Inquiry Labs In The High School Classroom

EDTL 611 Final Project
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Rationale

When we both began this journey to education we assumed that it would be easy to find materials to teach high school science… and it was. We were naïve to believe that the lessons found would be inquiry-based and purposeful in light of the Ohio Science Standards. We have been analyzing and observing science lessons throughout our educational experiences, and we have found that most of the lessons were comprised of two components: A lecture and an experiment. The lecture portion often involves extended explanations of the ideas with little student input. This lecture covers the majority of the lesson, leaving little time for the second portion…an experiment. The experimental portion of the science lesson is often the application of the idea. It is intended to allow the students to create a first-hand experience of the science concept and to build a deeper understanding of its connectivity to the world.

Although we agree with the idea of hands-on science, we acknowledge that some teachers will not have the resources to purchase expensive materials to help their students understand science concepts. We also believe that an effective science lesson should not rely solely on lecture. A productive science lesson should use techniques to reach all of the learning styles (kinesthetic/tactile, auditory, and visual) and help students learn how to work cooperatively and make connections to the real world. Ideally, a single lesson would include multiple state standards.
Learning Styles

An integral part of a productive science lesson is meeting the needs of students’ individual learning styles. These learning styles determine how students will interpret and retain the concepts that are taught. They should be considered prior to teaching the lesson. The three learning styles commonly identified are kinesthetic/tactile, auditory, and visual. They can easily be addressed through the following techniques suggested by Marilee Sprenger (2005):

- **Kinesthetic/Tactile:** Activities such as role-playing, creating a concept or working with technology.
- **Auditory:** Debates, classroom discussions, or use of music to spark memory.
- **Visual:** Pictures, video clips, handouts, graphic organizers, overhead transparencies and textbook readings (pp. 26).

Another way to assist students is to identify and incorporate their personality types when designing group activities. The six personality types include reactors, workaholics, persisters, dreamers, rebels, and promoters. Identifying these personality types may help teachers to understand how well the students will work together or how they may react to certain assignments. Pauley, Bradley and Pauley (2002) state that if personality types are acknowledged at the beginning of the school year, a teacher will be able to use these personality types to assist students to learn the material and communicate with their peers (pp. 2-6).
Cooperative Learning

The second piece to an effective science lesson is allowing students to learn cooperatively. In the book entitled, The First Days of School, Wong describes the cooperative learning experience as one in which the teacher presents the lesson and group strategies and allows the students to “help one another master the objectives”. (2005, pp. 245). We feel that this concept is very important in science because many students may have difficulty with, or disinterest in, the subject matter. Cooperative learning gives students the chance to exhibit leadership abilities and teamwork while exploring new concepts. We tried to incorporate cooperative learning when redesigning science lessons to meet our ideal standard.

Real World Connections

The next step, application to the real world, is critical for reaching students who do not have a strong science background. This concept is often shown using elements that are of interest to students. Racecar driving, household chemicals, sports and even makeup can all be connected to science. As teachers we must acknowledge that our students need these relationships to help them interpret the phenomena around them. (Brooks & Brooks, 2001, pp. 42).

Multiple Standards

The final step to having a productive classroom is addressing many of the standards for science. Teachers can do this with the addition of the previous suggestions and by integrating meta-cognitive skills (Bybee, 2002, pp.123). The State of Ohio
Science Standards incorporates many indicators that are unrelated to content knowledge. Educators may be overwhelmed by the sheer number of standards and have no idea how to effectively incorporate scientific ways of knowing or scientific inquiry. Teachers who employ meta-cognitive skills can help students by encouraging them to connect ideas and think logically while meeting the scientific inquiry standards.

**Problem & Potential Solutions**

We are both science educators who find it unfortunate that many teachers do not have access to materials to create a productive science lesson. We have selected lab activities utilized in Laura’s classroom and modified them to include background information, state indicators, safety requirements, materials lists, detailed procedures, and analysis questions. These inexpensive lessons utilize common household supplies and materials readily available to anyone. They will also incorporate the following strategies:

- Allow students to use simple materials to understand difficult science concepts
- Create workgroups for students (cooperative learning)
- Thoroughly explain safety precautions
- Teach students how to collect and analyze data
- Utilize different techniques to present data
- Enable students to describe results, in their own words
- Access a higher level of thinking
- Make science connections to the world around them
Bibliography


Introduction to the Lab Activities

I began my teaching career this year at Fostoria High School through a BGSU grant program. Prior to this I spent eleven years working as a Medical Technologist in a clinical laboratory, so most of my experience in science is laboratory-based. Those of us who entered the teaching profession this year through this program were paid a graduate assistantship, but required to act as the “teacher on record” and design and implement all lesson plans. This required some flexibility and ingenuity since we were placed in high need districts with many students at or below the Federal Poverty Level and very limited supplies. As I searched for lab activities in textbooks and on the internet, I found that most of the activities were “cookbook” in nature and guided the students through the lab with explicit directions. Often the provided analysis questions only required students to demonstrate knowledge and understanding, but they did not incorporate more complex thinking skills found in higher levels of Bloom’s Taxonomy (application, analysis, synthesis, evaluation).

