20 in 20

And Beyond…

This document contains both the original activities (P generation) and the offspring (F_1 generation)

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Resources:
I purchase my scientific supplies from Carolina Biological and miniOne. Living material is purchased from Carolina Biological. Many of the other materials I find in the grocery store or at building supply stores.

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Examining Polarity Using Milk and Water

Overview: Students will use whole milk, water, food coloring and detergent to investigate polar and nonpolar solutions.

Background/Content Connection: This lesson will help students visualize some the polar properties of water, while looking at the properties of a nonpolar solution, as seen in whole milk. Students will be able to see that water being a polar molecule will mix with the polar food coloring. They will also be able to see that the polar food coloring will not mix with the polar portions of whole milk. Additionally, students will discover that soap has a polar and a nonpolar end, as they will see that soap will mix with water, food coloring and whole milk.

Materials: Whole milk, water, 1 Petri dish per group, food coloring, detergent

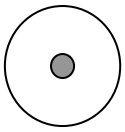


Figure 1

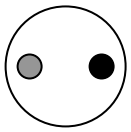


Figure 2

Protocol:

1. Fill up one side of the Petri dish with water.
2. Place one drop of food coloring in the center of the Petri dish (Figure 1)
3. Have students make initial observations and again after 2 minutes
4. Clean Petri dish
5. Add whole milk to Petri dish.
6. Add one drop of food coloring near the side of the Petri dish. Add a drop of a different color of food coloring to the other side (Figure 2).
7. Have students make initial observation and again after 2 minutes.
8. Add one drop of soap into center of the Petri dish.
9. Have students make observation.

Modeling Animal Mating Behaviors

Overview:
Students will act out mating rituals to entice other classmates.

Background/Content Connection:
Looking at animal behavior, one can have their students act out different animal calls and gestures to try to attract other students. This is a way to have students look at mating behaviors and go into behaviors that allow some species to mate only with their own species. Some ideas to be covered are: animal behavior, temporal isolation, behavioral isolation, and habitat isolation. After the students act out their behaviors, the class can have a discussion about behaviors that were attractive to some students and other behaviors that were not attractive. Upon realizing that some students did not have someone who liked their behavior, the class will realize that there is some sort of barrier not allowing these species to mate with one another. The class is to be split into two groups. One group will be given instructions to behave a certain way. The other half of the class is to be given instructions that they are only to react to a certain behavior. Some behaviors to consider:

- Squawk
- Whistle
- Flapping arms
- Sitting in the corner peeping
- Standing on the lab table cawing
- Hopping on one leg
- Squatting and cooing
- Making a face like a fish
- Not doing anything because it is not nighttime

Materials:
Index cards with behaviors and index cards with behaviors that are “attractive.”

Protocol:

1. Have one half of students follow the teacher into the hallway.
2. The students in the hallway are to be given the cards that express their behavior. They are to enter the classroom and only perform their behavior in the designated area.
3. The other half of students stay in the classroom. These students will be given an index card that tells them to only be attracted to a specific behavior, call or human in a specific location.

Polygenic Nature of Height

Overview: Students will line themselves up by height to demonstrate an example of polygenic inheritance.

Background/Content Connection: Traits that are inherited due to multiple genes working together is termed polygenic Inheritance. Usually, traits acquired through polygenic inheritance show a continuum over large spectrum. A good example of a trait controlled by such inheritance is height, which is controlled by over 400 genes in a human. This lesson should be conducted after the students have had a chance to read about or be exposed to the idea of polygenic inheritance.

Materials: Students

Protocol:

1. Have the students line up by height.
2. Ask the students if they see any patterns and if so, what might have caused these patterns.
3. Ask students to suggest other human traits that might be controlled by numerous genes.

Caterpillar Behavior and Food Choice

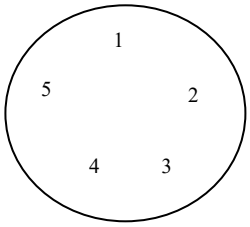
Overview: Students will discover the feeding behaviors of *Pieris rapae* caterpillars.

Background/Content Connection:
In this lesson students will focus on animal behavior in accordance with food choice. Within this lesson, students may investigate chemoreceptors and chemical recognition of food. *Pieris rapae* caterpillars are to be placed in a Petri dish with 5 different food sources. The caterpillar will move around the dish and select the food that it can eat. *Pieris rapae* caterpillars feed on Brassica plants, such as broccoli, cauliflower and cabbage. Therefore, when selecting food for the caterpillar, be sure that there is at least one type of Brassica plant available to the caterpillar. During the observation period, the students can multi-task. The teacher can discuss food selection and chemoreceptors.

Materials:
Pieris rapae caterpillars, Petri dishes, paper towel, pencil, and different types of food

Protocol:

1. Cut a piece of paper towel to fit the bottom of a Petri dish and place it in the dish.
2. Number the paper towel 1-5 in a circular pattern.
3. Dampen the paper towel.
4. Place a small piece of a different type of food on each number.
5. Place one *Pieris rapae* caterpillar in the center of the Petri dish.
6. Observe the feeding behavior.



Butterfly Egg-Laying Behavior

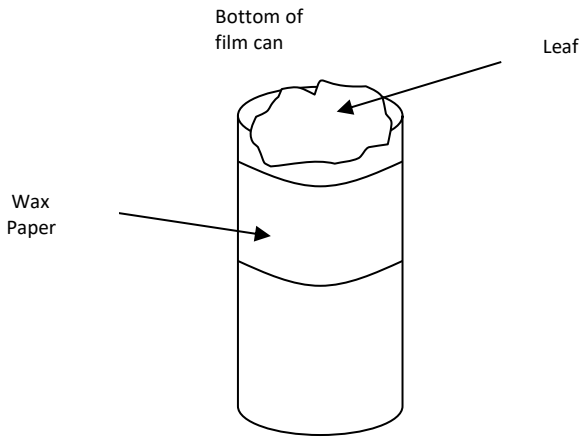
Overview: Students will examine the egg laying behavior of *Pieris rapae*. Students will discover that there are certain chemical messages that the butterflies will read. Chemoreceptors on the feet of the butterflies help them in laying their eggs on the correct food source.

Background/Content Connection:
In this lesson students will focus on animal behavior by observing egg-laying choice. Within this lesson, students will investigate chemoreceptors and chemical recognition. *Pieris rapae* butterflies are placed in the butterfly cage with multiple "ovipositrons" (egg laying devices), made from a film can, wax paper, and a piece of leaf. The leaf can be lettuce, spinach, or a tree leaf. However, because *Pieris rapae* butterflies are attracted to Brassica plants, it is important that at least one of your ovipositrons has a Brassica leaf on it. Some Brassica plant leaves that can be used are cabbages, *Brassica rapa*, bok choi, mustard plants or Brussels sprouts. The Pieris butterflies lay the eggs on these plants because it is a type of food that is palatable to the larvae when they hatch. The object of the lesson is to see the types of leaves the butterflies select to lay their eggs. The butterflies use chemoreceptors on their legs to determine the chemical composition of the leaves. The butterflies will sense the Brassica leaf and will attempt to lay their eggs on the underside of the leaf. However, the butterfly will instead lay its eggs on the wax paper. Once the butterflies have laid their eggs, students can count the number of eggs on the different cans. During the egg laying period, the teacher can discuss chemoreceptors, the biochemistry of the brassiniods, and/or plant/insect interaction

Materials:
Pieris rapae butterflies, film cans, wax paper, different types of leaves, glue stick, and butterfly cage

Protocol:

1. Create an ovipositron by wrapping a 2 cm wide strip of wax paper
2. around a film can and, using a glue stick, glue the wax paper to the film can. Glue down one type of leaf on the can.
3. Repeat using another type of leaf.
4. Place 3-4 egg laying devices in a butterfly cage that houses several female Pieris butterflies.
5. Allow the butterflies to lay eggs for at least 20 minutes. At the end of 20 minutes, have the students count the number of eggs on each ovipositron. Students could also return later in the day to count the eggs. In captivity, the *Pieris rapae* tends to lay more eggs in the morning than later in the day.



