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Introduction to Biotechnology

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Biotechnology, as the word implies, is a combination of various technologies, applied together to living cells and bacteria for production of numerous goods that benefit the human beings. The name biotechnology was given by Hungarian engineer Karoly Ereky in 1919 to describe a technology based on converting raw materials into a more useful product. These technologies are including not only biology, but also subjects like mathematics, physics, chemistry and engineering.

The applications of biotechnology range from agriculture (animal reproduction, cropping systems, soil science and soil conservation, plant physiology, seed and crop management) to industry (food, pharmaceutical products, chemicals, textiles etc.), medicine, nutrition, environmental conservation and cell biology, making it one of the fastest growing fields. Health, life quality and expectancy of life have been increased worldwide through the services provided by biotechnology (1).

Biotechnology also contributes towards the growing public health needs in industrialized and developing countries. It provides effective diagnostics, prevention and treatment measures including production of novel drugs and recombinant vaccines (2). It gives effective drug delivery approaches, new methods for therapeutics, nutritionally enriched crops and efficient methods for environmental cleanup.

Many conventional diagnostic tools are inaccurate, time consuming, laborious and expensive. In contrast, modern biotechnology comprised of molecular diagnostic tools sketches recent advances in biology for the detection of diseases. Molecular diagnostics have been ranked by the scientific panel in the University of Toronto as the best set of technologies for improving the health status (3). Parasitic and infectious diseases like Acquired Immunodeficiency Syndrome (AIDS) and tuberculosis (TB) have been diagnosed rapidly at relatively low cost.

Molecular diagnostic tools including polymerase chain reaction (PCR) (4), recombinant antigens and monoclonal antibodies have been used for this purpose. Biotechnology has offered modern diagnostic test kits, bacterial and viral vaccines along with radiolabelled biological therapeutics for imaging and analysis. Vaccines have eliminated small pox, polio and other deadly diseases for the last hundred years. Biotechnology has made advancements in vaccination by making recombinant vaccines that have the potential to eradicate non-communicable diseases like cancer. Naked DNA vaccines, viral vector vaccines and plant-derived vaccines are found to be most effective against a number of bacterial and viral disorders (5).

Biotechnology offers cheaper drug and vaccine delivery tools that eliminate blood-borne infections caused by re-use of needles. The modern needle-free technologies use high speed jets of gas to introduce the vaccine inside the human body. The drugs and vaccines can be diffused into the body or inhaled through nasal sprays. Lately, drugs are efficiently delivered into the body using nano-particles.

Another promising direction in biotechnology is the research and production of recombinant therapeutic proteins that will be used for the cure of rare diseases which are impossible to treat by conventional therapies. In the future, therapeutic proteins may be used against asthma, different cancers, Parkinson’s and Alzheimer’s diseases (6).

As mentioned before, the application of modern biotechnologies offers nutrients-enriched genetically modified food. This is critically important in developing countries where over half of the infant deaths occur due to the deficiency of essential nutrients and vitamins. Malnutrition causes impaired cognitive and physical development and multiple illnesses such as anemia. Also, malnutrition has adverse effects on immune system. In order to overcome these nutrients and vitamin’s deficiency, biotechnology enables to introduce new genes and new traits into crops more precisely than traditional breeding. Some of the nutrients- enriched food are the ‘Golden Rice” (rice enriched in beta-carotene, the precursor of vitamin A), zinc- and iron-enriched maize, potato, soybean and milk (enriched in a protein called casein) (7).

Environmental biotechnology improves the safety of public health through efficient methods of pollution prevention and treatment of human or industrial waste products. Biodegradation of heavy metals and bioremediation are two of the commonly used methods of treatment. The first technology uses microorganisms that have enzymes to reduce or oxidize the heavy metals which helps in the biodegradation of waste containing these heavy metals. The second technology uses microorganisms like bacteria and fungi to biodegrade, breakdown or convert the pollutants and contaminants into non-toxic chemicals. Contaminants are used as an energy source by the microorganisms and then they are converted to less toxic forms.

In this unit, students will be exposed to the main concepts of Biotechnology and learn that through the use of Biotechnology, the scientists and engineers are attempting to modify genetic structure in animals and plants to improve them in a desired way for getting beneficial products.

