ACTIVITY LIST FOR SENIOR SCHOOL AND HIGH SCHOOL STUDENTS BY TEAM iGEM ICT-MUMBAI

INDEX

Activity 1

Aim

To extract DNA from the fruit

Materials

125 ml rubbing alcohol (cold), 2.5 ml salt, 80 ml water, 15 ml dish soap, 3-4 fresh or frozen strawberries (cold & no stems!), 2 beakers/bowls/glasses, coffee filter, funnel, sandwich bag, toothpick, timer, freezer and/or ice

Theory of the Experiment

In animals and plants, DNA is organized into chromosomes located inside the cell nucleus. Strawberries have 7 chromosomes that may be in diploid pairs or octoploid sets, depending on the species.
Knowing a plant's genome helps scientists genetically engineer crops to possess more desirable traits, like:

- the ability to resist disease (instead of using fungicides & pesticides)
- the ability to withstand extreme growing conditions, like drought or cold
- better quality, ex. scab resistance
- improved nutritional value
- and even make them tastier!

To sequence, an entire strawberry genome, first need to extract the DNA from cells.
Probably won't have the equipment (or time) to sequence an entire strawberry genome and study individual genes in science class. But can do this first step and show students what DNA looks like!

3 Steps to DNA Extraction:

STEP 1 – CELL LYSIS

First, need to break open the cells to release the DNA from the nucleus. Plant cells are tough because of cellulose, so *mechanically* mushing the strawberries is an important first step to breaking down the strong cell walls. Next, a detergent is needed to *chemically* break down the lipid cell membrane of the strawberries. Detergents (dish soap in this lab) make proteins

in the lipid layer more soluble. This disrupts the protein-protein, lipid-lipid, and protein-lipid bonds in the membrane, causing the cell membrane to lyse and release its contents.

STEP 2 - PRECIPITATE THE DNA

At this point DNA has been released from the strawberry cells, however, it's mixed in with other organelles and cellular bits. DNA is highly polar due to the negative charges on its phosphate groups. This makes DNA very soluble in water. To separate DNA from the other cellular contents released during cell lysis, we need to reduce DNA's solubility in water and cause it to precipitate.

To do this, we need an ion like Na^+ (salt) that has a stronger positive charge than water. The Na^+ from salt and the $PO3^-$ from the DNA backbone form ionic bonds, which causes the DNA to disassociate from the weak positive charge of water.

The nonpolar rubbing alcohol added in the final steps of this strawberry DNA extraction lab forces the phosphate groups and sodium ions to form even stronger ionic bonds, which further helps the DNA to precipitate out of the solution.

STEP 3 - DNA PURIFICATION

If this strawberry DNA was destined for biotechnology or genetic engineering applications (like those mentioned above), it would likely be further purified to remove additional contaminants and the sequence amplified using PCR.

However, in science class, we just want to get a look at strawberry DNA, so this is where our DNA extraction lab ends.

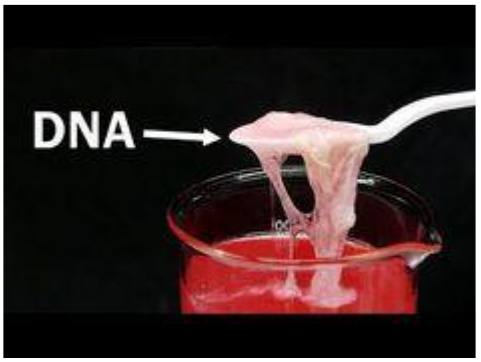
Keep in mind, that a single strand of DNA is too small to see with the naked eye. In this strawberry DNA extraction lab, we are extracting DNA from A LOT of strawberry cells. Since *many* strands of strawberry DNA clump together when we swirl the stick at the layer between the filtrate and the alcohol, we can see it!

Procedure

1. Keep the alcohol in the freezer or on ice until you're ready to use it.
2. Place the funnel in a beaker.
3. Put the coffee filter inside the funnel – wet the coffee filter a little bit to help it stick to the funnel. Set aside.
4. Put 3-4 strawberries in a *sealed* sandwich bag with as much of the air removed as possible. Mush up the strawberries as much as you can. Set aside.
5. MAKE LYSIS SOLUTION: In a bowl mix 2.5 ml salt, 80 ml water & 15 ml dish soap.
6. To the bag of mushed strawberries, add 45 ml of the lysis solution. Seal the bag.
7. Mush this together for about 1 minute.
8. Pour the strawberry mixture into the funnel with the coffee filter and

let the liquid drip down into the beaker – this is the FILTRATE. Let it drip for 2-3 minutes.

9. Remove the funnel with the coffee filter and remaining strawberries.
10. Then, very slowly and carefully, pour the cold alcohol down the side of the beaker to form a ~3 cm layer on top of the filtrate. DO NOT MIX THE LAYERS!
11. Twirl a toothpick or stirring rod where the layers meet. Look closely, DNA is wrapping around the stick.



Discussion Questions and Answers

1. Define cell lysis. Identify the part(s) of the procedure where i) mechanical cell lysis, and ii) chemical cell lysis occurred.
2. Explain the role of dish soap in a DNA extraction lab procedure. Use the terms lipids, proteins, and membrane in your answer.
3. Explain the role of salt in DNA extraction. Use the terms water, sodium ions, phosphate groups, and ionic bonds in your answer.
4. Explain the role of alcohol in DNA extraction. Use the terms sodium ions, phosphate groups, ionic bonds, and precipitate in your answer.
5. What was the purpose of using cold rubbing alcohol?

Activity 2

Aim

To observe how bile breaks down fat

Materials

Shallow dish or pie pan, Cotton swab, Whole milk (at least 2% fat), Food coloring, Liquid dish soap or hand soap

Theory of the Experiment

The liver makes a liquid called bile, which is used to break down the fat from our food as it enters the small intestine. Bile acts to some extent like a surfactant. When soap (a surfactant) surrounds a fat (or dirt or grime), it starts to break down the fat (or dirt or grime) into smaller particles. In this experiment, the soap represents bile as it attempts to break down the fat that's inside the milk. But the fat in the milk is so spread out that the soap cannot easily surround it, which causes it to swirl as it continues to try to surround the fat particles, the food coloring gets moved around as well.

Procedure

1. Pour about 1/2 inch of milk into the dish/pan.
2. Put a drop of food coloring in different spots in the milk, far away from each other.

3. Put some dish soap on the tip of a cotton swab.
4. Insert the cotton swab into the center of the pan of milk.
5. Observe the food coloring drops start to swirl around.

Discussion Questions and Answers

1. What is Bile? What is its function in our body?

2. Why do we use a Surfactant to represent Bile in this experiment?
3. What is the purpose of Milk in this experiment?

Activity 3

Aim

To demonstrate Aerobic Cellular Respiration with Germinating Seeds

Materials

Hydrated Seeds, Sealable Bag, Bromothymol Blue 0.04%, Sodium Hydroxide 1%, Test Tubes, Rubber Stoppers, 250-mL Flask, Test Tube Rack, Distilled Water, Paper Towel

Theory of the Experiment

Cellular respiration processes provide a means for cells to convert existing nutrient materials into energy. During dormancy periods, plant seeds respire just enough to maintain food, or nutrient supplies within a specialized seed layer known as the endosperm. Within flowering plants, endosperm structures are the product of a double fertilization process that takes place when a plant ovule, or ovary, is first fertilized. In effect, the endosperm provides for the seed's nutrient needs and carries out necessary cellular respiration functions throughout the dormancy period. The start of germination places substantial energy demands on the seed as plant growth processes take shape. As a result, cellular respiration rates increase to accommodate the cell-building activities required to break open the seed and produce the initial root and stem structures.

Plant seeds originate from flowers, fruits, green plants, and trees that grow within a myriad of environmental conditions. Not surprisingly, each seed type seeks out certain environmental triggers that prompt the start of germination processes. According to Cornell University, environmental triggers may appear as increased levels of nutrients in the soil, changes in soil temperature, increased rainfall amounts or increases in the amount and quality of light. Once the needed conditions are met, seeds begin to increase their water-absorption rates, which marks the start of germination. Increases in water absorption enable seeds to mobilize food reserves stored within endosperm layers. These processes activate certain enzymes that trigger increases in a seed’s cellular respiration rates.