Addendum: Throughout the United State, garlic mustard is an invasive species. Like Brassica species, garlic mustard is a member of the 4ardiff4ae family. However, unlike most 4ardiff4ae garlic mustard is not palatable to the Pieris larvae. If the butterflies lay their eggs on garlic mustard, the larvae will starve once they are hatched, and they will die. You could add this type of leaf to one of the egg laying devices and bring up the idea of invasive species.

Glucose Hunt

Overview: Students will test for the presence of glucose in the nectaries in a flower. You can also use this opportunity to discuss the location of the nectaries in terms of the evolutionary adaptations that the flower is utilizing to ensure pollination.

Background/Content Connection: Flower nectaries can be found at the base of the sexual parts of a flower, the stamen and the carpel. The nectarines are rich in glucose, and one can use glucose test strips to look at the type of macromolecule found in them. Glucose test strips can be purchased at your local drug store. A good example of a flower to use is a *Brassica rapa* or Wisconsin Fast Plants. The plants are easily grown in your classroom and can flower within 14 days of planting.

Materials: Wisconsin Fast Plants, hand lenses, toothpick and glucose test strips

Protocol:

1. Harvest flowers and pass out one flower and a hand lens to each student.
2. Ask the students to examine the flower and tell them that they are looking for something that looks like a glistening drop of water within the flower.
3. Ask the students where the water droplet is situated and ask them why they believe it to be there.
4. Hand out a glucose test strip and ask the students to test for the presence of glucose.
    a) moisten the end of the test strip with water
    b) poke the nectary with the end of a toothpick
    c) touch the end of the toothpick to the test strip
    d) observe color change
5. Continue discussion about the location of the droplet and the reason why the droplet has tested positive for glucose

Flower Dissection

Overview: Students will do a flower dissection to look at the structure of a flower. From the structure, students can examine the function of the flower.

Background/Content Connection: Dissecting a flower will give students the opportunity to examine the form and the function of a flower. Students can examine the parts of the flowers while thinking about the evolutionary context of the flower. Students will determine the number of petals and the number of stamens to determine whether or not the flower comes from a dicot or monocot plant. Monocots will have leaves with straight venation and flowers and stamens in groups of 3. Dicots, on the other hand, will have leaves with palmate venation and flowers and stamens in multiples of 4 or 5. The students will also examine the stamen and the carpel to examine the pollen grains and the ovules. After the dissection, the teacher can direct discussion towards structure and function of flowers as well as evolutionary adaptations.

Materials: Flowers, scalpel, and dissecting microscope or hand lens.

Protocol:

1. Have the students examine the flower and make a labeled drawing.
2. Count the number of petals and stamen to determine the flower is from a dicot or monocot.
3. Remove the stamen and examine the stamen under a microscope or with a handheld lens. Have the students estimate the number of pollen grains that they see.
4. Remove the all of the stamen, sepals, and petals to expose the carpel.
5. Make a longitudinal cross section of the carpel to examine the ovules.
6. Estimate the number of ovules.
7. A discussion can ensue about the relative number of pollen grains compared to ovules and the reproductive success of flowers with varying number of ovules and pollen grains.

Amylase and Starch Plates

Overview: Students will use salivary amylase and starch agar plates to demonstrate enzymatic action and digestive enzymes.

Background/Content Connection: Students will observe the enzyme amylase breaking down starch. They will use the indicator IK_2I to stain starch. This activity can be used during the lesson on enzymes to illustrate the speed of enzymes or as an introduction to the process of digestion. To initiate the activity, suggest to students that due to recent budget cuts the local police have had to find ways to save money in their forensics lab. They have come to you to see if you have any suggestions. Specifically, they are hoping to find a way to identify items that might have human saliva (contains DNA) on them.

Materials: Sterile cotton swaps, dilute IK_2I and starch agar plates
Recipe for starch agar: Add 2 g of cornstarch and 7.5 g of agar to 500 ml of water. Heat to boiling in a microwave or on a hotplate (stirring constantly to prevent burning). Cool until it is safe to handle and pour into Petri dishes. Plates can be stored at 4°C for 1 month.

Protocol:

1. Each student will receive one starch plate and a sterile cotton swab.
2. Each student should place his or her cotton swab into his or her mouth for about 5 seconds.
3. The students can then write their initials onto their starch plate with their cotton swab. They do not need to dig into the agar. They simply need to rub their cotton swab on the agar. Let the starch plates sit for about one minute
4. After about one minute, the students should add dilute IK_2I to the starch plate, swirling the plate so that the entire agar is covered.
5. The salivary amylase breaks down starch, so the iodine should not stain the initials.

Catalase: An Enzymatic Study

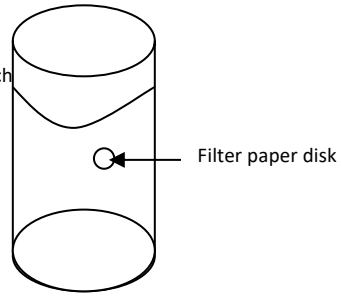
Overview: Students use catalase to examine an enzymatic reaction. Students soak filter paper disks in catalase and submerge the disks into hydrogen peroxide. The disks will float as the catalase breaks down the hydrogen peroxide into oxygen and water.

Background/Content Connection: In this lab, students study catalase, an enzyme found in the cells of many living tissues. Catalase speeds up a reaction that breaks down hydrogen peroxide into water and oxygen, a waste product in every cell of the human body. The rate of this reaction can be determined by measuring the amount of oxygen produced. Filter paper disks are soaked catalase solutions and dropped into hydrogen peroxide. The oxygen builds up on the disk, causing it to float. To find the best concentration of catalase to use, it is recommended that you add pinch of dried catalase to about 100ml of distilled water. Test the solution by doing a few trials. The general rule of thumb is to have a solution that will allow a disk to sink and then float to the top in about 5-10 seconds. You may have to dilute the catalase solution or add a little more catalase. Diluting the hydrogen peroxide can also slow the reaction down. Fruit fly vials are a great substitute for test tubes.

Materials: Lyophilized Catalase**,** Carolina Biological Supply Company item #, 746821, filter paper disks (made by using a hole punch), hydrogen peroxide, distilled water, tweezers, paper towels, and flat bottom test tubes.