I created the following eleven lab activities for my Physical Science and Biology classes at Fostoria. Through my reading, research, classes, and past experience I have discovered the usefulness of common, inexpensive household materials such as candy, teddy graham, batteries, Christmas lights, and cleaning products for lab activities. When combined with inquiry methods and complex questioning, the simplest premise for a laboratory activity can be effectively transferred to a high school classroom. For all of these activities I have included the State of Ohio Indicator for content, background information, materials list, safety precautions, the procedure, and the analysis questions. Many of these labs have been modified since I first introduced them, with changes in the procedures or questions to address difficulties my students faced in the learning process.

Laura Rettig
June 2007
State of Ohio Indicators for Scientific Inquiry

The eleven lab activities meet one or more of the following State of Ohio Indicators for Scientific Inquiry by grade level:

1. Grade 9 and 10, Research and apply appropriate safety precautions when designing and conducting scientific investigations (e.g., OSHA, Material Safety Data Sheets [MSDS], eyewash, goggles and ventilation.

2. Grade 9, Construct, interpret and apply physical and conceptual models that represent or explain systems, objects, events or concepts.

3. Grade 9, Develop oral and written presentations using clear language, accurate data, appropriate graphs, tables, maps and available technology.

4. Grade 9, Draw logical conclusions based on scientific knowledge and evidence from investigations.

5. Grade 10, Present scientific findings using clear language, accurate data, appropriate graphs, tables, maps and available technology.

6. Grade 10, Use mathematical models to predict and analyze natural phenomena.

7. Grade 10, Draw conclusions from inquiries based on scientific knowledge and principles, the use of logic and evidence (data) from investigations.
State of Ohio Indicators for Physical Science

The eleven lab activities meet one or more of the following State of Ohio Indicators for Physical Science by grade level:

1. Grade 9, Investigate the properties of pure substances and mixtures (e.g., density, conductivity, hardness, properties of alloys, superconductors and semiconductors).
2. Grade 9, Compare the conductivity of different materials and explain the role of electrons in the ability to conduct electricity.
3. Grade 9, Demonstrate that the pH scale (0-14) is used to measure acidity and classify substances or solutions as acidic, basic, or neutral.
4. Grade 9, Show how the properties of a wave depend on the properties of the medium through which it travels. Recognize that electromagnetic waves can be propagated without a medium.
5. Grade 9, Demonstrate that motion is a measurable quantity that depends on the observer’s frame of reference and describe the object’s motion in terms of position, velocity, acceleration and time.
6. Grade 9, Demonstrate that any object does not accelerate (remains at rest or maintains constant speed and direction of motion) unless an unbalanced (net) force acts on it.
7. Grade 9, Explain the change in motion (acceleration) of an object. Demonstrate that the acceleration is proportional to the mass of the object. (F = ma. Note that weight is the gravitational force on mass).
8. Grade 9, Demonstrate that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object.
9. Grade 9, Demonstrate the ways in which frictional forces constrain the motion of objects (e.g. a car traveling around a curve, a block on an inclined plane, a person running, and airplane in flight).
State of Ohio Indicators for Life Science

The eleven lab activities meet one or more of the following State of Ohio Indicators for Life Science by grade level:

1. Grade 10, Compare the structure, function and interrelatedness of cell organelles in eukaryotic cells (e.g., nucleus, chromosome, mitochondria, cell membrane, cell wall, chloroplast, cilia, flagella) and prokaryotic cells.

2. Grade 10, Explain the characteristics of life as indicated by cellular processes including a. homeostasis b. energy transfers and transformations c. transportation of molecules d. disposal of wastes e. synthesis of new molecules.

3. Grade 10, Illustrate the relationship of the structure and function of DNA to protein synthesis and the characteristics of an organism.