Germinating seeds carry out cellular respiration processes in much the same way as plant and animal cells do. Cellular respiration takes place in three stages starting with glycolysis. The glycolysis stage uses glucose molecules to produce two units of energy or ATP (adenosine triphosphate) molecules along with other chemical materials. The Krebs Cycle makes up the second stage of cellular respiration. This stage uses the products from glycolysis to produce two more energy units and transforms the chemicals left over from glycolysis into hydrogen-carrying molecules. The Electron Transport Chain is the third stage in the respiration process and is fuelled by the two ATP molecules produced in the Krebs Cycle. This stage combines the energy contained inside the hydrogen molecules

from the Krebs Cycle with oxygen to create 38 ATP molecules. This three-stage process repeats over and over again within each plant cell. The ATP molecules produced by cellular respiration provide the energy for seed germination to begin and fuel the cell-building activities that ultimately form the plant body.

Procedure

1. Two days before the demonstration, rehydrate the seeds (recommend wheat, barley, peas, or mung beans). Place the seeds in a cup or beaker. Use dechlorinated water to cover the seeds to a depth at least 3 times their height in the container to compensate for the expansion of the seeds as they swell. Allow the seeds to soak overnight.
2. Pour off the remaining water and fold the seeds into a wet paper towel. Place the towel in a sealable bag. Close the bag and store the seeds in a dark place over a second night.
3. Prepare the bromothymol blue solution by adding 1.5 mL (about 30 drops) of 0.04% bromothymol blue to 80 mL of distilled water. The prepared bromothymol blue solution should be green, but the shade of green may vary depending on the pH of your water source. A color change will easily be observed if the solution given is slightly basic. To create a slightly basic solution, add the sodium hydroxide dropwise to the bromothymol blue until the color changes from green to a deep blue (10 to 20 drops).

4. The chemical bromothymol blue is an indicator that appears blue in an alkaline (base) solution and yellow in an acidic solution. The carbon dioxide that is added to the solution surrounding the seeds combines with water to form carbonic acid (H_2CO_3), turning the bromothymol blue to a yellow-green color. Remove the carbon dioxide from the solution and the bromothymol blue will turn a deeper blue.
5. Fill a test tube ¾ full with rehydrated seeds. Pour the bromothymol blue solution over the seeds until the tube is full. Seal the tube with a rubber stopper.
6. Prepare a control tube with only bromothymol blue solution. Fill the tube until it is full, and seal it with a rubber stopper.
7. Store the samples until the end of the class period or overnight and make observations regarding the color of the solution or any other changes. (You may set up duplicate samples in the dark to rule out any possible effects of photosynthesis on the experiment.)

Discussion Questions and Answers

1. What is the use of Bromothymol solution?
2. What is the purpose of the control tube with only bromothymol blue solution.?
3. Why did the blue shade of Bromothymol change after the removal of carbon dioxide?

Activity 4

Aim

To Demonstrate Fermentation with Yeast

Materials

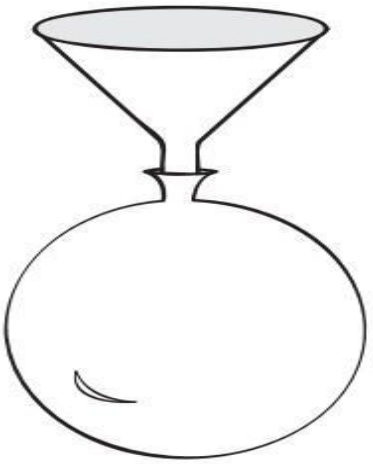
1 tbsp (15 ml) active dry yeast (not fast-acting), 1 teaspoon (5 ml) sugar, 1 cup (250 ml), warm water (41–46°C), funnel, balloon, measuring tape (flexible kind), a spot near a heat source (like a radiator or a sunny window)

Theory of the Experiment

Fermentation is the biological process by which yeast consumes simple sugars and releases alcohol and carbon dioxide. For the most part, fermentation requires a mostly aquatic environment to occur. Different yeasts respond differently to changes in the environment, making some better for baking and others for brewing. Bakers use fermentation to add CO_2 bubbles to bread dough. During baking, these bubbles make the bread light and fluffy while the alcohol boils away. Brewers take care to preserve the alcohol of fermentation and use the CO_2 to help build a frothy head for their potent beverages.

Procedure

1. Measure the length and circumference of your balloon. Record the results.
2. Place the small end of the funnel into the opening of the balloon
3. Pour 1 tablespoon of yeast and 1 teaspoon of sugar into the balloon using the funnel.
4. Slowly add a cup of very warm water.
5. Remove the funnel from the balloon and tie it closed.
6. Place the balloon in a warm place.
7. Measure the length and circumference of the balloon every 15 minutes for an hour. Record the results.



Discussion Questions and Answers

1. How do you know fermentation is taking place?
2. What special characteristic of yeast made the balloon inflate?
3. Why was the sugar added?

4. Why did we need to put the balloon in a warm place?
5. Would you get the same results if the balloon was untied?

Activity 5

Aim

To observe Osmosis with Potato Slices

Materials

A potato, salt, distilled water, and a couple of drinking glasses.

Theory of the Experiment

Ever cut up some apples or potato slices just to see them turn funky colors and not be as fresh as they could be? What can you do to protect these fruits and vegetables and keep this from happening? What will keep potatoes (or other veggies) fresher: soaking them in regular water or saltwater? Osmosis is a property of matter that deals with diffusion; a spreading out of particles from high concentration to low concentration More stuff balances out with less stuff.

You will notice some immediate differences in the potato slices. The color of the salted water one is dark brown; not a nice image of how you would like your potatoes preserved! The one in the regular water looks like a nice white freshly cut piece of potato. Moving on to the flexible test, the regular water one again feels firm and crisp (try to break the piece, it snaps!). The saltwater potato is bendy and doesn't snap at all.

Osmosis is the key to understanding this issue. Osmosis is the diffusion of water across a semi-permeable membrane (yikes!) from an area of high concentration of water, to an area of low concentration.

***Semi-permeable membrane*:** a layer that only certain things can go through. For example, parts of the potato that water can pass through.

Salt is the key here. Water will move from an area of less salt to more salt (more water to less water), and so when the potato is placed in the salt water, all the water that is inside the potato (yes, plants have a lot of water inside of them, that's what gives a plant it's structure) moves out by osmosis. Thus, the potato gets all flimsy and not crisp anymore. Much like if you were to water all your houseplants with salt water. They would all get flimsy and then die, and then your parents would be upset so don't try that at home, please.

Human blood, at 0.9% salt concentration, is a little less salty than seawater, which has a salt concentration of about 35 parts per thousand (3.5%). If we take seawater as an example of a solution, the salt is called the solute (the particles that are dissolved) and the water is the solvent (the liquid that dissolves the particles). Osmosis is the movement of a solvent across a semi-permeable membrane from an area of lower solute concentration to an area of higher solute concentration. The water (the solvent) can move across the membrane but the dissolved solutes (the sodium and chloride ions that form salt) cannot. In such situations, water will move across the membrane to balance the concentration of the solutes on both sides. Cells tend to lose water (their solvent) in hypertonic environments (where there are more solutes outside than inside the cell) and gain water in hypotonic environments (where there are fewer solutes outside than inside the cell). When solute concentrations are the same

on both sides of the cell, there is no net water movement, and the cell is said to be in an isotonic environment.

Procedure

1. Fill two glasses with water.
2. In one of the glasses add 2-3 tablespoons of salt and stir it in.
3. Slice up a potato into French fry-like pieces.
4. Make your observations on these pieces: pay attention to color, how flexible it is, smell, etc.
5. Guessout how you think these slices might change by putting them into the different types of water.
6. Dunk the pieces in the water, and then let them sit overnight in it.
7. Remove the pieces onto a plate and make your final observations

Discussion Questions and Answers

1. Why did some potato samples gain water and others lose water? Was there any pattern?
2. When you drew the best fit line through your data and dropped the vertical line to the x-axis, what salt concentration did you obtain (Estimate if it is between numbers)? What does this mean for the potato?
3. Why can't we use seawater to irrigate our crops?
4. What happens when a thirsty person drinks salt water to try to quench their thirst?
5. Why does salted popcorn dry your lips?
6. What happens to a cell's water when the exterior liquid is saltier than its interior?
7. What happens to water outside the cell when the interior is saltier than its surroundings?
8. When a cell gains water, what happens to its size and weight?
9. When a cell loses water, what happens to its size and weight?
10. When you put limp celery stalks in water, they firm up. Why?
11. Challenge question: Saltwater fish are hypotonic (less salty) to their surroundings while freshwater fish are hypertonic (saltier) to their surroundings. Assuming the salt can't move, what must each fish do with its fluids to compensate for the difference in salinity between the body and the surrounding environment?

