nutrients from the essential nutrients or other substances it already has on hand, such as some amino acids (such as alanine, arginine, asparagine, aspartic acid, cysteine, cystine, glutamic acid, glycine, proline, serine, and tyrosine), monounsaturated fatty acids, cholesterol, and others. It is impossible to exaggerate the significance of non-essential nutrients for our systems' healthy operation, and nutritional deficiencies do not occur.

### **1.6.2.3. Energy and Non-energy yielding**

Body growth and development are significantly influenced by the body's ability to produce energy through some substances. The three main dietary components for generating energy are carbohydrates, proteins, and lipids. Protein and carbohydrates provide more energy than lipids. On the other hand, vitamins, minerals, and water are non-energy-producing nutrients that are mainly engaged in bodily regulating processes and support muscle growth.

### **1.6.2.4. Organic and inorganic nutrients**

The categorization of nutrients is based on whether carbon is present or absent in their molecular composition. Organic nutrients, such as carbs, proteins, lipids, and minerals, are

those that have a carbon atom as part of their composition. Organic nutrients, which are those that are not vitamins, give the body energy and serve as sustenance for its processes. Because they don't contain a particle of carbon in their composition, water and minerals are instances of inorganic nutrition.

## **1.7. Macronutrients**

### **1.7.1. Carbohydrates**

Carbohydrates, also referred to as carbon hydrates, are biological substances composed of carbon, hydrogen, and oxygen ( $C_n(H_2O)_n$ ). In our everyday diet, they are the primary source of energy. Depending on the financial situation of the nation, carbohydrates make up 40–80% of energy. Foods like grains, bread, noodles, and other grain-based meals are full of carbohydrates. All of the essential carbs in our diet—sugars, dextrin, polysaccharides, cellulose, hemicellulose, gums, and pectin—are also a significant source of fibre. Various food formulas use carbohydrates as thickeners, binders, sweeteners, and oil substitutes. Scientific data indicates that carbohydrates make up 1% of the human body's makeup (Cui 2005). According to the degree of polymerization, carbs are divided into three main categories: basic sugars (mono- and disaccharides), oligosaccharides, and polysaccharides.

#### **1.7.1.1. Simple carbohydrates/sugars**

Simple carbs are also known as monosaccharides and disaccharides because they are composed of just one or two sugar molecules, respectively. Disaccharides and monosaccharides are both sugars that digest quickly and offer a fast supply of energy. Because their extreme intake can be detrimental to human health in some circumstances, they are rich in calories but low in nutrients. The terms mono, which means "one," and saccharide, which means "sugar," are combined to form the word monosaccharide. They are the fundamental components of carbs and are also referred to as basic sugars. They have a sweet flavour. Only six carbon monosaccharides are typical, but they do contain 3 to 8 carbon atoms. The general formula for them is  $C_nH_{2n}O_n$ . Galactose, fructose, and glucose are examples of monosaccharides. When measured against sucrose, glucose has a sweetness level of 0.74, fructose ranges from 1.6 to 1.9, and galactose has a sweetness level of 0.35.

#### **1.7.1.2. Oligosaccharides**

The Greek terms oligos, which means "a few," and sacchar, which means "sugar," are combined to form the word "oligosaccharide." Oligosaccharides are carbohydrates that only have three to ten sugar molecules, with raffinose (a trisaccharide having galactose, glucose, and fructose) and stachyose serving as typical examples (tetrasaccharide containing glucose, fructose, and two galactose units). They are used in the food business as bulking agents, fat replacements, and to enhance the texture of some dishes. They have a slightly sweet taste. Due to their advantages as bacterial sustenance in the lower gut system, oligosaccharides have lately attracted more focus. Nearly 90% of them avoid digestion in the small intestine and make it to the colon, where they function as pro-biotics for intestinal microbes. They are mostly indigestible by humans' digestive systems. Depending on the oligosaccharide, various bacterial groups are either activated or repressed. According to clinical research,

oligosaccharides encourage the development of good bacteria in the colon while inhibiting the growth of bad bacteria.

### **1.7.1.3. Polysaccharides**

Polysaccharides are compounds formed by the glycosidic linkage of numerous monosaccharides (ten). Starch is one such polysaccharide, consisting of a significant number of glucose molecules linked together by a glycosidic link. Pure starch is a tasteless white powder that is impermeable in frigid water. It is produced by all green plants during photosynthesis and acts as an energy reserve for plants that store energy in the shape of starch. When necessary, specific enzymes degrade starch into basic sugar (glucose). Potato tubers and cereal cereals are both rich in starch (wheat, rice, corn, oats, and barley). Amylose and amylopectin are the two kinds of compounds found in starch. Both consist of extended strands of glucose molecules connected by 1,4-glycosidic links. In contrast, amylopectin has branches while amylose is a straight strand. Amylopectin is less water soluble than amylose due to the branches. Depending on the plant, starch includes 20–25% amylose and 75–80% amylopectin by weight. The two kinds of starch are typically found together, but they can also be separated into amylose and amylopectin-only carbohydrates.

Human gut endogenous fluids are unable to process other polysaccharides like cellulose, hemicelluloses, pectin, gums, and mucilages. Due to their non-digestibility and possible health advantages, these polysaccharides are categorised as nutritional fibre (Izydorczyk 2005). Consumable plant material or similar carbs that are refractory to digestion and absorption in the small intestine of humans but fully or partly ferment in the large intestine are referred to as dietary fibre. Dietary fibre includes compounds found in plants such as lignin, polysaccharides, and oligosaccharides..

Dietary fibres support bodily advantages like bowel movements, lowering blood lipids, and/or lowering blood sugar (AACC 2001). Dietary fibre is described as carbohydrate polymers with 10 or more monomeric units (2) that are not hydrolyzed by natural enzymes in the human small intestine. These types of polymers include:

- Polymers of carbohydrates that are edible and appear naturally in food.
- Carbohydrate polymers produced by physical, enzymatic, or chemical processes from dietary raw materials that have been shown to responsible authorities to improve physiological health in accordance with widely recognised scientific proof.
- Synthetic carbohydrate polymers that have been demonstrated to competent authorities by widely acknowledged scientific proof to have a physiological advantage to health.

#### **Notes:**

- 1) If measured using AOAC 991.43, includes lignin and other substances.
- 2) Deciding whether to add carbs to the DP polymerization process.
- 3) Dietary fibre cannot be digested because the human GI system lacks the enzymes necessary to break it down. However, the colonic microflora ferments most of the nutritional fibre, which has advantageous health benefits.

A select few microbes in the intestines are stimulated by certain non-digestible carbohydrates, improving human health. These are known as pre-biotics.

### **i) Sources of carbohydrates**

Various natural and manufactured foods contain sugars. Foods like table sugar, brown sugar, honey, soft beverages, fruit drinks, jams, jellies, sweets, and fruits are popular sources of sugar. The majority of people in the world can afford the main forms of complex carbohydrates in our diet, which are cereals, grains, legumes, fruits, and starchy veggies. Fruits, veggies, Isabghol husk, beans, cereal, and other meals are full of dietary fibre.

### **ii) Functions of carbohydrates**

Carbohydrates serve as an abundant source of stored energy for the body, support bodily processes, add sweetness to food, and act as dietary fibre to lower the risk of diabetes, constipation, cancer, obesity, heart attacks, and other illnesses.

#### **1.7.2. Proteins**

Nitrogen, carbon, hydrogen, and oxygen are the main components found in proteins, which are large, complex polymers. But phosphorous and sulphur can also be found in some protein molecules. Numerous hundreds to thousands of smaller building blocks known as amino acids make up every protein. There are 20 different types of amino acids that are naturally required for the formation of various proteins in the human body. As was already mentioned, they are joined in a particular order to create a particular protein. Protein properties are primarily determined by the type and quantity of amino acids. A basic R group, an acidic carboxylic group (COOH), and an amine group (NH<sub>2</sub>) make up an amino acid. The nature of the R group largely determines how an amino acid behaves.

On the basis of nuclear structure—alpha, beta, gamma, and delta amino acids—polarity, pH base, and type of side chain group—aliphatic, acyclic, aromatic, hydroxyl, or sulphur, among others—approximately 500 amino acid variations are recognised and categorised. After water, amino acids make up the second-largest portion of human muscle fibres and other organs. Aside from the production of proteins, amino acids play a crucial role in the transfer of neurotransmitters and metabolism.

Prior to now, amino acids in terms of nutrients were categorised as essential or non-essential (Vaclavik and Christian, 2008). In order to release one molecule of water, the amino group of one amino acid peptide bonds with the carboxyl group of another. Children/adolescents and adults consume different amounts of protein, with the former needing more and the latter needing less per unit of weight for development.

One of the basic components of extracellular and intracellular structures like cartilage, nails, muscles, hair, antibodies, hormones, bodily fluids, and enzymes, proteins are one of the building blocks of life. They make up the bulk of muscles and tissues.

##### **1.7.2.1. Protein Sources**

The two primary forms of proteins in the human diet are animal and plant proteins. Animal proteins are commonly referred to as complete proteins because they have reasonably

balanced quantities of all essential amino acids. Meat, eggs, seafood, and milk are a few of the primary dietary forms of animal protein. However, plant proteins are viewed as imperfect proteins because they are deficient in some crucial amino acids. To satisfy the body's protein needs, animal proteins must be eaten in addition to plant-based proteins. Legumes, grains, and seeds are the main sources of plant proteins.

#### **1.7.2.2. Functions of Protein**

When the body's primary fuel source, carbohydrates, is used up, proteins step in to provide energy while also assisting in the transportation and storage of molecules. Proteins are crucial for the growth and maintenance of body tissues and muscles. The nature of many hormones, enzymes, and antibodies is also proteinaceous.

#### **1.7.3. Lipids**

Lipids are a heterogeneous class of substances linked to living things that are insoluble in water but liquid in non-polar solvents such as alcohols or hydrocarbons(Vieira 2013). The lipids group is primarily made up of fats and oils, but it also includes waxes, phospholipids, sterols, and sphingo-lipids. For liquid oils, shortenings, and margarines, fat and oils serve as the basic ingredients. These also contribute to the food's flavor, aroma, and texture as well as its ability to nourish and satiate. The primary difference between fats and oils is their physical condition, or the fact that while oils are liquid at room temperature and comprised of unsaturated fatty acids, fats are solid at room temperature and are made up of saturated fatty acids. Glycerol-esters of fatty acids are what lipids and lubricants are chemically. As part of the esterification process, the glycerol's alcoholic group and the fatty acids carboxylic group interact to form an ester bond and a water molecule.



Alcohol acid Ester Glycerol can combine with fatty acids to create up to three ester bonds because it is a trihydric alcohol. Monoglyceride is created when one fatty acid joins with one glycerol molecule; diglyceride is created when two fatty acids join with one glycerol molecule; and triglyceride, which makes up the majority of lipids and oils, is created when three fatty acids join with one glycerol molecule.

O'Brien (2009) asserts that the types and concentrations of fatty acids in lipids have a significant impact on the properties of fats and oils. Fats and oils are made up primarily of fatty acids, which are open chain carboxylic acids also referred to as aliphatic substances. The fatty acids present in fats and oils naturally have an even number of carbon atoms varying from 4 to 28, either saturated or unsaturated, due to the existence of double bonds or the lack of hydrogen at certain positions in carbon chains.

Based on their dietary significance, fatty acids are divided into cis or trans-, omega-, and essential or non-essential categories. The FDA advises consuming 0 grams of trans-fat per day because it is thought that trans-fat is bad for the body. Examples of essential fatty acids that must be obtained through food because the human body is unable to make them include linoleic acid and alpha-linolenic acid. However, it does not mean that other fatty acids are not important for maintaining human health.

### **1.7.3.2. Functions of Oils and Fats**

Oils and fats are essential to human health. The body absorbs the majority of the fat ingested through food because lipids make up only about 3.3% of faeces. The advantage of fats and oils over other energy-producing nutrients is that they have a high energy density because they contain fat-soluble vitamins such as A, D, E, and K and provide 214 times more calories than an equivalent amount of carbohydrates and proteins.

Essential fatty acids are provided by fats, which also serve as energy storage reservoirs in animals and provide a layer of protection for the organs. Additionally, fats and oils give food flavor and texture, serve as a vehicle for flavoring agents, and give food a soft, creamy consistency. The amount of fat consumed and human health and wellbeing are strongly correlated.

## **1.8 Micronutrients**

### **1.8.1. Minerals**

When food is burned, minerals are the inorganic substances that are left behind in the ash. Minerals are present in both rigid and flexible body tissues in humans, and they are primarily obtained through diet, albeit in very small amounts. The body uses minerals primarily for the regulation and edification of bodily processes. Ca is the primary component of bones, while Cl and other minerals are crucial components of gastric juice and act as enzyme activators. Magnesium, calcium, phosphorus, sodium, chlorine, potassium, magnesium, and sulfur are examples of macro minerals (iron, iodine and zinc). Cobalt, copper, manganese, molybdenum, selenium, and fluorine are examples of trace substances.

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### **1.8.2. Vitamins**

Vitamins are complex, organic dietary ingredients that can be classified as either water-soluble or fat-soluble. Although only in very small amounts, vitamins are essential for the body's normal growth and maintenance. Since mammalian cells are unable to synthesize vitamins, they must be obtained through diet. The class of vitamins known as water soluble vitamins is one of the most diverse and is crucial for red blood cell formation, protein metabolism, and energy transport. The B-group vitamins include biotin (vitamin H), ascorbic acid, riboflavin (vitamin B2), niacin (vitamin B3), pantothenic acid (vitamin B5), pyridoxine (vitamin B6), cyanocobalamin (vitamin B12), and thiamine (vitamin B1) (vitamin C). Examples of fat-soluble vitamins that the body can obtain through foods that contain fat include vitamins A, D, E, and K. Serious health consequences could result from a vitamin deficiency in any of these.

## **1.9. Nutrients in Human Body**

Water is the most abundant nutrient in the human body, followed by proteins, lipids, minerals, and then, in varying amounts, carbohydrates. Depending on factors like gender, age, activity level, location, and climate, the percentage may change.

## **1.10. Nutrition**

The process through which living things consume food and use it to fuel their development, produce energy, maintain their survival, and maintain the health of their organs and tissues (Bender 2006). Nutrients interact with an organism's body in relation to development, maintenance, reproduction, health, and illness; this is what nutrition refers to. Food must be consumed, digested, absorbed, transported, and assimilated in order to be properly assimilated and for the body to eliminate waste.

## **1.11. Food Processing**

Any and all methods that are used to prepare food after it has been harvested in order to improve its flavour, texture, nutritional value, storage capacity, and convenience of preparation as well as to get rid of microbes, toxins, and other unwanted elements (Bender 2006). Food processing is the process of transforming raw components into foods that can be distributed to customers and are well-liked by them. Enhancing the food categories to provide flexibility based on customer desire is involved. In general, food processing operations may entail tasks like cleaning, preparation, temperature control, shelf-life extension tactics, and marketing strategies specific to the foods. Food preparation and preservation are frequently based on the modification of food moisture, pH, temperature, air, radiations, and additives in order to enhance food quality, increase storage life, and guarantee food safety.

Food preservation is the process of keeping food fresh until it is consumed by protecting it from organisms, enzymes, and oxidation. Thus, extending food's shelf life is the fundamental goal of food preservation in order to make it easier to store and ship food to remote locations. Various technologies have been developed to process food so that it can be made available for a longer time, in distant locations, and according to the specific needs of the consumer.

## **1.12. Food Spoilage**

The term "food spoilage" refers to a decline in food quality that renders it unpleasant or unsafe to consume, whether it occurs naturally over time, is brought on by microbial contamination, or is the result of poor storage (Bateman et al. 2006). The main causes of food spoilage include autolysis, spoilage microorganisms, pests, and physical phenomena. Enzymatic and non-enzymatic/chemically induced autolysis are two different types of autolysis. Bacteria, yeast, and moulds are some examples of food spoilage microorganisms, and rodents, insects, birds, and parasites are considered pests. Contrarily, the deterioration of food brought on by changes in water activity, temperature, and mechanical effects while it is being harvested, stored, or transported is attributed to physical phenomena. Food spoilage results in nutrient value loss, modifications to the food's organoleptic characteristics, and other unwholesome impacts because it produces toxins, biogenic amines, and other unwholesome substances. These four spoilage agents serve as the foundation for the food preservation principles.

### **1.13. Current Trends in Food Science and Technology**

In the twenty-first century, customers' demands and standards for safe, wholesome, and healthy foods in their native forms from the food industry have considerably altered. To satisfy the constantly evolving needs of consumers, a transition in food processing technologies from "conventional to advanced" is unavoidable. In addition to reducing the nutritional value of many foods, conventional heat processing can also alter their functionality and flavor. As a result, non-thermal processing methods are becoming more and more common in the food industry as a substitute for thermal processing because of their alleged safety and negligible impact on food's sensory and nutritional qualities. By eliminating and destroying bacteria, the techniques are demonstrating potential in the field of food preservation because they aid in the production of high-quality, minimally processed, additive-free, and microbiologically secure food. High pressure processing is one such innovative non-thermal technology that has the ability to create food safety standards that are on level with heat pasteurisation. With little to no effect on the nutritious value and taste quality of food, high-pressure processing has the power to change structures while inactivating pathogenic and spoilage microbes and enzymes. Similar techniques include extruder processing, freeze drying, microfiltration, ultrafiltration, reverse osmosis, ultrasonic processing, microwave aided processing, active & intelligent packing, and advanced emulsion technologies. Attention has also been paid to the creation of partly dehydrated, ready-to-eat meals with intermediary moisture levels. Other methods of food storage include osmotic drying and hurdle technology. The technology's basic principles include the use of high and low temperatures, decreased water activity, increased acidity, decreased redox potential, and the use of bio-preservatives to prevent the development of microbes. Therefore, recent developments in food processing and preservation technologies are primarily focused on creating foods that are more wholesome and safe than those produced conventionally. The main drivers of this change are increased consumer awareness, resulting demands, and scientific evidence of the connections between diet and health.

Recent ideas of functional and nutraceutical foods have come into focus for scientists as a result of this advancement in food science. There are currently efforts being made to investigate the bioactivity of food and its components. The new spectrum of healthy foods has been introduced by functional foods. Regulatory agencies have given their approval to a number of health claims involving these foods. In terms of nutrition, functional foods are those that offer additional health benefits. Therefore, if a food has experienced a change that shows good health advantages, it can be referred to as a functional food. Contrarily, the name "nutraceutical" is a combination of the terms "pharmaceutical" and "nutrient."



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## CHAPTER 4

### BASICS IN FOOD PRESERVATION

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**4.1 Introduction:** Food preservation involves treating and handling food in a way that stops or significantly slows down its deterioration and prevents food-borne illness while preserving the food's nutritional content, texture, and flavour. Whereas the combination of methods and processes used to prepare processed food from raw food materials for consumption by humans or animals collectively constitute food processing. The food processing frequently transforms clean, harvested, or slaughtered components into appetizing and marketable food items. So food preservation also involves several food processing or value addition techniques. The major aim of food preservation as the name suggests is to enhance its shelf life means it should be edible and nutritive with good quality for maximum number of days. Various methods and techniques are employed for preserving the food and utmost care is given to the organoleptic/sensory qualities of that food product including the nutrition value both must intact to make the preservation successful.

**4.2 Methods of Food Preservation:** The popular methods of food preservation involve using the high temperature, low temperature, chemicals or preservatives. Both the use of high and low temperature are also known as non chemical methods or preservative free methods, whereas when the chemicals/preservatives are used that method is called chemical method of food preservation. The food preservation methods performed using heat is known as thermal Processing, different methods of thermal; processing are as mentioned below:

**4.3 Blanching:** The basic aim of blanching is to reduce the initial microbial load and it is mainly used in case of fruits and vegetables mainly prior to drying/dehydration as well as other processes. Blanching may involve the least amount of heat of the but leaching is another factor that can cause nutrients to be lost during blanching. The two most widely used blanching methods are steam and hot water. These traditional procedures are straightforward and low-cost, but they also consume a lot of energy, leach a lot of soluble materials (which happen both during heating and cooling), and produce a lot of effluent. Leaching losses and effluent volume can both be greatly decreased using steam blanching. The two-stage heat-hold approach is the foundation of the novel individual quick blanching (IQB) technology, which has been demonstrated to considerably increase nutrient retention. The loss due to blanching can be up to 40% for minerals and vitamins (particularly vitamin C and thiamin), 35% for sugars, and 20% for proteins and amino acids, depending on the method of blanching, commodity, and component involved. As a result of the thermal degradation of blue/green chlorophyll pigments into yellow/green pheophytins during blanching, various undesired colour changes may occur.

**4.4 Pasteurization:** It is method of food preservation where the packaged or unpackaged food is subjected to mild heat treatment to enhance its shelf life. Pasteurization destroys pathogenic microorganisms in foods making it safe for consumption along with maintaining the quality of food. Most viable vegetative germs are rendered inert by pasteurisation, however heat-resistant spores are not. Pasteurization was initially developed to destroy bovine TB in milk. Numbers of viable organisms are reduced by ratios of the order of  $10^{15}:1$ .