Unit Content

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1. “Molecules of life” - Fundamentals of proteins, carbohydrates, lipids, nucleic acids

All life on Earth is built from four different types of molecules. These four types of molecules are often referred to as the molecules of life. The four molecules of life are proteins, carbohydrates, lipids and nucleic acids. Each of the four groups is vital for every single organism on Earth. Without any of these four molecules, a cell or an organism would not be able to live. All of the four types of molecules of life are important either structurally or functionally for cells and, in most cases, they are important in both ways.

Proteins

Proteins are the building blocks of life. They are the most common molecules found in cells. If all the water is removed from a cell, proteins make up more than half of the remaining weight. The diversity and abundance of proteins within biological systems contribute to the large range of functions for which proteins are responsible. In fact, the large variety of protein structures inform their wide range of functions. Such functions include muscle movement, storage of energy, digestion, immune defense and much more.

Among their many functions, proteins provide structural support to specific tissues and organs within an organism. Keratin, for example, is the protein found in the outer layers of skin, making the skin a strong protective layer to the outside world. Keratin is also the structural protein that comprises the vast majority of tissues like hair, horns and nails.

Digestion is a function that is driven by proteins, specifically a protein type known as enzymes. Enzymes facilitate digestion by speeding up chemical reactions and cleaving large molecules into small and consumable molecules. Digestion specifically, is the breakdown of food from large, insoluble molecules into smaller molecules that can dissolve in water. These water-soluble molecules can enter the bloodstream and are transported throughout the body.

A very important protein for animals, both mammals and birds is hemoglobin. It is the protein in blood that binds to oxygen so that oxygen can be transported around the body.

The primary structure of a protein is a long chain made of many smaller molecules called amino acids. There are 20 different amino acids that are used to build proteins. The different amino acids can be arranged into trillions of different sequences that each creates a unique protein. The long chain of amino acids twists and folds on itself to produce the final shape of a protein (8).

An amino acid consists of a carboxyl group (chemical structure -COOH), an amine group ($-NH_2$), and a sidechain made mostly from carbon and hydrogen. The sidechain is often referred to as the R group. The differences in the R group make the 20 amino acids different from each other.

An amino acid can be water-soluble (polar), water insoluble (non-polar), or contain a positive or negative charge. These characteristics determine how the amino acids behave as they link up and influence the overall shape and function of a protein.

All 20 amino acids are necessary for good health. If an organism is low in one of the 20 amino acids, certain proteins are not built, causing health issues for the organism.

Some amino acids can be created by the body using other molecules while other amino acids must be sourced from food. The amino acids that must be eaten are known as the “essential amino acids” because they are an essential part of a healthy diet. The amino acids that can be made by the human body are known as “non-essential amino acids”.

The simplest form of a protein is called a polypeptide. A polypeptide consists of a chain of amino acids. Amino acids are bonded together between the amine group ($-NH_2$) of one amino acid and the carboxyl group (-COOH) of a second amino acid. The order the amino acids link together determines the final shape and structure of the polypeptide chain.

Carbohydrates

Carbohydrates are an important source of energy. They provide structural support for cells and help with communication between cells. A carbohydrate molecule is made of atoms of carbon, hydrogen and oxygen. They are found in the form of either a sugar or many sugars linked together.

Carbon atoms have the ability to bond to four other atoms. In carbohydrates, carbon atoms form a linear chain by bonding to two other carbon atoms. The chain ends when a carbon uses three of their bonds with oxygen and hydrogen rather than bonding to two carbons.

The oxygen atoms of a carbohydrate can be bonded to carbon with double or single bonds. If an oxygen forms a double bond to a carbon atom (C=O), this is known as the carbonyl group. Oxygen can form a single bond to a carbon atom when is part of hydroxyl group (-OH). A carbohydrate can contain more than one hydroxyl group.

Hydrogen atoms take up most of the remaining carbon bonds. Generally, there is around twice as many hydrogen atoms in a carbohydrate as there are oxygen atoms.

The most basic carbohydrates known as simple sugars are called monosaccharides. They include sugars such as glucose and fructose. Monosaccharides are the building blocks for larger carbohydrates, and are also used in cells to produce proteins and lipids. Sugars that are not used for production of cells' energy are often stored as lipids or more complex carbohydrates.