Activity 6

Aim

To observe how enzymes work

Materials

Small disposable cups or test tubes, test tube rack (optional), 1 large potato, blender, water, spoon, hydrogen peroxide, vinegar, measuring spoons

Theory of the Experiment

Enzymes are a special type of protein that performs extremely important functions within our bodies and those of all other living organisms. They are responsible for carrying out chemical reactions within our cells that either join atoms and molecules together or break them apart. The function of an enzyme is to make these naturally occurring processes happen more quickly and with a lower requirement of energy. Enzymes are like a lock and the substrate that enters at the beginning of the chemical reaction is like a key. Each enzyme is specifically shaped to accept only one type of substrate. The portion of the enzyme that attaches to the substrate is the active site. After a substrate attaches to the active site of the correct enzyme, it is converted into a product, which leaves the enzyme. The enzyme facilitates this process and is not used up or changed.
In a post a while back we discussed the enzyme catalase and its presence in animal tissues such as liver, kidney, and muscle. Catalase was and is found to be extremely abundant in the liver, a reflection of the liver's cleansing function. It is also present, but much less so, in the kidneys, also a reflection cleansing function. Muscle tissue however had no detectable catalase because it is not a cleansing organ, waste products from the muscles are rather filtered and cleaned by the liver and kidneys. Catalase also has been found in plants, where its presence is often mysterious. Plants of course are not producing waste products similar to what animals produce, so why would they need catalase? We can discover the answer partially by simply understanding the function of catalase.

This is what catalase does in general:
Hydrogen Peroxide + Catalase → Water and Oxygen

Hydrogen peroxide is a highly oxidative molecule, meaning it causes processes similar to rusting to occur. Metals rust as they react with oxygen and oxidative molecules causing rusting to occur. Similar "rusting" or oxidative reactions can occur in plant or animal tissues if oxidative molecules are present. This is why anti-oxidants are such a big deal, they prevent tissue from oxidizing by getting rid of oxidizing molecules such as hydrogen peroxide. Catalase is such an anti-oxidant molecule. Catalase also converts reactive oxygen, which also oxidizes, into hydrogen peroxide and then into harmless water and oxygen. At the end of a reaction, catalase is preserved and available to repeat the reaction over again with more oxidative molecules. Amazingly, one catalase enzyme can repeat this reaction up to 40 million times in one second!

Another catalase reaction:
Reactive Oxygen + Catalase → Hydrogen Peroxide + Catalase → Water and Oxygen

In animals, such as us, oxidative molecules are most often produced through our

metabolizing of food molecules. So the presence of catalase makes sense. Plants do not eat, so why would they need catalase? If we study the process of photosynthesis, we may come across a term called photorespiration. Photorespiration simply is when a plant receives too much light and not enough water. As a result, the plant can produce large amounts of hydrogen peroxide which can kill the plant. Fortunately, catalase prevents the accumulation of hydrogen peroxide by converting it to water and oxygen, and so saves the plant from oxidative damage.

Some plants such as potatoes and spinach have very high levels of catalase, far higher than they would likely ever need to prevent photorespiration damage.

The foam produced is a result of catalase converting hydrogen peroxide into water and oxygen, the bubbles are filled with this oxygen. The more bubbles produced the faster catalase is carrying out this reaction, or the more catalase present. The above would be considered the control for the experiment and simply indicated the presence of catalase in the potato. Tests can be performed to determine the effects of different conditions on the enzyme function. By adding baking soda to the potato, a high pH or basic molecule, will change the pH and affect how well catalase functions. To another test tube, add vinegar to the potato which will lower the pH, making it acidic and also having an effect. Also, try freezing or cooking the potato before adding hydrogen peroxide to determine its effects. Remember, the more foam produced the better the catalase enzyme is working. Less foam means it is not working as well, and no foam means it is not working at all.

Procedure

1. Line up to 3 cups.
2. Cut your potato into 1-inch chunks.
3. You don't need to peel it.
4. Put HALF of the potato chunks into the blender and add ¼ cup of water.
5. Blend on high until the mixture is the consistency of oatmeal.
6. Put about 1 teaspoon of the potato mixture into the 3 cups.
7. You can discard the rest of the potato mixture in the blender, but you might want to set it aside for later in case you need to (or want to) redo the experiment.
8. Next, add 1 teaspoon of water to cup 1.
9. Add 1 teaspoon of vinegar to the cup 3.
10. As quickly as possible, add 1 teaspoon of hydrogen peroxide to the last 2 cups.

Discussion Questions and Answers

1. What are enzymes?
2. What did the catalase do? How do you know?

3. What did grinding the potato up do to the rate of reaction? Why did this change the rate?
4. What did cooking the potato do to the rate of reaction? What conclusion can you draw?

Activity 7

Aim

To Explore Germs and Bacteria at Home (DIY Agar Petri Dishes)

Materials

Cotton swabs, agar powder, water, petri dish, plastic wrap, Glass bowl, spoon,

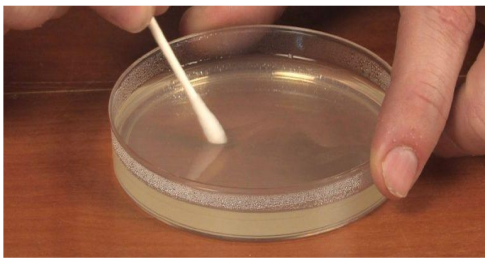
Theory of the Experiment

Bacteria are one-celled, or unicellular, microorganisms. They are different from plant and animal cells because they don't have a distinct, membrane-enclosed nucleus containing genetic material. Instead,
their DNA floats in a tangle inside the cell.
Individual bacteria can only be seen with a microscope, but they reproduce so rapidly that they often form colonies that we can see. Bacteria reproduce when one cell splits into two cells through a process called binary fission. Fission occurs rapidly in as little as 20 minutes. Under perfect conditions, a single bacterium could grow into over one billion bacteria in only 10 hours!
Bacteria are everywhere, and since they reproduce rapidly, they are easy to study with just a few simple materials. All you need are some Petri, agar, and stee swabs or an inoculating needle. Agar is a gelatinous medium that provides nutrients and a stable, controlled environment for bacteria growth. Most bacteria will grow well-using nutrient agar, but some more fastidious bacteria (those with more complex nutrient requirements like *Bacillus stearothermophilus*, *Branhamella catarrhalis*, and *Bacillus coagulans*) prefer tryptic soy agar.

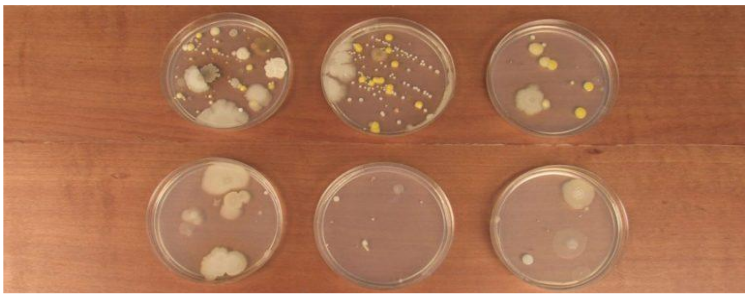
Procedure

1. Microwave your microwave-safe glass bowl, ramekins, and liquid measuring glass for two minutes to sterilize. This is known as autoclaving!
2. To make your agar Petri dishes or ramekins, pour 625ml of water into a clean microwave-safe medium-sized glass bowl. Add 25g of agar into the same bowl, and stir until completely dissolved with a clean spoon or fork
3. Put the agar-water solution into the microwave and set the timer for 4 minutes. Keep a close eye on the solution to make sure it does not boil over the bowl.
4. Let the solution cool for 1 minute before removing it from the microwave. Be careful, the glass and agar-water solution will be hot!