4. Grade 10, Analyze how evolutionary mechanisms (e.g. genetic drift, immigration, emigration, mutation) and their consequences provide a scientific explanation for the diversity and unity of past life forms, as depicted in the fossil record, and present life forms.
Physical Science Laboratory Activities
For Grade 9

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Lab 1: Properties of Substances
Lab 2: Identifying Acids and Bases
Lab 3: Measuring pH
Lab 4: Experimenting with Waves
Lab 5: Understanding Motion
Lab 6: Understanding Forces
Physical Science
Properties of Substances

State of Ohio Indicators for Physical Science: Grade 9. 1. Investigate the properties of pure substances and mixtures (e.g., density, conductivity, hardness, properties of alloys, superconductors and semiconductors). 2. Compare the conductivity of different materials and explain the role of electrons in the ability to conduct electricity.

Background: Substances have specific properties that determine their usage. In this lab activity we will determine characteristics and properties of pure substances and mixtures.

Materials: Aluminum nails, steel nails, galvanized steel nails, copper wire, aluminum wire, steel wire, brass hooks, wooden dowels, jute twine, foam cups, salt, calcium carbonate tablets, coated electrical wires, Christmas lights, D batteries, graduated cylinders, rulers, scales, pH paper, five clear liquids.

Safety Precautions: Please use care when handling sharp objects such as nail and wires. Do not point toward yourself or others. Goggles and aprons will be worn while handling liquids to prevent splash related injuries. Please try to avoid contact with the copper ends of the stripped wires; they may become warm while in contact with the battery. The battery only provides 1.5 Volts of electricity and will not cause injury. When observing the odor of a substance, do not directly inhale!! Gently wave your hand over the top of the beaker and observe the odor in this manner.

Procedure and Analysis:

Procedure: Day 1

You are to work in pairs to analyze the properties of the following substances. You will each create a data table that lists the item and all of its measurable properties.

1. Aluminum nail
2. Steel nail
3. Galvanized steel nail
4. Copper wire
5. Aluminum wire
6. Steel wire
7. Brass hook
8. Wooden dowel
9. Jute twine
10. Foam cup
For each of the above items you will be responsible for determining the following properties:

1. Color
2. Shape
3. Size
4. Mass
5. Volume
6. Density
7. Conductivity

Note: You may not be able to measure every property for all of these items. If you are unable to adequately measure an item or determine a specific property then mark this on your table!! Create your data table here:

In addition to the above items, you will examine two ionic compounds and determine if they are conductors or non-conductors of electricity.

1. Salt (Sodium Chloride); pour a small amount into the foam cup and measure.
2. Calcium tablet (Calcium Carbonate)

For these two items, check the conductivity of the substance in dry form as well as dissolved in water. Is there any difference in conductivity? Should there be a difference? Why?
Procedure: Day 2

You may finish any data collection needed for Day 1. Once finished with Day 1 data, you will need to put on goggles and an apron. There are five unknown liquids in beakers on the laboratory counter. You will need a 5 ml aliquot (portion) of each liquid for testing. Please test one liquid at a time and clean your graduated cylinder in between measurements. You will be required to make the following measurements/observations:

1. Color
2. Clarity
3. Odor
4. Volume
5. Mass
6. Density
7. pH
8. Any other observable characteristics

Create a data table to organize your results here:

Analysis:

What do you think each substance is? Why? What other properties, either physical or chemical, would help you to make a determination?
Final Analysis: Day 2/Day 3

1. Describe and differentiate among the following: pure substances and mixtures, elements and compounds, elements and their isotopes, atomic number and atomic mass; protons, electrons, and neutrons; atoms vs. ions.

2. Which of the substances tested were pure substances? Which were mixtures?

3. Compare the conductivity of metals, nonmetals, semi-conductors, and ionic compounds. What role do electrons play in conductivity?

4. What is an alloy? What is their purpose/use? Which of the substances tested were alloys? What are some other common alloys?

5. One of the nails was “galvanized” steel? What is galvanization and why is it useful for metals?

6. What is the difference between a semi-conductor and a superconductor?
Physical Science
Identifying Acids and Bases

State of Ohio Indicator for Physical Science: Grade 9, Demonstrate that the pH scale (0-14) is used to measure acidity and classify substances or solutions as acidic, basic, or neutral

Background:

Many common household products are either acids or bases. Today you will be utilizing litmus paper to determine if twelve common substances are acids, bases, or neutral.

Materials: Baking powder, baking soda, vinegar, milk, bleach, dish detergent, soda, bubble solution, apple juice, antacids dissolved in water, ketchup, laundry detergent, litmus paper.