Pasteurization may be taken into account in regard to dietary enzymes that are present and can be rendered inactive by heat, in addition to the application to inactivate bacteria. For pasteurization, the same fundamental relationships that were covered for sterilization apply. It is necessary to use a temperature and time combination that will effectively inactivate the specific bacterial or enzyme species in question. Fortunately, the majority of pathogenic organisms that can be spread from food to a person who eats it are not particularly heat-resistant. The most common application is pasteurization of liquid milk. The post-pasteurization packing conditions and storage environment affect the shelf life. Milk is the most significant non-acid liquid food, and as a result, it has drawn a lot of attention. There are typically no vitamin losses during pasteurizing milk for the fat-soluble vitamins A, D, E, and K. The extent of loss in thiamin, vitamin B6, vitamin B12 and folic acid is less than 10% as a result of pasteurization. Up to 25% of vitamin C can be lost. Pasteurization doesn't significantly change the colour of milk. Raw and pasteurized milk's different colours are primarily related to homogenization.

**Sterilization:** Sterilization procedures go further than the standard heat treatment used to establish commercial sterility. There will undoubtedly be nutritional loss in these items. Vitamins A, B1, B6, B12, C, D, E, folic acid, inositol, and pantothenic acid, as well as amino acids like lysine and threonine, are more susceptible to being destroyed by heat. The impact of the process cannot be easily assessed due to the potential of using multiple (infinite) time temperature combinations to achieve thermal sterilization. The food's pH determines the heat treatment's severity (low-acid foods require a more intense heat treatment to ensure the destruction of *C. botulinum*), the food's composition; the way the food heats up (conduction or convection); the food type, size, and shape of the container and mode of application of the heating medium. Food (protein, fats, and high concentrations of sucrose improve the heat resistance of microorganisms). Additional variables for process optimization are provided by agitation during processing. Studies on the microbes found in food have led to the selection of particular types of bacteria as indicator organisms. These are the bacteria that seem to cause problems in foods; these are the most challenging to kill in their spore forms.

**4.5 Food Drying/Dehydration:** One of the first ways to preserve food is by drying or dehydrating it. Long before any historical records exist, primitive societies were using the sun to dry meat and fish. Food drying is still an important method of food preservation today. Foods that have been dried out can be kept for a very long time without deterioration. The main causes of this are that many of the enzymes that promote undesirable changes in the chemical makeup of the food cannot function without water, and the bacteria that cause food deterioration and decay are unable to develop and reproduce in the absence of enough water.

Dried goods have a longer shelf life because of the low water content they achieve during drying, which eliminates the need for refrigerated transportation or storage. Additionally, surplus that is on hand can be changed into stable forms. For instance, milk in liquid form is easily spoilable, however milk in powder form is more stable and convenient to store and manage. Egg and juice powders are further examples of dehydrated goods in this category. Generally, drying results in a substantial reduction in weight and bulk volume, which can lower the cost of shipping.

A modern store will have a large selection of dry goods if you take a quick look around. Examples of these foods for use in home cooking include instant coffee, tea, milk, chocolate, drinks, soup mixes and instant meals containing dried vegetables, rice, pasta, dried vegetables (such as potato flakes or granules), peas, beans, and carrots, dried meat and fish ingredients, dried fruits for use as snacks or in desserts or baked goods, and many more. It is evident that food dehydration constitutes a large and very significant part of manufacturing or food processing activities globally in order to provide such a broad range of products.

**4.6 Basic Drying Categories:** The drying basically can be divided in to three categories.

1. In air and contact drying, drying with hot air or passing the air through heated surfaces under atmospheric pressure. In this type of drying hot air come in direct contact of food materials and the drying takes place through the evaporation under atmospheric pressure. The water vapour so generated is removed with air.
2. In vacuum drying, the fact that water evaporation happens more quickly at lower pressures than at higher ones is utilized. Vacuum drying typically transfers heat through conduction, but in some cases radiation is also used for heat transfer.
3. Freeze drying, often referred to as lyophilization or cryodesiccation, is a low-temperature dehydration technique that involves freezing the product, reducing pressure, and sublimating the ice. This contrasts with dehydration caused done by the majority of conventional methods, which use heat to evaporate water.

**4.7 Mechanism of Preservation through Drying/Dehydration:**

There are two main ways that dehydration achieves preservation. First, it eliminates the water required for enzymatic action and the growth of bacteria. Second, by eliminating the water, it raises the osmotic pressure and concentrates salts, sugars, and acids, resulting in a chemical environment that is adverse to the development of many bacteria. There are two main ways that dehydration achieves preservation. First, it eliminates the water required for enzymatic action and the growth of bacteria. Second, by eliminating the water, it raises the osmotic pressure and concentrates salts, sugars, and acids, resulting in a chemical environment that is adverse to the development of many bacteria. The interruption of critical steps necessary for microbial growth or spore germination results in the microbiological stability of dehydrated foods. There are different kinds and numbers of microbes that might be connected to food. Additionally, they differ based on the food type. and could change over the course of a food's life. Both the raw material and contamination (by people, animals, insects, water, air, contact surfaces, etc.) are potential sources of these.

Fresh fruits, vegetables, meats, and milk all have water activities that lie between 0.97 and 0.99. The majority of dried foods have a maximum water activity of 0.70, which is below the threshold at which bacteria in food can exist. Only *Staphylococcus aureus* has the ability to grow at 0.85 aw. Unless bacterial growth is restricted, fungi (yeasts and moulds) generally grow more slowly than bacteria, but they are also more resistant to harsh environmental conditions and can degrade food in these circumstances. Some moulds have the ability to create mycotoxins, which can cause a range of acute and chronic toxicities in both humans and animals.

The microbial growth will be influenced by water activity as well as a number of other variables, including temperature, pH, nutrients, preservatives, other food ingredients, and oxygen levels. It's vital to keep in mind that different water activity ratings are conceivable for foods with the same water content. The food's shelf life will be greatly impacted by this.

Only when a dehydrated product is shielded from additional exposure to the environment (such as water, air, sunshine, and pollutant) it remains stable. Consequently, choosing the right packaging for a dried product is important for its better shelf life and quality.

**Cooling and Freezing:** In the event of freezing, the product is cooling, and in the case of thawing, the product is warming. (usually at a temperature above its freezing point) until it reaches its initial freezing point. As the latent heat is then released, the product's temperature remains comparatively stable. Instead of remaining constant, the temperature for food goods gradually decreases until the majority of the water has turned into ice, at which point temperature falls more quickly. On the other hand, in the case of thawing heat is applied so that a product that is entirely frozen at a temperature well below its freezing point heats up. Ice along the surface first warms up until it reaches the freezing point, just like during the freezing process. After that, the latent heat is introduced and the ice starts to melt. It should be noted that while freezing, the latent heat of ice must be eliminated from the product after the phase shift process has started. The water layer on the surface freezes first as the heat is removed, followed by the layer below it, and so on. In order to extract the heat from the inner, unfrozen layers, we have an increasing layer of ice as the freezing process progresses. As a result, during the freezing process, heat is mostly transferred through a growing ice layer.

The different methods of freezing are generally grouped as:

1. Air freezing
2. Plate freezing
3. Liquid immersion freezing
4. Cryogenic freezing

**Air Freezing** The most widely used commercial freezing technique is air freezing. When exposed to air at -18 to -40 °C, the substance, whether packaged or unpackaged, freezes. Freezing in a space with very slow airflow is known as "slow" freezing. Additionally, it is uncommon this method, which tends to produce huge ice crystals that degrade the quality of the final product and will freeze very slowly, is plainly undesired. The product's gradual chilling may also let some unwanted enzyme and microbial activity before freezing is

complete, lowering the quality of the final product. Air blast freezing refers to freezing the product in a powerful blast of circulating cold air at temperatures ranging from  $-18$  to  $-40^{\circ}\text{C}$  under forced circulation. Various systems are available including cabinet, tunnel, belt, fluidized bed, etc. The product can be placed on trays or one conveyor. When the latter is employed, it is sometimes referred to as a “tunnel” freezer. In this case, generally, the product is conveyed through an insulated tunnel through which cold air is forced to flow at high velocity.

**Plate Freezing:** In this kind of freezer, the food, which is often packaged in regular-sized packaging, is frozen by coming into contact with a metal plate that has either cold brine or refrigerant circulated around it to cool it. In most cases, two contact plates are used, sandwiching the packaged goods between them under a light pneumatic pressure to provide a good seal between the package and the contact surface.

Heat is transferred from the package's two sides thereby reducing moisture loss from the product during freezing, this approach has several advantages over air-freezing.

**Liquid Immersion Freezing:** The product, whether packaged or not, is submerged in the chilling medium using this approach, as the name suggests. Because heat transmission through direct contact liquid media is substantially more effective than from air, the process is rather quick. The freezing of orange juice concentrates is one application where aqueous solutions of propylene glycol, glycerol, sodium chloride, calcium chloride, and sugars as chilling medium have been tested successfully.

**Cryogenic Freezing:** Due to the extremely low temperatures of the cooling medium, cryogenic freezing allows for a very quick freezing. Common cryogenic freezing agents include liquid or solid carbon dioxide and liquid nitrogen. Solid  $\text{CO}_2$  sublimates at  $-79^{\circ}\text{C}$  while liquid nitrogen boils at  $-196^{\circ}\text{C}$ . The conversion of  $\text{CO}_2$  from a solid to a gas through sublimation can absorb around three times as much latent heat as liquid  $\text{N}_2$  (246 to 86 Btu/lb). In this process, a tunnel is typically used to transport the product through the freezing chamber. The emerging nitrogen gas vapors will encounter the product as it enters at a temperature of between  $-30$  and  $-40^{\circ}\text{C}$ , pre-cooling it. The item is frozen in the tunnel's freezing chamber, which also exposes it briefly to a liquid  $\text{N}_2$  spray. The contact time is determined by the conveyor speed. The product will then flow out with the  $\text{N}_2$  vapors after that, where it will equilibrate to the preferred finishing temperatures. The process of applying  $\text{CO}_2$  includes swirling the product with powdered  $\text{CO}_2$ , which may not be the best option for sensitive products.

**Food Preservation Using Chemicals:** Chemicals Food preservation today involves the use of several chemicals. They range from extremely basic substances like salt and sugar to complicated chemicals like benzoates. According to FSSAI the preservatives can be categorized as (i) Class I preservatives obtained from natural sources (ii) Class II preservatives obtained synthetically.

Example of Class I preservatives are sugar, salt, vinegar, honey, spices, edible oils and Class II preservatives or the chemical preservatives are such as benzoates, sorbates, nitrites and nitrates of sodium or potassium, sulfites, glutamates, glycerides and the like. The natural

preservatives (Class I) act by inhibiting microbial cell walls/membranes, DNA/RNA replication and transcription, protein synthesis and metabolism. Natural preservatives have been recognized for their safety; however, these substances can influence color, smell, and toxicity in large amounts while being effective as a food preservative.

These substances use a mechanism called drying, which can also be employed by other means. The outcome, nevertheless, remains the same, the majority of microorganisms cannot survive in an environment that is primarily dry. Sugar and salt both work the same way. Actually the available water can easily pass through the membrane of a microorganism in a non-saline environment. Water inside and outside of the cell reach equilibrium in the non-saline environment due to diffusion. Water travels through a mechanism called diffusion from low solute concentration areas to high solute concentration areas. Any material that may dissolve in water is a solute. This indicates that the amount of water leaving the cell is equal to the amount coming in. The organism needs this condition to survive. The cell, however, is placed in an isotonic state if salt is added to the water to create a saline environment. It indicates that more water is leaving the cell than is entering it. The bacteria either grow more slowly as a result or perhaps perishes. Salt has been utilized for thousands of years because of its drying properties. Typically, 20% salt is required to suppress bacteria, however in case of sugar we need more sugar to create the same effect as the salt in case of sugar as a preservative.

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## CHAPTER 5

### BASICS OF HYDROPONICS FOR GROWING FOOD PLANTS

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Soil-based agriculture is presently experiencing a number of issues, including urbanisation, natural disasters, climate change, and the indiscriminate application of herbicides and pesticides, all of which are reducing soil fertility. Today, hydroponics, a soilless farming method, promises to deliver high quality, nutritious, residue-free, fresh vegetables and fruits, overcoming the multi-manifestation of climate change, shortage of fresh water, and the pressing requirement of the expanding food demand. This review study explores the meaning of hydroponics, including its many kinds, nutrient content such as Hoagland solution composition, influencing variables, and benefits for producing vegetables.

#### **1. Introduction**

Hydroponics is new way of science of rising plants lacking use of soil. Plants are grown-up devoid of soil in hydroponics by giving them through nutrient-rich solutions in water, which they would normally get from dirt in conventional agriculture. The basic goal of hydroponics is to supply the ideal nutritional setting for most favourable plant progress, which is more improved by climate control. Soil is merely a container for nutrients in conventional farming; it is also a location where plant roots usually dwell and a basis of hold for the plant organization (Somerville, et al., 2014). For a variety of reasons, hydroponic cultivation has remained popular. To begin with, there is no requirement for soil, and a big plant population may be cultivated in a very tiny space. Second, when appropriately supplied, maximum output may be achieved (Deutschmann 1998; Saffell 1993). Finally, fertilisers, water, and aeration can all be accurately managed. In solid media, this level of control is difficult to replicate. Hydroponics is currently an entrenched discipline of agricultural research (Steinberg et al. 2000).

Hydroponic technique efficiently grows crops in deserts, parched plains, hilly terrain, city rooftops, and concrete schoolyards. Hydroponics is a high-yielding, semi-automated crop. Plant factories have far more closely controlled environments than greenhouse, where soil is reinstated with non-soil resources and nutrients are acquired from water-rich nutrients (Wang 2011). Hydroponics is most accepted as a technique to grow bigger, improved meals on a huge scale. People may produce flowers, herbs and vegetables in their basements, huge closets, or even on their kitchen counters using simple hydroponic systems. Hydroponics may become the sole option to cultivate food crops and medical plants in the future to ensure the planet's survival. As a result, hydroponics is the way of the future for farming for food plants. So, this review paper reveals the importance of Hydroponics, types, chemical composition and its role in vegetable cultivation.

## **2. Background of hydroponics**

The term hydroponics came from two Greek words: 'hydro' (water) and 'ponos' (work). Dr. Gericke, a California professor, starts to change what had earlier been a laboratory method into a industrial resource of making plants, gave the term in 1929 (Jones 2014). Throughout World War II, the US Army engaged hydroponic culture for hordes stationed on barren Pacific islands. America, Africa, Asia and Europe all had money-making industrial farms by the 1950s. Hydroponic culture had a surge in 1990, with purpose counting space programs, rising flora in desert and polar region, vertical cultivation and large-scale manufacturing (Jones 2014).

## **3. Components of Hydroponic solution**

Hoagland solution is the most well-known and widely approved hydroponics solution. Hoagland and Snyder devised the Hoagland solution in 1933, which was later improved by Hoagland and Arnon (1938) and updated by Arnon (1950). It is one of the most widely used solution composition for growing plants, according to Google Scholar, which lists over 18,000 citations. The Hoagland solution includes each vital nutrients requisite by green plants and is suitable for a broad series of plant types (Smith et al., 1983; Google Scholar, 2020).

The Hoagland solution (Arrhenius 1922), designed to replicate a nutrient-rich soil solution, contains elevated amount of N and K, making it ideal for the growth of big plants like tomatoes and bell peppers (Genzel et al, 2021). To fertilise tomato seedlings, a half-strength nutrient solution (1) from Hoagland, mixed with a complete micronutrient solution from Long Ashton and a tenth-strength ferric EDTA solution (He et al., 2019). With supplementary dilution of the preparation to 1/4 or 1/5 of the modified solution, the solution is enormously appropriate for the development of plants with lesser nutritional requirement, such as lettuce and aquatic plants, due to comparatively high concentrations in the aqueous stock solutions (Science in Hydroponics, 2014).

Salts and acids to formulate Hoagland culture solution (1) and (2) (Epstein 1972):

1. Potassium nitrate ( $\text{KNO}_3$ )
2. Calcium nitrate tetrahydrate [ $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ ]
3. Magnesium sulfate heptahydrate ( $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ )
4. Potassium dihydrogen phosphate, ( $\text{KH}_2\text{PO}_4$ ) or Ammonium dihydrogen phosphate, [ $(\text{NH}_4)\text{H}_2\text{PO}_4$ ]
5. Boric acid ( $\text{H}_3\text{BO}_3$ )
6. Manganese chloride tetrahydrate ( $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$ )
7. Zinc sulfate heptahydrate ( $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ )
8. Copper sulfate pentahydrate ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ )
9. Molybdic acid monohydrate, ( $\text{H}_2\text{MoO}_4 \cdot \text{H}_2\text{O}$ ) or Sodium molybdate dihydrate, ( $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$ )
10. Ferric tartrate or Iron(III)-EDTA– or Iron chelate (Fe-EDDHA–)

At first, stock solution of these components prepared and need to store at 4°C. Hoagland solution needs to prepare freshly with maintain pH, when it's required for vegetable growth. There are two types of composition available. Which are as follows:

Component	Stock Solution	mL of Stock Solution/ Ltr.
<b>Composition of Macronutrients</b>		
KNO <sub>3</sub> (2M)	202 g/L	2.5
Ca(NO <sub>3</sub> ) <sub>2</sub> •4H <sub>2</sub> O (2M)	236 g/0.5 L	2.5
MgSO <sub>4</sub> •7H <sub>2</sub> O (2M)	493 g/L	1
KH <sub>2</sub> PO <sub>4</sub> (1M)	136 g/L	1
<b>Composition of Micronutrients</b>		
H <sub>3</sub> BO <sub>3</sub>	2.86 g/L	1
MnCl <sub>2</sub> •4H <sub>2</sub> O	1.81 g/L	1
ZnSO <sub>4</sub> •7H <sub>2</sub> O	0.22 g/L	1
CuSO <sub>4</sub> •5H <sub>2</sub> O	0.08 g/L	1
H <sub>2</sub> MoO <sub>4</sub> •H <sub>2</sub> O or	0.09 g/L	1
Na <sub>2</sub> MoO <sub>4</sub> •2H <sub>2</sub> O	0.12 g/L	1
<b>Composition of Iron</b>		
C <sub>12</sub> H <sub>12</sub> Fe <sub>2</sub> O <sub>18</sub> or	5 g/L	1
Sprint 138 iron chelate	15 g/L	1.5

**Table (1) Stock solution's composition and a full strength Hoagland solution (1)**  
(Hoagland and Arnon; 1938 with modification)

Component	Stock Solution	mL of Stock Solution/ Litre
<b>Composition of Macronutrients</b>		
KNO <sub>3</sub> (2M)	202 g/L	3
Ca(NO <sub>3</sub> ) <sub>2</sub> •4H <sub>2</sub> O (2M)	236 g/0.5 L	2
MgSO <sub>4</sub> •7H <sub>2</sub> O (2M)	493 g/L	1
NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub> (1M)	115 g/L	1
<b>Composition of Micronutrients</b>		
H <sub>3</sub> BO <sub>3</sub>	2.86 g/L	1
MnCl <sub>2</sub> •4H <sub>2</sub> O	1.81 g/L	1
ZnSO <sub>4</sub> •7H <sub>2</sub> O	0.22 g/L	1
CuSO <sub>4</sub> •5H <sub>2</sub> O	0.08 g/L	1
H <sub>2</sub> MoO <sub>4</sub> •H <sub>2</sub> O	0.02 g/L	1
<b>Composition of Iron</b>		
C <sub>12</sub> H <sub>12</sub> Fe <sub>2</sub> O <sub>18</sub> or	5 g/L	1
Sprint 138 iron chelate	15 g/L	1.5

**Table (2) Stock solution's composition and a full strength Hoagland solution (2)**  
(Hoagland and Arnon; 1950 with modification)

#### **4. Types of various Hydroponics and Their Function**

There are various types of Hydroponics and their methods. The reprocessing of nutrient solution and assisting medium are modified and attuned in hydroponic systems. Wick, drip, ebb-flow, deep water culture, and nutrient film technology (NFT) are examples of frequently utilised systems.

##### **a) Wick System**

Wick system is most fundamental hydroponic arrangement, as it doesn't need any aerators or pump power (Shrestha and Dunn, 2013). Plantation of plantlets is done in an porous media (vermiculite, perlite or coco coir). A wick of nylon is arranged from the plant roots to a nutritional solution tank. With the help of capillary action of wicks, nutrients are delivered to plants. Wick system is superlative for spices and herbs, but unproductive for plants with high water requirement.

##### **b) Ebb and Flow system**

Ebb and Flow is the initial industrial hydroponic system that has mechanism based on flood and drain method. Hoagland solution and water from the tank are impelling into the cultivation bed with the assist of water pump to provide nutrients with moisture content to plantlets. Additionally, although abundant sort of crops can be grown-up, algae, root rot and mould are extremely frequent (Nielsen et al., 2006). That's why modified system of Ebb and Flow arrangement with a filtering unit is mandatory.

##### **c) Drip system**

It is a most accepted expertise for both residential and industrial purpose. Through pump assist, Hoagland solution from the tank is transferred to individual plantlet roots in a suitable amount (Rouphael and Colla, 2005). Plantlets are usually grown-up in solution that is somewhat absorbent so that the nutrition solution drops gradually. So, different crops may be cultured in an efficient way while conserving water.