5. Pour the solution into your five empty Petri dishes or ramekins and cover with the plastic lid or plastic wrap.
6. After one hour, the solution will solidify. You should now have 5 agar-filled Petri dishes or ramekins.
7. Set one of your agar-filled Petri dishes or ramekins aside and label it, "Control" using the permanent marker.
8. For your other four agar-filled Petri dishes or ramekins, identify four different surfaces you want to test for bacteria. Use a cotton swab to collect bacteria samples (e.g., door handle, unwashed or clean hands, your mouth before and after brushing your teeth, kitchen sink). Make sure to use one swab per surface.



9. After swabbing a surface, softly draw a squiggly line across the agar and close the lid/recover with plastic wrap. Use one swab per agar plate and make sure to label each agar plate with what was swabbed.
10. For the next week, analyze your Petri dishes every day and write down your observations in your notebook. You can also take photos to document "Day 2", "Day 3", "Day 4", etc. If bacteria start to appear on any of the agar plates, take a ruler to measure the bacteria, and record your observations in your notebook (e.g., color(s), size, clusters). You can even draw or snap a picture of the agar plates each day to include with your notebook entries.



Discussion Questions and Answers

1. Why do we use agar gel for this experiment?
2. Which petri dish started to grow bacteria first? Why do you think it grew bacteria first?
3. Did any of your Petri dishes not grow bacteria? Why do you think it didn't grow bacteria?
4. What petri dish grew the most bacteria? Why do you think it grew the most bacteria?
5. What petri dish grew the most diverse range of bacteria? Why do you think it grew different types of bacteria?
6. If all the Petri dishes grew bacteria, including the control, what do you think could be the reason?
7. Why do you think there is a "Control" petri dish?

Activity 8

Aim

To perform some simple tests to identify the presence of proteins in the given sample

Materials

Glass Beaker, Egg white, Copper sulfate solution

Theory of the Experiment

Proteins are a class of biologically important compounds having high molecular weight. Proteins are perhaps the most complex organic materials produced in nature. Plants build up their proteins from carbon dioxide, water, and minerals in the presence of sunlight. Animals derive proteins from plants.

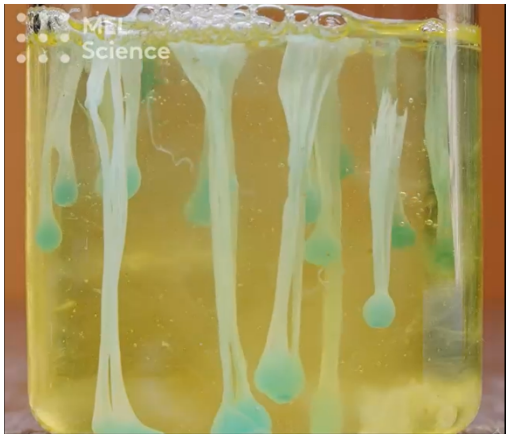
Protein has a high molecular mass long chain polymer composed of α-amino acids. Proteins are constituents of cells and are hence present in living bodies. Proteins contain carbon, hydrogen, nitrogen, oxygen, and sometimes phosphorus and sulfur.

Biuret Test*:* The compounds with peptide linkage undergo this test. Proteins are polypeptides of amino acids linked together by peptide bonds. An alkaline solution of protein is treated with a drop of aqueous copper sulfate when a bluish violet color is obtained. This test can be used for the identification of proteins and also for protein estimation. Biuret is the chemical product formed when urea is heated to 180^{o}C. In this reaction, two molecules of urea condense to form a bi-urea or biuret molecule. Biuret reagent in the presence of copper ions forms a violet color complex.

Note: *The formation of violet coloration confirms the presence of Proteins.*

Procedure

1. Take isolated egg white to be tested in a clean beaker.
2. Add 2ml of sodium hydroxide solution to it.
3. To that add 5 to 6 drops of copper sulfate solution to it.
4. If there is the appearance of bluish violet color indicates the presence of protein.



Discussion Questions and Answers

1. What are Proteins?
2. Why are only a few drops of $CuSO_4$ solution added during the biuret test?
3. What happens if our body lacks protein?

Activity 9

Aim

To Study the Coaguable and Non-Coaguable Milk Proteins

Materials

Milk, Test tubes, Rennin tablets, Millon's reagent, Beaker, Burner

Theory of the Experiment

Milk is considered an ideal food as it contains most of the constituents of our diet. It is a rich source of proteins and fats. It also contains calcium and phosphorous in sufficient quantity. Therefore, milk is considered to be an important diet for growing children, and pregnant and lactating women. The milk of buffalo, cow, and goat is commonly used for human consumption. Milk is slightly heavier than water (specific gravity = 1.035) and has a slightly acidic pH (pH =6.7).

The various constituents of milk are

1. Water - 87.3%
2. Butterfat - 3.8%
3. Casein (a protein) - 2.5%
4. Albumin and globulin - 0.7%
5. Lactose (milk sugar) - 5.0%
6. Ash (minerals) - 0.7%

Casein is the principal type of protein present in milk. It represents about 80% protein nitrogen of tin milk. β-Lacto globulins and α-lactalbumin are the other proteins of the milk. Some antibodies called immunoglobulin present in milk are also proteins.

Casein can be coagulated by acid, rennet, and heating. It is a coaguable protein. The other milk proteins i.e., β-lactoglubind and αLactoo albumins are called non-coaguable proteins as they can be coagulated only by heating.

The study of the presence of coaguable and non-coaguable proteins in milk has been taken in this project.

Casein is the name for a family of related phosphoprotein proteins. These Proteins are commonly found in mammalian milk, making up 80% of the proteins in cow milk and between 60% and 65% of the proteins in human milk. Casein has a wide variety of uses, from being a major component of cheese, to use as a food additive, to a binder for safety matches. As a food source casein supplies amino acids; carbohydrates; and two inorganic elements, calcium, and phosphorus.

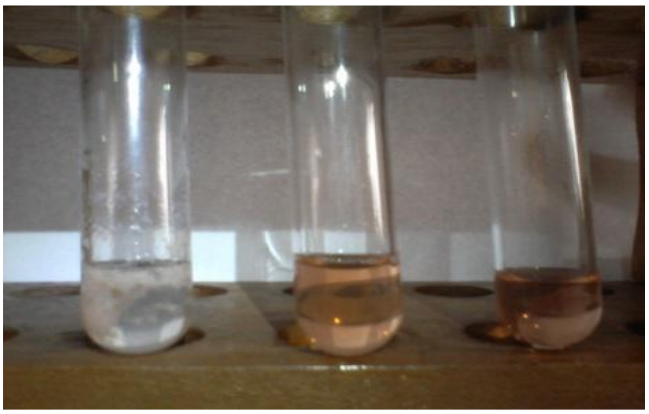
Whey Protein Is a mixture of proteins isolated from whey, the liquid material created by-product of cheese production. Some preclinical studies in rodents have suggested that whey protein may possess anti-inflammatory or anti-cancer properties; however, human data are lacking. The effects of whey protein on human health are of great interest and are currently being investigated as a way of reducing disease risk, as well as a possible supplementary treatment for several diseases. Whey protein is commonly marketed and ingested as a dietary and various health claims have been attributed to it in the alternative community. Although whey proteins are responsible for some milk the major allergens in milk are caseins.

The thermal coagulation of unfractionated whey proteins was inhibited by various sugars. The disaccharides, sucrose, and lactose, were most effective, and the amino sugar, glucosamine, was the least effective in this respect. Ultraviolet absorption and

light-scattering measurements on the thermal denaturation and coagulation of both unfractionated and individual whey proteins (b-lactalbumin Lactoacto globulin, and bovine serum albumin) showed that sucrose promotes the denaturation of these proteins but inhibits their subsequent coagulation. These results are interpreted in terms of the effect of sucrose on the hydrophobic interactions between solvent and protein.

Procedure

1. Take about 20ml of milk in a beaker. Grind a rennin tablet and add it to the milk.
2. Warm the milk. The milk will coagulate.
3. Filter the coagulated (solidified) milk. The liquid filtrate is whey.
4. Take a small amount of whey in separate test tubes and test it for the presence of protein by using Millon's reagent.



Discussion Questions and Answers

1. What are Proteins?
2. What are the constituents of milk?
3. What are coaguable and noncoaguable proteins?
4. What is the use of the rennin tablet in this experiment?
5. What are whey proteins?