Safety precaution: Please wear goggles and aprons to prevent any splashing. Although these are common household items, they can be eye irritants. Some items may stain clothing.

Procedure: There are two solutions at six different stations around the lab. At each station you will dip one strip of red litmus paper and one strip of blue litmus paper into each solution and record the results. After you have completed your testing, please discard the used litmus papers into the provided containers.

1. Baking powder =  
2. Baking soda =  
3. Vinegar =  
4. Milk =  
5. Bleach =  
6. Dish Detergent =  
7. Soda =  
8. Bubble Solution =  
9. Apple Juice =  
10. Antacids dissolved in water =  
11. Ketchup =  
12. Laundry detergent =  

Page 1
Analysis:

1. What is the difference between a strong acid or base and a weak acid or base?

2. What is litmus paper?

3. Can we determine if a substance is a strong or weak acid or base using litmus paper?

4. What are some properties of acids and bases?

5. Could any of these substances be conductors of electricity? Why?
Physical Science
Measuring pH

State of Ohio Indicator for Physical Science: Grade 9, Demonstrate that the pH scale (0-14) is used to measure acidity and classify substances or solutions as acidic, basic, or neutral

Background:

Common household products that are acids or bases can be further tested to determine their exact pH. Today you will be utilizing pH paper to measure the pH of twelve common substances.

Materials: Baking powder, baking soda, vinegar, milk, pineapple juice, dish detergent, soda, bubble solution, apple juice, antacids dissolved in water, ketchup, and laundry detergent.

Safety precaution: Please wear goggles and aprons to prevent any splashing. Although these are common household items, they can be eye irritants. Some items may stain clothing.

Procedure: There are two solutions at six different stations around the lab. At each station you will dip one strip of pH paper into each solution and record the results. After you have completed your testing, please discard the used pH papers into the provided containers.

For each of the following substances, please write down the measured pH as well as the Molar Concentration for acids and neutral substances. For example, a pH of 7 would have a Molar Concentration of $1 \times 10^{-7}$ M or 0.0000001 mol/L.

1. Baking powder =
2. Baking soda =
3. Vinegar =
4. Milk =
5. Pineapple juice =
6. Dish detergent =
7. Soda =
8. Bubble solution =
9. Apple juice =
10. Antacids dissolved in water =
11. Ketchup =
12. Laundry detergent =
Analysis:

1. What is the pH scale? How are acids, bases and neutral substances numerically classified on this scale?

2. Would pH testing be a qualitative or quantitative test? Would litmus testing be a qualitative or quantitative test? Why?

3. When would a solution be neutral? How would the ion concentration be different in an acid or base?

4. If one acid has a pH of 1 and a second acid has a pH of 3, how much more acidic is the first substance?

5. If one base has a pH of 11 and a second base has a pH of 14, how much more alkaline is the second substance?

6. On a separate piece of paper draw a replica of the pH scale. Mark all twelve substances on this pH scale and label appropriately.
State of Ohio Indicator for Physical Science: Grade 9, Show how the properties of a wave depend on the properties of the medium through which it travels. Recognize that electromagnetic waves can be propagated without a medium.

Background:

You will be working in pairs to discover the characteristics and properties of waves. There are four different stations in this activity: One area utilizes rope to create waves, a second area uses Slinky toys, a third area involves dropping tennis balls into water, and the final station allows you to experiment with tuning forks. Carefully read the directions for each activity and record all of your observations on a separate piece of paper. You will only submit one set of observations and one set of answers to the analysis questions per pair.

Materials: Ropes, ribbon, Slinkys, tennis balls, tuning forks, and a plastic tub filled with water.

Safety Precautions: None

Procedure:

Station 1: Ropes

Tie a small piece of ribbon in the center of the rope. Each partner will grab one end of the rope and create a wave pattern. Which direction does the ribbon move in relation to the wave? If you move the rope more quickly, do the waves get smaller, larger, or stay the same size? If you move the rope more slowly is there any change in appearance? What other observations can you make?

Station 2: Slinky

Tie a small piece of ribbon in the center of the Slinky. Each partner will grab one end of the Slinky and create compressions and rarefactions. Do not stretch the Slinky out of shape!! Which direction does the ribbon move in relation to the wave? What other observations can you make?
Station 3: Tennis Balls

Drop a tennis ball into the water and observe the waves. In which direction do the waves travel? If you drop the ball from a higher point or a lower point does it change the waves in any way? Try placing tiny pieces of paper in the water before the ball is dropped. Is it easier to visualize the direction of the wave? What other observations can you make?