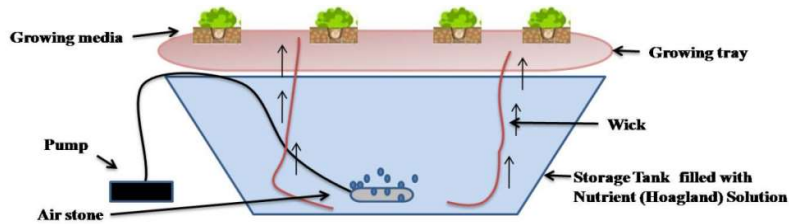
##### **d) Deep water culture system**

In deep water culture, Plantlet roots are pendant in nutrient solution and air is delivered straight to the roots by the use of an air stone. A prominent model of this system is the hydroponics buckets system. Plantlets are laid in net pots with their roots hanging in nutritional solution, in which they speedily expand into an enormous mass. Since algae and moulds possibly will rise rapidly in the tank, checking oxygen and nutrient concentration, salt level, and pH is requested (Domingues et al., 2012). Deep water culture is model for higher plants that make fruits (cucumbers and tomatoes), which succeed with this atmosphere.

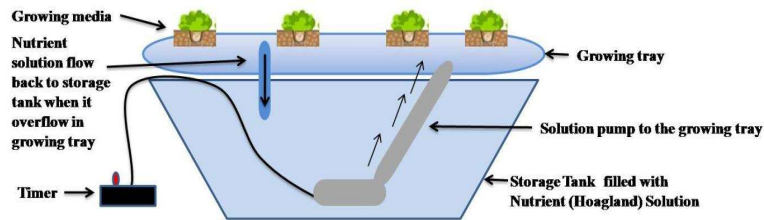
##### **e) System for Nutrient Film Technique (NFT)**

NFT was created by Dr. Alen Cooper (in the mid 1960s) to deal with the limits of the ebb and flow method. Nutrient solution or water flows in the system and reaches the growing plate through a water pump with no timer (Domingues et al., 2012). The system is slightly sloped to let nutritional solution flow through the roots and reverse into the tank. Plant's roots hanging in a hydroponic solution are put in a conduit or pipe. On the other hand, roots are prone to fungal disease since to their regular

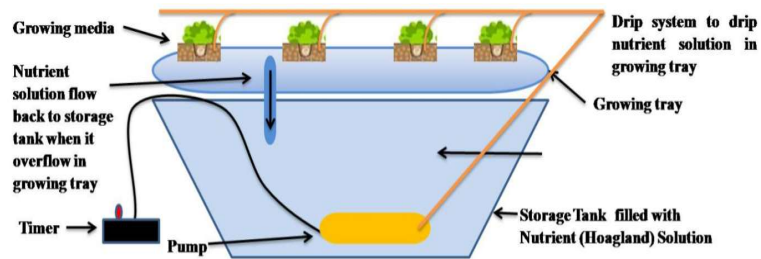
engagement in water or nutrients. Numerous leafy greens can be simply produced in this method, and lettuce is the main example which expansively utilised commercially through this method.



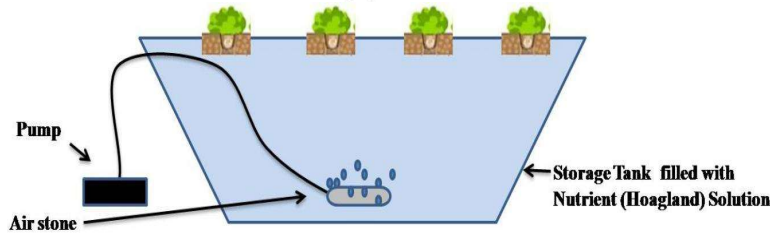
**Wick System**



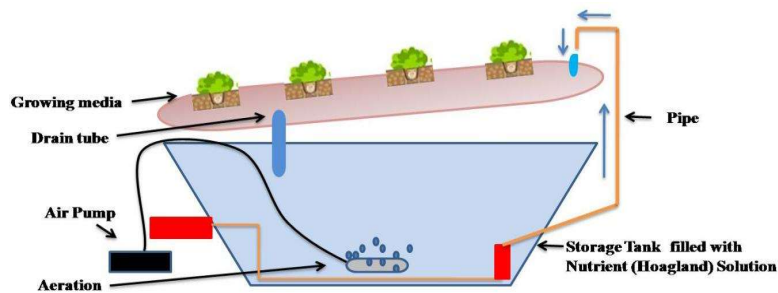
**Ebb and Flow system**



**Drip system**



**Deep water System**



**Nutrient Film Technique System**

**Figure: 1 Types of Various types of Hydroponics and their Working Pattern**

## 5. Influencing Factors affecting the efficiency of Hydroponics

### a) pH and Electrical Conductivity (EC)

The main established composition for hydroponic systems is Hoagland's solution. The pH and EC of the nutrient solution are extremely significant for maximum plant performance and should be maintained appropriately. Table 3 revealed the best range of EC and pH value for numerous hydroponic crops. Due to osmotic pressure, higher EC prevents nutrient absorption, whereas lower EC has a unenthusiastic effect on plant health and productivity. As a result, proper EC control in hydroponics can be an efficient tool for increasing crop productivity and quality (Gruda, 2009; Sharma et al., 2018; Khan et al., 2021).

Crops	EC (mS/cm)	pH
Asparagus	1.4 to 1.8	6.0 to 6.8
Bean	2.0 to 4.0	6
Banana	1.8 to 2.2	5.5 to 6.5
Basil	1.0 to 1.6	5.5 to 6.0
Cabbage	2.5 to 3.0	6.5 to 7.0
Celery	1.8 to 2.4	6.5
Courgettes	1.8 to 2.4	6
Cucumber	1.7 to 2.0	5.0 to 5.5
Eggplant	2.5 to 3.5	6
Leek	1.4 to 1.8	6.5 to 7.0
Lettuce	1.2 to 1.8	6.0 to 7.0
Okra	2.0 to 2.4	6.5
Peppers	0.8 to 1.8	5.5 to 6.0
Parsley	1.8 to 2.2	6.0 to 6.5
Rose	1.5 to 2.5	5.5 to 6.0
Spinach	1.8 to 2.3	6.0 to 7.0
Strawberry	1.8 to 2.2	6
Tomato	2.0 to 4.0	6.0 to 6.5

**Table: 3 List of Crops with their optimum pH and EC**

### b) Light

Light is a crucial element that controls development of a plant by regulating photosynthesis, photoperiodism, and photorespiration. The most favourable light intensity is in the range of 50000–70000 lux for the majority of the greenhouse vegetable crops. Plant development needs the presence of light. Photosynthesis rate is determined by the accessibility of nutrients, water, CO<sub>2</sub>, temperature, and light. Photosynthesis slows down and has an impact on growth when light intensity is

reduced. If greater optimum intensities are applied, it harms to the chloroplasts and growth slows. Light regulates a next job in photoperiodism, is reply of plant throughout the day-night cycle (Khan et al., 2021).

**c) Temperature**

Even though temperature has not any consequence on the light-dependent procedure of photosynthesis, temperature has an outcome on the light-independent reactions of photosynthesis. These are enzyme-dependent responses (Kume, Akitsu, and Nasahara, 2018). The whole rate amplifies when the enzymes arrive at their most favourable temperatures. With each 10°C rise in temperature, it approximately doubles. Temperature has a significant impact on plant's vegetative and photosynthetic activities. More than the idyllic temperature, the rate continues to decline as enzymes are denatured, awaiting it eventually ceases. It influences plant development by affecting the rate of several plant processes such as photosynthesis, transpiration, and respiration. For most crops, the highest activity is reached at temperatures range from 21 to 27<sup>0</sup> C throughout the day in a greenhouse (Khan et al., 2021).

**6. Vegetables Grown Under Hydroponics**

A hydroponics system can cultivate an enormous amount of plants, vegetables, and crops. The superiority of the construct, as well as the flavour and nutritional content of the ended products, is regularly better to that of natural soil-based farming. Several experimental studies revealed that Leafy greens (such as atriplex, parsley, celery, and spinach, among others) may be produced efficiently and willingly in hydroponic systems. Since their amplified development and nutrient assimilation ability, spinach is the most potential species to cultivate in combined hydroponics and aquaculture culture.

**a) Lettuce, spinach and other leafy vegetable growth in Hydroponics**

Lettuce can be produced effectively in the NFT system, and it is possible to grow more than 8 harvests each year in this method (Khan et al., 2021). Aside from lettuce, several hydroponic studies employing spinach as a model crop have lately been done. Ranawade et al. (2017) examined spinach production in hydroponic, aquaponic, and conventional systems in which the plants were supported by perlite (aquaponics) and sphagnum moss (hydroponics). The yield of aquaponic grown spinach was somewhat upper than that of hydroponically grown spinach. Hydroponically grown Swiss chard, lettuce, and sweet basil have elevated mineral ratio, a elevated root/shoot ratio, and inferior nitrate levels than soil cultivated, but their nutrient absorption and yield are inferior (Bulgari et al., 2016). The efficiency of rice husk as a substrate, both alone and in conjunction with perlite, was too tested in an NFT system for producing cabbage, mallow and red lettuce (Awad et al., 2017).

**b) Tomato and Pepper growth under Hydroponics**

Tomatoes may be grown in a variety of hydroponic systems, although the NFT and deep flow technique (DFT) are two of the most popular. Tomato had cultivated in an NFT system with frequent nutrient solution recycling. It enhanced growth, efficiency, and mineral composition. On the other hand, growing tomatoes in an NFT system

with delayed nutrient solution reprocessing, lowered yield (Khan et al., 2021). Effect of Hydroponics on growth of Pepper was also investigated by investigators. The effects of several substrates (vermiculite + sand, Peat + perlite, and rockwool) on the development and yield of hydroponically grown-up green pepper were investigated, and it was shown that peat + perlite had the mainly noteworthy influence on green pepper growing qualities and yield (Majdi et al., 2012; Khan et al., 2021).

## **7. Conclusions**

Hydroponics has just gained recognition as an alternative method for cultivating an assortment of crops. Because of the possibility to grow vegetables, all year in small spaces with few labour are enough. Hydroponics can create a momentous input in areas where soil and water level not suitable. The hydroponic in India is expected to blow up in the near future. It is significant to develop low-priced hydroponic setup that decrease dependence on human labour and inferior on the whole start up and functioning costs in order to support industrial hydroponic farms.



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## **CHAPTER 6**

### **FUNDAMENTAL OF PLANT TISSUE CULTURE**

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Plant tissue culture is a process of vegetative propagation in which plant parts, such as cells, tissues, or organs, are grown in cultured cells in sterile conditions. For the production of aseptic conditions, rapid production and exclusive plant material, plant tissue culture technique is imperative and widely used for the developing countries. Plant tissue culture techniques are the most largely used biotechnological implements for research into plant physiological process, efficient gene study, micro-propagation of commercial plants, transgenic plant cultivation with precise industrial and agronomical qualities, plant breeding and genetic enhancement, virus removal from infected materials to effectively make elevated healthy plant material, conservation. This chapter aimed to illuminate the role of plant tissue culture applications in developing countries.

#### **Introduction**

Tissue culture (TC) technique played a vital role for the advancement of plant cells, organs, or tissues on artificial medium under hegemonize environment (Mukund et al., 2012). Since more than 30 years this technique is used. It involves from single cell whole plant can be regenerated under sterile conditions. For the production of aseptic conditions, rapid production and exclusive plant material, plant tissue culture technique is imperative and widely used for the developing countries. For the small scale and large scale plant propagation companies Plant tissue culture technique is very effective (Bhatia and Ashwath 2008). Plant medium is taken from a mother plant, and the cells or tissues are grown and multiplied into hundreds of similar plants. Tissue culture enables propagators to conserve plant DNA, create more vigorous plants, and save money while increasing revenue. Its utilisation simply necessitates a nursery, a stable work environment, a green house, and skilled labour (Pawar et al., 2017).

#### **Importance of plant tissue culture**

Plant tissue culture methods have gained industrial importance and appeal in recent years, especially among firms trying to improve propagation efficiency. (Sathyanarayana 2007). Tissue culture has numerous advantages for anyone interested in plant multiplication, from a small-scale farmer to large-scale agriculture.

#### **Crop Enhancement**

Few things are more vital to a farmer than a large output. What factors influence a crop's ability to provide a healthy yield? The yield will be affected by anything from genetics to disease management (Aina 2012). Tissue culture allows a farmer to carry the desirable

genetics of a healthy mother plant throughout the crop. For various reasons, this is a game-changer:

- **Consistent Planting:** By eliminating the guesswork, a farmer may better manage harvesting and maintenance.
- **Genetic Enhancement:** Farmers can reap the benefits of ideal genetics over and time again. The best profit potential is found in genetics that promote high yields in the shortest amount of time and generate strong, disease-resistant plants.
- **Genetic Preservation:** Farmers can retain favourable genetics and minimise the risk of losing the genetic profile over time by applying a plant preservative mixture in the cultures.

### **For banana production**

However, banana production has dropped dramatically in the last 20 years due to significant soil deterioration and pest and disease infestations in banana orchards. The widespread technique of cultivating edible banana plants with contaminated suckers exacerbated the problem (Georgiev et al., 2017). The situation posed a threat to global food, employment, and wages in banana-producing area. Tissue culture technology was thought to be a viable solution for supplying adequate quality and quantity of such resources.

### **Basic terminologies in plant tissue culture**

**Micropropagation:-** Plant clonal multiplication in vitro from shoot tips or nodal explants which is frequently accompanied by increased shoot proliferation during subcultures.

**Differentiation:-** It is a biochemical or physical change in meristemic cells (at the root and shoot apex) that causes them to develop into permanent cells.

**Dedifferentiation:-** It is the process of persistent tissue regeneration that leads to meristematic renewal.

**Redifferentiation:** Meristems and tissues can create new cells that lose their ability to proliferate yet mature to execute specialised roles.

**Callus :-** a collection of cells obtained from healthy source tissue that have been grown in vitro to generate an undifferentiated mass of cells.

**Suspension culture:-** Individual cells or micro clumps of cells proliferate in a swirled liquid medium in this cultivation techniques.

**Inoculation:-** Contamination control is largely dependent on the care taken to prevent bacteria from entering the nutritional medium when the sterilised explants are transplanted.

**Subculture:-** a fresh cell or microbiological culture produced by transferring a number of or all cells from a prior culture to rapid developing media.

**Steps followed in plant tissue culture are as follows:-**

**Procedure for Sterilization:**

Principle: Microorganisms such as bacteria, fungus, and other microbes will multiply in the culture media, especially if it includes sugar (Pawar et.,al 2017).Due to its short life cycle when they in contact of media, microorganisms will occur speedy than the higher plant As a result, the surface of plant tissue and all non-living objects are prohibited (Akhond and Machray 2009).

**Procedure:**

**Non-living Articles Sterilization:-**

Non-living materials, such as medium supplemented, glassware, distilled water, and equipment, are properly sterilized at temperature of 120°C and pressure of 15 lb/in<sup>2</sup> for 15 minutes.

**Plant Material Sterilization:**

To eradicate surface born bacteria Plant material that will be cultured in the surface should be properly sterilized, this process is performed in laminar air flow to provide contamination free artificial environment.

- (1) Firstly the explants should be properly washed in tap and then for 10 minutes dip the explants in liquid detergent (Teepol). Afterwards, wash with distilled water.
- (2) In the laminar air flow for 60 seconds soak the explants in 70% ethyl alcohol.
- (3) After this Immediately pour 0.1 percent mercuric chloride for 2-3 minutes.
- (4) Decant the sterling after 10-15 minutes and carefully wash the explants with numerous changes of water.
- (5) The explants are now ready to be cultured.

**MS Media preparation**

For plant cell culture production Murashige and Skoog media used in laboratories.

Preparation of stock solutions as we can see in Table1.1 (Azad et.,al 2012)

Stock solutions & components	Amount per litre mg
<b>Stock A (Macronutrients 10x)</b>	
NH <sub>4</sub> NO <sub>3</sub> ,	16500
KNO <sub>3</sub> ,	19000
CaCl <sub>2</sub> .2H <sub>2</sub> O	4400
MgSO <sub>4</sub> .7H <sub>2</sub> O	3700
KH <sub>2</sub> PO <sub>4</sub>	1100
<b>Stock B (Micronutrients 100x)</b>	
Mn SO <sub>4</sub> .4H <sub>2</sub> O	2230
Zn SO <sub>4</sub> .4H <sub>2</sub> O	860

H <sub>3</sub> BO <sub>3</sub>	620
KI	83
<b>Stock C (Vitamins 100x)</b>	
Glycine	20
Nicotinic acid	5
Pyridoxine HCL	5
Thiamine HCL	1
Myo-inositol	1000
<b>Stock D(Fe-EDTA 100x)</b>	
FeSO <sub>4</sub> .7H <sub>2</sub> O	278
Na <sub>2</sub> EDTA.2H <sub>2</sub> O	373

**Table1.1** MS Media Composition

**\* Preparation of 1 L of MS medium from stock solutions**

1. To 600 mL of distilled water (with stirring):
  - (a) Addition of 100 mL of macronutrient (stock solution I)
  - (b) Addition of 10 mL of micronutrient (stock solution 2).
  - (c) Addition of 10 mL of vitamin (stock solution 3).
  - (d) Addition of 10 mL of Fe-EDTA (stock solution 4).
2. Addition of cytokinin and/or auxins as required.
3. Addition of sucrose (usually 30 g/L)
4. Make up volume to 1 L with distilled water.
5. Adjust pH to 5.8.
6. Addition of agar, usually 6-10 g/L and dissolve.
7. Dispense into suitable culture vessels and autoclave

**Inoculation**

Contamination control is largely dependent on the handling engaged to avoid microbe ingress during the transfer of sterilised explants to the nutrient medium. (Lowder and Malzahn 2018) Contamination can be spread by dust, hair, hands, and clothing. Before entering the culture area, the inoculating chamber should be dust-free, and the operator should wear sterile equipment and clothing (aprons) as we can see in following (Fig1.1)



Fig 1.1 Inoculation of Explants

Before beginning the transfer process, cleanse your hands with 95 percent alcohol and clean and wipe the transfer surface with 95 percent alcohol as well. During the transfer of the explant into the media, avoid talking or sneezing (Manoj et.,al 2011). The culture container's neck or mouth should be flamed, and the transferring devices should be flamed and dipped in alcohol as well.

### **Incubation**

For inoculation at the temperature of below or above 25°C cultures are incubated in growth rooms. Some tissues develop in low light, rejuvenation necessitates light and dark periods and regenerated plantlets require a environment with 16 hours of light and 8 hours of night (Zhou et.,al 2017). To provide luminance in the culture chamber, a cool white fluorescent light is placed approximately 18" above the culture racks as seen in (Fig 1.2). In the culture room, a specific relative humidity of 20-98 percent must be maintained, as well as sufficient air circulation (Wang et.,al 2015).

### **Subcultures**

Tissues cultivated in vitro are usually observed at recurring at short intervals in the culture room or incubators to monitor their growth and development (Soyk et.,al 2017). Depending on the status of cell or tissue growth, explants may be required to be transferred to new media (freshly prepared), new components, or hormone composition based on interpretation prepared with a hand lens or a basic microscope with aseptic conditions (Waghmare et.,al 2017). During the transfer process, the same precautions and aseptic conditions are followed. Delaying this process may cause tissue development to be inhibited, as well as plantlet regeneration to be delayed (Babili and Beyer 2009). In the case of suspension culture, it is necessary to change the media or inoculate with fresh inoculum at regular intervals.



Fig 1.2 Growth Room (cultures placed)

### **Transplantation of the Regenerated Plant:**

For regeneration process the culture plants are transferred to soil under *in vitro* condition. Acclimatization of these regenerated plants is required prior to their transfer to pots. At this point, the plants have developed enough root systems and cuticular leaf surface organization to tolerate the field atmosphere (Pazuki et.,al 2013). In the greenhouse, an simulated light arrangement made up of a combination of fluorescent and incandescent lamps that generate light with impartial wavelengths for optimum growth and photosynthesis of plant should also be installed (Srivastava et.,al 2017). The greenhouses are required for both winter and summer crops.

### **Conclusion**

Plant tissue culture is one of the most viable areas of application right now, with a favorable outcome ahead of it. *In vitro* culture has a distinct responsibility in agriculture and forestry, and it has been widely used in plant breeding to introduce enhanced plants rapidly. Plant tissue culture has become an important aspect of the plant breeding process. It can also be utilized for making edible vaccinations by growing plants. Tissue cultures can create a variety of useful plant-derived chemicals. Cell culture has a lot of potential in terms of developing important secondary metabolites. Plant tissue culture is a decent technique for extracting these compounds in big quantities.



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## CHAPTER 7

### FOOD MICROBIOLOGY BASIC CONCEPTS

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#### **Introduction**

Biotechnology has been applied food industry for longer time. The major example is Fermentation, which is being used to develop some food products like wine, beer and bread for about ten thousand years. Various techniques are used to modify the genes of our food producing plants is known as food biotechnology. Biotechnology is being used to improve food products and develop new varieties of food. Major improvement in food involves making food affordable to produce, longer life, potential of disease resistant and also improve quantity of nutrients. The International Food Information Council Foundation writes about harnessing biotechnology to help provide the food we need. The another field which is combination of technology and microbiology is food microbiology. In this chapter we will discuss some important aspects of food microbiology.

#### **The origins of food fermentation**

Unlike Darwin and Mendel, who were pure scientists in today's terms, Pasteur took a more pragmatic approach as an applied scientist. One of his main concerns was vinegar production, which had previously had variable results due to infection by unsuitable microorganisms. Pasteur was the first to recognise the microorganisms required and isolate them in their purest form. Vinegar may then be reliably manufactured under regulated conditions, allowing for large-scale and cost-effective manufacturing.