Activity 10

Aim

To observe the major difference between fresh water and frozen seawater

Materials

Table salt, Water (tap water is fine), Transparent container, for example, a clear water bottle with the top cut off or a drinking cup (x2), Food Dye (any color will work), Measuring cup, Measuring spoon (teaspoon), Tape and marker for labelling

Theory of the Experiment

When sea ice forms, freshwater freezes, and leaves behind a concentrated salt solution called brine. This brine is found in pockets throughout the ice. Brine pockets allow organisms that get trapped in the ice to avoid freezing and survive until the next spring. The pockets are small and isolated in winter, but in spring, as the ice begins to warm, the brine pockets get bigger and combine with other pockets to form channels that allow the organisms to move throughout the ice. You can explore the differences in channels between seasons in our channel maze.

Procedure

1. Measure out two cups of water into each of your two containers (you can use less if your container is too small). Make sure to leave a little room as the water will expand when it freezes.
2. Using your tape and marker, label one container "water" and the other "salt water."
3. In your "saltwater" container, dissolve 1.5 teaspoons of salt for every cup of water (so, if you have two cups, use 3 teaspoons).
4. Put the containers in a freezer (this will take a few hours to freeze, best done overnight) and keep frozen until ready to perform an experiment.
5. Take the ice out of the containers and set them next to each other. These are going to melt and make a mess so put the containers on a tray or a sink.
6. Add 5 drops of dye to the top of the freshwater ice and note what happens. (If nothing seems to happen, you can add a few more drops of dye.)
7. Add 5 drops of dye to the top of the saltwater ice and note what happens.

Discussion Questions and Answers

1. Do you think the dye will act the same in both ice types?
2. What is the main difference between fresh water ice and sea water ice?

Activity 11

Aim

To Demonstrate How to Break Proteins

Materials

Stove or microwave, Pot or microwave-safe container to boil water, 1 fork, 1 pair of scissors, 1 bowl, 4 small glass containers of the same size, 1 egg (split egg white into four parts); additional can be used, 2/3 cup water (150 ml), 1/3 cup of rubbing alcohol (75 ml)

Theory of the Experiment

Proteins are essential for all living things to function. They are large molecules made up of long chains of amino acids. Depending on the types of amino acids they have, proteins fold in very specific ways. The way they fold controls what the proteins can do. Proteins help move other molecules, respond to signals, make reactions happen more quickly, and replicate DNA, among other things. However, if proteins lose their specific folded shape, they are not able to work properly. Proteins require specific conditions to keep their shape. For example, most proteins in our bodies rely on us to keep a warm (but not hot) body temperature, stay hydrated, and take in enough of special nutrients like salt. If our bodies aren't able to maintain these conditions, some of our proteins may not function as well, or at all. Most organisms actually primal proteins called "molecular chaperones" that help other proteins and molecules continue to work even if conditions are becoming difficult to tolerate.
When a protein is exposed to conditions too far outside of a range it can tolerate, that protein's shape will come undone. This is called "denaturing" (basically, breaking) a protein. We denature proteins all the time when we cook food (think: eggs).

1. **Control**: Egg whites start clear. They are almost 90% water, but the other 10% is packed with proteins. Egg whites contain more than 50% of the proteins found in the egg. The main protein in egg white is called albumin. The small, folded proteins in the egg white don't take up much space, and the gel-like egg white looks clear. The control egg showed us that, when left at room temperature, the egg whites stay clear, meaning the proteins maintain their original shape. These proteins were not denatured.
2. **Cooking (hot water)**: Whenever eggs are cooked with heat, the egg whites turn from clear to white, and the gel becomes more rubbery. As heat denatured the proteins in the egg white, it broke apart some of the bonds (mostly hydrogen bonds) that were holding the proteins in their original shape. The proteins unfolded, taking up more space (turning the gel white) and hardening them in place next to one another.
3. **Alcohol**: Alcohol also denatures proteins. It does this the same way as heat, by breaking the bonds that hold parts of the protein in a folded shape. Sometimes the alcohol molecules bond directly to some of the parts of the protein, disrupting the normal way the protein would bond to itself. (So alcohol is called a "bond disruptor.") The proteins again unfolded, taking up more space and hardening in place next to one another. This process took much longer with alcohol than it did with heat, however. The longer time for

denaturation with alcohol is simply because it spreads more slowly than heat. The alcohol had to diffuse (or move through the fluid) into the egg to affect the proteins it touched.

4. **Room temperature water**: Sometimes in this experiment, room temperature water has a small denaturing effect on some of the egg white. It acts in the same way, by breaking bonds, but its effect isn't nearly as strong as alcohol or hot water.

Procedure

1. Pour 1/3 cup rubbing alcohol into one glass container, room temperature water (1/3 cup) into another, and the rest of the water (1/3 cup) into a microwave-safe container (or into a pot).
2. Crack an egg into the bowl, removing the yolks.
3. Cut the egg white into pieces so you can add ¼ into each glass container.
4. Heat the water for your hot water treatment and pour intit o one of the empty glass containers.
5. Quickly put ¼ of the egg yolk into the boiling water. Then put ¼ into the alcohol, ¼ into the room temperature water, and the remainder into the final, empty glass container.
6. Observe any immediate changes that occur in terms of egg white color and consistency. If you try stirring the different treatments, rinse your fork between stirs.
7. Wait for 30 minutes.
8. Use the fork to inspect the state of the egg whites in each treatment and note how they may have changed over time.

Discussion Questions and Answers

1. Do you think the water itself was denaturing proteins? If not, what was? If so, what was having the larger effect on the water treatments?
2. Are there any other processes you know of that turn egg whites from clear to white? What is it and do you think the same processes are happening?
3. Name another condition besides heat and exposure to a bond disruptor (like alcohol) that could affect the ability of a protein to maintain its shape.
4. What other things change color when their proteins are denatured?
5. Why might a living organism want to keep its proteins from denaturing?
6. In this activity, why was it important to have egg whites that we did not cook or add alcohol to?

Activity 12

Aim

To experimentally demonstrate that carbon dioxide is released during the process of respiration.

Materials

Soaked gram seeds, U-shaped delivery tube, Conical flask, Blotting paper (moist) /cotton wool, Thread, Water, Beaker, Test tube, Rubber cork with a single hole, freshly prepared KOH solution (20%), Vaseline

Theory of the Experiment

One of the basic life processes that are carried out by living entities is respiration. It is a catabolic process wherein complex organic molecules are broken down into simpler molecules. The process releases energy either in the absence or presence of oxygen, and hence respiration can be of two kinds:

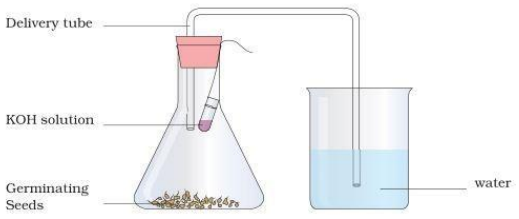
Aerobic respiration – This kind of respiration takes place in the presence of oxygen; hence it results in complete glucose oxidation with the release of energy. It includes three stages – namely, Krebs cycle, ETS and, Glycolysis. All events relating to ETS take place inside mitochondria while stages connected with glycolysis take place in the cytoplasm.

Anaerobic respiration – In this type of respiration, oxidation of food takes place in an environment lacking oxygen supply. Less energy is released as a result of incomplete oxidation of glucose.

The process of respiration is biochemically carried out wherein food, glucose to be precise, is oxidized and energy is released. In this experiment, gram seeds (moistened) are used. The purpose of using these seeds is that they release carbon dioxide and are respiring actively. The released carbon dioxide is consumed by the solution of KOH.

Procedure

1. Germinate close to 25 seeds. This can be done by wrapping them in moist blotting paper or cotton wool for around 3 to 4 days.
2. Set up the germinated or sprouted seeds in the conical flask. Spray some water into the flask to dampen the seeds.
3. With the help of a thread, suspend the conical flask containing the test tube having a freshly prepared 20% KOH solution.
4. Use the rubber cork to seal the opening of the conical flask.
5. One edge of the U-shaped glass delivery tube present in the conical flask should be inserted through the hole in the rubber cork. The other edge should be placed into a beaker that is saturated with water.



6. All attachments of the set-up should be sealed. This can be done using vaseline to create an air-tight environment.
7. The initial water level present in the U-shaped delivery tube needs to be marked.
8. Leave the experimental set-up uninterrupted for 1 to 2 hours. Observe the fluctuations in the water level in the tube.