Protocol:

1. Give pairs or groups of students, catalase stock solution, vial of hydrogen peroxide, filter paper and hole punch
2. Students should do several trials to determine the average reaction time.
3. Assign each group a different dilution factor and have them do several more trials.
4. Compile student data on the board and discuss the results.



Acting Out Action Potentials

Overview: Students can act out action potentials moving down a neuron using pieces representing Na^+ ions, K^+ ions, Ca^{2+} ions and neurotransmitters. Students will set up desks in the classroom so that the represent a neuron. They will then pass Na^+ and K^+ in and out of the neuron as the action potential goes down the axon, reaching the axon terminal. At that point, students will pass neurotransmitters to the next neuron.

Background/Content Connection: As an action potential moves down an axon, Na^+ initially moves inside of the cell, creating an electrical imbalance and depolarization. This causes, K^+ ions to move out of the cell to repolarize the cell. This in turns causes Na^+ to move into the next segment of a neuron, moving the action potential down the neuron until the terminal is reached. At the terminal, the last influx of K^+ causes Ca^{2+} to move into the cell, provoking the neurotransmitter vesicles to move to the cell membrane. The release of neurotransmitters and eventual attachment to ion channels on the next neuron causes the action potential to move down the postsynaptic neuron. After the action potential moves down a neuron the potential is then reset with the aid of sodium-potassium pumps. Desks can be set up in the classroom so that the spaces between the desks represent nodes of Ranvier, the site where ion transfer happens.

Materials: Students, desks, 8 x 11 cards labeled with Na^+, K^+, Ca^{2+}, and neurotransmitters.

Protocol:

1. Have the students create two neurons with the desks in the classroom. Point out to them that the spaces between the desks should represent nodes of Ranvier. Make sure that they can understand where the cell body, dendrites, and axon terminals are within the model.
2. Starting at the cell body, have the students demonstrate how Na^+ will enter the cell and K^+ will leave the cell at each node, moving the action potential down the neuron. Students should act at the ions, moving in and out of the cell as the action potential moves down the axon.
3. Once the action potential reaches the axon terminal, a student representing Ca^{2+} should go into the cell, gently nudging other students, who represent neurotransmitter vesicles to move towards the axon terminal.
4. These students should move their neurotransmitters to the outside of the cell, moving towards the start of the next neuron.
5. The students representing the neurotransmitters should help to move Na^+ into the next neuron starting the action potential in that neuron.
6. After the neurotransmitters leave the first neuron, the Na^+ and the K^+ should reset the neuron by moving back into and out of the cell.

Human Transport

Overview: Students will use kinesthetic learning to review diffusion, osmosis, passive transport, active transport, and facilitated diffusion.

Background/Content Connection:
This lesson will cover transport of molecules using kinesthetic learning. The teacher will ask the students to model different types of transport by having the students form a circle by standing side-by-side. The circle represents a cell membrane. The teacher will assign certain students to be molecules. These students will be given armbands and will move into the center of the circle. The students who are molecules will act out diffusion by passing through the membrane made by the other students. The "molecules" should move through the membrane freely as to establish dynamic equilibrium. From this point, the teacher can ask the students to demonstrate facilitated diffusion. Some students will have the idea to make channel proteins by holding hands and making bridges where the "molecules" can pass through. Afterward, the teacher can introduce the idea of active transport. The students can use the tennis balls to represent phosphate molecules from an ATP molecule. It is important to allow all of the students to speak to one another while they do this lesson. They are trying to demonstrate all of the molecular movements together. The teacher should do their best to not give the students any ideas, but to rather simply ask them to demonstrate different types of molecular movement.

Materials: Students, armbands, and a few tennis balls.

Protocol:
1. Explain to students that they will demonstrate molecular movement across a membrane. They will work together to figure out the best way to demonstrate each type of transport.
2. Instruct the students to form a circle. Ask the students what the circle may represent. The instructor can ask the students how they might be like a plasma membrane, and how they might not be like a plasma membrane.
3. Assign a few students as molecules. Give the "molecules" an armband to represent that they are molecules.
4. Ask the students to demonstrate diffusion, allowing them to discover dynamic equilibrium.
5. Once the students have successfully achieved diffusion ask them to demonstrate osmosis.
6. Once the students have successfully achieved osmosis, ask them to demonstrate facilitated diffusion.
7. Once the students have successfully achieved facilitated diffusion, ask the students to demonstrate active transport. At this point, the students will need to find an object to represent ATP. Tennis balls might be useful to represent phosphates.

Human Protein

Overview: Students will examine the properties of amino acids and how amino acids interact with one another.

Background/Content Connection: Amino acids have different properties based on their R groups. The R groups can be charged, polar, nonpolar, acidic or basic. Like R groups attract to one another, and unlike R groups will repel each other. In this activity, students will be assigned to their own amino acid. They must figure out the properties of their amino acids R group and embody those properties. Once each student is assigned to a specific amino acid and has determined the properties, the students will all hold hands, so that all of students have made a very long chain. The students should then embody their amino acids R groups and be attracted to other like R groups while being repelled by the others. Allow the students to interact and then finish the activity with a discussion of primary, secondary and tertiary structure of proteins.

Materials: Students and a chart of amino acids.

Protocol:
1. Assign each student in the class to one amino acid. It is ok to repeat amino acid.
2. Have the students stand in a line and hold hands. (or hold a pencil between them)
3. Explain that the polypeptide chain has just been thrown into a beaker of water. Tell the "hydrophobic" students that they should move to the center of the group while the "hydrophilic" students would move to the perimeter.
4. Tell students to return to their chain formation and devise another scenario such as having amino acids with positive charge attract those with negative charges or have cysteine amino acids form disulfide bridges
5. Allow the students to interact for a few minutes to form the tertiary structure of a protein.
6. Discuss amino acid interactions and tertiary structure of proteins with the students.

Homologous Structures of Skeletons

Overview: Students can examine different skeletons to examine homologous structure.

Background/Content Connection: Homologous structures are good examples of evidence for evolution, and homologous structures can be examined quickly in your class. Homologous structures are structures that are similar in design, but have different functions, such as the forearm of a human and the fin of a whale. Students can examine skeletons to determine evolutionary relatedness between species in reference to their homologous structures.

Materials: Skeletons of a combination of the following organisms: cat, frog, bat, rat, snake, human, and bird.

Protocol:
1. Have the students examine the skeletons and come up with a list of structures that are similar between the skeletons.
2. Discuss why these structures are homologous and what homologous structures have to do with evolution.

Addendum: show the students examples of analogous structures, such as the wings of a butterfly and compare them to the skeleton of bird. You can discuss with your students the significance of analogous structures in terms of evolution.

Meiosis Dance and Independent Assortment

Overview: Students can act out meiosis in a kinesthetic activity. In doing so, students will act out independent assortment of chromosomes. The activity should result in gametes with different chromosomes.

Background/Content Connection: Students can act out the movements of the chromosomes during meiosis. Students will act as chromosomes and will be pulled in opposite directions during meiosis. Ahead of time, students should be assigned to a partner so that they act as homologous chromosomes. The homologous chromosomes will be doubled during interphase, so make sure that each chromosome will ultimately have 4 sister chromatids, represented by 4 students. In order to understand independent assortment, students will have to perform this activity multiple times to ensure that there is a random alignment of chromosomes at the equator during metaphase I and metaphase II. In a class of 20, there will be 5 pairs of chromosomes.