The monosaccharides are compounds used by cells to get energy. Glucose is arguably the most important monosaccharide because it is used in respiration to provide energy for cells.

Two monosaccharides joined together form a disaccharide. The best known disaccharide is sucrose, commonly used as sugar because of its sweetness. Sucrose is made by bonding together one fructose and one glucose molecule. Another well-known disaccharide is lactose, the sugar found in dairy products. Lactose is made from one molecule of glucose and one molecule of galactose. It is not uncommon for humans to have difficulties breaking down lactose into glucose and galactose after eating dairy products. This is the cause of the health condition known as lactose intolerance which can cause diarrhea, bloating, gas and vomiting.

The names of monosaccharide and disaccharide carbohydrates end with the suffix -ose. For example fructose, glucose, galactose, sucrose and lactose.

Polysaccharides are made out of three or more monosaccharides joined together. A single monosaccharide in a polysaccharide is referred to as a monomer. A polysaccharide, which is made from many monomers, can be called a polymer. Some polymers are more than 1000 monomers (or monosaccharides) long.

Polysaccharides have a range of biological functions. A key function they fill is as a temporary storage of energy. Plants store energy in the form of a polysaccharide known as 'starch'. Many crops, such as corn, rice and potatoes, are important because of their high starch content. Humans and other animals store energy in their muscles and liver using a polysaccharide known as glycogen.

Using carbohydrates to produce energy prevents proteins being used for that purpose. This is important because it allows proteins to be used for other functions, such as metabolism and muscle contraction.

Lipids

Lipids are a group of molecules that include fats, oils, waxes and steroids. These molecules are made mostly from chains of carbon and hydrogen, called fatty acids. Fatty acids bond to different types of atoms to form many lipids. Cells require lipids for a number of functions that include insulation of heat, storing energy, protection and cellular communication.

Fatty acids

Fatty acids are a defining feature of lipids. A fatty acid is a long hydrocarbon (alkyl) chain with an acidic end. The acidic end is known as a "carboxylic acid" and has the chemical structure RCOOH, the same structure that makes vinegar acidic.

A fatty acid can be saturated or unsaturated. If two carbon atoms of the hydrocarbon chain share a double bond, then a fatty acid is known as "unsaturated". If there is no double bonds along the alkyl chain, the fatty acid is saturated. This is because all of the carbon atoms bond to as many hydrogen atoms as possible. The alkyl chain is therefore saturated in hydrogen. The presence of a double bond makes a fatty acid unsaturated because it is possible for the alkyl chain to bond to more hydrogen atoms.

Fats and Oils

Fats are a well-known form of lipids. They are made by bonding fatty acids to an alcohol. The most common fat is a triacylglycerol. A triacylglycerol is a fat made from three fatty acids bonded to an alcohol called "glycerol". Glycerol is a three carbon alcohol, and each of the carbons bond to one fatty acid.

The structure of fatty acids in a fat determine if that fat is saturated or unsaturated. Double bonds in one or more alkyl chains of the fatty acids create an unsaturated fat. A fat molecule with no double bonds in any of its alkyl chains is known as a saturated fat.

A double bond creates a bend in an alkyl chain. This reduces how tightly fat molecules can be packed together. Loosely packed fats have lower melting points which is why unsaturated fats, such as vegetable oils, are commonly liquid at room temperature. Saturated fats on the other hand have higher melting points, and are more likely to be found as solids at room temperature.

The main function of a fat is to store energy. They are most common in animals because they contain a very large amount of energy for their weight. A fat molecule will hold far more energy than a carbohydrate molecule of the same weight. For mobile animals, carrying extra weight is not ideal, so storing energy in lightweight molecules is beneficial. Fats are stored in tissue known as adipose tissue and in cells known as adipose cells.

Phospholipids

Phospholipids are less known than fats and oils but are essential to life on Earth. They are the molecules used to build the membranes found around and inside cells. Without a membrane, a cell would not be able to survive.

A phospholipid is similar in structure to a triacylglycerol. It contains two fatty acids plus a phosphate group bonded to the three carbons of a glycerol molecule. The sole difference between a phospholipid and a fat is the replacement of one fatty acid with a phosphate group (-PO4). A phosphate group has a negative charge (3-) so many other molecules can attach themselves to the phosphate group. This makes a large variety of different possible phospholipids.