Discussion Questions and Answers

1. Why is the energy output of anaerobic respiration lesser than aerobic respiration?
2. List the levels of aerobic respiration.
3. What is the purpose of keeping the seeds moistened in the experiment?
4. Can boiled seeds be used in place of moistened germinating seeds?
5. State the significance of using KOH solution in the experiment.
6. In the experiment, what is the purpose of using Vaseline?

Activity 13

Aim

This experiment will determine how microwave radiation affects fungi, bacteria, and plant life.

Materials

Packet of radish seeds, Paper towels, four small containers filled with sterilized potting soil, Four packets of bakers' yeast, Four small bowls, Four prepared Petri dishes with agar (available from biological supply companies), Sterilized swabs, Gloves, Microwave

Theory of the Experiment

In recent years, the use of microwave radiation has become popular in the food industry for thawing, drying, and baking foods, as well as for the inactivation of microorganisms in foods. In particular, microbial destruction by microwave radiation has great potential in the pasteurization of foods. It's short heating and exposure time is less destructive to food than longer conventional heating. There have been many studies on the use of microwaves for the reduction of microorganisms in various foods, including turkey, beef, corn-soy milk, chicken, frozen foods, and potatoes. All of these works have led to the conclusion that microwave radiation extends food preservation by reducing microbial cells in food. Microwave heating is known to inactivate many microorganisms, such as *Escherichia coli*, *Streptococcus faecalis*, *Clostridium perfringens*, *Staphylococcus aureus*, *Salmonella*, and *Listeria* spp. Bacterial and mold spores, as well as the bacteriophage PL-1, which is specific to *Lactobacillus casei*, have also been reported to be sensitive to microwave radiation.

Procedure

1. Plant several radish seeds in a small container. Put them in a sunny, warm location. This is the control sample.
2. Place several more radish seeds on a paper towel. Microwave the seeds for five seconds.
3. Plant these seeds in another pot and place them in the same location as the control group.
4. Repeat Steps 2 and 3 for two more samples, except microwave one group of seeds for fifteen seconds and the other for thirty seconds.
5. Tend the samples by watering the pots once a day and ensuring they get enough sunlight
6. Take pictures every day and note if and how quickly the samples grow.
7. Dump a packet of bakers' yeast into a small bowl of warm water. Stir. This is the control sample.
8. Take note of how long it takes for the yeast to bubble up and how vigorous the reaction is. Take photos.
9. Dump another packet of bakers' yeast onto a plate. Microwave for five seconds.
10. Mix this yeast into another bowl of warm water. Repeat Step 8.
11. Repeat steps 9 and 10 for the other packets of yeast, except microwave one sample for fifteen seconds and the other for thirty seconds.
12. Wearing gloves, use the sterilized swab to collect a sample of bacteria and swab it on a prepared Petri dish. Good places to find bacteria are areas where lots of people touch

something, like doorknobs or faucets. Seal the dish and label it "control." Put it in a warm, dark place. This is your control sample.

13. Swab another sample from the exact location as the control sample. Smear it on another Petri dish. Seal and label the dish. Place it in a warm, dark place.
14. Repeat Step 13 for the other two samples.
15. Let the samples alone overnight.
16. Take one sample out (not the control) and microwave it for five seconds. Place it back in a warm, dark place.
17. Repeat Step 16 for the other two samples, except microwave one for fifteen seconds and the other for thirty seconds.
18. After another day, take out all the samples. Note how many colonies of bacteria are growing and their size.

Discussion Questions and Answers

1. Does microwave radiation destroy all life?
2. Will varying lengths of radiation affect organisms differently?
3. Does the time of radiation's interaction matter?
4. How does each type of organism respond to the radiation?

Activity 14

Aim

To experimentally demonstrate that whether the music of different varieties affects the growth of bacteria.

Materials

2 or more prepared Petri dishes with agar (available from biological supply companies), Sterilized swabs, Rubber or plastic gloves, 2 or more portable CD or MP3 players, several pairs of cheap headphones

(NOT earbuds (same number as music players) You will want to throw them away after the experiment), Several songs or albums of various music, the more diverse the better (such as classical, hard rock, and dance)

Theory of the Experiment

Although bacteria cannot hear, they are very perceptive to changes in vibration. Physically speaking, music is essentially various changes in vibration. This experiment might help figure out better ways to process sewage and other essential microbe-assisted duties.

Procedure

1. Wearing gloves, prepare the Petri dishes. Following the manufacturer's instructions, take them out of the refrigerator for about an hour before experimenting.
2. Using the sterilized ed swabs, collect bacterial samples while wearing gloves. Good places to nab some bacteria include faucets or any other area that is touched by a lot of people. Ensure that you swab from the same area to get roughly the same amount and type of bacteria. Swipe the swab against the agar in the Petri dish and then close and seal the dish. Label each sample.
3. Place the samples in a warm, out-of-the-way place. Leave one sample alone, this is the control.
4. For the other samples, place the headphones snugly around the dish.
5. Connect the headphones to the music players. Play a different song or album on repeat on each player.
6. Let the samples grow for a week. Make sure to keep the music players charged and playing at all times. Take pictures of the developing bacteria every day.
7. Take off the headphones and compare each sample. Take note of the number of colonies in each sample and measure the size of each colony.
8. Carefully dispose of the Petri dishes.

Discussion Questions and Answers

1. Did the music affect the size or number of bacteria colonies?
2. Did a certain genre of music have a greater effect than others?
3. Does music alter the growth of bacteria?
4. Do different kinds of music make the bacteria grow differently?

Activity 15

Aim

To demonstrate how light affects the yeast

Materials

5 packets of baker's yeast, 4 Petri dishes, 5 bowls, 3 cardboard boxes, White light bulb, Blue light bulb, red light bulb, Warm water

Theory of the Experiment

Yeast is a common fungus that we rely on to bake fluffy bread. Since it's so sensitive to light, it's often placed in a dark place so that the light does not break apart the cell membranes and destroy them. Different colors of light destroy the cells at different rates, so this experiment will help you find out the best conditions to store and package yeast.

Procedure

1. Screw each light bulb into different rooms, and make sure that each room will remain undisturbed for the length of the experiment (about 24 hours). Also make sure that no other light can enter the room besides the light emitted from the light bulb.
2. Take a Petri dish and packet of yeast into the first closet, and turn on the light. Tear open the packet and pour the dry yeast into the Petri dish. Place it as close to the light as possible.
3. Repeat Step 2 for the other two closets.
4. Place one packet of yeast in the dark cupboard.
5. Take one packet of yeast and a Petri dish outside. Pour the packet into the dish and leave it in bright sunlight, and make sure no water can get in.
6. Leave the samples alone in their environments for 24 hours.
7. Place a cup of warm water into each of the five bowls, labelled with the type of light they received.
8. Retrieve a sample of yeast and quickly stir them into its corresponding bowl of warm water.
9. Time how long it takes the water and yeast mixture takes to bubble. For undamaged yeast, it should take about 10 minutes. Take a picture of the bowl at 10 minutes, 15, and 20 minutes.
10. Repeat step 9 for all of the yeast samples.

Discussion Questions and Answers

1. Which sample took the longest to bubble?
2. Did any not bubble at all?
3. Which sample bubbled in the shortest amount of time?
4. What sample bubbled the most or least?
5. Did the color seem to make a difference or was the exposure to light of any kind the biggest factor?
6. What color light does the most amount of damage to yeast?
7. What color does the least?
8. Where should a baker store their yeast?

Activity 16

Aim

To demonstrate the type of exercise is that makes people produce the most carbon dioxide.

Materials

liquid measuring cup that reads in mL, several glasses to hold water, several straws of equal length and diameter, microwave timer, tap water, pH testing paper-hydron lab quality.

Theory of the Experiment

When we work out, the muscles we utilize require more energy. At the point when exercise can be controlled, this requirement is met essentially by aerobic means. Vigorous energy generation in muscles brings about an increase in the gas exchange rate in the lungs since more oxygen is taken in and more carbon dioxide is discharged. Your blood transports these metabolic gasses to and from your tissues.
Carbon dioxide yield depends to a great extent on the measure of energy your body is utilizing. Your body continually needs vitality for fundamental operations, for example, your heart and digestive system. This implies carbon dioxide is continually being released as well.