Materials: Students (if students are willing they can wear hats or bandanas to keep track of the maternal/paternal chromosomes)

Protocol:

1. **Interphase**: Have the students who will act as the original chromosomes stand in the center of a large space. The students who represent the sister chromatids of each chromosome should be arm-in-arm as to represent one double stranded chromosome. You can tell the students that their arms represent the centromere.
2. The chromosomes (students) will double during interphase, so the other students assigned to their chromosome pairs should join their partners. Make sure that the students understand that each original sister chromatid has been duplicated, and that each new student should join one of the original sister chromatids. All four students at this point should be linked arm-in-arm.
3. **Prophase I**: Students/chromosomes have doubled. At this point, the student groups should begin to wander around the designated area of the cell. They should not move all in a circle, but in all different directions.
4. **Metaphase I**: To induce metaphase, the teacher should ask the students to line up in the center of the cell. The students should do this at random and should not line up until instructed to do so. You can tell the students that they should get to the equator of the cell as soon as possible after they are instructed to do so. You could liken this part of the activity to musical chairs.
5. **Anaphase I**: The students should be directed to divide towards opposite poles of the cell, separating at the original centromere.
6. **Telophase I**: Once the students reach the opposite poles, two cells have been formed. At this point, you can ask the students how these new cells compare to the original cells.
7. **Prophase II**: Students should be directed to move around their respective cells, holding onto their partner. Their movement should be random, as it was in step 3.
8. **Metaphase II**: Once directed by the teacher, the students migrate to the equator lining up whichever way they happen to end up.
9. **Anaphase II:** The students should let go of each other, breaking their centromere, and move to opposite sides of their cells.
10. **Telophase I**: Once the students reach the opposite poles, four cells have been formed. At this point, you can ask the students how these new cells compare to the original cells.
11. Ask the students to take note with who they are in the new cell.
12. Model independent assortment by acting out meiosis again. It is likely that the last cells formed in the second meiosis will have different students in them compared to the first meiosis.

Alternation of Generations

Overview: Alternation of generations is often a difficult concept for students to understand. In this activity students will examine C-Fern gametophytes and sporophytes. The sperm can also be used to demonstrate chemotaxis.

Background/Content Connection: C-Fern is a derived cultivar of a tropical fern, *Ceratopteris richardii.* Although C-Ferns can be grown in soil, they are usually grown on agar for classroom use. Spores will germinate in 3-4 days after sowing, producing male and hermaphroditic gametophytes. Sperm release can be induced, and the motile sperm can be viewed under 100X magnification 10-18 days after sowing. Sporophyte embryos are visible several days after sperm release. C-Ferns can be introduced as part of the unit on life cycles, algae, and/or plants. Depending on how they are to be used, students can sow the spores, induce sperm release, or examine the gametophyte and sporophyte stages. Once the sporophyte starts growing the C-Ferns can be transferred to a terrarium. The C-Ferns can be grown from spores in moist soil, but it is more difficult to see the early stages.

Protocol:

1. Give each pair of students a plate that has 12-15 day old gametophytes.
2. Using a dissecting scope, students should examine the two different types of gametophytes (mitten-shaped gametophyte produces both eggs and sperm and the smaller thumb-shaped gametophyte produces only sperm)
3. Using a toothpick, students transfer a few gametophytes of each type onto a microscope slide and examine under 100X. Students can draw and label the different gametophytes.
4. Add a drop of spring water and after five minutes careful observation should lead to visualization of the motile sperm.
5. Chemotaxis can be demonstrated by placing the tip of a toothpick that has been stuck into an apple on the edge of the slide. The chemicals in apple mimic the chemicals released by the female archegonia.

Gravitropism and Phototropism

Overview: Students can examine hormone induced plant tropisms using Wisconsin Fast Plants.

Background/Content Connection: When plants respond to gravity their shoots will grow away from gravity. When plants respond to sunlight, they will grow towards the sunlight. Both of these responses are due to the plant hormone auxin. Wisconsin Fast Plants, or *Brassica rapa*, will respond to light and gravity quickly enough that responses will be seen within one class period. Each tropism can be seen using four-day-old Wisconsin Fast Plant cuttings. Therefore, Wisconsin Fast Plants must be sown approximately four days before this lesson. Wisconsin Fast Plants can be planted in the quad growing systems sold by Carolina Biological Supply or in film cans. Directions for both methods can be found on www.fastplants.org.

Materials: Four-day-old Wisconsin Fast Plants, scissors, empty black film cans, paper towels (cut in strips about 1 cm x 4 cm), and grid strips. (grid strips will be the same size as the paper towel and can be made by photocopying graph paper onto a transparency.)

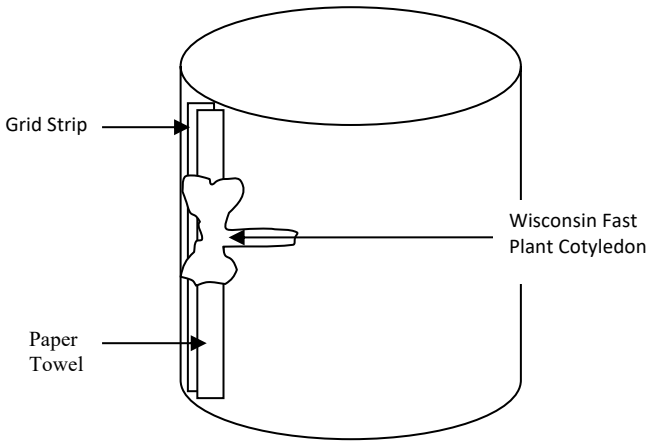
Protocol for Phototropism:

1. A day before the class position the growing Wisconsin Fast Plants to one side of the light source so that they will bend toward the light.
2. For the class, show the students the plants and then place them facing the opposite direction so that they will bend in the opposite direction.
3. Have the students predict what will happen.
4. Examine the plants at the end of class.

Protocol for Gravitropism:

1. While some plants are responding to light, have the students set up the apparatus to examine gravitropism.
2. Give each student or group of students a black film can, a piece of paper towel, a grid strip and 4 four-day-old Wisconsin Fast Plant cotyledons.
3. Dampen the paper towel and stick it to the grid strip (adhesion!).
4. Position the grid strip so that it is standing upright inside of the film can.
5. Stick the Wisconsin Fast Plant cutting on the paper towel by adhering the cotyledons to the paper towel. Position the plant so that it is approximately halfway down the can as shown in Figure 1.
6. Repeat with three more cotyledons so they are arranged as shown in Figure 2.
7. Place the cover on the can. Use a piece of double-sided tape to secure film can and let it sit for the duration of the class.
8. Students should make and draw predictions of what will happen to the stem of each cotyledon.
9. At the end of class have the students open the film can to see what has happened to the Wisconsin Fast Plant cutting. (the cut end of the Wisconsin Fast Plant should have responded to gravity and started to bend upward.)
10. Students should discuss predictions and results with each other.