Steroids

Steroids are a particular type of lipid with a unique chemical structure. They are characterized by having carbon atoms arranged into four adjacent rings - three rings made from six carbon atoms and the final ring made from five carbon atoms. Steroids are produced naturally in the body. Examples include cholesterol and the sex hormones testosterone, progesterone and estrogen. Cholesterol is the most abundant steroid in the body and is produced in brain, blood and nerve tissue.

Nucleic acids

Nucleic acids are long chains made from many smaller molecules called nucleotides. Each nucleotide is made of a sugar, a base and a phosphate group. There are two types of nucleic acids that are essential to all life. These are DNA (deoxyribonucleic acid) and RNA (ribonucleic acid). DNA is a very well-known type of molecule that makes up the genetic material of a cell. DNA is responsible for carrying all the information an organism needs to survive, grow and reproduce.

For animals, plants, fungi and other eukaryotic organisms, the majority of DNA is found within the cell nucleus (chromosomes). In organisms which have prokaryotic cells, such as bacteria, DNA can be found coiled together anywhere within the cell in a nucleus-like structure called a nucleoid.

Structure of DNA

A DNA is a large molecule (macromolecule) and is made up of many smaller molecules connected together to form a long chain. The smaller molecules are known as nucleotides and each nucleotide consists of a sugar (deoxyribose), a base and a phosphate group. Nucleotides are bonded together by the phosphate group of one nucleotide and the sugar on the next nucleotide.

One strand of DNA is almost always found bonded to another strand in a structure known as the double helix. The double helix DNA structure is sort of the unofficial emblem of biology.

Two strands of DNA bind together to form the double helix because of the way each strand is both attracted and repelled by the other strand. The two strands bind through the bonding of the bases of each nucleotide (the bases from one strand bond to the bases of the second strand of DNA). This makes the two chains run anti-parallel to each other and gives the DNA the spiraling structure that makes the double helix.

The bases that are responsible for the bonding of two DNA strands are known as nitrogenous bases. Each nucleotide has one nitrogenous base but there are a total of four different nitrogenous bases in DNA molecules. The nitrogenous base molecules are bonded to the deoxyribose sugar of a nucleotide.

Differences in the arrangement of these four bases along a strand of DNA is how different genes are formed. A specific sequence of nitrogenous bases provides the information for a cell to produce a specific protein. The four different bases are adenine (A), thymine (T), guanine (G), or cytosine (C). The nitrogenous bases of one DNA strand bonds to the opposite bases in the second strand. This brings the two DNA strands together to form the double helix.

The bases bond in pairs and will only bond with one of the three other bases, that means adenine only bonds with thymine and guanine only bonds with cytosine. The size of a double stranded DNA molecule is measured by the number of base pairs it contains and a single strand is measured by the number of nucleotides it has. As humans, we have a total of 6,000,000,000 base pairs in all of our chromosomes and the entire sequence of base pairs was published by the Human Genome Project in 2003.

RNA is a less-known molecule but it also plays an important role in cells. RNA molecules are used to translate the information stored in DNA molecules and use the information to help build proteins. Without RNA, the information in DNA would be useless.

The two differences between DNA and RNA are their sugars and their bases. DNA has a deoxyribose sugar while RNA has a ribose sugar. DNA has four different bases – adenine (A), thymine (T), guanine (G), and cytosine (C). RNA has three of the same bases but the thymine base is replaced with a base called uracil (U).

2. Producing food and alcohol through fermentation

People used biotechnology techniques for thousands years to produce food and drinks. For example, ancient Egyptians applied fermentation technologies to make dough rise during bread-making. Due in part to this application, there were more than 50 varieties of bread in Egypt more than 4,000 years ago.

The first beer known to humans was brewed by Sumerians in Mesopotamia (modern-day Irak) approximately 7,000 years BC (9). Egyptians made also beer and wine using fermentation techniques based on an understanding of the microbiological processes that occur in the absence of oxygen. In wetter parts of the Nile Valley, Egyptians bred geese and cattle to meet their society's nutritional and dietary needs. Yogurt was made at homes but the reason of the conversion of milk into yogurt was unknown to old people.