Procedure

1. Measure 240 mL. of tap water and pour into glass-repeat 4 times so you end up with 5 glasses of tap water -having the water ready before makes things easier.
2. Dip a piece of the pH paper in the water and compare it the color scale-recorded pH.
3. Have the subject blow into the first glass of water through the straw for 30 seconds.
4. Test the pH of the water immediately. Record this as: "pH before exercise." Dump water, set the glass aside, and replace it with fresh glass.
5. Have test subjects run in place for 5 minutes, then quickly repeat steps 3 and 4.
6. Have the test subject rest for 2 minutes, then have him/her do sit-ups ups. Quickly repeat steps 3 and 4.
7. Have the test subject rest for 2 minutes and then do 10 push-ups. Quickly repeat steps 3 and 4.
8. Have the test subject rest for 2 minutes and then do 20 military presses.
9. Repeat steps 3 and 4.
10. Repeat the experiment with each subject.

Discussion Questions and Answers

1. What are aerobic and anaerobic respiration?
2. Why is the energy output of anaerobic respiration lesser than aerobic respiration?

Activity 17

Aim

To make a naked egg.

Materials

One cup, vinegar, egg

Theory of the Experiment

The de-shelled eggs serve as good models of human cells. After the eggshell is removed, a thin membrane (actually, two membranes held tightly together) remains. This membrane, like those in human cells, is selectively permeable, allowing certain substances to pass through while blocking others.

Substances that can pass easily through the membrane of the egg will follow the principles of diffusion. They will move through the membrane from the side where they are at a higher concentration to the side where they are at a lower concentration. This movement will continue until the concentration on both sides is the same. While random molecular motion will cause individual molecules to continue moving back and forth across the membrane, the overall concentration on each side will remain in equilibrium, with equal concentrations on both sides. The egg's membrane is permeable to water. The movement of a solvent (such as water) across a semipermeable membrane from a less concentrated solution to a more concentrated one is called *osmosis*. When an egg is soaked in a solution that has a higher solute concentration (the relative amount of dissolved stuff) than the solute concentration inside the egg, water moves out of the egg and into the solution. As a result, the egg loses mass and ends up looking deflated. An egg naturally has a lot of stuff inside, so the outside solution has to be very concentrated for this to happen. That's the case when an egg is treated with corn syrup or buried in salt. By contrast, when an egg is treated with distilled water, or a dilute salt solution, the solute concentration is higher inside the egg than out, so the water moves into the egg, increasing its mass. It may be easier to think about osmosis in terms of *water* concentration rather than *solute* concentration. If the solute concentration is high, then the water concentration will be low by comparison.

Rubbing, or isopropyl, alcohol is at least 70% alcohol and therefore less than 30% water. This should cause water to move from the egg into the solution, and the egg should lose mass. In addition, the egg may appear white and rubbery. Alcohol that diffuses into the egg can denature the proteins, unravelling their three-dimensional structure and causing them to coagulate or join together. Egg proteins turn from translucent to white when they are denatured. In cooking, the temperature is used to denature these proteins, but you may have noticed that alcohol has also "cooked" the egg and caused it to look hard-boiled.

The plasma membranes of your cells behave much like those of the egg. All of the trillions of cells in your body are like busy seaports with materials coming in and going out. Water, oxygen, and nutrients must pass through the plasma membrane into your cells, and wastes must leave. When the concentration of oxygen is higher in your lungs than it is in your blood, for example, the oxygen diffuses into red blood cells through capillary walls. Your flowing blood then transports that oxygen to your tissues. From there, the oxygen diffuses into other cells to be used in cellular respiration. Through a similar process, water in the stomach moves into the bloodstream and is then carried to the cells, where it supports a variety of essential bodily functions.

Procedure

1. Place the egg in a tall glass, jar, or a plastic cup and fill the glass with white vinegar, submerging the egg.
2. Leave the egg in the vinegar for a full 24 hours. Look closely. You'll see any bubbles forming on the shell.

3. Change the vinegar on the second day. Carefully pour the old vinegar down the drain and cover the egg with fresh vinegar. But remember, use a strainer to catch the egg so it does not fall down the drain. Place the glass with the vinegar and egg in a safe place for 1 day- Don't disturb the egg, but pay close attention to the bubbles forming on the surface of the shell.
4. Pour off the vinegar and carefully rinse the egg with water. The egg now looks translucent because the outside shell is gone! The only thing that remains is the delicate membrane of the egg!

Discussion Questions and Answers

1. Why do you see bubbles on the shell of an egg when immersed in vinegar?
2. Why vinegar is used?

Activity 18

Aim

To determine your threshold of taste for sweetness, sourness, and saltiness.

Materials

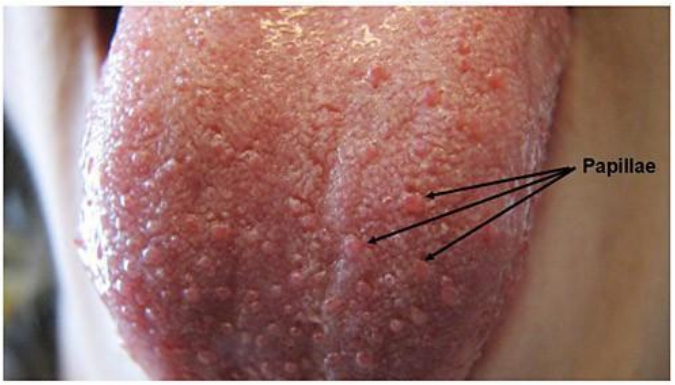
Table salt, or sodium chloride (10 g), Granulated sugar, or sucrose (10 g), Vinegar (2 mL), Water, Stirring rod or spoon, Gram balance, 100 mL graduated cylinder, 10 mL graduated cylinder, Cotton swabs (at least 12), Paper or plastic cups (at least 12), Paper towels (at least 12)

Theory of the Experiment

Our sensory system for taste, or our taste perception, is remarkably sensitive. Not only can we detect compounds at extremely low concentrations, but we can also discriminate

between *molecular compounds* that are closely related. For example, for some *molecules,* we can distinguish between different *stereoisomers*, which are molecules that are made of the same components but are mirror images of one another. The artificial sweetener aspartame is an example of this. It tastes sweet to us, but its stereoisomer does not. Our noses are similarly sensitive: one stereoisomer of carvone smells of spearmint while its mirror image smells of carraway (Dodd & Castelluci, 1991).

This amazing sensitivity is made possible by our taste buds. Taste buds are located on small bumps on the tongue called papillae, which are shown in Figure 1, below. Each taste bud is made up of about 50 to 150 *taste receptor cells*. On the surface of these cells are *receptors* that bind to small molecules related to flavor. The receptors then relay the taste sensation information to the brain. This entire process allows us to discern the five basic tastes.



Procedure

1. Measure 90 ml of distilled water and pour it into a paper or plastic cup. Add 10 grams (g) of granulated sugar. Stir until dissolved. This gives you a 10% (weight/weight, or w/w) sucrose solution.
2. Rinse your mouth with plain tap water and wipe your tongue dry with a clean paper towel.
3. Dip a clean cotton swab into the 10% sugar solution and smear it all around your tongue. Note observations that you make.
4. Now measure out 10 ml of the 10% sucrose solution and pour it into a clean paper cup. Add 90 ml of distilled water and stir. (*Note:* Use a clean stirrer, or else thoroughly rinse and dry the previous stirrer, so that you don't carry over-concentrated solution into the dilute solution.) This will give you a 1% sugar solution.
5. Repeat step 3. Then dip a clean cotton swab into the 1% sugar solution and smear it all around your tongue. Note observations that you make.
6. Continue making serial dilutions (by repeating step 5), rinsing and drying your tongue, and testing each new solution with the cotton swab procedure until you no longer taste the sweetness. Record the results in the data table in your lab notebook. The lowest concentration at which you can still taste the sweetness is your approximate taste threshold.
7. Repeat steps 2–7 with salt (sodium chloride) and vinegar (main ingredient: acetic acid), separately, instead of using sugar. To make a 10% (volume/volume, or v/v) solution of vinegar, use 2 ml of vinegar and 18 ml of water.

Discussion Questions and Answers

1. Were your thresholds the same for all three tastes, or did you have different thresholds?

2. Can you think of reasonable explanations for your results?
3. Do sugar solutions that are 10-fold more concentrated taste 10× as sweet? Same question for salt and vinegar solutions.