Many food components are now manufactured using microorganism in large scale fermenters. For example citric acid is produced from the fungus *Aspergillus niger* in a less expensive and time-consuming process. Monosodium glutamate is a flavour enhancer generated from the bacteria *Corynebacterium glutamicum*; worldwide production of this substance was over 300,000 tonnes in 1993. Fermentation is used to make yeast extracts for use as food flavourings, and it is also used to make lactic acid.

#### **History of Food Microbiology**

The history of the discipline of food microbiology is obscure. Events spanning decades led to the eventual recognition of the significance and function of bacteria in foods. Foodborne illness and food deterioration have been in some form or another since the beginning of mankind. Although the precise cause of these problems would not be known for tens of thousands of years, numerous ancient civilizations created and put into practice great methods for food preservation and protection, including:

Evidence that the Babylonians brewed beer dates back to 7000 BC (fermentation). Wine first appeared around 3500 BC. The local water supply was frequently contaminated with

intestinal microorganisms that caused cholera, dysentery, and other serious diseases in early civilizations (and even today in underdeveloped countries where modern sanitation is lacking). As a result, alcoholic beverages like beer and wine were much safer to consume than the local water supply.

3000 BC - For the first time in recorded history, the Egyptians created cheese (fermentation) and butter in 3000 BC. The oldest known mention of food spoilage in written history dates back to 6000 BC (fermentation, low aw). It has been discovered that foods that have undergone fermentation, such as cheese and sour milk (yoghurt), are both safer to consume and more durable than their raw farmed counterparts. Around this time, several societies learnt to preserve meat and other goods with salt (low aw).

1000 BC — There are accounts of foods being smoked and fermented, and the Romans used snow to preserve shrimp (at a low temperature).

Early human cultures learned how to effectively preserve food through the use of salt, ice, drying, and smoking, but they were unaware of how these techniques prevented food deterioration or disease. Their ignorance was made worse by their belief that living things spontaneously developed from nonliving matter (Theory of Spontaneous Generation).

1665 – Italian physician Francesco Redi discovered that maggots on decaying meat were fly larvae; he advised placing the meat in a container wrapped with small gauze to prevent flies from laying eggs. This was the first step away from the idea of spontaneous generation.

In 1683, Dutchman Anton van Leeuwenhoek used a microscope to research and write about germs. In order to share and publish scientific research, the Royal Society was established in England at this time, and Leeuwenhoek was invited to present his results. He performed this for approximately 50 years, up to his demise in 1723. As a result, Leeuwenhoek's reports gained widespread recognition, and he is justly given the credit for discovering the world of microbes.

1765 – Spallanzani, an Italian, attempted to dispute the hypothesis of spontaneous production of life by demonstrating that boiling and sealed cow broth remained sterile. Supporters of the hypothesis dismissed his study, claiming that his treatment left out Oxygen, which was necessary for spontaneous generation.

1795 – The French government offered a prize of 12,000 francs to anyone who invent an effective method of food preservation. After demonstrating that meat could be kept by boiling it in glass bottles, a French confectioner, Nicholas Appert was granted the patent. This was the start of canning as a method of food preservation.

1837 – Schwann establishes that heated infusions remain sterile in the presence of air in 1837, refuting the theory of spontaneous generation (which he introduced through heated coils). While both Spallanzani and Schwann used heat to preserve food, it's important to note that neither man seemed to realise the potential in turning their discoveries into a widely used commercial food preservation technique.

The causal link between bacteria in infusions and the chemical changes that took place in those infusions was first recognised and understood by **Louis Pasteur**. The scientific world

was persuaded by Pasteur's studies that all fermentative processes are caused by bacteria, and that particular types of fermentations (such as alcoholic, lactic, or butyric) are caused by different microorganisms.

Pasteur demonstrated that bacteria created sour milk in 1857 and that heat eliminated undesired microbes in wine and beer in 1860. Pasteurization is the latter procedure, which is presently utilised for a range of foods. Pasteur is regarded as the inventor of food microbiology and microbiological science due to the significance of his work. With his renowned swan-necked flasks, he disproved spontaneous generation by demonstrating that air does not need to be heated to be sterile.

Some of Pasteur's most notable achievements include:

- Demonstrated that fermentation is a result of microbial processes different bacterial species which generate different types of fermentation (e.g., lactic, butyric, etc.). Pasteur argued that because bacteria were responsible for fermentation and putrefaction, they were also causative agents in disease. These ideas finally reached Joseph Lister, an English physician who used them to create the first aseptic surgical methods.
- He developed vaccination to defend sheep against anthrax by isolating an attenuated (avirulent) strain of the dangerous bacteria, *Bacillus anthracis*. Pasteur was able to isolate the weaker germs by cultivating them at a high temperature (42°C C). The attenuated bacteria caused sheep to become resistant to the more dangerous strains. Although Pasteur did not understand the cause of attenuation, we now understand that the pathogenicity of these bacteria depends on the presence of a plasmid that cannot reproduce at 42°C.

Using an attenuated strain of the bacteria he had isolated in his laboratory, Pasteur also devised a method to immunise chickens against the cholera produced by *Pasteurella septica*.

Microbiological discoveries and advancements began to accelerate after Pasteur's period. Microbes were linked to a variety of diseases, heat-resistant spores were discovered, poisons were discovered, and countries began to establish legislation to preserve food quality by the late 1800s.

Before adopting industry-wide microbiological standards, many food companies in the United States waited until they were put in financial risk due to the publicity surrounding outbreaks of food-borne illness. The United States canning industry adopted the 12D method, which lowers the likelihood of survival of the most heat resistant *C. botulinum* spores to one in a billion, as a result of several botulism outbreaks in the early 1920s (10-12). The canning industry has produced more than a trillion containers since 1925 with just 5–6 known cases of botulism, and this process is still used today. The majority of these incidents involved broken containers that weren't being handled at the time.

Around the same time, outbreaks of typhoid fever, diphtheria, tuberculosis, and brucellosis that were transmitted through milk prompted the dairy industry to develop microbiological control over milk. Public health authorities demanded pasteurisation (which had an immediate and very effective impact on the problems), cleanliness, refrigeration, and all of

these practises were upheld by bacterial standards. Because of this, pasteurised milk was one of our safest foods by the middle of the nineteenth century.

A woman who became known as "Typhoid Mary" was institutionalised by the New York state government in one of the more strange incidents in early food microbiology. Mary was a typhoid carrier who was asymptomatic at the turn of the century and a chef for several different families. She was directly connected to seven typhoid outbreaks over a ten-year period, and estimates place 51 cases of typhoid fever at her disposal. She was taken into custody by New York authorities, who tried to remove her gall bladder, but she was eventually released after promising never to work as a cook again. She was detained as a threat to public safety when a further outbreak was linked to her a few years later, and she remained in the hospital until her death in 1938.

### Types of Microorganisms in food

Microorganisms play a big part in the food industry. Numerous meals are produced by microorganisms, and they are also in charge of causing food to spoil, which can result in illness and poisoning.

The most frequent times that food products become contaminated by microorganisms are during the transfer from the farm to the processing plant, as well as during processing, storage, transportation, and distribution, as well as just before consumption. The microorganisms that cause food to spoil and that are used most extensively in the production of food and food products include bacteria, moulds, and yeasts.

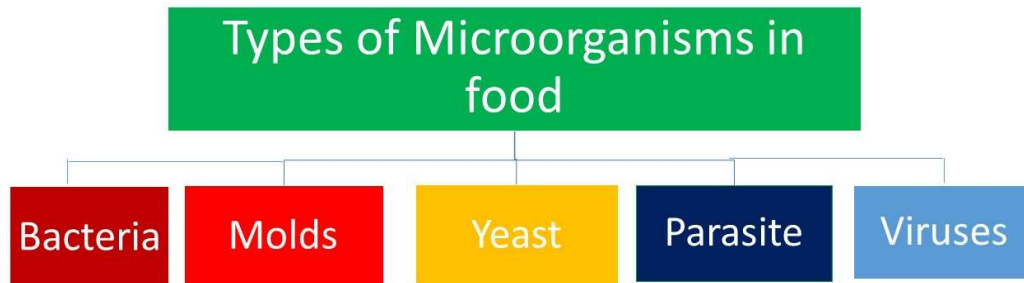


Figure 1: Types of Microorganisms in food

#### Bacteria

The most prevalent single-celled bacterial species are bacteria. The three types of therapeutically important bacteria are cocci, or spherical cells, bacilli, or cylindrical or rod-shaped cells, and spiral, or curved forms. Despite the fact that gram-negative bacteria often cause disease, three gram-positive rods have been connected to food poisoning: *Clostridium perfringens*, *Bacillus cereus*, and *Clostridium botulinum*.

Some of the other most common bacteria causing food spoilage, infections and disease are *Acinetobacter*, *Aeromonas*, *Escherichia*, *Proteus*, *Alcaligenes*, *Flavobacterium*, *Pseudomonas*, *Arcobacter*, *Salmonella*, *Lactococcus*, *Serratia*, *Campylobacter*, *Shigella*, *Citrobacter*, *Listeria*, *Staphylococcus*, *Micrococcus*, *Corynebacterium*, *Vibrio* *Enterobacter*, *Paenibacillus*, *Weissella*, *Enterococcus*, *Yersinia*

Additionally, different bacterial strains are used in the production of various meals and dairy products. To produce fermented foods and dairy products, bacteria strains such as *Streptococcus*, *Lactobacillus*, *Erwinia*, and others are used. *Streptococcus thermophilus* and *Lactobacillus bulgaricus* microorganisms are used to make yoghurt.

### **Groups of Bacteria important in food Bacteriology**

#### **1. Lactic acid – forming bacteria or lactics:**

Lactic acid is formed when carbohydrates are fermented by these microorganisms. This could be beneficial when creating items like sauerkraut and cheese. However, because they usually form acid quickly, they are undesirable in terms of wine spoilage.

Ex: *Leuconostoc*, *Lacto bacillus*, *Streptococcus* and *Pediococcus*.

#### **2. Acetic acid forming bacteria or acetics:**

Bacteria from two genera, are mostly used for the Acetic acid production: *Acetobacter* and *Gluconobacter*. Both can convert ethyl alcohol to acetic acid, but *Acetobacter* can also convert acetic acid to CO<sub>2</sub>.

The importance of acetic acid bacteria can be attributed to a number of factors.

1. Their ability to convert ethanol to acetic acid by oxidation.
2. Their great oxidising capacity causes acetic acid to be oxidised by either desirable or undesired sps under favourable conditions.
3. Some species have excessive sliminess.

*Acetobacter acetic* subsp. *suboxydans*, for example. Vinegar generators become clogged as a result of this microorganism.

#### **3. Butyric acid forming bacteria or butyrics:**

These bacteria grow in anaerobic conditions and produce spores- Example genus *Clostridium*.

#### **4. Propionic acid – forming bacteria or propionics:** Ex: Propionic bacterium

#### **5. Proteolytic bacteria:**

They generate extracellular proteinases. Proteolytic bacteria come in a variety of forms, including facultative, spore-forming, anaerobic, and spore-forming bacteria.

An aerobic, spore-forming bacteria is called *Bacillus cereus*.

Non-spore-forming and facultatively aerobic *Pseudomonas fluorescens*.

*Clostridium sporogenes*: anaerobic and spore-forming Additional examples include *Proteus*, *Bacillus*, and *Clostridium*. For instance, *Streptococcus faecalis* var. *liquefaciens*. proteolytic acid *Caseolytic Micrococcus*

#### 4. **Lipolytic Bacteria:**

Lipases are enzymes that catalyse the breakdown of fats to create fatty acids and glycerol. Many aerobic bacteria that are actively proteolytic are also lipolytic. Strongly lipolytic *Pseudomonas fluorescens*

*Pseudomonas*, *Alcaligenes*, *Staphylococcus*, *Serratia*, and *Micrococcus* are some of the bacteria found in the genera *Pseudomonas*, *Alcaligenes*, *Staphylococcus*, *Serratia*, and *Micrococcus*.

#### 5. **Saccharolytic bacteria:**

Disaccharides or polysaccharides are hydrolyzed by these bacteria into simpler sugars. Amylase is produced by amylolytic bacteria and is used to hydrolyze starch outside of the cell.

*Bacillus subtilis* and *Clostridium butyricum* are amylolytic bacteria.

#### 6. **Pectinolytic Bacteria:**

Pectins are complex carbohydrates that give vegetables and fruits their hard cell walls. Citrus-derived pectic compounds can be employed as gelling agents in commercial products. Ex: *Erwinia*, *Bacillus*, *Clostridium*, *Achromobacter*, *Aeromonas*, *Arthrobacter*, *Flavobacterium*.

#### **Molds:**

Moulds are multicellular filamentous fungus. The growing moulds have a fuzzy or cottony appearance on food. With a low pH and a low moisture need, they are mostly causative agents for food deteriorating at room temperature, between 25 and 30 degrees Celsius. Mold can quickly develop on grains and corns that are stored in wet settings. Molds grow on the surface of contaminated food since they require free oxygen to grow.

Additionally, moulds are employed in the production of numerous foods and food products. They're used to mature cheese, among other items (e.g. Roquefort, Camembert). Additionally, chemicals like citric acid, which is used in soft drinks, and enzymes like amylase, which is needed to make bread, are produced by moulds. Moulds are also used for ripening of many Asian food. A fungus called *Bothrytis cinerea* helps grapes decay so that wine can be made. Viili is a distinctive fermented milk made in Finland via lactic fermentation and mould.

#### **Yeasts:**

Yeasts are frequently utilised in the food industry because they can convert carbohydrates into ethanol and carbon dioxide. The most popular yeast, baker's yeast, is produced industrially. *Saccharomyces carlsbergensis* is the yeast that is most frequently employed in the fermentation of beer. *Brettanomyces*, *Schizosaccharomyces*, *Candida*, *Cryptococcus*, *Debaryomyces*, *Zygosaccharomyces*, *Hanseniaspora*, and *Saccharomyces* are some of the other yeast strains that are significant.



**Parasites**

Parasites do not have beneficial role in food. Many parasites, such as helminths, have a complicated life cycle that involves multiple hosts. The most common way for these parasites to spread to people is through food. The tendency appears to be the intake of undercooked pork or beef, as well as raw salads rinsed in contaminated water.

**Viruses**

Viruses have not beneficial role in food industry as bacteria, yeast and molds. Viruses are not able to multiply in foods. Viruses are transmitted to food by food handlers and the use of dirty utensils. Viruses mostly cause food poisoning and other diseases.

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## **CHAPTER 8**

### **SIGNIFICANCE OF MICROORGANISMS IN FOOD**

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#### **Description :**

This book chapter is related to important role of microorganisms in food microbiology. In this book chapter, beneficial role of microorganisms like bacteria, molds and yeast are described. Microorganisms also cause food spoilage and some of the microorganisms are pathogenic in nature. In this chapter, a brief on microorganisms in food production, microorganisms in food spoilage and microorganisms with pathogenic nature, are explained.

#### **Introduction :**

Microorganisms play a significant role in the development of many different types of food products. Microorganisms have been assisting humans with food and nourishment since the dawn of time through the use of fermentation processes. Nature utilises microbes to carry out fermentation processes, and for thousands of years, people have used yeasts, moulds, and bacteria to produce foods like bread, beer, wine, vinegar, yoghurt, and cheese as well as fermented fish, meat, and vegetables.

One of the earliest processes for preserving and transforming food is fermentation. This biological mechanism preserves food while improving its nutritional and organoleptic qualities. In order to minimise spoilage and increase taste and texture, a well-run fermentation will favour beneficial organisms over undesired flora. But microorganisms also cause some food spoilage. Some of them cause complete spoilage of food and can even cause serious infections to humans and animals. These kinds of microorganisms are considered as pathogenic microorganisms.

#### **Microorganisms in Food production**

The three types of microorganisms that are most frequently used are yeast, bacteria, and moulds. The fermentation process, which yields organic acids, alcohols, and esters, is a good illustration of how microorganisms are used in the manufacture of food. These help to either:

1. Preserve the food
2. generate distinctive new food products

#### **Yeast in food production**

##### **Yeasts of industrial importance**

The *Saccharomyces* genus is the mostly utilised yeast in industry. Any yeast different than the one being used or fostered is referred to as "wild yeast." As a result, yeast used in one process may be wild yeast in another. Asporogenous, or fake, yeasts make up the majority of the harmful wild yeasts.

***Schizosaccharomyces*** is a yeast that belongs to the genus Schizosaccharo. They are present in molasses, tropical fruits, soil, honey, and other places. *Schizosaccharomyces* reproduce asexually by binary fission and form ascospores after isogamic conjugation. *S. pombe* is a common species.

**Genus *Saccharomyces*** These are most important yeast. Cell of these yeast can be found in different shapes like round, ovate, or elongated. Some of them can form pseudo-mycelium. *Saccharomyces* reproduce by multipolar budding or ascospore formation. Shape of ascospores are generally spherical or oval, with one to four ascospores per ascus. The most prevalent species, *S. cerevisiae*, is utilised in a wide range of food industries. *S. cerevisiae* is used to leaven bread, as top yeasts for ales and wines, and to produce alcohol, glycerol, and invertase.

Bread that rises and bakery goods: *Saccharomyces cerevisiae* ferments carbohydrates to release CO<sub>2</sub>, which gives baked goods their porous structure. It also contributes to flavour by producing alcohols, aldehydes, esters, and other compounds.

- Wine
- Vinegar
- Pickles
- Beer

### **Bacteria in food production**

- Fermented milk products: *Lactobacillus*, *Lactococcus*, *Bifidobacterium*
- Production of some food like Indian dosa, rabri: fermentation by *Leuconostoc mesenteroides*, *S. faecalis*
- Prebiotics - Production of living food supplements called probiotics. It contains *Bifidobacterium bifidum* and *Lactobacillus acidophilus*. To have any discernible impact, at least 10<sup>8</sup> bacteria per 1 ml must reach the colon alive.
- These microorganisms broaden the gut's microbial population, which has the following effects:
  1. Have an impact on immunity, preventing or milder diarrheal illnesses
  2. Reduce the chance of colon cancer
  3. Reduce the absorption of cholesterol
  4. Generate acids that lower the gut's pH and boost the absorption of minerals like calcium and phosphorus.

### **Molds in food production**

Molds have an important role in food production as well as in production of some important vitamins, flavours and nutrients. Some molds important in food production include:

***Mucor*:** *Mucor* has a beneficial role as production of some foods and also a harmful role as they are involved in spoilage of food and food products. *Mucor* helps in ripening of cheese. *M.*

*Racemosus* and *M. rouxii* are used in saccharification of starch. Some species of *Mucor* are being used in production of Oriental foods.

**Penicillium:** This is another genus that is widespread in occurrence and important in foods.

Some food products from molds are:

- *Penicillium camemberti* and *roqueforti*, two species for cheese production
- Dry salami: produced by *Scopulariopsis* and *Penicillium* moulds.
- Soy sauce production involves *Aspergillus* species, particularly *A. oryzae*. Additionally, lactic bacteria produce lactic acid during the subsequent lactic fermentation.
- Sake is made by combining yeast and the mould *Aspergillus oryzae*.

### Food Spoilage

Microorganisms such as bacteria, yeast, and moulds can grow in food and spoil it. Food poisoning can also be caused by bacteria. Food deterioration, which is brought on by bacteria, moulds, and yeasts, occurs when foods change in appearance, consistency, flavour, and odour.

**Bacteria:** Examples of action of bacteria involved in food spoilage:

1. Lactic acid forming bacteria: *Lactobacillus*, *Leuconostoc*
2. Lipolytic bacteria: *Pseudomonas*, *Alcaligenes*, *Serratia*, *Micrococcus*
3. Bacteria involved in pigment formation in food: *Flavobacterium*, *Serratia*, *Micrococcus*
4. Bacteria involved in Gas formation in food: *Leuconostoc*, *Lactobacillus*, *Proteus*
5. Bacteria involved in Slime or rope formation in food: *Enterobacter*, *Streptococcus*

Some important Bacteria in food spoilage

- *Bacillus cereus* (*B. cereus*)
- *Brucella* species (*Brucella* spp)
- *Campylobacter* spp
- *Clostridium botulinum* (*C. botulinum*)
- *Clostridium perfringens* (*C. perfringens*)
- *Escherichia coli*
- *Listeria monocytogenes* (*L. monocytogenes*)
- *Salmonella* spp
- *Shigella* spp
- *Staphylococcus aureus* (*S. aureus*)
- *Yersinia enterocolitica* (*Y. enterocolitica*)

### Molds in food spoilage

*Aspergillus:* Many species of *Aspergillus* are involved in the spoilage of foods

**Rhizopus** *Rhizopus stolonifer*, can spoil many foods like berries, fruits, vegetables, bread, etc.

**Thamnidium:** *Thamnidium elegans* can cause "whiskers" on the meat.

**Geotrichum (Oospora or Oidium)** *Geotrichum candidum* (Oosporalactis), often called the "dairy mold," gives white to cream-colored growth.

**Neurospora (Monilia):** Also known as "red bread mold" because its pink, loose-textured growth often occurs on bread.

### **Pathogenic micro-organisms in food**

Pathogenic microorganisms include bacteria, viruses, parasites, and moulds, which can result in food-borne diseases or poisoning. It's important to keep in mind that because harmful bacteria and viruses are invisible or difficult to detect, they rarely cause food to spoil.