Station 4: Tuning Forks

Strike the tuning fork and observe the vibrations. What type of sound is produced when striking the fork more forcefully? By striking the fork more gently? What happens to the sound as you move the fork away from your body? What happens to the sound if your partner strikes the fork and moves toward or away from you? Observe what happens if you strike the fork and gently touch the top of the water. Try placing tiny pieces of paper in the water and then strike the fork and touch the water. What other observations can you make?

Analysis:

1. What types of waves require a medium?

2. What is a medium?

3. What types of waves do not require a medium? What are some examples of this?

4. What type of wave is created by the rope...transverse, longitudinal, or surface waves? Why?
5. What type of wave is created by the slinky…transverse, longitudinal, or surface waves? Why?

6. What type of wave is created by the tennis ball…transverse, longitudinal, or surface waves? Why?

7. What type of wave is created by the tuning fork on water…transverse, longitudinal, or surface waves? Why?

8. How are vibrations and waves related?
State of Ohio Indicator for Physical Science: Grade 9, Demonstrate that motion is a measurable quantity that depends on the observer’s frame of reference and describe the object’s motion in terms of position, velocity, acceleration, and time.

Background:

We will utilize toy cars and ramps to demonstrate that motion is a measurable quantity and calculate the velocity and acceleration of each car.

Materials: Matchbox or Hot Wheels toy cars, ramps (use wood, plywood, metal or cardboard to create), meter stick, stopwatch. Make sure each ramp is equal in length and is placed at the same height.

Safety Precaution: None

Procedure and Analysis:

At each lab station are two different models of toy cars. One ramp has been placed between each lab station, for a total of six ramps. Each one of you will examine the cars at your station and determine which of the two cars you believe will have the fastest overall velocity. You will measure the time it takes for each of the cars to travel down the ramp and from this calculate the velocity and acceleration. You will perform all testing in groups of 4, but you will submit lab reports as pairs.

1. State your hypothesis (which car will be the fastest) and explain why.

2. What is the independent variable in this experiment (what is manipulated)?

3. What is the dependent variable in this experiment (what is measured)?

4. What is a reference point? What is the reference point for the motion you are measuring?
5. Each car at your station (total of 2) will have three time trials to determine its velocity. Create a data table to organize this information here:

6. What is velocity? How is it different than speed? Calculate the average velocity for both of the cars at your station. Hint: Distance should be calculated in meters. Include the correct units!

7. What is acceleration? Assuming the velocity you calculated for each car in step 6 is the final velocity, what would the average acceleration be in .5 seconds? Remember to use the correct units!
Physical Science  
Understanding Forces

State of Ohio Indicators for Physical Science: Grade 9. 1. Demonstrate that any object does not accelerate (remains at rest or maintains a constant speed and direction of motion) unless an unbalanced (net) force acts on it. 2. Explain the change in motion (acceleration) of an object. Demonstrate that the acceleration is proportional to the net force acting on the object and inversely proportional to the mass of the object. \( F = ma. \) Note that weight is the gravitational force on a mass. 3. Demonstrate that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object. 4. Demonstrate the ways in which frictional forces constrain the motion of objects (e.g. a car traveling around a curve, a block on an inclined plane, a person running, and airplane in flight).

Background: Newton’s Three Laws of Motion explain the relationship between forces and motion. In this lab activity we will observe the affect force has on the motion of an object (a toy car).

Materials: Matchbox or Hot Wheels Toy Cars, a section of vinyl flooring, a section of carpet, stopwatch, and a meter stick.

Safety Precautions: None.

Procedure and Analysis:

1. What is Newton’s First Law of Motion? In the previous lab experiment involving cars and ramps, what force(s) initially acted on the cars to create movement?

2. If an outside force did not act on the cars at the top of the ramp, what would happen? If additional force were applied to the cars at the top of the ramp, what would happen?
3. What is inertia? Why did the cars stop moving after leaving the ramp? What might happen if the cars’ masses were significantly greater?

4. What is Newton’s Second Law of Motion?

5. Select one car from your lab station. Propel the car across a one-meter section of vinyl flooring, recording the time it takes to travel this distance. Using the equation, Force = Mass x Acceleration, calculate the force necessary to propel the car across the floor. (Hints: Assume the calculated velocity is your final velocity. Find the acceleration in 0.5 seconds. Mass should be in kg). Report the correct units!

6. What is friction? Propel the car across a one-meter section of the carpeted flooring in the same manner as you did in step #5. Record the time it takes to travel this distance, and calculate the force necessary to propel the car across the floor. How do the calculated forces compare between vinyl and carpet? Would you expect to see a difference in the force? Why?