Scientists proved that yogurt is made due to the action of yeast added to milk, which is also biotechnology as it uses a micro-organism for fermentation of lactic acid.

3. Genetic engineering, artificial tissues

Genetic engineering, also called genetic modification (GMO), is the direct manipulation of an organism's genome using biotechnology methods. Through genetic engineering, organisms can be given targeted combinations of new genes, and therefore new combinations of traits that do not occur in nature and cannot be developed by natural means. Such an approach is different from classical plant and animal breeding, which operates through selection across many generations for traits of interest.

The new genes can be obtained through any one of the following methods: cloning, hybridization, reverse transcription of the RNA, chemical synthesis (if the sequence of the gene is known), or by polymerase chain reaction (PCR) if the gene specific primer is available (10).

With the advancement of methods of genetic engineering in the 1980s, it became possible to transfer specific genes from other organisms including microbes and animals into plant cells and protoplasts and regenerate the whole plant - that is the transgenic plants. The introduction of transgenic plants or genetically-modified crop plants with improved agronomic characteristics is a real boost to agriculture and may be responsible for the second green revolution. In addition to the applications in agriculture, genetic engineering of plants has also helped to understand the basic mechanism of gene expression and its involvement in various activities such as morphogenesis and differentiation (11).

A relatively new field in biotechnology is tissue culture. It is a method in which fragments of tissue from an animal or plant are transferred to an artificial environment in which they can continue to survive and function. The cultured tissue may consist of a single cell, a population of cells, or a whole or part of an organ. Cells in culture may multiply, change size, form, or function. They can exhibit specialized activity or interact with other cells. Many tissues such as cardiac muscle, heart valves, and blood vessels have distinct elastomeric properties, so engineering these tissues has been a continuous effort in the tissue engineering community (12).

The ability to generate functional tissues and organs as replacements for their damaged or diseased counterparts is a rapidly advancing pursuit in the field of tissue engineering and regenerative medicine. Interest in this field has been motivated by clinical needs: an increase in chronic disease due to increased life expectancy, the low availability of suitable donor tissue for transplantation and the fact that medical implants cannot fully replicate all of the functions of a replaced tissue and have a finite life. Recent scientific and technological developments in materials, particularly at the nanoscale level have had a great impact in the development of tissue engineering (13). One application is represented by the organ transplant.

Due to the scarcity of organs available for donations and incompatibility of donor organs with hosts, many research groups are currently working to develop Extra Cellular Matrix (ECM)-like scaffolds for engineered tissues or whole organs. One of the biggest challenges in the field of tissue engineering is biocompatibility, which is critical to ensure that patients do not develop an immune response and reject the implant.

First, the tissues and organs must be size matched to have the appropriate dimensions that allow for true biocompatibility with the recipient. One solution to this problem is the development of advanced synthetic materials incorporating biomimetic ECM components for cellular recolonization. Polymers and polymer blends are, today, the most commonly used base for creating synthetic soft tissue ECM scaffolds, and many are already being used for functional in vivo studies to assess their utility for tissue regeneration. Polymers are an ideal material for biomedical applications because their properties are highly adjustable and can be engineered to have a variety of mechanical and biological properties. Polymers can be modified via surface functionalization to control wettability, electric charge, morphology, and roughness. Some polymers are also biodegradable and have modifiable degradation rates (14).

However, synthetic polymers inherently lack cell recognition signals, and this presents a hurdle to their adoption as scaffold materials (15). This limitation can be addressed by chemical modification of the polymer before scaffold formation, or surface treatment after scaffold formation, to make the material functional.

Although still largely in the research and development phase, a number of fibrous self-assembling peptide hydrogels are candidates for new biomaterials (16). Utilizing natural amino acids in designed sequences, it may be possible to achieve biocompatibility and safe degradability without provoking any immune response from the receiving organism. The range of amino acid side chains allows tuning to specific uses by varying the primary structure, for example, altering self-assembly may influence the physical properties (pore size, fiber thickness and mechanical properties), different side chains may influence chemical properties (pH and surface properties), and biologically relevant peptide sequences can be included to modify the material’s biological properties. Certain types of self-assembling peptides (ex. RAD16 sequences) have been widely studied, tested in areas as diverse as nerve repair, heart and endothelial treatments and model skin replacements (17).