The following are the primary causes of foodborne illnesses:

1. Collection of raw material from unreliable sources
2. Inadequate heat for frying or processing
3. Poor cooling and storage practises, such as keeping prepared foods at room temperature for long periods of time or keeping products in oversized refrigerator containers.
4. Delaying the eating of food for several hours.
5. Inadequate reheating
6. Food handling by infected individuals or carriers
7. Inadequate hot holding, or holding at temperatures below 65 °C
8. Cross-contamination of raw food to cook food.
9. Inappropriate cleaning of equipment and utensil

### **Bacteria**

Some bacteria cause food poisoning diseases and also cause spoilage in food products. The important bacteria with pathogenic nature in food include:

- ***Campylobacter jejuni*:** Both humans and animals can get diarrhoea from this pathogen. The disease can spread through direct human contact with infected animals as well as through their excrement. The most common way for it to spread from person to person is through the consumption of contaminated food or drink. From moderate diarrhoea to a serious invasive disease with fever, stomach pain, and blood and mucus in the stools, the symptoms may vary.

- ***Non-typhi salmonellosis*:** Only a small number of the more than 2000 serotypes of *Salmonella* spp. cause human *Salmonella* gastroenteritis. Symptoms include fever, nausea, cramps, and acute watery diarrhoea. There is also chances of bleeding in patient's stool. Animals serve as the main reservoir for the disease, and transmission occurs by ingestion of contaminated food.

***Salmonella typhi* and *paratyphi*:** These two bacteria cause typhoid and paratyphoid fever. The main reservoir is humans and transmission occurs through person-to-person contact or food contamination by food handlers.

***Staphylococcus aureus*:** This sickness originates in people. Clinically healthy individuals usually have lower concentrations of germs found in their noses and on their skin. Higher quantities can be seen in pus-draining skin lesions like infected eczema, psoriasis, or any other. Food poisoning from this bacteria, which manifests as diarrhoea, vomiting, cramps, and fever, is brought on by heat-resistant staphylotoxin. The symptoms appear out of nowhere and typically disappear in a day.

- ***Escherichia coli*:** *E. coli* comes in a variety of serotypes, some of which are safe for humans but can still give some people diarrhoea. The enterotoxigenic strain of *E. coli* is the most frequent cause of traveler's diarrhoea. The infection comes from people and is spread by contaminated food and drink.

- ***Listeria monocytogenes*:** These bacteria have capacity to develop at low temperatures, so are frequently associated with food kept in the refrigerator for extended periods of time. It can cause septicemia and meningitis in susceptible individuals, both of which are potentially fatal.

- ***Shigella*:** *Shigella* infect humans and primates. Due to the low infectious dosage, person-to-person contact is the main way that the disease is spread. Additionally, it can spread through contamination in food and water. Shigellosis symptoms include fever and watery diarrhoea. The infection may also result in a condition known as dysenteric syndrome, which includes mucus- and blood-filled, small-volume faeces on a regular basis.

- ***Vibrio cholerae*:** This bacteria infect humans. Contaminated water, food, and person-to-person contact in crowded, unclean settings are the main means of transmission. Up to 20 litres of severe watery diarrhoea can be produced daily by it.

- ***Clostridium Botulinum*:** Fish, birds, and mammals' digestive tracts are the primary reservoirs for the bacterium *Clostridium botulinum*. Additionally, nature is abounding with it. An anaerobe, the bacteria forms spores and has a potent heat-labile toxin that harms the nervous system.

**Moulds:** Some strains produce mycotoxins under certain conditions

1. *Aspergillus* produces aflatoxin, ochratoxin, citrinin and patulin
2. *Fusarium*
3. *Cladosporium*
4. *Alternaria*

Mycotoxins can also enter food components that don't appear to be mouldy. Therefore, if any food item is mouldy, the entire batch must be thrown away. Due of their stability against heat and chemicals, they are extremely tough to destroy.

- Hepatotoxins such as luteoskyrin, sporidesmins, and aflatoxins

- Ochratoxin and citrinin are nephrotoxins.
- Trichocetins are GIT toxin.
- Tremorgens and citreoviridin are neuro- and myotoxins.
- Dermatotoxins, including trichocetes, psoralen, verukarins, and sporidesmins
- Patulin is a respiratory tract toxin.

Foods most at risk for moulds:

1. Grains and grain products contain various types of mycotoxins
2. Peanuts, nuts and pulses may contain aflatoxin
3. Fruits and vegetables (raw and preserved) are contaminated by patulin
4. Milk and milk products also contain aflatoxin

It is important to note that if any contaminated fodder is fed to animals, this is metabolized and the toxic derivatives can be found in animal products consumed by humans, e.g. milk and meat.

## Viruses

Viruses are incapable of reproducing in food. Food handlers and the use of dirty utensils are the main modes of transmission, as the virus is transferred to food and then consumed by humans.

- The most common causes of gastroenteritis are rotaviruses and Norwalk virus.
- Asymptomatic carriers who handle food are the main source of viral hepatitis A outbreaks.

Viruses

- Hepatitis A and D
- Norovirus
- Rotaviruses

## Parasites

Pig and beef are sources of parasites *Taeniasolium* and *Taeniasaginata*, respectively. The mature worm emerges in the intestine when the animal's muscle is devoured by its cysts. The ova have the ability to develop into larvae that attack many tissues, including the brain, leading to cysticercosis and other severe neurological conditions.

**Trichinellaspidualis:** Undercooked pork contains *Trichinellaspidualis*. The larvae have the ability to enter tissues and produce a fever.

**Giardia lambila:** A parasite infection called *Giardia lambila* can spread via food, water, or personal contact. Along with abdominal pain and bloating, it also leads to acute or subacute diarrhoea, malabsorption, greasy stools, and abdominal pain.



***Entamoebahistolytica*** : The main ways that food or water transfer are *Entamoebahistolytica*. Cysts pose a serious concern because they are very resistant to chemical disinfectants, including chlorination. Although it may present as fulminant dysentery or chronic, severe diarrhoea, the sickness is typically painless.

#### **Important examples of microorganisms usesin food**

- The most prevalent microorganisms that cause food to spoil are bacteria, moulds, and yeast, which are also extensively used in the manufacturing of food and food products.
  - A wide variety of cultured milk products are made by fermenting dairy products using different strains of bacteria and fungi. These cheese-making processes use both bacteria and fungi.
  - The food and health sectors use the microorganisms *Lactobacillus* and *Bifidobacterium*.
  - Milk is used to manufacture a variety of cheeses, including soft unripened, soft ripened, semisoft, hard, and extremely hard kinds, by using lactic acid bacteria to coagulate it
- An another well-liked food source that is sold in specialised shops is spirulina, a kind of *cyanobacterium*.
- For the production of different wine varieties, moulds are used to rot grapes.
  - Mushrooms are one of the most significant fungus used as a food source (*Agaricusbisporus*).
  - Alcoholic drinks, including beer, are created by fermenting grains and cereals with different yeast strains.

#### **Conclusion**

In this book chapter, function of microorganisms in food microbiology is covered . Since many different types of dairy products are produced by microorganisms and humans . Since ancient times, microorganisms have been employed to produce a variety of food products through fermentation. Those bacteria that can produce food are categorised as helpful microorganisms. However, some microorganisms cause some foods and food products to deteriorate. Even certain microbes have the potential to infect humans and animals severely. These microorganisms belong to the class of pathogenic microorganisms. In this chapter, both beneficial and pathogenic microorganism are briefly described.

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## CHAPTER 9

### BASICS CONCEPTS OF ENVIRONMENTAL BIOTECHNOLOGY

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Environmental biotechnology, specifically, refers to the application of technological methods to preserve and improve the condition of the environment. The environment is a complicated concoction of many different factors made up of the physical and biological surroundings as well as their interactions. Every organism is impacted by environmental problems such as ozone depletion, global warming, overpopulation, resource depletion, loss of biodiversity, and more. The current environmental problems make us vulnerable to catastrophes and tragedies both now and in the future. The precarious state of environmental health can only be improved by having a deeper understanding of the interactions between various living species and physical and chemical processes.

Environmental biotechnology is the expanding field of biotechnology that applies to agriculture, resource conservation, environmental preservation, monitoring of polluted environments, and waste management. It could be seen as a motivating factor for all-encompassing environmental conservation that promotes sustainable growth.

Development that can be sustained over many generations as opposed to just a few years is referred to as sustainable development. It calls for the creation of an international framework for fusing environmental policy with development programmes. Environmental biotechnology has the potential to revolutionise several fields, including genetic engineering, solid waste and wastewater treatment, production with less pollution or raw resources, and environmental monitoring. Environmental biotechnology is a long-term strategy to create safe processes and products that are less hazardous and have a smaller environmental impact than their predecessors because it has a significant potential to help with the prevention, detection, and repair of pollution and waste degradation. When it comes to clean technology solutions, it is crucial in the industrial, agroforestry, food, raw material, and mineral sectors.

To identify, stop, and correct hazardous emissions into the environment, environmental biotechnology can be used in a number of ways. Wastes that are solid, liquid, or gaseous can all be modified, either to create new products or to lessen their environmental impact. By substituting biological components for chemical ones in technological processes, we can reduce our influence on the environment. Environmental biotechnology can considerably contribute to long-term growth in this strategy. Today, one of the scientific fields with the most rapid growth and application is environmental biotechnology. Exploitable bacteria' genetics, biochemistry, and physiology are rapidly being translated into economically viable technology for reversing and preventing further environmental damage.

## **Applications of Environmental Biotechnology:**

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### **Bioremediation**

Utilizing microorganisms to remove or detoxify chemicals from sediments, water, or soil that could otherwise be hazardous to human health is known as bioremediation. Other names for bioremediation include biotreatment, bioreclamation, and biorestitution. The idea of bioremediation is not new. Microorganisms have been used to eliminate organic waste and harmful substances from household and industrial waste for a long time.

Environmental biotechnology, on the other hand, focuses on bioremediation to address various forms of pollution. The vast majority of bioremediation applications rely on naturally occurring microorganisms to either identify or filter harmful material before it reaches the environment or to solve existing pollution issues.

In waste treatment and pollution control, more advanced techniques employing genetically modified bacteria are being tested to remove toxins that are difficult to decompose. It is possible to do bioremediation in situ or in specialised reactors (ex situ). A suitable habitat is necessary for microorganisms to bioremediate a polluted location.

Nutrients, terminal electron acceptors ( $O_2/NO_2$ ), temperature, and moisture may be required for microbial activity in a polluted environment to support the growth of a certain organism. Operations for bioremediation might be done in situ or ex situ, on or off-site. A wide variety of hazardous pollutants, household wastes, radioactive wastes, and other contaminants can be removed from soil and water via bioremediation.

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The proportional importance of biotechnology increases with the development of scientific knowledge and procedures. It is a more appealing alternative to more conventional chemical

and physical procedures of clean-up due to its lower energy and chemical needs as well as lower minor waste formation. Bioremediation has a variety of uses in protecting the environment. This chapter covers a variety of subjects, including the handling of waste water and industrial effluents, soil and land treatment, and the management of waste gas and air.

### **Waste Water and Industrial Effluents:**

The problem of water contamination is serious in many places of the world. Surface and ground water supplies are now in poorer condition as a result of the rapid industrialisation and urbanisation. There is biological, organic, and inorganic contamination in the water bodies. In many circumstances, these sources have become unsafe for use in industrial applications and other uses like irrigation. This illustrates how low water quality may reduce the amount of water available for both human and environmental use, resulting in a water shortage. The treatment of waste water before disposal is a significant issue everywhere in the world.

Before waste water is discharged into rivers or the ocean, microorganisms are used in sewage treatment plants to remove common contaminants from the water. As industrial and agricultural pollution has expanded, there is a greater need for techniques to remove specific pollutants, such as chlorinated compounds, heavy metals, and nitrogen and phosphorus compounds.

Among the techniques utilised are aerobic, anaerobic, and physico-chemical processes in fixed-bed filters and bioreactors containing suspended materials and bacteria. Sewage and other waste waters will naturally purify themselves if not handled, but this process will take a very long period. To expedite the procedure, bioremediation techniques are used.

### **However, Five Key Stages are recognized in Wastewater Treatment:**

- a) Preliminary treatment – grit, heavy metals and floating debris are removed.
- b) Primary treatment – suspended matters are removed.
- c) Secondary treatment – bio-oxidize organic materials by activities of aerobic and anaerobic microorganisms.
- d) Tertiary treatment – specific pollutants are removed (ammonia and phosphate).
- e) Sludge treatment – solids are removed (final stage).

**Aerobic Biological Treatment:** On an inert substrate (rocks, ash, wood, or metal), microorganisms typically grow as a complex biofilm in trickling filters, rotating biological contactors, or contact beds. They have been used to treat sewage and waste water for more than 70 years. Microorganisms break down biodegradable organic material into CO<sub>2</sub>, which can subsequently be discharged into the atmosphere.

### **Activated Sludge Process:**

This technique is used to treat and remove organic compounds, waste from petroleum refining, textile wastes, and sewage from local governments. Microorganisms from inactivated sludge are composed of 70–90% organic matter and 10–30% inorganic components.

Bacteria, fungus, protozoa, and rotifers are the most common microorganisms discovered in this sludge. Bacteria (*Acinetobacter*, *Mycobacteria*, *Pseudomonas*, and others), yeasts, *Cladosporium*, and *Scolecobasidium* breakdown petroleum hydrocarbons. The fungus *Xylariaxylestrix* detoxifies pesticides (aldrin, dieldrin, parathion, and malathion). Organic substances such as hydrocarbons, phenols, organophosphates, polychlorinated biphenyls, and polycyclic aromatics can be detoxified by *Pseudomonas* (a common soil microbe).

In order to remove nitrate, nitrite, and phosphate from water, Garbisu et al. (2003) reported employing immobilised cyanobacterium *Phormidium laminosum* in batch and continuous flow bioreactors. *Phormidium laminosum* immobilised in microporous polymeric matrices can absorb heavy metals, as Blanco et al. (2003) showed. Today, high-value goods (such beta-carotene and gamma-linoleic acid) are produced by growing algae and cyanobacteria in photo-bioreactors under strictly controlled conditions. These plants are also used to create effective wastewater treatment systems and create new energy sources. The cost of wastewater treatment is reduced by turning wastes into useful products. Sulfur-metabolizing bacteria can extract and use heavy metals and sulphur compounds from the waste streams of the galvanization industry. Biogas is a beneficial byproduct of most anaerobic wastewater treatment methods.

In rare cases, the byproducts of pollution-fighting microbes can be useful. For instance, a specific type of bacterium that consumes sulphur liquor, a byproduct of the paper industry, can make methane.

### **Soil and Land Treatment:**

The need for food from crops grows along with the human population, making soil protection more and more crucial. Deforestation, excessive growth, and pollution from man-made toxins, to name a few, are all outcomes of human activity and neglect. As more fertilisers and other agricultural chemicals are applied to soils, along with methods for disposing of industrial and household waste, there is growing concern about soil contamination. The development of plants and the health of animals are adversely affected by persistent toxic compounds, chemicals, salts, radioactive elements, or disease-causing agents that pollute soil.

Fungi can be employed for soil bioremediation in a variety of ways. Herbicide paraquat may be degraded by *Lipomyces sp.* Benzaldehyde may be converted to benzyl alcohol by *Rhodotorula sp.* In the soil, *Candida sp.* destroys formaldehyde. Tannins (present in tannery effluents) are degraded in the soil by *Aspergillus niger* and *Chaetomium cupreum*, which aid plant development.

In the bioremediation of soils contaminated with a variety of chemical compounds, the majority of which are refractory and are regarded as environmental pollutants, *Phanerochaete chrysosporium* has been used. Within six weeks, PCP (Pentachlorophenol) levels decreased by 88–91% in the presence of *Phanerochaete chrysosporium*. Bioremediation of contaminated soil has been used as a safe, trustworthy, economical, and environmentally friendly method for the degradation of various pollutants. There are several ways to do this, including in situ or by mechanically removing the dirt and treating it somewhere else. In situ

therapy includes the inclusion of nutritional supplements, the introduction of microorganisms, and ventilation.

Ex situ treatment is the process of removing the soil and treating it above ground, either as compost, in soil banks, or in specialised slurry bioreactors. When compared to physical methods, land bioremediation is generally less expensive, and the final products are typically harmless.

During biological treatment, soil microorganisms transform organic pollutants into CO<sub>2</sub>, water, and biomass. Both aerobic and anaerobic conditions are capable of undergoing degradation. Additionally, bioreactors can help with soil bioremediation. Both aerobic and anaerobic conditions are capable of undergoing degradation. Additionally, bioreactors can help with soil bioremediation. Liquids, vapours, or solids in a slurry phase are processed in a reactor. Microbes can be cultivated, collected from the wild, or even genetically altered.

It is now possible to clean up soil that has been contaminated by mineral oils thanks to environmental biotechnology research. Petroleum-contaminated soils are dug out using solid-phase technologies and placed in a containment system where water and nutrients can permeate. It has been shown that biological oil degradation is commercially viable on both large and small scales, in situ and ex situ.

A crucial aspect of in situ soil bioremediation is the support of local microbial populations (by adding nutrients or aeration). In this process, the ambient conditions for biological degradation of organic pollutants are optimised to the maximum extent possible. Oxygen must be added artificially, either through aeration or by adding electron acceptors like nitrates or compounds that release oxygen.

### **Air and Waste Gases**

Since the beginning of human civilization, the air has been one of the most polluted parts of the atmosphere. Humans using fossil fuels like natural gas, coal, and oil to run machinery and drive vehicles is the main cause of air pollution. Different substances known as volatile organic chemicals (VOCs) are emitted into the atmosphere when fuels are burned inefficiently. There are many different sources of pollution. For instance, methane gas is produced as waste decomposes in landfills and other solid waste disposal facilities, and many household items release volatile organic compounds (VOCs). Airborne pollution have increased as a result of expanding industrial operations.

At first, biological air cleaning seemed impossible. This issue has been resolved as a result of the development of biological waste gas purification technology based on bioreactors, which includes membrane bioreactors, bio filters, bio trickling filters, and bio scrubbers. These reactors all function in a similar way.

Air containing volatile compounds is introduced into the bioreactors, where they are transferred from the gas phase to the liquid phase. A microbial community (a combination of bacteria, fungi, and protozoa) develops and eliminates the chemicals absorbed from the air in this liquid phase.

In the bio filters, the air is passed through a bed of organic materials, which gives the microorganisms the nutrients they require to grow. To keep this medium moist, the entering air's humidity is maintained. In biological off-gas treatment, VOC in waste gases are absorbed into the aqueous phase and then directly oxidised by a variety of voracious bacteria, including *Nocardia* sp. and *Xanthomonas* sp.

### **Prevention:**

For sustainable growth and high quality of life, natural resources must be used sensibly and sustainably while the economy is expanding. Industrial development must change from a degradative to a sustainable one in order to stay up with this trend, which necessitates the employment of cleaner technology.

The United Nations Environment Programme (1996) defines the term "eco-friendly" as "the continuous application of an integrated preventive environmental strategy to processes, goods, and services to increase eco-efficiency and lessen dangers to humans and the environment." The only way to apply the preventative and clean idea is through the 5R policies (Olguin et al, 2003).

### **Five Environmental Buzzwords are the 5Rs for Efficient Use of Energy and Better Control of Waste, Which Might Help in Sustainable Development and Quality Living:**

1. Reduce (Reduction of waste)
2. Reuse (Efficient use of water, energy)
3. Recycle (Recycling of wastes)
4. Replace (Replacement of toxic/hazardous raw materials for more environment-friendly inputs)
5. Recover (useful non-toxic fractions from wastes)

Research and development efforts worldwide are concentrated on the innovation and deployment of clean technologies. Industrial companies are developing techniques that have a lesser environmental impact in response to the global demand for the development of a sustainable society. There is a general shift away from "end-of-pipe" waste stream treatment and towards less harmful products and processes. Due to its applicable technologies, environmental biotechnology is well-suited to support this trend.

### **Enzyme Application**

Enzymes have been extensively utilised in business for a long time. Enzymes are very effective biological catalysts that offer a number of advantages over non-biological catalysts. They are biodegradable and non-toxic. For thousands of years, both directly and indirectly, man has used enzymes. In recent years, the role of enzymes in the manufacture of drugs, fine chemicals, amino acids, antibiotics, and steroids has increased. Industrial processes can be made more ecologically friendly by using enzymes. Utilizing enzymes increases energy and resource efficiency while assisting in the reduction or elimination of the use of dangerous chemicals in the pulp, paper, food, textile, and leather industries.



Food products' nutritional value, functional capabilities, and shelf life can all be improved using biotechnological methods. Instead of having to extract the compounds from vanilla beans, plant cells can produce vanilla flavour when grown in fermenters. Food processing has benefited from the development of biotechnologically produced chymosin, which is used in the production of cheese, alpha-amylase, which is used in the production of high-fructose corn syrup and dry beer, and lactase, which is added to milk to reduce the lactose content for people who suffer from lactose intolerance. Since they don't produce food by-products or undesirable flavours, genetically engineered molecules are chosen over chemically produced molecules since they are simpler to manufacture than enzymes taken from natural sources.