Activity 19

Aim

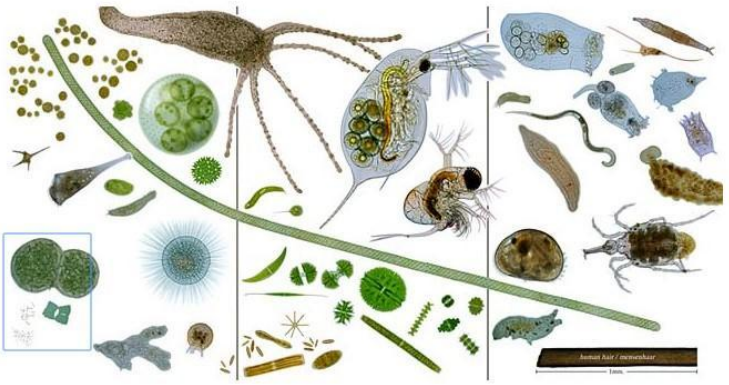
To analyse living organisms in water samples

Materials

Water samples from different water bodies (lake, pond, river etc.), beakers, a few vials or small test tubes, slides and cover slips, watch glasses, dropper, compound microscope and 5% FAA (Formalin Aceto Alcohol 5:5:90: Formalin: Acetic acid: Ethanol) as preservative

Theory of the Experiment

The productivity and the trophic status of a water body is determined by assessing the number and type of organisms (micro as well as macro) present in the water body. Water body with very high density of phytoplankton per unit area is a productive water body. Such water bodies are usually turbid and have high amounts of nutrients and dissolved oxygen. These water bodies support fairly large number of organisms of different trophic levels. This is in contrast to non-productive water bodies, which have very low density of organisms per unit area, fairly transparent waters with low mineral concentration and dissolved oxygen and also fewer trophic levels. The status of health of a water body can be determined by analyzing water samples for the number and type of organisms present in it at a given time. Such assays also help us to find out whether a water body is polluted as some of the organisms are strong indicators of water pollution.



Procedure

1. Collect about a liter of water sample from nearby water body (pond lake, reservoir, river etc).
2. Add about 5 ml of FAA to fix and preserve the living organisms present in each sample at the place of collection.
3. In the laboratory, transfer the water sample into a measuring cylinder of one litre capacity. Label each water sample to indicate the site from which the water sample has been collected.
4. Leave the water samples undisturbed for 48-72 hours.
5. Decant off the clear water, leaving concentrated sediment at the bottom.
6. Transfer the sediment into a vial or a small test tube. Cork and label each vial for future use.
7. With the help of a dropper, transfer a few drops of sediment liquid from a vial into a watch glass. Dilute the sediment with water if the sediment is highly concentrated.

8. With the help of a dropper transfer a drop of water from the watch glass on the center of a slide and mount it. Blot the excess water using blotting paper.
9. Prepare a few more slides of each water sample in the same way.
10. Observe each slide, first under lower magnification and then under higher magnification.

Discussion Questions and Answers

1. Why do you find few organisms in polluted water? Explain.
2. Why is FAA (Formaline Aceto Alcohol) added after collecting the water sample?
3. Name at least one phytoplankton and zooplankton commonly found in polluted water.

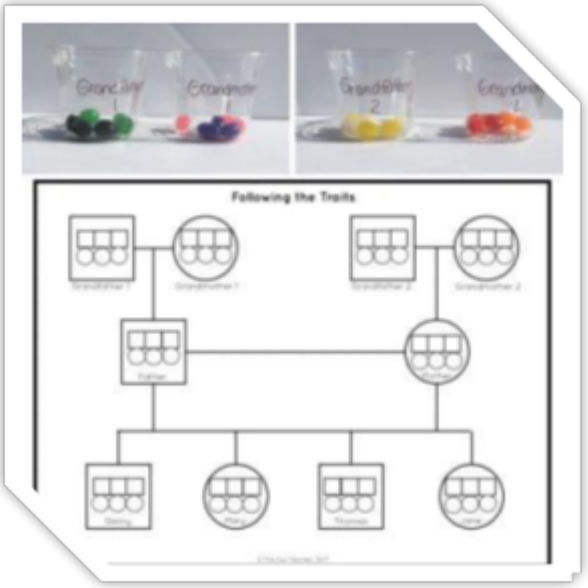
Activity 20

Genetics with Jelly Beans

In this fun activity, you will begin by preparing 10 plastic cups for each group (you may want to decide how many groups you will have – read on first…) with the following labels:

- Grandfather 1
- Grandmother 1
- Grandfather 2
- Grandmother 2
- Father
- Mother
- Child 1
- Child 2
- Child 3
- Child 4

You could also have students label the cups if you prefer. Then, place jelly beans in the cups as stated below:



- Grandfather 1 – three green and three black
- Grandmother 1 – three purple and three pink
- Grandfather 2 – three yellow and three white
- Grandmother 2 – three orange and three red

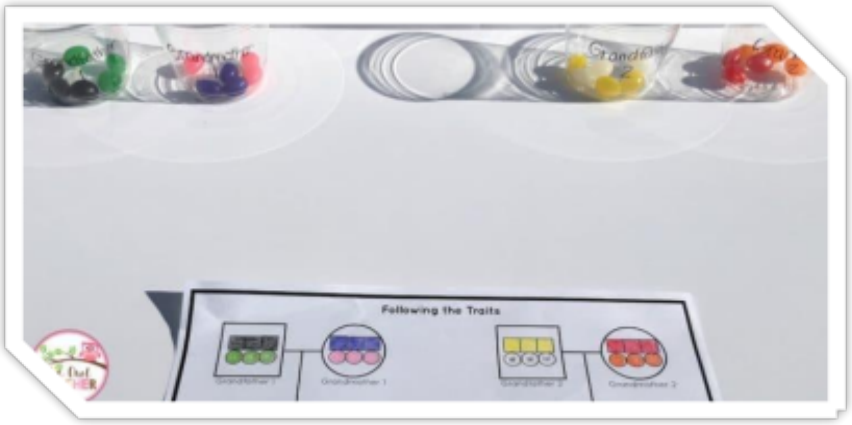
The remaining cups will not be filled with any jelly beans at the start of the activity.

First, break the students up into groups and provide them with the cups and the student genetics sheet. We discuss how, on the sheet, the circles stand for the females, and the squares stand for the males. This is important when we get to the children later on.

I also assign students in the group a role (grandfather, grandmother, father, mother, and so on) to make it a bit entertaining. It's not necessary, but it also gives each student an active part in the demonstration.

Next, the student who is grandfather 1 share what traits (colors of jelly beans) he has in his cup (three green and three black). He picks which color he got from his father. Whichever color he picks represents information that he got from his father, so the squares inside of grandfather 1's square should be colored to match the jelly beans. The other colored jelly beans must have come from his mother, so the circles inside grandfather 1's square should be colored to match.

For the example below, grandfather 1 may have gotten the green jelly beans from his mother and the black from his father. Therefore, students would color the squares black and the circles green to represent which color came from which gender. For grandmother 1, the student chooses that she got her purple "trait" from her father (squares) and the pink "trait" from her mother (circles). Make sure students do this with all of their parents.



Now it is time to share genetic information between grandmother 1 and grandfather 1 as they pass it to their offspring, father. Have the student who is playing grandfather 1 close his eyes and reach into his cup, randomly choosing three jelly beans. These beans should be placed into the father's cup. Then grandmother 1 do the same. Now, the father has all of his characteristics, half from grandmother 1 and a half from grandfather 1. Have the students color in the father's section on the chart. Remind students the circle represents the mother and the square represents the father. We then repeated the entire process to create the genetic make-up of the mother.

Now it is time to determine what traits are passed to the offspring of mother and father. Start with Child 1. Father close his eyes and randomly choose three jelly beans. Then the students stop and color in the squares of those three colors before moving on to the mother's traits. Next, the mother do the same and the color in the chart to match. When they each finished, they had to return the jelly beans to each parent's cup and repeat the procedure for each of

the remaining children. Each sibling must get to pick from the same set of traits; that is why the jelly beans are returned to the cup after each child's genetic make-up is created.

After we completed our charts, we talked about them and what we noticed. We talked about

how half of our characteristics come from each of our parents and how we can't pick what gets passed on, but instead, they are randomly chosen. We also talked about how some siblings look a lot alike and some look very different from one another – even with the same parents! We also had some great discussions about how some traits got passed on from grandparents, while others died out. For instance, one group had the father choose only green jelly beans, so the black jelly bean trait was never passed on. It was interesting!