Classroom Activities

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1. What is Biotechnology? Lesson plan (one class period)

Learning objectives

Students will be able to define the Biotechnology as a branch of science, explain its role in everyday life, and describe how its products affect the overall quality of life.

Materials and teacher-developed resources

- Paper (Student Notebook), pencils, software (ActivInspire / Promethean)

Learning activities

For the first part of the lesson, students will read an article about the history of Biotechnology. Then, the teacher will split the students in groups of three or four and conduct a class discussion about the topics mentioned above. Ask students to describe the applications of biotechnology and give examples of these applications (in agriculture, industry, medicine, nutrition, environmental conservation, cell biology).

Furthermore, the teacher will explain how biotechnology contributes towards the growing public and global health needs by producing new drugs and vaccines. At the end of the lesson, students will complete a Biotechnology timeline worksheet that underlines the most important dates and events in the development of this branch of Science.

2. Organic Compounds - Carboxylic Acids Lesson plan (one class period)

Learning objectives

Students will be able to identify and name the most usual carboxylic acids.

Materials and teacher-developed resources

- Paper, pencils, software (power point presentation)- Few 100 ml jars containing acetic acid

Learning activities

The teacher will explain that carboxylic acids are organic compounds that contain the carbonyl group C=O bond together with the hydroxyl group –OH. Students will identify the most commonly used organic acids and using IUPAC system, name them (the alkane/ alkyl radical root followed by the termination -oic for each term of the series.) Examples: Ethanoic, Propanoic, Buthanoic acids.

3. Organic Compounds - Amines Lesson plan (one class period)

Learning objectives

Students will be able to identify and name the organic compounds containing the amino- group.

Materials and teacher-developed resources

- Paper, pencils, software (power point presentation)

Learning activities

The teacher will ask the following question: “What do heroine, morphine, tranquilizers, decongestants and dyes have in common?” The answer is that they are all amines, organic compounds that contain the amino- group, -NH2 bond together with an alkyl radical. Students will identify the most commonly used amines and using IUPAC system, name them. The teacher will present some of their physical and chemical properties and mention that they are components of proteins.

4. Protein Test Lesson plan (one class period)

Learning objectives

Students will be able to identify the presence of proteins in two essential food, egg and milk.

Materials and teacher-developed resources

- Paper, pencils- Two small bottles containing sodium hydroxide (NaOH) 1M and copper sulfate CuSO4 1M solutions- One glass of milk- One egg- Two test tubes- Two pipettes- Stirring rod

Learning activities

The teacher will introduce the characteristics of proteins and their role in nutrition.

Then ask students to take one test tube and fill it up to a quarter with milk.

1. Using the pipettes, put few drops of each chemical (sodium hydroxide and copper sulfate) into the test tube. Stir the tube using the stirring rod. The solution will change its color from white to violet.
2. Crack the egg and fill about a quarter of the second test tube with egg white
3. Using the pipettes, put few drops of each chemical (sodium hydroxide and copper sulfate) into the test tube. Stir the tube using the stirring rod. The new solution will also change its color to violet.
4. Clean up the stirring rod after each use
5. The violet color indicates the presence of proteins in both milk and egg

The teacher will direct the students to write for ten minutes in their journals summarizing the lab and all procedures used in this lesson.

5. Carbohydrates Test Lesson plan (one class periods)

Learning objectives

Students will be able to identify the presence of carbohydrates in glucose and starch.

Materials and teacher-developed resources

- Paper, pencils- Two small bottles containing glucose and starch- Two test tubes- Two pipettes- Stirring rod- One spatula- Plastic gloves

Learning activities

The teacher will introduce the characteristics of carbohydrates and their role in nutrition.

Then ask students to take one test tube and using a pipette, add 10 mL of glucose. In the second test tube, students will add a half spatula of starch. Add about 20 ml of water to each test tube.