### **Environmental Detection and Monitoring**

Various biological techniques are employed to identify pollution and continuously monitor toxins. Advances in biotechnology have produced new instruments for identifying environmental issues and tracking typical environmental conditions, enabling people to be more conscious of their surroundings. These techniques are more portable, speedier, and less expensive. Instead of collecting soil samples and sending them to a lab for analysis, scientists can assess the level of contamination right away and get quick results. For biological detection, biosensors and immunoassays have been developed and are currently on the market. Biosensors use microbes to identify metal or pollution contamination. The green alga *Selenastrum capricornatum* is used to detect heavy metals, whereas the yeast *Saccharomyces cerevisiae* is utilised to detect cyanide in river water. Immunoassays use labelled antibodies and enzymes (complex proteins produced during a biological reaction to specific chemicals) to measure pollution levels. The antibody binds to a pollutant if it is there, making it visible by causing it to glow, change colour, or emit radioactivity.

### **Biosensors**

Biological reactions can be translated into physical, chemical, or electrical outputs via a biosensor, which is a sensor. Biosensors are made by combining sensitive and specialised biologically derived sensing components (such as immobilised cells, enzymes, or antibodies) with physical-chemical transducers (either electrochemical or optical). When they are immobilised on a substrate, their features can be sensed electrically or optically and change in response to some environmental input. Then, it may be possible to do quantitative measurements of pollutants with remarkable accuracy or extraordinarily high sensitivities. The bio catalytic membrane, which converts reactant to product, controls the biological response of the biosensor. Enzymes that have been immobilised offer a number of benefits that make them particularly suitable for use in these systems.

They might be employed once again to guarantee that the same catalytic activity persisted over a number of experiments. The manufacturing, engineering, chemical, water, food, and beverage industries have all benefited from biosensors, which are powerful tools that harness biological processes to identify specific compounds. They are quick, easy, and precise in their ability to detect even very low concentrations of their target compounds. This has led to the widespread use of biosensors in a variety of process monitoring applications, most notably in the assessment and management of pollution. Previously, organic acids, glucosinolates,

aromatic hydrocarbons, pesticides, pathogenic bacteria, and other chemicals could all be detected using biosensors.

It is possible to create biosensors that are highly sensitive or selective to a large range of substances. For instance, algal-based biosensors may identify a variety of herbicides in river water, with the stressors that are applied to the organisms being measured as changes in the chlorophyll's optical properties. Biosensors include, for instance, calorimetric biosensors, immunosensors, optical biosensors, BOD biosensors, and gas biosensors. The amazing ability of microbes to break down chemicals makes them useful for both contaminant identification and environmental cleanup. Scientists at the Los Alamos National Laboratory are researching the phenol-degrading bacteria.

When phenolic compounds are consumed by bacteria, the phenols bind to a receptor on the surface of the bacterium. The phenol-receptor complex binds to DNA and then activates the genes responsible for phenol breakdown. The Los Alamos scientists created a reporter gene that, when activated by a phenol-receptor combination, produces a readily recognisable protein that indicates the presence of phenolic compounds in the surrounding environment. Using biosensors that make use of acetylcholine esterase, one may identify the presence of organophosphorus compounds in water.

### **Genetic Engineering**

Since it is anticipated that biotechnology would significantly improve human welfare, it is an essential technology that should be continuously developed. The application of DNA technology, one of the many forms of biotechnology, offers the possibility of creating novel gene combinations that have never occurred in nature.

Since its inception, genetic engineering has asserted that it may produce unique bacteria with improved capacities for degrading hazardous chemicals. The stability of plasmids is required for the development of GEM (genetically engineered microbes) and their prospective application in the rehabilitation of polluted soil and water. Circular DNA strands called plasmids can divide on their own without the help of their host chromosome. Plasmids can range in size from those carrying a small number of genes to those containing several genes. Small plasmids may exist in several copies. Through the conjugation process, plasmids can exchange genetic data. Certain DNA fragments that can be transmitted to a cell that lacks them have been isolated thanks to restriction enzymes. Plasmids frequently, but not always, include genes that direct the metabolism of xenobiotic substances like PCBs and other environmental pollutants. The ability of non-biodegradable microbes to transmit genetic information has created new opportunities for waste biotreatment. The recombinant DNA has the capacity to multiply and may also have the power, through a specialised derivative capability, to detoxify environmental pollutants.

Gene transfer between microbial communities increased derivative capability in vitro. For a bacteria named *Pseudomonas putida* that can break down hydrocarbons, Professor A. M. Chakrabarty filed the first patent application for a genetically modified organism (GMO) or genetically engineered microbe (GEM) in the United States. In later research, plasmids have been linked to the breakdown of alkanes, naphthalene, toluene, and m- and p-xylenes.

Genetic engineering has the potential to be a very potent tool for creating environmentally friendly substitutes for goods and processes that currently pollute the environment or use up its non-renewable resources, given the enormous diversity of species, biomolecules, and metabolic pathways found on this planet. With the advent of genetic engineering, organisms can now be enhanced with additional genetic features for the biodegradation of certain pollutants if naturally occurring organisms cannot complete the task effectively or quickly enough. By combining different metabolic capabilities in one microorganism, environmental cleanup obstacles may be overcome. Several genetically modified bacteria have been authorised for use in bioremediation in the US, but no widespread applications have been noted. Only carefully supervised field testing has been allowed in Europe. In the same way that light, heat, and moisture break down a variety of materials, biotechnology uses naturally occurring, live microbes—but much more quickly. In their normal condition, certain bacteria feed on waste materials such as harmful toxins and other substances. These chemicals are ingested, metabolised, and replaced by harmless substances in excretion. To break down dangerous and damaging substances that are already present in the environment, bioremediation employs both naturally occurring and recombinant microorganisms. Before they impact the ecosystem, waste streams can be detoxified via bio treatment at the source rather than at the disposal site. This process requires the selective use of organisms known as biocatalysts, which are enzymes that break down specific materials and quicken the process. On the other side, using GMOs or GEMs in the environment for bioremediation may have negative effects on the ecosystem. These artificial creatures do not get the chance to experience the wide range of environmental conditions that naturally occurring species have to deal with over the course of millions of years of evolution.

They are therefore well adapted to shifting environmental conditions, such as shifting temperatures, substrates, and waste concentrations. However, when exposed to a polluted environment, GMOs have a higher survival rate than naturally existing microorganisms because of their specialised enzymatic machinery.

Due to competition or genetic material exchange, there are worries that these GMOs will negatively affect the delicate and complex microbial communities in the soils where they are sprayed. Much more worrisome is their possible impact on areas outside the treatment area. Recombinant strains may appear harmless in the lab, but it can be very difficult to predict how they will behave in the field. Currently, biotechnological procedures are used to create a large number of proteins for pharmaceutical and other specialised uses. A copy of the human insulin gene is inserted into a nonvirulent strain of *Escherichia coli* to create human insulin, the first commercially produced genetically edited product (1982). When a gene is "amplified," bacteria produce enormous amounts of purified human insulin that is used to treat diabetes in humans. Only a few genetically modified products have been approved since then, including tissue plasminogen activator, alpha interferon, human growth hormone, and recombinant erythropoietin.

Biotechnology techniques are being used to create plant materials that have superior compositions and functional characteristics. One of the first entire foods to be commercially marketed was the slow-ripening tomato, which lacks the gene for the softening enzyme

polygalacturonase. Additionally, plants that are resistant to particular insecticides or herbicides as well as diseases and pests are being created. In 1995, the Environmental Protection Agency (EPA) gave its approval for the production of transgenic maize, cotton, and seed potatoes. These products enable the use of safer, more environmentally friendly herbicides and insecticides. The first acknowledged use of biotechnology in animal agriculture was the use of recombinant bovine somatotropin (BST) in dairy cows. Bovine somatotropin, a protein hormone made by cows naturally, is necessary for milk production. Recombinant BST has been shown to increase milk production in dairy cows under ideal management conditions by 10% to 25%.

Other uses of biotechnology in animal production include the creation of disease-prevention vaccinations, the cloning of animals to produce several calves from a single embryo, artificial insemination, enhancement of growth rate and/or feed efficiency, and quick disease diagnosis. Natural biopesticides are another biotechnology development that aids farmers in reducing their use of chemicals. They only pose a risk to the insects they target and dissolve fast, leaving no behind. For some insects, *Bacillus thuringiensis* (B.t.) produces a naturally toxic protein. Scientists have taken the B.t. gene, which produces the pesticide, and placed it into ordinary bacteria that can be produced in big quantities using the same fermentation procedures that are used to make beer and medicines. These bacteria, which are spread on cotton and other crops, naturally reduce insects.

The cry genes (found in B. t.) have also been genetically engineered into a range of agricultural plants, causing the insects to perish as they consume the crops. Genetic engineering is likely to work successfully when pollutants are a known mixture of highly concentrated organic compounds that are structurally related to one another, when traditional alternative organic nutrients are lacking, and when there is no competition from local bacteria. Utilizing the amazing metabolic adaptability of bacteria and fungus, environmental bioremediation techniques like sewage and waste water treatment, xenobiotic degradation, and metal abatement are possible. Microorganisms can be genetically modified to deal with a contaminant or a group of pollutants that may be in a waste stream from an industrial operation.

The simplest strategy is to modify the specificity or catalytic processes of the enzymes already present, or to introduce new enzymes from different species, to increase the degradative capacity of the organism's existing metabolic pathways.

4 million gallons of cyanide-containing wastewater are cleaned daily in a treatment facility at the Homestake Mine near Lead, South Dakota, by converting cyanide to nitrate. Together, Nitrosomonas and Nitrobacter and Pseudomonas sp. convert ammonia to nitrate and cyanide and thiocyanate to ammonia and bicarbonate, respectively. Recombinant DNA technology has significantly impacted various fields that enhance people's quality of life as well as environmental protection over the past several years.

### **Environmental Biotechnology is divided into Different Areas:**

There are three types of environmental research:

- (i) Direct studies of the environment,

- (ii) Research with an emphasis on environmental applications, and
- (iii) Research that uses data from the environment in other contexts.

In addition to DNA found in living things, there is a lot of free DNA in the environment that could be a source of new genes. The study of previously unstudied biological forms as well as DNA has been altered by the science of environmental biotechnology. This approach comprises a direct investigation of the surrounding environment and existing biochemical natural processes. Key research in this field is metagenomics. The study of entire communities of tiny living things' genomes is known as metagenomics, and it uses a variety of DNA sources, including viruses, viroids, plasmids, and free DNA.

Metagenomics, or the genomic analysis of a population of microbes, is a method for discovering information on the physiology and genetics of uncultured organisms.

Metagenomics is a technique used by researchers to examine and catalogue the current diversity of microbes. New proteins, enzymes, and metabolic processes have been found. The results of metagenomics could alter how we use the environment. Metagenomic research includes the following steps: isolating DNA from an environmental sample, cloning it into an appropriate vector, transforming the clones into host bacteria, and screening the resultant transformants. The clones can be examined for phylogenetic markers like 16S rRNA and rec A, as well as other conserved genes, by hybridization or multiplex PCR. They can also be examined for the expression of specific traits like enzyme activity or antibiotic production, or they can be randomly sequenced.

An essential technique for metagenomic research is stable isotope probing (SIP). A precursor, such as methanol, phenol, carbonate, or ammonia, that has been labelled with a stable isotope like  $^{15}\text{N}$ ,  $^{13}\text{C}$ , or  $^{18}\text{O}$  is first mixed with an ambient sample of water or soil. If the organisms in the sample metabolise the precursor substrate, the stable isotope is incorporated into their DNA.

When the DNA from the sample is removed and separated by centrifugation, the genomes that integrated the tagged substrate will be heavier and can be separated from the other DNA in the sample. The heavier DNA will advance further in a cesium chloride gradient during centrifugation. The DNA can be used straight or cloned onto vectors to construct a metagenomic library. This technique is crucial for finding novel bacteria that can break down contaminants like phenol.

By transforming dangerous compounds and chemicals into forms that are safe for both people and the environment, microorganisms play a significant part in the cleaning of a wide variety of harmful substances and chemicals. Here is a prime example of what I'm referring to. In the United States, gasoline escapes from every gas station. It's likely that gasoline will mix with groundwater, a significant source of drinking water. On the other hand, the breakdown of the dangerous chemicals in gasoline is encouraged in the active soil microbial community. A wide variety of bacteria are needed to completely decompose gasoline because it is composed of hundreds of different chemicals. Microorganisms that can use nitrate as an energy source start biodegrading the gasoline when bacteria deplete  $\text{O}_2$  in ground water near a gasoline spill. Bacteria that use iron, manganese, and sulphate are next. All of these microbial groups

work together to break down gasoline leaks into CO<sub>2</sub> and water. The precise community member and function needed to finish the entire chemical change needed to make our planet habitable may be found through metagenomic study.

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## **CHAPTER 10**

### **FUNDAMENTAL OF FOOD AND WASTE BIOTECHNOLOGY**

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Industrial biotechnology is one of the most innovative new strategies for cost-cutting, resource management, and pollution control. It is frequently referred to as the third wave in biotechnology. If developed to its full potential, industrial biotechnology will have a greater impact on the globe than medical and agricultural biotechnology. This gives businesses a way to reduce expenses, create new opportunities, and preserve the environment. Since many of its goods do not require the extensive regulatory processes that medication products do, it is also a simpler, more straightforward path to market. The transition from laboratory research to commercial application can now be completed in two to five years thanks to modern manufacturing technology, as opposed to up to ten years for pharmaceuticals.

The incorporation of biotechnology into manufacturing processes has changed the way we make goods, but it has also given rise to new items that were unthinkable just a few years ago. Due to its recent development, industrial biotechnology is still not well known or understood by the general public, industry, or policymakers.

Since its inception, industrial biotechnology has blended product improvement with pollution reduction. The way industrial biotechnology dealt with the issues of phosphate water contamination brought on by the usage of phosphates in laundry detergent in the 1970s is the best example of this. Biotechnology firms have created enzymes that are more effective in removing stains from clothing than phosphates, enabling the replacement of a polluting ingredient with a non-polluting bio-based additive while increasing the effectiveness of the finished product. This innovation allowed customers to wash their garments at lower temperatures while simultaneously conserving energy because it dramatically decreased phosphate-related algae blooms in surface waters all around the world.

Existing industrial biotechnology is at least 6000 years old. When microbiological yeast was utilised by Babylonians to make beer and grapes were fermented by Neolithic cultures to make wine. As human understanding of fermentation has grown, cheese, yoghurt, vinegar, and other food products have been produced. Louis Pasteur demonstrated in the 1800s that fermentation was a byproduct of microbial activity. In 1928, Sir Alexander Fleming succeeded in removing penicillin from the mould. The 1940s saw the development of large-scale fermentation techniques for the production of this wonder medicine. However, the biotechnology revolution that gave rise to modern industrial biotechnology did not start until after World War II.

Since then, industrial biotechnology has created enzymes for both everyday use and the manufacturing industry. For instance, a meat tenderizer is an enzyme, and sticky protein deposits are broken down by enzymes in some cleaning solutions for contact lenses.

Industrial biotechnology generally entails the microbial digestion of complex proteins called enzymes. These enzymes have developed in nature into high-performance biocatalysts that facilitate and speed up intricate biochemical reactions. These amazing enzyme catalysts are what make industrial biotechnology such a potent modern technology.

Industrial biotechnology necessitates interaction with nature in order to maximise and improve currently usable biochemical processes. The industrial biotechnology revolution is built on a number of related innovations in the three domains of study of detailed knowledge extracted from cells: genomics, proteomics, and bioinformatics. As a result, scientists can use cutting-edge techniques to apply a wide range of microorganisms, including bacteria, yeasts, and fungus as well as marine diatoms and protozoa.

Modern biotechnology companies use a variety of cutting-edge methods to find and improve the enzymes found in nature. Researchers can take use of the rich genetic variety found in microbial communities by using the knowledge gained about microorganisms from genomic studies. In the natural world, researchers initially look for microorganisms that produce enzymes before using DNA probes to look for genes that produce enzymes with specific molecular biocatalytic capabilities. Certain enzymes can be categorized and characterized based on their capacity to function in specific industrial processes when they are separated. If necessary, biotechnology techniques can be used to improve them. Numerous biocatalytic instruments are gradually becoming available for industrial applications as a result of the recent and dramatic advancements in biotechnology techniques. Many chemical engineers and private sector product development experts are still unsure whether biocatalysts or whole-cell methods are suitable for deployment because they are often so new. This is an obvious instance of a "technology gap," which is a discrepancy between the availability of a new technology and its broad adoption. This gap needs to be closed in order to hasten the development of more affordable and sustainable manufacturing techniques using biotechnology. The book "New Biotech Instruments for a Cleaner Environment" provides compelling illustrations of what can be accomplished using these strong new tools. The paper seeks to increase interest in this potent technology, close the technology gap, and advance the transition to a more sustainable future.

### **Industrial Biotechnology: An Introduction to Industrial Biotechnology and it's Applications**

The earliest manifestation of the industrial uses of biotechnology was discovered in the production of beer, wine, cheese, bread, and other fermented foods. Such applications in the chemical, pharmaceutical, and food industries have expanded over time to encompass a very broad spectrum of goods. Genetic engineering and molecular biology have proven beneficial in the development of novel and more effective bioprocesses, in addition to manufacturing a variety of goods.



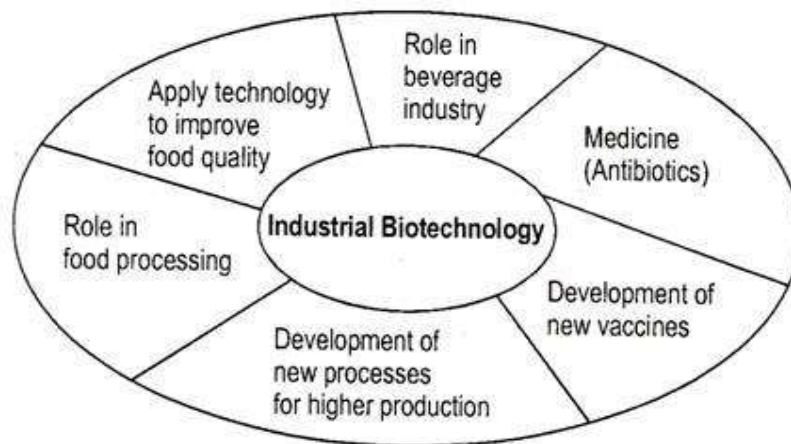


Fig 10.1 Diagram of Industrial biotech classes/groups

### **Biotechnology and Medicine:**

The application of biotechnology in the medical field has created a whole new range of opportunities. This broad range of uses has also given the medical sector tremendous promise. For instance, several "genetic markers" for oncogenes have been created to recognise breast, colon, bronchus, oesophageal, and prostate cancers. Many psychological disorders that cause memory loss and abnormal behaviour are now understood in light of gene suppression or activation. Dementia, schizophrenia, and Alzheimer's disease are some of them (the latter is incurred by a single aberrant gene). Additionally, biotechnology has enormous potential for regulating fertility. The body has also enabled safe organ transplantation and immune system modification. The designer medicine is another invention that is specifically crafted to alter entire genes or specific gene regions and to suppress or activate particular actions.

Some of the other applications of biotechnology to medicine are:'

### **Antibiotics:**

The manufacture of antibiotics is the pharmaceutical industry's most fruitful activity. More than a hundred antibiotics are already in use, and many dreadful bacterial illnesses have been controlled. Among the major classes of antibiotics are erythromycin, penicillin, tetracycline, and cephalosporin.

Fleming made penicillin from a fungus called *Penicillium notatum* in 1928, and Howard made it from *Pchrysogenum* in 1944. When the cells finish proliferating, the penicillium releases the most penicillin.

Fermentation of penicillin requires seven to eight days for the highest yield. Cephalosporin C, an antibiotic that can kill even penicillin-resistant bacteria, was created using the *Cephlosporium* fungus. The filamentous bacterium *Streptomyces griseus* served as the source for the discovery and production of streptomycin.

As such, genes do not specifically encode antibiotics. The majority of them are created within the cell through a sequence of chemical processes that are aided by enzymes. The enzymes

are built from distinct gene instructions, and cells might be used to make novel antibiotics. The creation of novel gene combinations is facilitated by cell fusion.

The cell may contain genes that can direct the cells to produce new antibiotics, but those genes cannot be expressed. This gene may be triggered, new enzymes may be produced, and new antibiotics may be produced as a result of the fusion of these cells.

### **Therapeutic Applications:**

The tumour may shrink as a result of monoclonal antibodies made against a particular type of cancer cell, which are identified by the body as extraneous. Monoclonal antibodies will stimulate a patient's immune system to start attacking a tumour. Additionally, it is conceivable to provide anti-cancer medications that are biologically linked to monoclonal antibodies that specifically target cancer antigens to malignancy.

### **Autoimmune Disease:**

Since both B and T cells react to their own tissue antigens, this condition compromises the body's ability to fight off its own antigens. In rheumatic fever, the body develops an immunity to heart and joint tissues after an infection. Many autoimmune illnesses are studied and treated with T-cell antigen monoclonal antibodies.

### **Prediction of Disease Risk:**

The relative risk of developing conditions like rheumatoid arthritis has been linked to specific antigens on the cell surface (such those of human leukocytes). Therefore, employing monoclonal antibodies to detect these antigens early can help with the development of effective preventive interventions.

### **Developing Recombinant Proteins for Medical and Therapeutic Use:**

Different expression systems are used to express the recombinant proteins. Such speaking systems could have yeast, insect, bacterial, or viral roots. Eukaryotic proteins can be easily produced using prokaryotic expression vectors, however many of the immunogenic qualities, 3D conformations, and other characteristics that are present in native eukaryotic proteins may not be present in the proteins.