7. How much more force will an object exert if its mass is doubled and its acceleration stays the same? If the force remains constant, what will happen to the acceleration if the mass doubles?

8. What is Newton’s Third Law of Motion?
9. If an object exerts 200 N of force on the floor, how much force does the floor exert on the object? Why?

10. All moving objects have momentum. What is momentum? How does mass affect momentum?

11. What is the Law of Conservation of Momentum?
Biology Lab Activities
For Grade 10

Index

Lab 1: Creating A Cell Model
Lab 2: Osmosis and Diffusion
Lab 3: Creating A DNA Model
Lab 4: Modeling RNA Transcription
Lab 5: Hardy-Weinberg Equilibrium and Evolutionary Mechanisms
Biology
Creating a Cell Model

State of Ohio Indicator for Life Science: Grade 10, Compare the structure, function and interrelatedness of cell organelles in eukaryotic cells (e.g., nucleus, chromosome, mitochondria, cell membrane, cell wall, chloroplast, cilia, flagella) and prokaryotic cells.

Background: Eukaryotic cells contain a nucleus and membrane-bound organelles that are necessary for the maintenance and survival of the cell. Prokaryotic cells do not contain a nucleus or membrane-bound organelles. In today’s lab activity you will create a model and sketch of a eukaryotic cell and label the appropriate parts.

Materials: Plastic bags, vegetable oil, beans, assorted pasta shapes (mini-lasagna noodles, elbow macaroni, corkscrew pasta), assorted candy (Mike ‘n Ikes, jelly beans, caramel nips, licorice, etc.).

Safety Precautions: None.

Procedure:

Create a cell model using the supplies available. Keep in mind the shape and purpose of each organelle as you select from the materials. Each of the following organelles must be represented in your model:

1. Nucleus
2. Mitochondria
3. Ribosomes
4. Golgi Apparatus
5. Endoplasmic Reticulum
6. Cytoskeleton components (microtubules)
7. Plasma Membrane
8. Cytoplasm

After creating the cell model, draw a sketch on the provided 11x14 sheet of paper. Identify each of the organelles in your model (as well as the food item that represents it) and explain their purpose and function in the cell.
Analysis:

1. How could you differentiate between a eukaryotic cell and a prokaryotic cell with an electron microscope?

2. What are some examples of eukaryotic cells? What is an example of a prokaryotic cell?

3. How are organelles interrelated in prokaryotic and eukaryotic cells?

4. What three structures may be present in a plant cell but not in animal cells? Why?

5. What is the purpose of cilia and flagella in cells?
Biology
Osmosis and Diffusion

State of Ohio Indicator for Life Science: Grade 10, Explain the characteristics of life as indicated by cellular processes including  a. homeostasis b. energy transfers and transformations c. transportation of molecules d. disposal of wastes e. synthesis of new molecules

Background:

Osmosis is the movement of water from an area of higher concentration to an area of lower concentration through a selectively permeable membrane. Diffusion is the movement of a substance from an area of higher concentration to an area of lower concentration (down a concentration gradient). Both processes occur in living cells to help maintain equilibrium.

Materials: Potatoes, eggs, vinegar, corn syrup, sugar, salt, water.

Safety: Students must wear goggles and aprons to guard against splashing.

Procedure: In Groups of 4

Day 1

1. Prepare a 50% sucrose solution and a 50% salt solution using water as your solvent in two separate beakers. Also fill a third beaker with water only.

2. Obtain slices of potato from Mrs. Rettig. Immediately measure the mass of each potato slice and note the texture of the potato. Is it firm or soft? Place each potato slice in one of the solutions. Allow it to sit for 30 minutes undisturbed.

3. Meanwhile, place a raw egg in a beaker and cover completely with vinegar. Observe what happens. What do you think will occur in the next 24 hours? Leave the egg, undisturbed, in the vinegar solution.
4. After 30 minutes, record any changes to your potato slices. Measure the masses and note any changes to texture. Empty the solutions and clean up the lab area.

Day 2

1. Check the egg. Note if any shell remains. If shell is still present, keep in vinegar for another 24 hours. Skip to Day 3 instructions.

2. If the shell has dissolved, remove the egg and empty the vinegar solution. What does the egg look like? Why does it have this appearance?

3. Each of the lab groups will be assigned a solution. Some will place their eggs in water and others will place their eggs in corn syrup. Leave them, undisturbed, for 24 hours. What do you think will happen?