1. To test for glucose, students will use a test strip with an indicator pad that changes color in the presence of glucose. Dip one test strip into each sample for 1-2 seconds. Remove the strips, put them in the appropriate spot and wait for 3 minutes.
2. After 3 minutes, look for a color change in each of the glucose test strips and record the color of each

glucose test strip.
3. To test for starch, students will use iodine as an indicator. In the presence of starch, iodine changes the color from yellow-brown to blue-black. Add 5 drops of iodine solution to each test tube. Stir the contents of each tube.
4. CAUTION: Students must be careful when handling iodine, because it can stain hands and clothing. ALL students must wear gloves.
5. Record the color of each solution; the blue-black color indicates the presence of starch.

The teacher will direct the students to write in their journals the summary of the lab and all procedures used in this lesson.

6. Lipids Test Lesson plan (one class periods)

Learning objectives

Students will be able to identify the presence of lipids in two essential food, butter and vegetable oil.

Materials and teacher-developed resources

- Paper, pencils- A small bottle containing vegetable oil- One cube of butter- One glass of water- One brown paper bag- Two pipettes- One spatula- A source of bright light (flashlight)

Learning activities

The teacher will introduce the characteristics of lipids and their role in nutrition.

Then ask students to cut the brown paper bag into 3 sections. Label the sections “butter”, “vegetable oil” and “water”.

1. Using the pipettes, put few drops of vegetable oil and water on each labeled piece of paper and rub individually the papers.
2. Using the spatula, put few grams of butter on the labeled piece of paper and rub the paper.
3. Use a paper towel to rub off any excess substance that may stick to each paper.
4. Put each paper aside until the spots appear dry (10 to 15 minutes).
5. After all three pieces of brown paper are dry, turn the flashlight “on” and hold each paper up against the bright light.
6. Students will notice that the papers labeled “butter” and “vegetable oil” have each a spot that allows the light to go through, while the paper labeled “water” does not.

This type of spot that allows the light to go through a brown paper indicates the presence of lipids.

The students to write in their journals summarizing the lab and all procedures used in this lesson.

7. Fermentation Process Lesson plan (one class periods)

Learning objectives

Students will be able to identify samples of fermented foods, describe the process of fermentation and learn that fermentation is one of the oldest methods of preserving food.

Materials and teacher-developed resources

- Paper, pencils- A small cup of sea salt- One pack sourdough bread- One cup of sauerkraut- One jar of chopped cabbage- Three empty jars- One spatula- Plastic gloves- pH strips- Three thermometers

Learning activities

Students will answer and share responses to the following questions: “What is fermentation?” “Can you name some fermented food products?” Then, the teacher will explain the process of fermentation and share that fermentation is one of the oldest food preservation method used worldwide. Students will analyze and describe the fermented food samples (sourdough bread and sauerkraut) and prepare the fresh cabbage for fermentation.

The teacher will discuss the processes of osmosis, maceration, aerobic and anaerobic respiration. Then, ask students to prepare the fresh food (cabbage) for fermentation.

1. Students will divide equally the amount of cabbage between the three empty jars.
2. Fill the three jars with fresh water.
3. Add two spatulas of sea salt to each jar.
4. Mix well the content of each jar.
5. Place one jar under the full sun, another jar in the shade and another jar in a refrigerator.
6. Ask students to make predictions about the relationship between temperature and speed of fermentation.

Using the pH strips, over the next 10 days students will measure the pH inside of each jar and graph the results. Students will record the results and the summary of the lab in their journals.

Appendix on Implementing District Standards

CT New Generation Science Standards:

HS-PS4-2. Engineers continuously modify the technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. This standard is addressed in the lesson #1.HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells. Students will learn about the DNA structure and function in the “Nucleic Acids” paragraph.HS-LS1-6. Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. (See lesson plans #2 and #3)HS-LS1-7. As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products. (See lesson plans # 4 - 7)

District Standards:

D.32 Describe how bacterial and viral infectious diseases are transmitted, and explain the roles of sanitation, vaccination and antibiotic medications in the prevention and treatment of infectious diseasesD.34 Describe, in general terms, how the genetic information of organisms can be altered to make them produce new materials.D.35 Explain the risks and benefits of altering the genetic composition and cell products of existing organisms.These standards are addressed in the introductory paragraph that explains the contribution of Biotechnology in improving public health in both industrialized and developing countries. D.45 Explain how technological advances have affected the size and growth rate of human population throughout history. (See lesson plan #7)

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