Figure 1



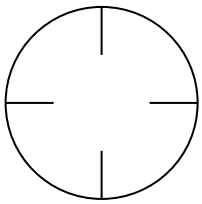


Figure 2

Green Road Race

Overview: Students will see that the chloroplasts in plant cells are mobile and can respond to environmental stimuli.

Background/Content Connection: Students often don't realize that organelles can move around the cell. They observe the movement (cyclosis) and can hypothesize about the reasons for the movement.

Materials: Elodea**,** slides, coverslip, and microscope

Protocol:

1. Expose the elodea to cool white light for at least one hour
2. Place a leaf from the growing tip on a slide with a drop of water and a cover slip
3. Bring into focus under low power and then switch to high power.
4. If the chloroplasts are not moving, leave the microscope light on and wait 5 minutes

The Cutting Ability of Restriction Enzymes

Overview: Students will model how restriction enzymes work by having them cut sections of DNA on a specific location along a chromosome.

Background/Content Connection: Restriction enzymes cut DNA at specific DNA sequences. Three common restriction enzymes are Eco R1, Hind III, and Bam H1. Eco RI cuts DNA at G/AATTC. Hind III cuts at A/AGCTT. Bam HI cuts at G/GATCC. Students can be given this information along with a hypothetical sequence for a plasmid. The plasmid can have several sites at which each of the restriction enzymes "cuts" the DNA. A commonly used DNA sequence to demonstrate electrophoresis is Lambda DNA. However, the entire genome of Lambda may be too extensive for this activity.

Materials: 4 copies of a hypothetical DNA sequence in a linear format, and scissors.

Protocol:

1. Give the students the background information about the three restriction enzymes and explain how they function.
2. Hand out the one copy of the hypothetical sequence of DNA, and have the students cut the sequence at the sites marked by Eco RI.
3. Hand out the second copy of the hypothetical sequence of DNA, and have the students cut the sequence at the sites marked by Hind HI.
4. Hand out the third copy of the hypothetical sequence of DNA, and have the students cut the sequence at the sites marked by Eco RI.
5. Give the students the 5th copy of the hypothetical sequence of DNA. Do not have them cut this sequence.
6. Have the students discuss how many cuts each restriction enzyme made, and how the segments compare in size.

Addendum:
From this, students can then guess as to where the bands of DNA created by the restriction enzymes may end up once the DNA is subjected to DNA electrophoresis. In order to do this, have the students use their desk as a gel and lay out where each segment of DNA may lie in a gel according to their sizes.

For reference, the sequence of Lambda DNA can be found at: http://www.cardiff.ac.uk/biosi/staffinfo/ehrmann/tools/dna/PhageLambda.html.

Baguette Operon

Overview: Students are given a loaf of French bread (or Swim Noodle) and challenged to make a model of an operon.

Background/Content Connection: Operons can be inducible or repressible. A repressible operon is one that makes a product that will eventually turn off the operon. The classic example of a repressible operon is the *trp* operon. An inducible operon is an operon that is turned on when a substrate not made by the operon is present to turn the operon on. The classic example of an inducible operon is the *lac* operon. Students should be allowed to use their books as a reference for this activity. The bread or noodle represents the DNA, shower curtain hooks could represent the amino acids to make the polypeptide, and a tennis ball or other object can serve as the repressor

Materials: French bread or pool noodle and knives,

Protocol:

1. Give the students advanced notice that they will be creating this model in class, so they can bring in assorted items for the amino acids, polymerase, repressor etc.
2. Hand out two pieces of slightly stale French bread and other assorted items to each group of students.
3. Assign each group to make a repressible or inducible operon.
4. Give each group 15 minutes to create their operon.
5. Have each group demonstrate and explain how their operon functions.

Red Onion Plasmolysis

Overview: Students examine hypertonic, hypotonic and isotonic solutions by using red onions, tap water, and salt water.

Background/Content Connection: A wet mount of a piece of red onion made with tap water will demonstrate a cell that is isotonic to its surrounding environment. If the environment is inundated with salt water, the environment around the cell turns hypertonic, and the cell exhibits plasmolysis.

Materials: microscope slide, cover slips, tap water, salt water, and red onion

Protocol:

1. Have the students make a wet mount of an epidermal peel of an onion.
2. Have the students examine the wet mount under a microscope and make a drawing of what they see.
3. Students should predict what they think will happen when salt water is added and why.
4. Add one drop of salt water to the wet mount by placing the pipette end along the edge of the cover slip and squeezing slightly. The salt water should go under the cover slip. It is important to add water slowly as it may move the cover slip and the specimen.
5. The students should then make a drawing of what they see and discuss the results with their partner.

Addendum: This activity can be done as a demonstration using a microscope connected to a projector.

3-D to 2-D and Back Again

Overview: Students use a three-dimensional cell model to draw a cross section. Using a two-dimensional micrograph, the students then construct a model of the cell shown in the photo.

Background/Content Connection: The purpose of this activity is to help students understand and visualize the three-dimensional nature of a cell or tissue. In theory, most students understand that a cell is not flat, but it is interesting to see the revelations as they attempt to create their own "micrograph" from a cell model. If time allows, having the students then construct a three-dimensional model from a picture in their book gives them an even better understanding of how to interpret the two-dimensional pictures. This activity is well suited to the first few weeks of class as it helps students make accurate observations and deepens their appreciation for the limitations of illustrations. This activity would also be appropriate as an introduction to microscope work and/or cell structure and function.

Materials: Cell model (preferably homemade out of soda bottles or clear plastic shoe box), paper, pencils, and assorted supplies for students to construct their own model.

Protocol:

1. Review the terms cross-section and longitudinal section with students.
2. Indicate on the cell model the section you would like students to draw.
3. Instruct students to make a drawing of the section you have indicated.
4. Pass the model around so students can thoroughly examine it.
5. Have students exchange their drawings and discuss the pros and cons of their work with a partner.
6. Choose an illustration from the text and have students attempt to construct a three-dimensional model.

Locating the 3' and 5' Carbons in Deoxyribose

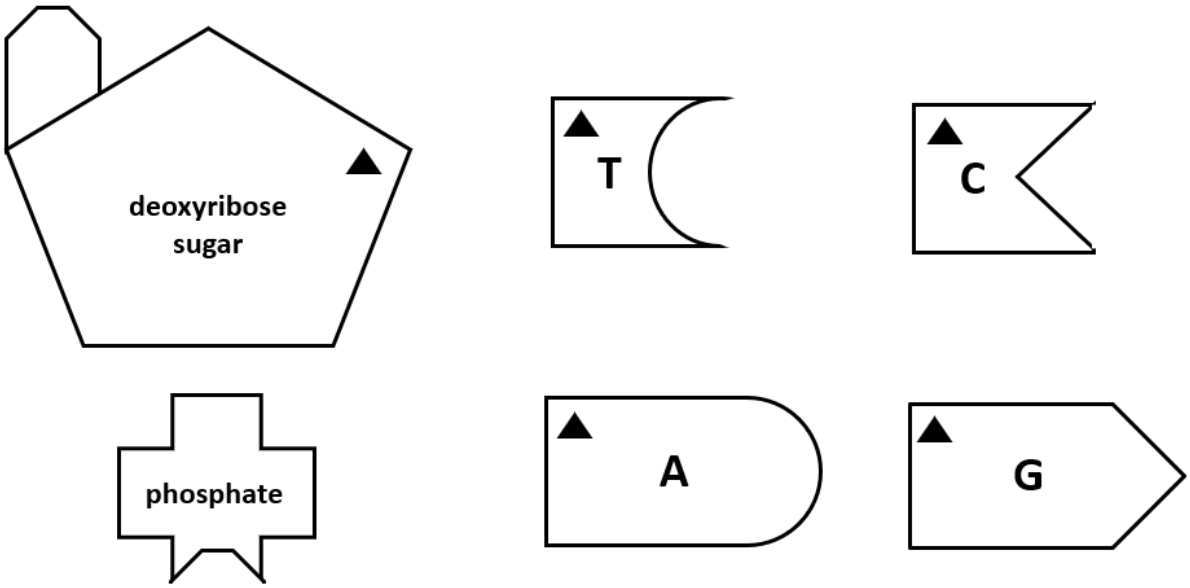
Overview: Using a picture of deoxyribose, students label the carbons in the 5-carbon sugar. Students then create a single nucleotide.

