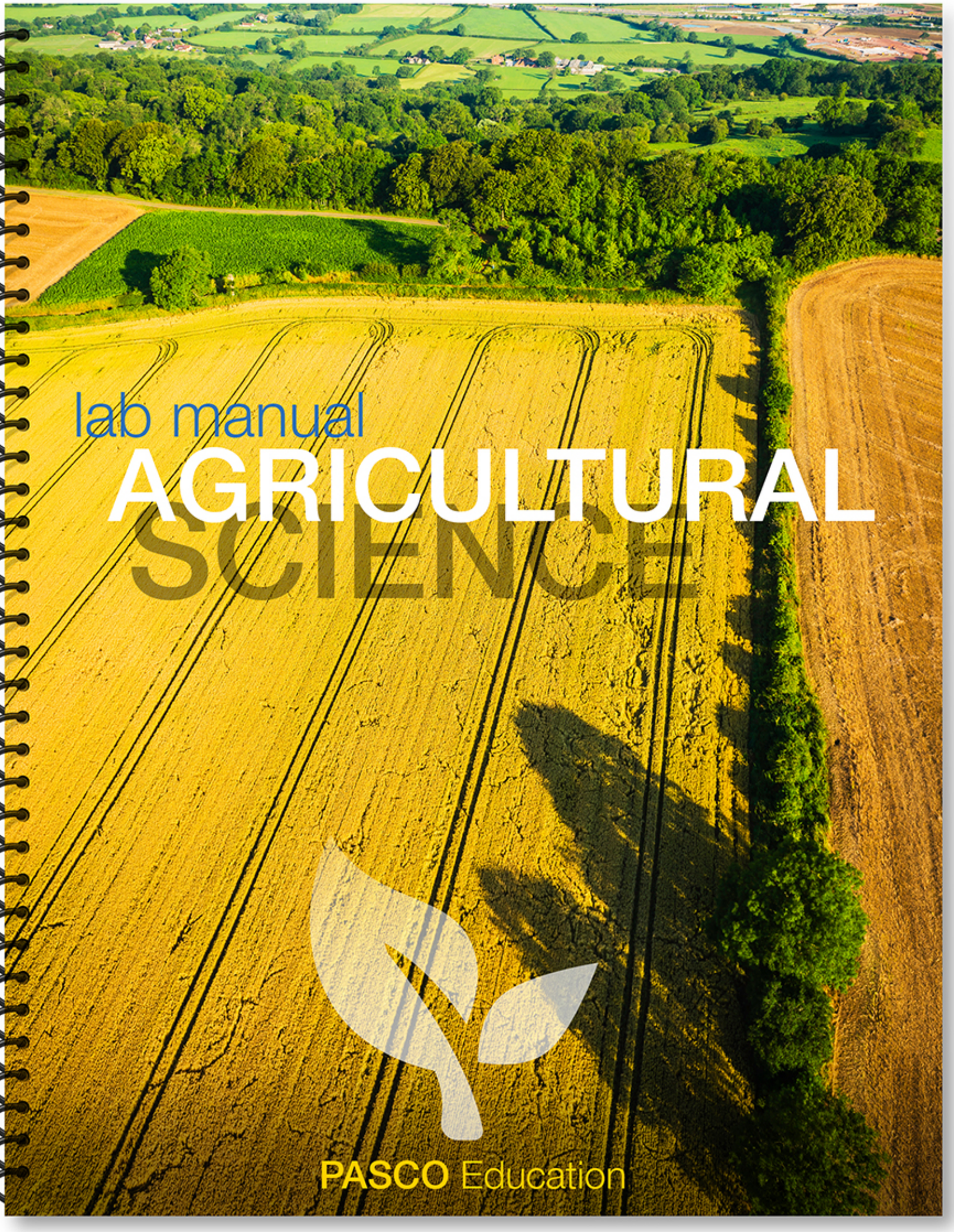

lab manual
AGRICULTURAL
SCIENCE
PASCO Education

DETERMINING SOIL QUALITY

Driving Question

What is a healthy soil and what physical, chemical, and biological characteristics are needed to grow our food?