Day 3

1. If the shell has now dissolved, follow the directions for Day 2, steps 2 and 3.

2. If the egg was already immersed in water or corn syrup, remove the egg and note any changes to its appearance. What do you think happened? Why?

Analysis:

1. Are osmosis and diffusion active or passive transport? Why?

2. At what point will equilibrium be achieved?

3. Will the molecules stop moving once equilibrium is achieved?
4. Why use eggs and potatoes to demonstrate this process?

5. If we used human red blood cells and placed them in a 50% sucrose solution, a 50% salt solution, and pure water…what would happen in each instance?
Biology
Creating a DNA Model

State of Ohio Indicators for Life Science: Grade 10, Illustrate the relationship of the structure and function of DNA to protein synthesis and the characteristics of an organism.

Background: DNA contains the information needed to synthesize proteins and create living things. In today’s lab activity you will create a 3-Dimensional model of DNA that will be used to demonstrate Transcription in a future lab activity.

Materials: Wire, gumdrops, toothpicks, tape.

Safety Precautions: Wires and toothpicks are sharp. Please point away from your body.

Procedure:

1. Select four different gumdrop colors to represent the four nitrogenous bases of DNA. Write down your color choices with the name of each corresponding nitrogenous base on a separate piece of paper.

2. Using the following DNA sequence, assemble your template DNA strand using wire and threading the gumdrops in the appropriate order. Label this strand as the “template” with a piece of tape.

   GGTAATTGACTT

3. Using the second piece of wire, assemble the complementary DNA sequence using the appropriate base pairing.

4. Connect the strands by placing toothpicks between each gumdrop base pair. Keep in mind that Adenine and Thymine are connected by a double hydrogen bond and Cytosine and Guanine are connected by a triple hydrogen bond.

5. Twist the two strands into the appropriate shape to mimic a DNA molecule.

6. Draw a sketch of this structure on the same piece of paper that you listed gumdrop colors.

7. The DNA model will remain in the lab and be utilized for a future lab involving RNA Transcription.
Analysis:

1. What are the four nitrogenous bases of DNA?

2. What are the complementary base pairs for these nitrogenous bases?

3. What does the wire represent in relation to the actual DNA molecule?

4. What do the gumdrops and toothpicks represent?

5. Which of the nitrogenous bases are purines and which are pyrimidines?

6. What scientists discovered the structure of DNA? What is the structure?

7. What is a nucleotide?
Biology
Modeling RNA Transcription

State of Ohio Indicators for Life Science: Grade 10, Illustrate the relationship of the structure and function of DNA to protein synthesis and the characteristics of an organism.

Background: DNA contains the information needed to synthesize proteins and create living things. RNA Transcription is necessary to take the information from DNA out of the nucleus to the ribosomes for protein synthesis.

Materials: Your DNA model from previous lab, gumdrops, toothpicks, wire.

Safety Precaution: Wires and toothpicks are sharp. Point away from your body.

Procedure:

1. Using your original DNA model, unzip the strands.
2. Create the corresponding RNA strand using your original DNA template strand. Write down your color choices for each nitrogenous base.
3. Connect the nitrogenous base pairs using toothpicks. Hydrogen bonds will remain the same.
4. Label the RNA strand with a piece of tape.

Analysis:

1. What are the four nitrogenous bases of RNA?
2. What are the complementary base pairs for these nitrogenous bases?
3. What enzyme bonds to the DNA molecule to allow transcription to begin?
4. What is the name of the sequence to which this enzyme binds?
5. What will happen to the DNA and RNA molecules at the end of transcription?