Eukaryotic expression systems, which are found in mammals, amphibians, plants, insects, and yeast, are able to overcome many of these restrictions. Recombinant proteins can be challenging to purify using the mammalian cell expression approach because of restrictions on the size of the generated recombinant protein and the way that protein expression is induced. Many of these flaws can be fixed by utilizing expression systems from insect and yeast cells.

Insulin, interferons, vaccines, blood proteins, and growth factors are just a few of the many products made by genetically engineered bacteria. Genes can now be transferred from one organism to another by genetic engineering, recombinant DNA technology, or genetic modification, leading cells to produce things in huge and inexpensive quantities that would not otherwise be produced. When a material is created by genetic modification, a microorganism that can synthesise the desired product is given the gene that will cause the

protein to be made. The moulded substance can then be put away. With the development of biotechnology, numerous critical biomedical chemicals have been created and successfully used. For instance, initial penicillin G (benzyl penicillin) cannot be delivered orally and has a somewhat narrow spectrum of action against bacteria.

The side chain is now removed from or substituted at various positions in the molecule to produce semi-synthetic penicillin members by chemical or biological processes. Penicillin and penicillin benzyl are dissimilar. It can be administered orally and has an extra amino group on its side chain, confirming a wider antibacterial range. The enzyme that cleaves the side chain of penicillin is called penicillin acylase, and it is obtained from a variety of bacteria, including *E. coli* and *Aspergillus repins*.

**New Drug Targets and Vaccine Production:** - Numerous potential pharmacological targets have already been found. These include vital metabolic enzymes, hormones, growth factors, neuropeptides, transmitter chemicals, oncogene products, and various receptor proteins. The power of rDNA technology can be directed at these objectives to fully define them.

Now, by removing and/or substituting the side chain at various positions in the molecule, chemical or biological processes can produce semi-synthetic penicillin members. Benzyl penicillin is distinct from penicillin. It can be administered orally and has an extra amino group that indicates a wider antibacterial range on its side chain. The side chain-cleaving enzyme, penicillin acylase, is obtained from a variety of bacteria, including *E. coli* and *Aspergillus repins*.

**Production of vaccines and new drug targets:** There are already a number of potential pharmacological targets known. Important metabolic enzymes, growth factors, hormones, oncogene products, transmitter chemicals, neuropeptides, and various receptor proteins are among them. These objectives can be fully defined by directing the power of rDNA technology in that direction.

Examples include the following:

**Insulin:**

Glucose levels are regulated by the hormone insulin.

**Anti-hemophilic Factor:**

Hemophilia is treated with an important substance called anti-hemophilic factor, which is isolated from human blood. Since haemophiliacs have been infected with the AIDS virus, taking action has been challenging.

One of the most widely used blood proteins for treating shock injuries like burns is human serum albumin.

**Engineered enzymes:** These enzymes are used to treat a variety of disorders, from cardiac problems to renal failure to some types of genetic enzyme deficits.

New horizons include the creation of enzymes that can serve as biosensors or bioelectrodes to monitor a variety of physiological processes. This field is undergoing rapid advancement at an accelerated rate.

## **Food and Beverage Industry:**

### **Xylanases:**

Enzymes are biological molecules that are present in several species. Microorganisms have been discovered to provide a rich source of enzymes that are useful in industry. Such an enzyme is called xylanase. Different xylanase forms have been described and distinguished by genetic modification. These include cellulose for natural fibres, wood, pulp, and digestive enzymes.

Xylanases play a crucial function in raising the calibre of baked goods. As an illustration, a specific xylanase enzyme from a fungal strain has been discovered and produced (*Aspergillus niger* var awamori). The rate of development of these enzymes has been twenty to forty times boosted via molecular modifications. Unilever invented this enzyme (EXLA), which is now readily obtainable on the market. When the genes responsible for manufacturing knaaf Xylanase were isolated and introduced into *E. coli*, which is inducted into chick-feed, it was discovered that Xylanase and cellulase decoction, known as Flaxzyme, produced a clean fibre. The bacteria produce xylanase, which breaks down the grain and aids the chick in digesting it more quickly, promoting rapid growth.

Another study looked at a new plasma protein-based gel-forming substance that may be produced enzymatically and used to improve beef products. The TNO Company created the Fibrimex fresh cold meat binding technology, which binds fresh meat chunks to a solution of fibrinogen, thrombin, and transglutaminase to create a cohesive mass of meat.

### **Emulsifiers: emulsifiers**

Acacia gum is mostly utilised as an emulsifier in the food sector because of its emulsifying and stabilising abilities. New molecular techniques are now used to create emulsifiers from covalently bound carbohydrates such starch, pectin, sugar, and wheat, milk, and soybean proteins.

### **Allergy Tests for Peanuts:**

Numerous individuals have shown allergic responses after eating peanuts. To address this issue, it is critical to identify the allergy's root cause. For this reason, a Dutch company has created an extremely sensitive immunological technique to find peanut proteins in food. This is the first assay for peanuts that may be used in commerce.

### **Effective Monitoring:**

Scientists are creating adaptable gastrointestinal models for careful monitoring of food and medicine digestibility, bioconversion, and biodegradability, as well as pollutants' functioning and protection. These models are being used to research how nutraceutical foods affect digestion (TIM-TNO-in vitro models).

### **High Intensity Sweetener:**

Hoechst developed "Aesulfamek," the high-intensity sweetener sold as Sunett™. Due to its potency and the results of toxicological safety testing, this chemical has earned a reputation as an incredibly effective sweetener.

### **Calcium Intake:**

An important and ground-breaking use of biotechnology is to increase the calcium content of our diets. According to studies, oligo-fructose, a naturally occurring low-digestible oligosaccharide, increases calcium absorption by up to 22%. These investigations will pave the way for brand-new ingredient categories and health application areas. The dairy, baking, confectionery and beverage industries can use these findings to create new products.

### **Foods from Microbes:**

Although brewing and baking have been around for a very long time, we are now using genetically pure strains in the process. According to studies, *Saccharomyces cerevisiae*, or baker's yeast, is produced worldwide on a yearly basis in amounts of close to 1.5 million tones. Additionally, modern plants have shortened the months-long fermentation process to only a few days. Similar to this, the fungus *Aspergillus oryzae* is utilized to produce a wide array of crucial enzymes.

### **Edible Mushrooms:**

A filamentous fungus called *Fusarium graminecerarum* recently sold Quorn myco-protein to Rank Hons McDougall PLC and ICI (Zeneca). Mycelia that has been grown in big fermenters is used to make quorn. The finished product, which resembles meat in texture, is the most rigorously tested meal ever. Only in the United Kingdom, Quorn has annual sales of 15 million pounds.

### **Industrial Products:**

Recently, it was found that the cellulose enzyme may take the place of the pumice stones used in the textile industry to create stonewashed denim. This will lessen the harm that the pumice stone will do to the cloth. The cellulose enzyme can also be utilised as a bio-polishing agent since it removes the fuzz off the surface of cellulose fibres.

Proteases and hydrolysis are employed in the production of starch and laundry detergents, respectively. Genetic engineering could create simpler molecules from these complicated ones or modify existing molecules' chemical structures to produce more potent chemicals.

For instance, chemical transformation can dramatically boost the sweetness of corn syrup by using the glucose isomerase enzyme. These innovations have a wide range of potential uses in the pharmaceutical, food, and agricultural industries.

Many important industrial products have been created from fungus using fermentation technology. Fungi produce specific enzymes that can swiftly degrade organic compounds. Additionally, fungi were used to isolate antibiotics.

Cyclosporine was shown to have immunosuppressive properties after being identified as an anti-fungal chemical from the fungus *Tolypocladium inflatum*. This drug is frequently used to stop organ rejection during transplants.

A source of fungal species is also biopolymers like polysaccharides. When produced under particular circumstances, these strains can help in generating these biopolymers, which are

very beneficial for industry. Numerous fungus produce a great number of pigments, which are then utilised to create textile dyes.

Some fungal pigments are classified as anthraquinone derivatives, which mimic a sizable group of Vat dyes. The use of these fungi-based colors in the textile sector solves the issues with synthetic chemical waste disposal.

Particularly susceptible to insect infestations are cotton plants. To address this issue, transgenic cotton plants have now been created. These plants include a gene from the bacteria "*Bacillus thuringiensis*" that guards the plant against insect attack.

Additionally, researchers are working to develop coloured transgenic cotton, which could displace the need for bleaching and dyeing. Additionally, animal fibre development has been influenced by biotechnology. Through genetic engineering, it is possible to stop sheep from losing their wool due to attack by fly larvae.

Many companies are attempting to make biopolymers that form fibres. One such item made by Zeneca Bio-products is called "Biopol." Polyhydroxybutyrate (PHB), a chemical molecule, is a thermoplastic linear polyester with a high molecular weight that can be melted and spun into fibres.

Due to its biocompatibility and biodegradability, it is also very helpful for making surgical equipment. For instance, PHB sutures may be quickly degraded by the enzymes found within the human body. Additionally, efforts are being made to clone specific genes and then transfer them to plants. This would make it possible to produce these compounds in considerably larger numbers, which would subsequently lower their price.

### **Benefits for the Textile Industry:**

Other biotechnology uses in the textile sector include:

1. Using enhanced plant types to produce textile fibres and fibre characteristics, in addition to cellulose, dyes, and improved cotton plants.
2. Improvement in animal-derived fibre.
3. New fibres made from microorganisms with genetically altered DNA and biopolymers.
4. Using environmentally friendly enzymes in place of harsh and energy-intensive chemicals to prepare textiles
5. Creation of detergents with minimal energy requirements.
6. New diagnostic tools for textile waste management quality control.

### **Paper Industry:**

Fungi that cause white rot have shown to be quite beneficial for the paper industry. Species like "*Phanerochaete chrysosporium*" and "*Trametes versicolor*" have taken the place of some of the chemical processes used in the production of paper. By doing this, the contamination risks brought on by the usage of chemicals will be eliminated.

A completely new technological revolution could be ushered in by current biotechnology advancements. This revolution's power would come from the exploitation of living things and

the effective replacement of raw materials based on conventional chemicals with molecular resources. And if recent patterns are any guide, this most recent transformation will alter the sector in the future.

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# **CHAPTER 11**

## **BASICS OF FOOD NUTRITION AND HEALTH**

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The term food brings countless pictures to our mind. It is not just linked to materials that a person eats or drinks but even linked to the environment, people and mood. Food is an integral part of our life and is directly linked to our existence as it is the most essential requirement for surviving.

Food when consumed is a whole pack of required elements, which are then broken down into smaller, easily digestible and absorbed forms. These elements of which food is consumed are known as nutrients. The meal consumed is a combination of different nutrients that includes both macro (carbohydrates, amino-acids and lipids) and micro (vitamins and minerals) nutrients. As a car needs fuel to run, similarly our body needs food as fuel to work. When the fuel is of not good quality the functioning of the car is impaired same happens in our body when the food consumed does not contain proper nutrients, the bodily functions get impaired.

All these nutrients are required by each one of us in varying quantities for performing specific functions. If body fails to get them in the required amounts the imbalance of nutrients is seen in the body. Which eventually impacts the body efficiency and various diseases, growth issues and ailments can be observed. This means that proper eating habits, nutritious food and adequate health are all integrally connected concepts of one's life.

In this chapter we will be learning about why food is essential for living, what are its functions and components. We would even cover different terms related to nutrition, their sources, functions and requirements by different individuals.

### **What Do You Mean by the Term Food ?**

Food can be defined as any substance that can be rigid, semi-solid or that can flow and can be consumed, when ingested it nourishes, provide energy, facilitate tissue buildup, maintain and protect bodily functions. It is a raw material that is needed for building our body using required nutrients. Considering the consumption of good food in right amount at proper time can all result in healthy living.

The essential factors for terming something as food are-

- Firstly it should be something that can be consumed that is it can be eaten.
- Secondly it must have nutritional importance and should nourish the body.

Food is considered basic necessity as it contains substances which are responsible for performing essential functions in the body.

### **11.2 What are the basic functions of food?**

Food has various functions in our lives. The three basic roles performed by food are-



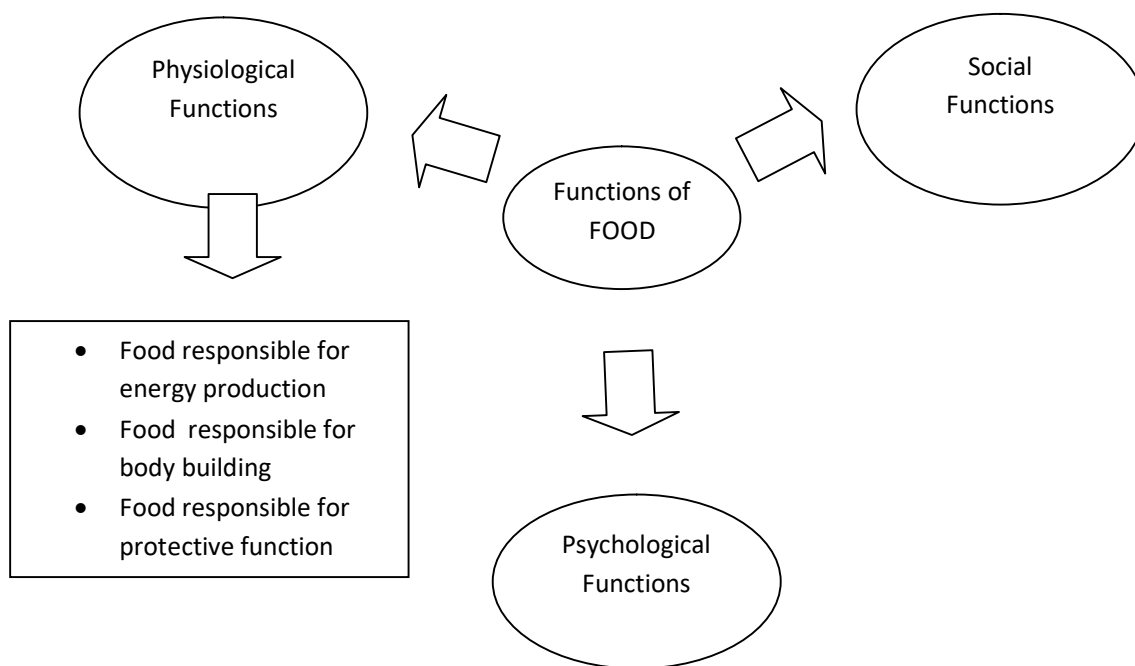


Fig 11.1 Basic Functions of Food

## 1. Physiological Functions

The three types of physiological functions performed by the food are-

### i.) Energy Yielding Foods-

Energy is required for performing everyday activities such as walking, sitting, playing and functioning of the organs.

Energy yielding foods include the one that are rich in carbohydrates and lipids as they responsible for providing energy to sustain the essential involuntary processes needed for live, to carry out different occupational, livelihood and recreational activities and to digest food ingested into needed nutrients in the body.

The body's requirement for energy is met by the oxidation of food that has been ingested. Good sources of energy include cereals, millets, roots and tubers, dried fruits, oils, butter, and ghee.

### ii.) Food for Building Muscle-

Thousands of tiny cells are responsible for the make up of our body. To aid the body's growth, new cells are added to them. The development of new cells necessitates the consumption of food. Injury causes cells to die or be harmed. Food is used to help produce new cells, which is a necessary part of the mending process.

Foods high in protein are those that promote muscle growth. High-quality proteins are found in abundance in milk, meat, eggs, and fish. Despite having a high protein content, the protein

in pulses and nuts is of low quality. These foods contribute to the preservation of life and the encouragement of growth. They additionally offer energy.

### iii.) Food for protective and regulatory purposes

Controlling biological processes, also referred to as regulatory functions, is one of the crucial functions of food. Human body temperature, for instance, is kept at 98.60 F or 37.0 C. The heart rate is maintained at 72 beats per minute in a similar manner. Additionally, the body regularly excretes its waste products. Otherwise, the body develops constipation, a condition that might cause more problems. Your diet has an impact on each of these processes. We gain power from the food we eat to fight against disease and infections.

Protective and regulatory foods are those that are high in protein, minerals, and vitamins. They are necessary for good health and govern various functioning. Protective foods include milk, eggs, liver, fruits, and vegetables.

## 2. Psychological Role

We all require emotional support, love, and care. Food is one way to fulfil these requirements. How do you feel, for instance, when your mother makes your favourite meal or food? She makes you feel as though she loves you and cares about your welfare. As a reward, food is frequently provided. Do you remember ever giving someone a chocolate after they did you a favour? In a similar vein, certain foods—such as khichri and bland dishes—have come to be linked to illness. Since being ill is an unpleasant experience, even the meals provided during this time may leave you feeling bad.

Therefore, we might conclude that some foods also satisfy the emotional needs of people. Among them are feelings of acceptance, love, and security. For instance, preparing delicious treats for family members is a symbol of love and affection.

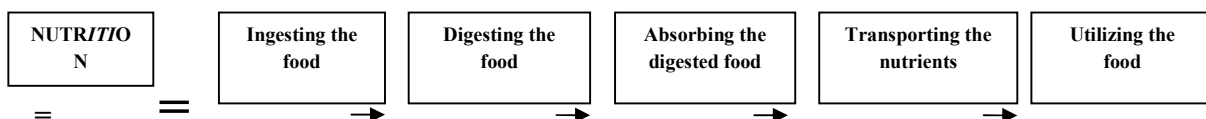
## 2. Social Functions

So, it stands to reason that some foods may also satiate people's emotional requirements. They include sentiments of security, affection, and acceptance. Making delectable goodies for family members, for instance, is a sign of love and affection.

### 11.3 What do you understand by the term nutrition and nutrients?

Each of us consumes food. The body is nourished by food, which enables it to stay fit and healthy. The food that we eat undergoes a number of procedures, including digestion, bloodstream absorption, and transportation to various bodily parts where it is used. Both waste products and partially digested food are expelled by the body.

Nutrition can be explained as a process by which food is consumed and absorbed by the body.



- Consuming food is referred to as **eating**, and it normally happens to give heterotrophic organisms energy and promote growth.
- The challenging process of turning food into nutrients that the body requires for development, energy, and cell repair is known as **digestion**. Additionally, waste is produced throughout the digestion process, which must be removed.

The digestive system starts in the mouth. Food scent, chewing, and breaking of the food all cause the production of saliva. It has enzymes that begin the process of converting food into a form that can be absorbed and used by your body.

The pharynx is the portion of the digestive system that receives food from your mouth. The pharynx is the beginning of the oesophagus, which brings food to the stomach, and the trachea, or windpipe, which carries air to the lungs. The tongue and soft palate (the soft portion of the roof of the mouth) moves the food into the pharynx region, which results in the sealing off the trachea. The meal then travels via the oesophagus. Food is pushed through the oesophagus and into the stomach through a series of contractions called peristalsis. A ring-shaped muscle called the lower esophageal sphincter is located directly before the stomach's opening (LES). This sphincter opens to let food enter the stomach and closes to block its passage.

The stomach has strong, muscular walls that resemble a bag. In addition to containing food, it also functions as a food mixer and grinder. The meal is further broken down in the stomach by powerful enzymes and acid, which causes the food to take on the consistency of a liquid or paste.

The small intestine is the next stop for the meal. The duodenum, jejunum, and ileum, which make up the small intestine, break down food using bile from the liver and pancreatic enzymes.

- **Absorption**

Food is absorbed in the small intestine. Food molecules that have been digested pass through the walls of the small intestine and into the bloodstream.

Food particles are transported to various parts of the body where they are required by the organism when they reach the bloodstream.

The walls of the small intestine can only accommodate tiny, soluble food molecules; larger, insoluble food molecules cannot.

### **Absorption Mechanism**

During digestion, a network of mucous membranes aids in the transport of digested, soluble food molecules into the circulation or lymph. The following are the steps in the absorption process.

Diffusion

Transportation that is active

Convenient Transportation

Transport in Passive Mode

## **Nutrients their Role and Importance**

We all know that food is important for our body's nourishment and wellness. Nutrients, are the small units found in the food, provide nourishment.

### ***What exactly are the nutrients?***

Chemical elements present in food that are responsible for nourishing an organism are called nutrients.

There are two sorts of nutrients:

- Macronutrients
- Micronutrients

Micronutrients and macronutrients are both necessary for optimal wellbeing. Every nutrient has a specific function in the human body.

#### **1. Macronutrients**

These are present in foods in high quantities and are likewise needed by the body in substantial quantities.

Carbohydrates, proteins, and fats are macronutrients.

#### **A. Carbohydrates**

##### **i.) Carbohydrates**

Carbohydrates are abundant in cereals, legumes, pulses, and potatoes in the form of starch. Sugar, jaggery, fruits, honey, and milk all include simple carbs.

Starch and sugars are easily absorbed and give the body energy.

##### **ii.) Carbohydrates or dietary fibre those aren't readily available**

They are found as the indigestible compounds cellulose and hemicellulose. They help to bulk up the stool and make defecation easier.

Energy is measured in kilocalories and can be derived from proteins, lipids, and carbs. However, the cheapest sources of energy are carbs. When the body's stores of fats and carbs are low, proteins are used to make energy. Proteins serve as building blocks for muscles. In order to save proteins for bodybuilding purposes, carbs must be ingested in the right quantities.

### **The following is a summary of the roles that carbohydrates play:**

- The primary source of energy is carbohydrate.
- Protein is saved for bodybuilding if sufficient amount of carbohydrates are consumed.
- Dietary fibre increases stool size and aids in defecation.