Background/Content Connection: Students often have difficulty understanding what is meant by 3' or 5' when discussing DNA replication and transcription. An easy way to help students understand this concept is to have the students label the carbons on a picture of deoxyribose. By constructing the nucleotide students then see the location of the 3' and 5' carbon and their role in bonding to the adjacent nucleotide.

Materials: Pen/pencil and pictures of deoxyribose (attached)

Protocol:

1. Each student is given one picture of deoxyribose.
2. The teacher should use an overhead projector or Smart Board™ to label the carbons on the deoxyribose.
3. Starting in the 1st position, label the carbons one at a time, discussing why each carbon is labeled as such.
4. At the end of labeling, the teacher should discuss the concept of building a DNA molecule by adding onto the 3' end of a nucleotide.



Dihybrid Genetics

Overview: Students will examine the F2 generation of Wisconsin Fast Plants and predict the original P1 and P2 plants.

Background/Content Connection: During the study of genetics much of the lab work is using case studies or nonliving examples. Most living examples take several weeks to prepare. The Wisconsin Fast Plant™ F2 seeds can be purchased and require three days to germinate. These seeds should produce a 9:3:3:1 ratio of tall/purple: short/purple: tall/nonpurple:short/nonpurple. The intensity of the purple color will depend on the lighting and is most easily seen in the stem. It is important to help the students score the plants to make sure they are differentiating between the green and purple. A cross of F1 plants produced the F2 seeds. The F1 plants were standard height (tall) and had purple stems. The P1 plants were standard height and had nonpurple stems. The P2 parent was a dwarf or rosette plant and had purple stems.

Materials: Wisconsin Fast Plant™ seeds (available from Carolina Biological #15-8895), Petri dishes, paper towels, and 24-hour fluorescent light (seeds need to be grown within 4-6 cm of the light source for best results)

Protocol:

1. Give students the plates and ask them to make careful observations about the plants.
2. By making suggestions/giving hints, help the students distinguish between the different phenotypes.
3. Have students count the number of each phenotype and share data.
4. Ask students to predict the phenotypes of the original P1 and P2 plants

Cell Communication in the Real World

Overview: Students will gain an appreciation of the varied ways in which communication occurs.

Background/Content Connection: The varied ways in which cells communicate has led scientists to discover some basic universal mechanisms of cellular regulation. Cells communicate via chemical signals in three basic steps: reception, transduction, and response. By examining how humans communicate students can appreciate how such simple action can lead to such varied responses.

Materials: Students, markers, large poster paper

Protocol:

1. Divide students into groups of 5 or 6.
2. Each group will brainstorm ways of communication for different situations and record their results on poster board.
    a. Group A: humans are within sight but not touching
    b. Group B: humans are touching
    c. Group C: Humans are not in the same state
    d. Group D: Humans are not on the same planet
3. After 5 minutes, groups will report out. Focusing a common ideas and themes between each means of communication.

Regulation in Paramecium

Overview: Using paramecium, students can watch the ingestion and digestion of yeast. The role of the contractile vacuole in water regulation can also be observed.

Background/Content Connection: Paramecium sweep food particles down their gullet and into food vacuoles using their cilia. By dying yeast with Congo Red, the progression of the food through the paramecium can be followed. The red yeast will change to a blue color as the pH of the food vacuole changes so students can identify older vacuoles. The action of contractile vacuoles can be seen as paramecium collect excess water from their cytoplasm and expel it.

Materials: Paramecium culture (either *Paramecium multimicronucleatum* #131558 or *Paramecium caudatum* #131554 Carolina Biological), yeast, Congo Red, methylcellulose, cotton, and microscope supplies) Combine 1 gram yeast with 10 mls water. Leave in warm place (I use a beaker of 30–35-degree water) for 30 minutes. Use the flat end of a toothpick to “measure” two scoops of Congo Red, add to yeast and shake well.

Protocol:

1. Have students spread a thin film of methylcellulose on their slide. Add a few cotton fibers.
2. Place a drop of paramecium culture and a drop of yeast culture on slide. Add cover slip.
3. Exam under scanning or low power to locate paramecium.
4. Students can watch the cilia action—for both movement and ingestion of food particles.
5. When students find a slow-moving paramecium, they can watch to see the action of the contractile vacuole.
6. After 10-15 minutes, the yeast should be present inside the paramecium in food vacuoles. As the yeast is digested, the pH change will cause the color of the yeast to turn from red to blue.

Burping Yeast

Overview: Students watch the effect of different temperatures on yeast respiration.

Background/Content Connection: Cellular respiration is one of those complicated cellular processes that students struggle to learn. This activity provides a hands-on method for students collect quantitative data on the effect of temperature on yeast respiration by counting the number of bubbles produced. An extension of this experiment would be for students to design their own investigation to determine the effect of another variable (pH, food, salt concentration, etc).

Materials: Mix yeast (either live or lyophilized) and glucose to make a live, bubbling solution (20% yeast) about 15 minutes before needed, 2 plastic graduated 1ml droppers, 2 metal nuts (that will slide over the shaft of the dropper), 2 tall test tubes (deep enough for the entire dropper to be completely submerged), 500 or 1000ml beaker or 1 qt deli container, ice, and warm water (40°C), small beaker or cup. Although harder to maintain the temperature an economical substitution is to drop the droppers directly into a water bottle filled with water at the appropriate temperature.

Protocol:

1. Set up a cold water and hot water bath
2. Pour water from the each of the baths into a test tube and place the test tube in the bath.
3. Measure 2 ml of yeast solution into the cup.
4. Completely depress the bulb of the dropper, and suck up the yeast/glucose solution into the bulb of the dropper
5. Invert the dropper and slide the metal nut over the shaft.
6. Prepare a second dropper.
7. Lower the droppers into the test tubes.
8. Allow 2 minutes for the pressure to equilibrate.
9. Record data for 10 minutes.

Humpty Dumpty: Putting the Pieces Back Together

Overview: Ligase is used to reconnect the pieces of a DNA ladder.