Materials and Equipment

- Carbon dioxide sensor and sampling bottle
- Conductivity sensor
- pH sensor
- Beaker, 50-mL
- Beaker (4), 100-mL
- Wash bottle containing distilled or deionized water
- Distilled or deionized water, 300 mL
- Labeling tape
- Waste container
- Pipet, disposable
- Digging tool
- Soil samples (from 3 different locations)
- Graduated cylinder, 100-mL
- Permanent marker
- pH calibration buffers, pH 4 and 10
- 10% Vinegar solution, 12mL
- Plastic bags (4), sealable, about 1-L
- Magnifying glass or dissection microscope

Background

Soil quality, also referred to as soil health, is defined as the continued capacity of soil to function as a vital living agro-ecosystem that sustains plants, animals, and humans. This definition speaks to the importance of managing soils so they are sustainable for future generations. To do this, we need to remember that soil is a complex interaction between biotic and abiotic factors. Soil contains living organisms that when provided the necessities of life - food, shelter, and water - perform functions required to produce food and fiber. Monitoring soil health is essential to maximizing crop yield, managing watersheds, and maintaining soil quality for generations to come.

Soil health and quality can determined through several simple tests including;

- Carbon dioxide production: this can indicate the presence or absence of an active microbial community in the soil which is essential to recycling nutrients. A lack of carbon dioxide production indicates few decomposers.
- pH: soil alkalinity or acidity is critical to plant health, the optimum range depends on the crops being grown. While many plants prefer a slightly alkaline soil most citrus trees prefer a slightly acidic soil. A buffering test performed with a weak acid (vinegar) can be used to determine the buffer capacity of the soil which indicates how resilient the soil will be to changes in pH due to acid rain, runoff, or other factors.
- Conductivity: conductivity can be used to asses the levels of salt ions like sodium, potassium, and chlorine that are present in the soil. Again, the desired range is determined by the crop species and soil types in the area.

Procedure

1. Put on your safety goggles.

2. Collect 3 soil samples by doing the following:

   a. Using a clean trowel or soil sampling probe loosen the soil as deep as 10 centimeters and place about 200 ml into a plastic bag.

   b. Label the bag to indicate the soil's location and seal it.

3. Connect the CO_2 gas sensor.

4. Open the AGR01 Determining Soil Quality.spklab lab file.

   - If the file is not available create an experiment file with a graph of CO_2 versus time, a graph of pH versus time, and a digits display of conductivity, this will require multiple pages.

5. Using the 50-mL beaker, add approximately 40 mL (4 tablespoons) of soil from Soil Sample 1 to the 250-mL sampling bottle. Place the CO_2 gas sensor into the bottle and seal it using the attached stopper.

6. Start recording data. Data collection will stop automatically after 10 minutes. Record the change in CO2 gas in the table 1 below. While data collection is in progress, continue with preparing the next tests on step 8.

7. Repeat the CO2 reading for Soil Samples 2 and 3.

Table 1: Analysis of 3 soil samples

Soil Sample	Data Run	ΔCO_2 Gas (ppm)	Soil Conductivity (µS/cm)	Initial Soil pH	Final Soil pH After Adding 10% Vinegar	ΔpH
1	1					
2	2					
3	3					
4	4					

8. After 40-mL of soil sample has been set aside for the CO_2 gas tests, remove any rocks and sticks from the remaining sample. Crush the reaming soil sample into a fine dust with the end of the handle of your digging tool or other suitable instrument.

9. Place 40 mL of each soil sample into a 100-mL beaker. Label each beaker with the sample number. Mix 40 ml of distilled water into each beaker and shake or stir the mixture for 5 minutes, rinse the rod between each sample

10. Allow the samples to rest for at least 5 additional minutes so the sediment can settle before taking your measurements.

11. After CO_2 data collection has finished for all three samples, disconnect the sensor. Connect the conductivity and pH sensors and begin recording data.

12. Lower the conductivity and pH probes into the soil-water mixture. Very gently stir the solution with the probe during data collection. Wait for the measurement to stabilize (at least 30 seconds).

NOTE: Do not let the probes rest in the sediment, make sure the tip of the probe is in the middle of the water layer. If using a PASPORT (blue) conductivity sensor it may be necessary to adjust the range if the measurement plateaus at 1,000 µs/cm.

13. Enter the soil conductivity and initial pH values in Table 1. Repeat the step 11 for the other two samples, be sure to rinse the probes with distilled water between samples.

14. Rinse and disconnect the conductivity sensor.

15. 40mL of a 10% vinegar solution to the 100-mL beaker for each soil sample.