***4 kcal of energy are provided by 1 g of carbohydrate. The energy content of food is measured in kilocalories.***

**Food Sources:**

Wheat, rice, jawar, sago, and other cereals.

Dals, soy, and all types of pulses

Yam, potatoes, onions, and tapioca are examples of roots and tubers.

Jaggery, sugar

**B. Proteins**

Protein is necessary for the body to build muscle. Proteins are composed of amino acids, which are more compact building components. There are a total of 22 amino acids, but our bodies can't make 8 of them. The remaining amino acids can be made by the body. Since our bodies are unable to manufacture the essential amino acids, we must receive them from diet.

***Protein provides 4 kcal of energy per gm.***

A non-essential amino acid is one that our body can make on its own.

Functions

- (i) Required for the development, upkeep, and healing of tissues
- (ii) Required for the creation of enzymes, hormones, antibodies, haemoglobin, and other substances.
- (iii) Aid in blood clotting.
- (iv) Give energy, if necessary

**Sources:**

- Milk, cheese, paneer, curd, and meat
- poultry, fish, and eggs
- pulses, peas, and soybeans
- grains, nuts, and oilseeds such as groundnuts and til

**C. Fats and Oils**

Lipids and oils are the main concentrated source of energy in our diet.

One gram of fat provides 9 kcal.

Fats are made up of tiny molecules called fatty acids. The nature of fats depends on the kinds of fatty acids that are present. There are both saturated and unsaturated fatty acids. While oils generally contain unsaturated fatty acids, solid fats contain saturated fatty acids. Vegetable oils include a lot of unsaturated fatty acids.

Are you aware that there is a difference between fats and oils?

When a substance is liquid at room temperature, it is referred to as oil, and when it is solid at room temperature, it is referred to as fat.

**2. MICRONUTRIENTS**

Micronutrients are additional essential nutrients that are present in food in trace levels but are nonetheless important for human health. Very little amounts of these vitamins and minerals

are required. Inadequate ingestion of some micronutrients contributes to diseases brought on by nutritional deficits.

### i) Vitamins

You might be surprised to learn that, despite making up a very little fraction of our bodies, vitamins are crucial for all of the vital functions carried out by the body. There are two types of them:

A, D, E, and K can dissolve in fat.

B and C are soluble in water.

**Table 11.1 Fat Soluble Vitamins their functions and sources**

Vitamins	Functions	Sources
Vitamin A	<ul style="list-style-type: none"> <li>Helps in proper vision in dim light</li> <li>Important for healthy lining of different organs such as throat, nose, eyes etc.</li> </ul>	<ul style="list-style-type: none"> <li>Yellow and orange skin fruits and vegetables</li> <li>Liver, liver oil and fish</li> <li>Green leafy vegetables</li> </ul>
Calciferol (Vit. D)	<ul style="list-style-type: none"> <li>Aids in the proper absorption and usage of minerals like calcium and phosphorus;</li> <li>Important for the creation and mineralization of strong bones and teeth</li> </ul>	<ul style="list-style-type: none"> <li>Sun exposure on skin</li> <li>Milk, butter, poultry, liver, and fish liver oils</li> <li>Vitamin D-fortified refined oils and ghee</li> </ul>
Tocophero (Vit. E)	<ul style="list-style-type: none"> <li>Restricts the oxidation of specific compounds when oxygen is present.</li> </ul>	<ul style="list-style-type: none"> <li>Every type of cereal, legume, and vegetable oil.</li> </ul>
Phytonadione (Vit. K)	<ul style="list-style-type: none"> <li>Important for coagulation of blood</li> </ul>	<ul style="list-style-type: none"> <li>Formed by the bacteria present in the intestine</li> <li>Green leafy vegetables</li> <li>Eggs, liver</li> </ul>

**Table 11.2 Fat Soluble Vitamins their functions and sources**

Vitamins	Functions	Sources
Vitamin B Complex	<ul style="list-style-type: none"> <li>Necessary for the body to use complex carbs,</li> <li>Necessary for the neurological system to operate normally</li> <li>Necessary for healthy growth</li> <li>Aids in the regular operation of body organs</li> <li>Required for the synthesis of red blood cells</li> <li>Enhances appetite and aids with digestion.</li> </ul>	<ul style="list-style-type: none"> <li>Liver, poultry, meat, fish and egg</li> <li>Whole grains cereals and pulses</li> <li>Green leafy vegetables and milk</li> </ul>
Vitamin C	<ul style="list-style-type: none"> <li>It is required for the synthesis of the glue that binds cells</li> </ul>	<ul style="list-style-type: none"> <li>All the citrus fruits, amla, guava, oranges etc</li> </ul>

	<p>together and for the development of strong teeth and bones.</p> <ul style="list-style-type: none"> <li>• Aids in the formation of haemoglobin</li> <li>• Aids in the body's ability to use other nutrients</li> <li>• Aids in the fight against disease-causing bacteria</li> </ul>	<ul style="list-style-type: none"> <li>• Green leafy vegetables and sprouts.</li> </ul>
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## ii.) Minerals

The whole bodily tissues only make up a very modest portion of minerals. However, many important treatments as well as maintaining the body require these. The body requires around 19 minerals in total, in varying amounts.

Now let's look at a couple of the essential minerals.

**Calcium:** Ample levels of calcium and phosphorus can be found in milk, curd, green leafy vegetables, ragi, and oil seeds. Other meals also offer a respectable supply of calcium. Calcium's main function is the growth and development of bones and teeth. Calcium is also required for muscular contraction and blood clotting. Poor bone formation is caused by a calcium deficiency in the body, especially in children, women, and the elderly. Osteoporosis is the name of the deficient condition. As a result, people become more prone to fractures and their bones grow brittle.

**Iron:** The body simply requires a tiny amount of iron. It is an essential part of the protein known as haemoglobin, which is found in red blood cells and gives blood its distinctive red colour. Whole grain cereals and legumes are the major sources of iron in our diet. Additional sources of iron include liver, beef, green leafy vegetables, eggs, and egg yolk. The majority of people in our country suffer from anaemia, an iron deficiency condition, especially women and children.

This isn't because people don't eat foods high in iron, but rather due to inadequate iron absorption and use. This is caused by the presence of oxalates and phytates, two naturally occurring dietary components. These phytates and oxalates are referred to be iron inhibitors. Proteins and vitamin C are known as iron enhancers because they improve iron absorption.

**Iodine:** is a crucial component of the thyroid glands production of the thyroxine hormone. The hormone thyroxine controls a number of bodily processes. Iodine can be found in food and water. We get iodine from the vegetables that thrive in iodine-rich soil. Iodine is also abundant in seafood. Swelling in the neck area called a goitre is a sign of an iodine deficiency condition. Iodine deficiency in children results in mental impairment. Iodine shortage and children's academic performance are directly related, according to recent studies. Many regions of India have been found to have iodine deficiency illnesses.

Goitrogens are compounds found in some foods, such as oilseeds, radish, ladies' fingers, cabbage, cauliflower, and cauliflower, that prevent the body from making and using thyroxine. When cooked, these goitrogens are destroyed. As a result, these foods should be prepared before consumption.

### **3. Water**

Our bodies are mostly made of water. About two-thirds of the body's weight is made up of it. Food is easier for us to survive without than water. It is a crucial component of all living tissues and can be found in every cell. It protects against shock and envelops tissues and organs. Water aids in nutrient transportation, absorption, and digestion in the body. It assists in eliminating waste through urine and regulates body temperature through perspiration.

We should typically consume 6 to 8 glasses of water each day. We can also get water in other forms, such as milk, juice, kanji, etc.

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## CHAPTER 12

### FUNCTIONAL FOODS AND NUTRACEUTICALS

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With the development process and individual food preference a shift has been observed from healthy diet to unhealthy and ready to eat foods. Eating patterns and changes in food production and consumption have an impact on people's health, the environment, and society. This influences the health conditions of people impacting their quality of life.

The idea of optimal nutrition, whose objective is to improve daily diets in terms of nutrients and non-nutrients as well as other food aspects that encourage the preservation of health, is the focus of nutritional study today. Even the general populace today is growing more health conscious and expects foods that are good for their wellbeing. For today's health-conscious population, the adage "Let food be thy medicine and medicine be thy food" by Hippocrates serves as the moral compass.

Our improved awareness of the physiological rather than nutritional benefits of meals has led to a new trend of reevaluating foods and their appropriate intakes as the first line of defence against aberrant modes. In light of this, the terms "functional food" and "nutraceuticals" as well as their concepts have existed for some time.

#### **What are Functional Foods?**

The phrase "functional foods," which describes foods containing elements that support certain biological functions in addition to being nutrient-dense, was first used in Japan in the middle of the 1980s.

It is impossible for there to be just one functional meal with clear characteristics. In fact, a wide variety of food items are already classified as functional foods or will be in the future due to the presence of various nutrients and other ingredients that have an impact on a number of bodily functions that are either crucial for maintaining good health and wellbeing or reducing the risk of contracting specific diseases. Consequently, there isn't a simple, generally acknowledged definition of a functional food.

**The US Institute of Medicine's Food and Nutrition Board defined functional foods as "any dietary or food component that may provide a health benefit beyond the typical nutrients it delivers" in 1994.**

There are numerous definitions for the word "functional food," including:

- Food and beverage products manufactured from naturally occurring substances that are used as part of a normal diet and offer certain physiological benefits.

- Food prepared from elements found in nature that may and should be incorporated into a daily diet and that, when consumed, controls or in some other way influences a specific biological function.
- Food that, in addition to fulfilling basic nutritional needs, resembles conventional food in appearance, is consumed as part of a normal diet, and has demonstrated physiological benefits and/or minimises the risk of chronic illness.
- Food that contains ingredients that may be healthy, such as any modified foods or food ingredients that may be more beneficial to health than the ordinary nutrients they include.

Additionally, it is a concept that pertains to diet rather than medicines. Functional foods have no therapeutic effects and must thus be considered foods rather than medications. Additionally, rather than avoiding sickness, they frequently contribute to reducing the likelihood of it occurring.

Functional food has the following special qualities:

- Being a typical or common food
- Must be ingested as a regular/regular portion of the diet
- Made of naturally occurring (as opposed to manufactured) ingredients that may be present in foods in unusual concentrations or foods that wouldn't ordinarily include them.
- Improving goal function(s) other than nutrition value or basic nutrition
- It may improve physical, psychological, and behavioural performances as well as general quality of life. It may also lessen the risk of disease, increase overall health and well-being, or provide other health benefits.

### **Different Types of Functional foods**

Functional foods of either plant or animal origin can be categorized into the following categories based on how they work:

- Supplemented vitamins and minerals in food (e.g., vit C, folic acid, calcium, iron).
- Consuming certain foods can lower cholesterol (e.g., omega-3 fatty acids, phytosterols).
- Foods with fibre (e.g. nondigestible carbohydrates and lignin).
- Tribiotics, which include probiotics, prebiotics, and synbiotics (e.g., yoghurt, kefir, fruits, vegetables).

Functional meals come in a variety of flavours and forms. Some of them might be everyday foods with bioactive ingredients that have been identified and linked to advantageous health effects. Some of them might be foods that have been enhanced or fortified especially to reduce the risk of disease. Customers already have access to a variety of items that are either inherently beneficial (such soy protein, salmon, and olive oil) or fortified (like milk that is fortified with folate).

### **The unique features of functional foods may be classified in various ways-**

- i) They may be divided into nutrients and non-nutrients according to nutrition, as shown below:

#### **Nutrients:-**

- Lipids: n-3 fatty acids, and conjugated linoleic
- Vitamins: Carotene, Vitamin C, Vitamin E, and Folates
- Selenium is a mineral.

#### **Non-Nutrients:-**

- Fiber — both soluble and insoluble fibre,
- Phenolic substances include phenolic acids, flavonoids, isoflavones, and tannins.
- NDOs (Non-digestible Oligosaccharides)-
- Galactooligosaccharides, Isomaltooligosaccharides, Xylooligosaccharides, and Soy oligosaccharides are all examples of fructans.

The target organs and systems that have therapeutic significance, notably for the management and treatment of various diseases, are categorised as follows:

- Digestive tract is benefited by n-3 fatty acids, polyphenols, phytates, probiotics, soluble and insoluble fibres, micronutrients, etc.
- N-3 fatty acids, polyphenols, micronutrients, soluble fibres, etc. are beneficial to the cardiovascular system.
- Prebiotics, probiotics, nutrients, n-3 fatty acids, polyphenols, etc. for the immune system.
- Fructans make up the skeleton.
- Fructans, kidney

- iii.) Another division is based on origins from plants, animals, and microorganisms, and the following chemicals and substances are listed:

- Microbes: Probiotics .
- Plant: Fibres, polyphenols, fructans, n-3 fatty acids, phytates, carotenoids, and non-glycerides in edible oils.
- Animals: fish oils (-L-fatty acids), chitosan, conjugated linolenic acid (dairy products), etc.

### **Sources of Functional Foods**

The following list includes the many dietary sources of functional foods and the bioactive chemicals they contain:

Some functional foods and bioactive substances present in them are as follows-

- Oils, nuts, and seeds contain vitamin E.
- Omega-3 fats from fish

- Legumes, grapes, red wines, anthocyanins, catechins, and polyphenols Myricetin, flavonols, cyanidins, and quercetin
- Vitamin C-rich citrus fruits and veggies
- Flavonoid-rich dark chocolate
- Phytosterols in margarine
- Whole grains provide phytochemicals and fibre.
- Genistein and daidzein are soy proteins.
- Fruits and vegetables with green leaves - carotenoids
- Garlic and onions contain quercetin.
- Tea polyphenols: Green and black teas
- Phytochemicals, folate, and fruits and vegetables
- Vegetable oils, Tocopherol, and Tocotrienols
- Tomatoes, Lycopene

#### **12.4 Health Benefits Offered by different functional components**

The improvement of health is significantly aided by several functional food factors. In fact, the significance of these "bioactives," which are found in many foods either naturally or artificially, has prompted numerous studies to be conducted by scientists from a variety of fields in order to establish the scientific evidence for and validation of the health benefits of a given food or component.

##### **i) Fucoidan and dietary fibre**

These sugars are polymers of glucose molecules as well as galactose, fructose, xylose, arabinose, and other sugars, although they are not inherently starchy. They serve as storage and structural carbohydrates. As a result, they are fermented in the colon by probiotic microorganisms rather than being hydrolyzed by human digestive enzymes.

Dietary fibres (DF), lengthy fibrous properties, provide them the ability to entrap dangerous poisons and carcinogens in the digestive system, potential to decrease blood cholesterol and possess strong water-retention, gelling, and hydro-colloidal forming capabilities. Insoluble dietary fibre is useful for bulking up faeces and quickening the rate at which food moves through the digestive system since it does not dissolve in water. Additionally, insoluble dietary fibre dilutes away possible carcinogens, reduces toxins' interaction with the digestive system, and hastens their exit from the body.

Fucoidan has also been shown to stimulate the development of a variety of immune cell types and the phagocytic activity of macrophages, both of which increase resistance to infection and fortify the immune system. Fucoidan improves the body's first line of defence against diseases and infections by increasing the number of mature white blood cells that are circulating there.

Sources: Foods high in soluble dietary fibre include apples, cranberries, mango, oranges, asparagus, broccoli, carrots, peanuts, walnuts, most legumes, oats, and psyllium. In contrast, foods high in insoluble dietary fibre include apples, bananas, berries, broccoli, green peppers, spinach, almonds, sesame seeds, brown rice, whole-wheat breads, and cereals.

Many medicinal mushrooms and brown seaweeds contain large amounts of the compound fucoidan.

## **ii) Antioxidants, cancer-fighting, and immune-modulating substances**

Free radicals and reactive oxygen species (ROS) are fought off by antioxidants within the cell.

The following are a few examples of antioxidants:

*Lycopene, lutein, and other carotenoids, as well as polyphenols, phytosterols, tocopherols, and tocotrienols.*

*Antioxidants'* main jobs involve controlling a cell's redox state and minimizing agents that could trigger cell death and tumorigenesis. Antioxidants therefore act as anti-carcinogenic agents. In the digestive system, antioxidant molecules have the ability to bind to poisons or carcinogens, inhibiting their transformation or even absorption. The majority of common malignancies are protected from by *phytosterol/stanols*, which also have a lipid-lowering function. However, phytoestrogens or isoflavones have an antagonistic effect on oestrogen that reduces premenopausal women's overall exposure to oestrogen and lowers their risk of breast cancer. An important mechanism for immune-modulation is the wide range of antioxidant capabilities of polyphenols, tocopherols, carotenoids, isothiocyanates, and allyl sulphides, with lycopene being the most potent oxygen neutralizer with potential chemopreventive qualities. When these compounds are combined, the negative effects of reactive oxygen species (ROS) and free radicals, which cause the early death of immune cells, can be reduced.

Sources: Food sources of polyphenols and flavonoids include fruits, vegetables, grains, legumes, nuts, tea, wines, and other beverages made from fruits, vegetables, and grains. Lutein is abundant in dark green leafy foods like kale, spinach, mustard greens, and green beans. Both beta- and alpha-carotene are found in large quantities in spinach, winter squash, carrots, and carrots. The main food source of lycopene is tomatoes.

- ✓ Other bioactive tomato constituents include kaempferol and chlorogenic acid, which have anti-mutagenic capabilities. It appears that tomato suspension can reduce colon cancer as a result.
- ✓ The typical dietary sources of tocopherol and tocotrienols are vegetable oils, nuts, and the germ of grains.
- ✓ Several foods, including broccoli, garlic, onions, vegetable oils, almonds, and walnuts, have been shown to have beneficial immuno-modulatory effects.
- ✓ Garlic, soy beans, cabbage, ginger, licorice root extract, and umbelliferous vegetables have the strongest anticancer effects (vegetables that grow or generate their plant under the earth, such as carrots).

## **iii) Probiotics and prebiotics**

Probiotics, which include *Lactobacillus* (LAB), *Biofidobacterium*, and others, are beneficial living organisms that, when given in appropriate numbers, benefit the host's health. Prebiotics are dietary substances that cannot be digested but are thought to benefit health by encouraging the growth and activity of probiotics in the gastrointestinal tract. In addition to

having a positive impact on our immune system by producing inhibitory chemicals, preventing adhesion sites, competing for resources, weakening toxin receptors, and boosting immunity, probiotics are beneficial to humans because they maintain a healthy balance between beneficial and harmful microorganisms.

Prebiotics promote the development of beneficial bacteria (probiotics) in the gut, hence strengthening the body's defences against pathogen invasion.

Sources: It has been claimed that goods made from fermented foods and dietary supplements contain healthy cultures. Other conventional dietary sources of prebiotics include soybeans, uncooked oats, unprocessed wheat, and unrefined barley.

### 12.5 Nutraceuticals

Nutraceutical is a term that combines the words pharmaceutical and nutrition. The word is reported to have been coined in 1989 by DeFelice and the Foundation for Innovation in Medicine.

The phrase was reiterated and defined as follows in a press release dated 1994: "Any substance that may be considered food or a component of food and delivers medical or health benefits, including the prevention and treatment of disease. These goods can range from isolated nutrients to dietary plans, nutritional supplements, and meals that have been "created" using genetic engineering. They can also include herbal remedies and processed foods like cereals, soups, and drinks.

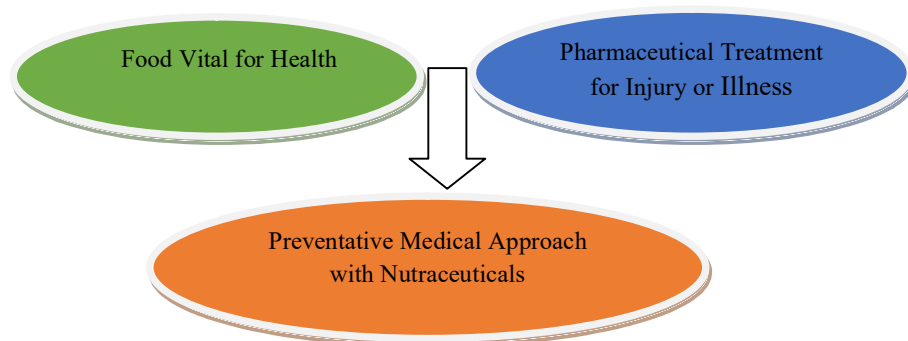


Fig: Concept of Nutraceuticals

nutraceuticals might be a specific component of a meal, like omega-3 oil from salmon, or it can be a food that is naturally abundant in nutrients, like spirulina, garlic, or soy. People can improve their health by taking supplements and consuming foods that have been produced

### 12.6 Classification

Nutraceuticals can be divided generally into two groups:

- Potential Nutraceuticals: Those with a viable strategy for specific medicinal or health benefits.
- Established Nutraceuticals – A potential nutraceuticals can only be considered established once it has received enough clinical use to show its advantages.

The following are some nutraceuticals with their sources and health advantages:

- Glucosamine and chondroitin, which are found in ligaments, cartilages, and tissues, are helpful for maintaining joint health.
- Co Q-10, melatonin, and DHA, which are present in bone marrow, fish oil, olive oil, and soybeans, are advantageous for cardiovascular health.
- For good eye health, consume foods like resveratrol from grapes, carotenoids from carrots, sweet potatoes, and tea extract, as well as pycnogenol from barley.

Most foods include nutraceuticals in variable amounts, which have an impact on human health when consumed. Nutraceutical-rich diets, consistent exercise, stress management, and maintenance of a healthy body weight will maximize health and lower illness risk.

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## Back Cover Page



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