Background/Content Connection: Ligases are enzymes that join large molecules together. Specifically, DNA ligase IV joins double stranded DNA together. This activity can be used to demonstrate how the enzyme ligase works, as an introduction to the action of enzymes, an illustration of how ligase can be used to "build" a vector, or as an introduction to electrophoresis.

Materials: DNA ladder, NEB Quick Ligation Kit, electrophoresis supplies

Protocol:

1. Set up Ligation Reaction
   - 9 ul sterile dH_2O
   - 2 ul DNA Ladder
   - 10 ul 2X Quick Ligation Buffer
   - 1 ul Quick T4 Ligase and mix thoroughly
   - Spin down and incubate at room temperature for 5 minutes
2. Add 5 ul 5X loading dye
3. Run on 1.5 % TAE gel

I used New England Biolabs Quick Ligation Kit (M2200S) www.neb.com

Cell Phone Microscope

Overview: Students use their cell phone to capture magnified images

Background/Content Connection: This technique allows students to take magnified images of specimens to use in lab reports or to record data for later analysis. This can save class time as students can snap a picture of things like leaf hairs and take the pictures home to count the hairs. It also provides a very quick way magnify and record specimens. Including the edge of a ruler in the image will record size.

Another fun way to use cell phones is to show students' images from their phone. You can purchase connectors to connect iPhones and iPads to projectors.

Materials: Cell phone with camera, dropper, water, ruler (optional)

Technique:

1. Place cellphone on flat surface with camera lens facing up
2. Place a single drop of water over the camera lens
3. Focus the image by moving the object up and down
4. Take picture

An additional phone can provide extra light if needed.

Long and Short of DNA Electrophoresis

Overview: Using one of the new miniature gel boxes that have come on the market recently, it is possible to see electrophoresis results within 20 minutes.

Materials: DNA fragments ranging from 200 base pairs to several thousand base pairs, gel reagents and miniature electrophoresis unit

Background/Content Connection: Most commercially available restriction digest fragments, PCR products, or DNA samples from forensic or fingerprinting kits can be used to illustrate the technique of gel electrophoresis. However, this can be done in much less time if one of the new miniature electrophoresis units is used.

Protocol:

1. Provide each group of students an electrophoresis unit with gel and buffer
2. Have students load and run DNA samples
3. Students should document their results using a cell phone or tablet

Once students have mastered the technique it is important to "put it in context." Doing electrophoresis is really not a lab; it is an exercise in learning a technique. Students should understand that the technique is used by research scientists to separate, size, and identify DNA fragments. Have students do an experiment where they use a restriction map, restriction digests and electrophoresis to figure out the identity of an unknown plasmid.

Purple Poop

Overview: This activity can be used as an introductory inquiry activity as students design an experiment to determine the nature of the mystery substance. Another variation would be to use the purple poop to demonstrate color changes indicating different pH values.

Background/Content Connection: The dried poop (frass) is a mystery substance for the students. Students practice the scientific method as they design an experiment to identify the substance. The alternative activity uses solutions of known pH to create a color scale to use as students test the pH of various kitchen solutions.

Materials: *Pieris rapae* caterpillars produce purple frass or poop when fed purple cabbage. The frass should be dried before use. The pH solutions can be made using pH buffers or using household chemicals such as vinegar and ammonia.

Protocol:

1. Pass out a small sample of purple poop and ask students to make predictions about the identity.
2. Students should design and perform an experiment to determine the identity of substance.

Nature vs Nurture

Overview: Students will grow the F_2 generation of corn that is 3:1 Green: Albino to see the effect of nature versus nurture

Materials: deep Petri dishes or other suitable growth chambers for corn seeds, is 3:1 Green: Albino (Carolina # 177130), light

Background/Content Connection: Students have trouble understanding the effect of the environment on genetic traits. In this activity, corn seeds are germinated in the dark, so they all appear to have white leaves. However, once the dishes are placed in the light, within one day students can see that some of the leaves start to turn green. This can lead to thoughtful discussions about nature versus nurture and other cases (such as human tanning) where the environment can affect the "phenotype."

Protocol:

1. Soak seeds 24-36 hours in water
2. Cut two thickness of paper towel to fit in each Petri dish.
3. Moisten the paper towel
4. Add 10 corn seeds to each dish
5. Have students make predictions of what they think will happen/what they think the seedlings will look like
6. Place in total darkness for 1 week (I put them in a plastic bag with a saturated paper towel to increase moisture)
7. Bring all the dishes, except one) into the light for 24 hours
8. Have students examine the seedlings, count each color, determine ratio and discuss what happened and why. Encourage students to draw connections to other experiences.

Addendum: This activity can be modified to just show the effect of the environment by growing similar Petri dishes of radish or Wisconsin Fast Plant seeds in the dark and the light for three days.

The Missing Macromolecule

Overview: A quick and easy way to determine if DNA is present in a sample.

Background/Content Connection: A survey of the majority of macromolecule identification/testing labs would lead one to believe that there are only three macromolecules—carbohydrates, lipids and proteins. Many of these labs only mention DNA in a cursory fashion or not at all. This is most likely due to the fact that there hasn't been an easy or quick DNA test, as there are for the other molecules. The test can be used to test for the presence of DNA in food samples as well as in the white "slime" that we get out of strawberries or bananas.

P**rotocol:**

1. Add 2 ul of Gel Green (10,000X) to 998 ul of dH_2O in a microcentrifuge tube.
2. Add 10 ul of lambda DNA (500ug/mL) to 196 of dH_2O in a microcentrifuge tube.
3. Label three microcentrifuge tubes: C+, C-, and E for positive control, negative control and experimental sample.
4. Add 30 ul of the Gel Green solution to each tube.
5. Add 30 ul of the lambda solution to the +C tube.
6. Add 30 ul of water to the –C tube.
7. Add 30 ul of sample to the E tube.
8. Place under UV or blue light to determine results.

One Period PCR

Overview: Yes, Virginia, you can do PCR in less than 30 minutes!

Background/Content Connection: The polymerase chain reaction has been elusive for most high school biology programs for a variety of reasons. Two of the more pertinent reasons have been the expense and the time required for the polymerase reaction. However, some of the miniature thermocyclers, such as the miniPCR (www.minipcr.com) or miniOne PCR (www.minione.com) can remove both of those obstacles.

Protocol: The protocol would vary depending on the sequence you are trying to amplify but if you are amplifying a relatively small fragment (200-400 bp) from a plasmid or lambda it can be done in less than 30 minutes using the miniOne PCR.

Zipping DNA

Overview: Using zippers to model DNA and RNA

Materials: Sets of two 24-inch jacket zippers in different colors. The jacket zippers are critical since they come apart at both ends and can be zipped in both directions

Background/Content Connection: This activity helps students visualize the process of DNA replication and RNA transcription. If teachers want to go further and label the ends with 3' and 5' the activity can address the directionality of nucleic acids and their formation.

Protocol:

4. Provide each group of students with a set of zippers
5. Give minimal instructions…such as "Figure out how you are going to teach the class about DNA and RNA using these props."
6. Have a variety of other items available that students could use to show 3' and 5', polymerases, promoter regions etc.
7. Stand back and let them figure out their own system/devices.
8. Have students share with the class and explain their reasoning.