16. Lower the pH probe into the vinegar solution and gently stir the solution with the sensor during data collection. Determine the final pH of the vinegar solution and record it in table 1.

17. Rinse the pH probe with distilled water and repeat for the remaining samples

18. Place a small sample of soil (no larger than a penny) from each soil sample on a sheet of white paper.

19. Compare the soil color, texture, structure, and apparent moisture level of each sample, and enter your observations in Table 2.

Table 2

Location	
Date/time	
Soil color	
Soil texture/Structure	
Moisture	
Observations	

Analysis & Questions

1. The rate of change of CO_2 gas concentration is indicative of the rate of change in cellular respiration. What kind of soil would you expect to produce CO_2 gas at a faster rate—dark, moist soil or dry, clayey soil? Why?

2. Which of the three soil solutions had the highest conductivity? Explain why it might be higher than the other two samples. Recall the location of the sample.

3. Each plant type possesses an inherent tolerance level to conductivity. In general, a crop should tolerate conductivity levels up to 700 micro Siemens per centimeter (µS/cm), without a decrease in yield; however, some plants tolerate even higher levels of conductivity. If a soil contains more than this level of salt, what types of crops might be successfully grown in it?

4. List some possible remedies for the soil samples that seem to be less capable of supporting plant growth. For example, how might a high (alkaline) soil pH be remediated?

NAME PERIOD DATE

WATER TREATMENT

Driving Question

What are some processes used in water treatment, and what contaminants are they effective in removing from water?

Materials and Equipment

- pH sensor
- Conductivity sensor
- Turbidity sensor
- Beaker (4), 150-mL
- Beaker (5), 50-mL
- Activated charcoal, 2 g
- Paper napkins (9), dinner, white, smooth
- Lint-free lab tissue
- Soda bottle, empty, 500-mL
- Distilled Water, 500 mL
- Wash bottle
- "Wastewater" sample, 500 mL
- Waste container
- pH calibration buffers, pH 4 and 10
- Stirring rod

Background

Water treatment concerns facing agriculture are complex due to competing demands for water resources. This includes; irrigation, navigable waters, recreation, wildlife, municipal uses all of which may have different management regulations and practices. Water sources include, ground and surface water, treated water from cities and industry. Major issues such as wastewater storage on swine and diary as well as vegetable/fruit wastewater recycling are being carefully analyzed. Wastewater management is key in being success in today's Agriculture operations. Treatment technologies that are used in the Agricultural industry are: filtration, biological treatment, aeration, mixing, reverse osmosis and disinfection.

Procedure

1. Put on your safety goggles.

2. Pour 100 mL of the a well stirred "wastewater" sample into each of four 150-mL beakers.

3. Label the beakers as follows:

    - Beaker 1 "Untreated"
    - Beaker 2 "Activated Charcoal"
    - Beaker 3 "Sedimentation"
    - Beaker 4 "Agglutination"

4. Set the beaker labeled "Sedimentation" aside for approximately 30 minutes. Why is it important to ensure that the beaker labeled "Sedimentation" is not touched or moved during these 30 minutes?

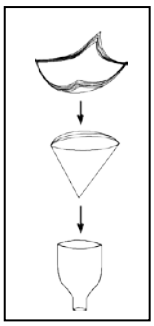
5. Put 2 mL of the 4% swimming pool clarifier solution in the beaker labeled "Agglutination" and use the stirring rod to thoroughly mix the pool clarifier into the wastewater.

6. Predict how each water treatment method will cause a change in the parameters of the wastewater. Use words such as increase, decrease, lighter, darker, clearer, cloudier, stronger smell or less odor. Record your predictions in Table 1.

Table 1 : Predictions

Water treatment method	**pH**	**Conductivity**	**Turbidity**	**Odor**	**Appearance (color, transparency)**
Filtration					
Activated charcoal filtration					
Agglutination					
Agglutination followed by filtration					
Sedimentation					

7. Make a filter as follows:



   a. Cut off the top half of a 500-mL soda bottle to use as a funnel.

   b. Fold a paper towel in half, and then fold it in half again. Separate the layers to make a funnel-shaped filter.

   c. Stack 3 paper napkins together and shape them into a shallow bowl. Tuck these into the paper funnel and push the entire membrane construction into the funnel, forming a bowl to hold the filtrate.

8. Open the AGR02 Water Treatment.spklab file.

   - If the lab file is not available create an experiment file to display the pH, conductivity, and turbidity readings in a table or digits displays.