6. What are the three types of RNA? What purpose does each serve?

7. What will happen during the process of Translation?

8. Utilizing the Amino Acid/ RNA Codon chart given, what amino acids would this strand of RNA code for?

9. What are the structural differences between DNA and RNA?
<table>
<thead>
<tr>
<th>AMINO ACID</th>
<th>RNA CODON</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALANINE</td>
<td>GCC, GCA, GCG, GCU</td>
</tr>
<tr>
<td>ARGININE</td>
<td>AGA, AGG, CGU, CGA, CGC, CGG</td>
</tr>
<tr>
<td>ASPARAGINE</td>
<td>AAC, AAU</td>
</tr>
<tr>
<td>ASPARTIC ACID</td>
<td>GAC, GAU</td>
</tr>
<tr>
<td>CYSTEINE</td>
<td>UGC, UGU</td>
</tr>
<tr>
<td>GLUTAMIC ACID</td>
<td>GAA, GAG</td>
</tr>
<tr>
<td>GLUTAMINE</td>
<td>CAA, CAG</td>
</tr>
<tr>
<td>GLYCINE</td>
<td>GGA, GGC, GGG, GGU</td>
</tr>
<tr>
<td>HISTIDINE</td>
<td>CAC, CAU</td>
</tr>
<tr>
<td>ISOLEUCINE</td>
<td>AUA, AUC, AUU</td>
</tr>
<tr>
<td>LEUCINE</td>
<td>UUA, UUG, CUA, CUC, CUG, CUU</td>
</tr>
<tr>
<td>LYSINE</td>
<td>AAA, AAG</td>
</tr>
<tr>
<td>METHIONINE (INITIATION)</td>
<td>AUG</td>
</tr>
<tr>
<td>PHENYLALANINE</td>
<td>UUC, UUU</td>
</tr>
<tr>
<td>PROLINE</td>
<td>CCA, CCC, CCG, CCU</td>
</tr>
<tr>
<td>SERINE</td>
<td>UCA, UCC, UCG, UCU, AGC, AGU</td>
</tr>
<tr>
<td>THREONINE</td>
<td>ACA, ACC, ACG, ACU</td>
</tr>
<tr>
<td>TRYPTOPHAN</td>
<td>UGG</td>
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<tr>
<td>TYROSINE</td>
<td>UAC, UAU</td>
</tr>
<tr>
<td>VALINE</td>
<td>GUA, GUC, GUG, GUU</td>
</tr>
<tr>
<td>STOP</td>
<td>UAA, UAG, UGA</td>
</tr>
</tbody>
</table>
Biology
Hardy-Weinberg Equilibrium and Evolutionary Mechanisms

State of Ohio Indicators for Life Science: Grade 10, Analyze how evolutionary mechanisms (e.g. genetic drift, immigration, emigration, mutation) and their consequences provide a scientific explanation for the diversity and unity of past life forms, as depicted in the fossil record, and present life forms.

Background:
You will be utilizing Teddy Grahams to determine gene frequencies within a population for two specific circumstances: First, if Hardy-Weinberg Genetic Equilibrium is observed; and second, if evolutionary mechanisms such as emigration, immigration, mutation and genetic drift had taken place. You may work in pairs for this activity.

Two types of bears are present in the Teddy Graham population. The first type is Happy Bear, who holds his hands up in the air. The second type is Sad Bear, who keeps his hands by his side. Happy Bear is homozygous dominant for the “happy gene”, Sad Bear is homozygous recessive for the “happy gene”

Materials: Teddy Grahams

Safety Precautions: None.

Procedure:

Activity One: Record all results on a separate piece of paper.
You receive a randomly selected population of twenty Teddy Grahams. Calculate what percentage of your population is composed of Happy Bears. Calculate what percentage is composed of Sad Bears. Assuming this population follows the rules of Hardy-Weinberg Genetic Equilibrium, how might you determine the percentage of Happy Bears and Sad Bears found in generation two? What would the gene frequencies be for these generation two offspring?

Activity Two: Record all results on a separate piece of paper.
Using the same randomly selected population of twenty Teddy Grahams, once again record the percentage of Happy Bears and Sad Bears. This population of bears is now subjected to a variety of evolutionary mechanisms:
1. Happy Bears taste sweet and are easy to catch. Sad Bears taste bitter and are sneaky and difficult to catch. Half of your Happy Bears are consumed by a hungry predator.

2. Happy Bears are very threatened by this new predator, so half of the remaining Happy Bears emigrate to a new community.

3. Sad Bears love to mate with other Sad Bears, so they immigrate to your population and take the place of all the Happy Bears.

4. Now, record the percentage of Happy Bears and Sad Bears within your population. Assuming that these bears practice non-random mating, so that Happy Bears only mate with Happy Bears and Sad Bears mate with other Sad Bears, what would the percentage of each type be in generation two? What would the gene frequencies be for these generation two offspring?

Analysis:

1. Define the following terms: Immigration, emigration, natural selection, genetic drift, and mutation.

2. What affect do the above mechanisms have on gene frequencies in a population?

3. How did immigration, emigration, natural selection, and non-random mating affect the Happy Bear population?

4. If all of these circumstances continued, what might happen to the Happy Bear population in this geographical area?

5. Would the population of Sad Bears remain consistent throughout time? Why?
6. In order for Hardy-Weinberg Genetic Equilibrium to occur what must happen? Does this occur often?

7. How does natural selection and evolutionary mechanisms such as immigration and mutation provide an explanation for the diversity of life?