Yeast Balls

Overview: Yeast, encased in gelatinous balls is used to study enzymatic rate.

Background/Content Connection: Yeast produce the enzyme catalase, which converts hydrogen peroxide to water and oxygen. When yeast balls are dropped into a solution of hydrogen peroxide the oxygen produced in the reaction makes the yeast balls less dense and they float. This activity can be used to help students understand enzymatic reactions and the environmental factors that affect them.

Protocol:

1. Mix equal parts of yeast culture (10% yeast) with 2% sodium alginate solution
2. Using a syringe or transfer pipet drip the algae/alginate solution into a 2% calcium chloride solution-let sit for 5 minutes
3. Remove and discard any floating yeast balls
4. Rinse the remaining balls with tap water and put into microcentrifuge tube or small glass vial.
5. Add 0.3% hydrogen peroxide to the containers and have students measure the time it takes for the balls to rise
6. Various environmental conditions such as temperature, substrate concentration, salt concentration can be investigated

Note: Yeast balls can be used to investigate respiration using same hydrocarbonate indicator from the algae ball experiment, but you should start with a 5X purple solution.

Algae Balls

Overview: Single cell algae, encased in a gelatinous ball are used to study carbon dioxide uptake during photosynthesis.

Background/Content Connection: By using a carbon dioxide indicator, students can "see" photosynthesis happening as the color of the indicator changes as the algae photosynthesizes. Students can measure the changes qualitatively by comparing their reaction tubes to a set of standards or they can collect quantitative results using a spectrophotometer. This activity can be used while studying photosynthesis, algae, effect of environmental factors on organisms, and human impact on the environment (by subjecting the algae to various pollutants, temperature fluctuations, etc)

Protocol: (please see http://www.saps.org.uk/secondary/teaching-resources/235-student-sheet-23-photosynthesis-using-algae-wrapped-in-jelly-balls for details)

1. Mix equal parts of concentrated algae culture with 2% sodium alginate solution
2. Using a syringe or transfer pipet drip the algae/alginate solution into a 2% calcium chloride solution-let sit for 5 minutes
3. Rinse the balls with tap water and put into microcentrifuge tube or small glass vial.
4. Repeat above procedure except substitute water for algae to make controls.
5. Add hydrocarbonate indicator (0.1 g cresol red, 0.2 g thymol blue in 20 mL ethanol; .85 g baking soda in 200 mL dH_2O; add cresol/thymol blue solution to baking soda solution and bring volume up to 1000 mL with dH_2O. This is a 10 X solution, dilute with dH_2O to 1 X to use)
6. If the indicator is not a yellowish color, bubble (using a straw) carbon dioxide into it until it changes to yellow color.
7. Place under bright light and monitor for color change.

Pipetting Challenge

Overview: The pipetting ability of middle and high school students is directly correlated to their success in performing biotechnology (and other) experiments.

Materials: diluted white vinegar (X), bromothymol blue (Y), water (W), parafilm, p20 micropipettes and tips

Protocol:

1. Provide students with materials (300 µL of each solution)
2. Instruct students to remove paper layer from Parafilm™ cover the grid with the "waxy" layer.
3. Students use the table to determine the make-up of each drop in each cell. Each drop is a combination of two liquids.

Cell	A	B	C
1	7 µL Y 2 µL X	6 µL Y 4 µL W	5 µL Y 5 µL W
2	18 µL Y 2 µL W	16 µL Y 4 µL X	12 µL Y 8 µL W
3	11 µL Y 19 µLW	13 µL Y 17 µL W	15 µL Y 15 µL X

cell	A	B	C
1			
2			
3			

Extensions: By substituting starch solution and iodine for the vinegar and bromothymol blue, this activity could be modified to provide another way for students to learn or practice their pipetting skills. It could also be used when investigating carbohydrates and gives students another chance to use the micropipettes.

Plasma Membrane

Overview: Students construct a model of a plasma membrane.

Background/Content Connection: The structure of the plasma membrane is critical to its function. Students use large paper models of phospholipids, proteins, transport proteins and cholesterol to build a plasma membrane in an open space. The students then become various types of molecules that are transported back and forth through the membrane.

Materials: Draw large phospholipids (one per page of 8.5" x 11" paper), peripheral proteins, channel proteins, cholesterol. If possible copy them on different colors of paper. The degree of complexity depends on the level of the students.

Protocol:

1. Have students cut out membrane components
2. In a large space in the room or in the hallway have students create the membrane.
3. Once the membrane is complete, different students can take the role of materials that pass through the membrane or, in the case of transport proteins, helper molecules.
4. Discuss the role of phospholipids in creating a boundary and the role of proteins as transport molecules.

Resource: https://teach.genetics.utah.edu/content/cells/BuildAMembrane.pdf

Micro-Macromolecules

Overview: Students learn how to use indicators to determine the presence of macromolecules.

Background/Content Connection: This activity is a modified version of the classic "macromolecule" lab where different substances are tested with indicators. This lab uses micro-amounts of indicators and samples

Materials: glucose solution, Benedict's solution, starch solution, Lugol's iodine, protein solution, Biuret solution, paper bag and oil.

Protocol:

1. Students use a permanent marker to put a circle on either end of a microscope slide.
2. For glucose, starch, and protein testing 50 μL of the sample (4%) is added to one circle and 50 μL of water is added to the other circle. The appropriate indicator is added (50 μL) to both the water and the sample.
3. The starch and protein will change the indicator immediately. The glucose and Benedict's needs to be microwaved for 8 seconds for the color change to occur.
4. Students will dip strips of brown paper into oil and water and then let them sit for 10 minutes.
5. DNA testing can be done as described in "The Missing Molecule."

Green and Red

Overview: Students can confirm the presence of chlorophyll.

Materials: fresh green leaves, ethanol, 1.5 mL microcentrifuge tubes, straws, and toothpicks or micropestles

Background/Content Connection: Chlorophyll looks green because it reflects green light. When viewed under blue light or UV light the molecules absorb the high energy light and the electrons jump to an excited state. As the electrons drop back to their normal state they release the energy as a longer wavelength red light.

Protocol:

1. Add 300-400 μL of ethanol to the microcentrifuge tube.
2. Use the straw to punch out a leaf disk and add it to the tube.
3. Use the micropestle to grind up the disc.
4. View the solution under blue light.
5. Try different colors of leaves or variegated leaves to see if there is a difference.

Bean Genes

Overview: Students use dried beans to represent genes to learn basic terminology and how to use a Punnett Square.

B**ackground/Content Connection:** This activity is designed as an introduction to genetics for middle school students. Different colors of dried beans are used to represent genes and help students learn how to set up a Punnett Square.

Materials: Paper and pencil, assorted colors of dried beans (white, black, red), student worksheet

Protocol:

1. Use 2 black beans and 2 white beans to illustrate homozygous.
2. Use a black and white bean to illustrate heterozygous.
3. Explain how some genes are dominant and some are recessive. Use black beans for the dominate trait and white beans as the recessive trait.
4. Use the images below to match outcomes.
5. Use various combinations to set up Punnett Squares so students can practice moving and combining the genes.
6. The black and white beans can also be used to illustrate incomplete dominance (producing gray) and the red and white beans can illustrate incomplete dominance.