9. Connect to the turbidity, pH, and conductivity sensors to your device.

10. Calibrate the pH and turbidity sensors using the directions that came with the equipment or go to https://www.youtube.com/pascoscientific to view calibration methods.

11. Examine the beaker labeled “untreated” and record its odor, color and general appearance in Table 2.

12. Place the pH and conductivity sensors in the wastewater labeled “Untreated” and allow the readings to stabilize and then record the values in Table 2. Remove the sensors from the sample and thoroughly clean them with distilled water.

13. Determine the turbidity of the wastewater and record the turbidity in Table 2.

    NOTE: turbidity sampling procedure in the product manual or see the demonstration, https://www.youtube.com/watch?v=BAyY0UrJrLI

14. Test the effect of filtration on the untreated wastewater sample.

    a. Arrange the filter you created earlier over a 50-mL beaker

    b. Pour 10 mL of the wastewater from the beaker labeled “Untreated” into the filter, inside the paper napkin "bowl".

    c. Filter the wastewater until you have 15 to 20 mL of filtrate in the 50-mL beaker.

15. Repeat the observations and measurements in steps 11-13 and record them in Table 2. for the filtered water.

16. Discard the paper towels and napkins from the filter and clean the bottle so that another filter can be made. Clean the beaker, test tube and sensors by thoroughly rinsing them with distilled water.

17. Make another filter as described in step 7 and then;

    a. Measure and add 1 gram of activated charcoal to 100mL of water and stir.

    b. Pour this slurry into the filter.

    c. After that slurry has drained, slowly pour another 100mL of water into the filter.

    d. The paper filter should be coated with a layer of activated charcoal. If the water is not clear add 100ml of water.

18. Arrange the activated charcoal filter over a 50mL beaker.

    a. Pour 10 mL of wastewater into the beaker labeled “Activated Charcoal” into the filter paper napkin bowl.

    b. Filter the waste water until you have 30mL of filtrate in the 50mL beaker.

    c. Pour the wastewater from the “Activated Charcoal” beaker into the filter in 10 mL portions stop at 20mL.

19. Repeat the observations and measurements in steps 11-13 and record them in Table 2. for the filtered with activated charcoal water.

20. What effects did adding activated charcoal to membrane filtration have on the results of the filtration?

21. Test the effect of agglutination by returning to the beaker labeled “Agglutination” that you have been stirring over the last 30 minutes. Repeat the observations and measurements in steps 11-13 and record them in Table 2. for the Agglutination.

22. Make another paper membrane filter as described in step 7, then filter the “Agglutination” sample and Repeat the observations and measurements in steps 11-13 and record them in Table 2. for the Filtered Agglutination.

30. Test the effect of sedimentation by returning to the beaker labeled “Sedimentation” that has sat undisturbed for approximately 30 minutes.

31. Use a pipette to transfer a 30-mL sample from the top of the beaker into the test tube, being careful not to disturb the sediment. Repeat the observations and measurements in steps 11-13 and record them in Table 2. for the Sedimentation.

Optional STEM Inquiry

Design a filter that will treat the wastewater using two or more of the techniques that you have tested and collect data to compare them with other filters your classmates have assembled. Record the data in table 2.

Data Summary

Table 2: Water treatment process results

Water treatment	pH	Conductivity (µS/cm)	Turbidity (NTU)	Odor	Appearance
Untreated "wastewater"					
Filtration					
Activated charcoal filtration					
Agglutination					
Agglutination followed by filtration					
Sedimentation					
My Designed Treatment System					

Analysis

Compare the data obtained from your designed water treatment system with the data collected in Part One by filling in “My Designed Treatment System” data and the "Best Individual Test System" in Table 4. Share the data with your classmates. Use Table 4.

Table 4: Designed water treatment system results

Water Treatment Data Summary	pH	Conductivity (µS/cm)	Turbidity (NTU)	Odor	Appearance
My Designed Treatment System					
Best Individual Test System (Optional)					
Best Designed System in the Class (Optional)					

Questions

1. What was the effect of filtration using a simple paper filter?
2. What was the effect of treatment with the activated charcoal filter?
3. What was the effect of treatment with an agglutinating agent? What was the effect of agglutination followed by filtration?
4. What was the effect of treatment with sedimentation?
5. Which treatment method worked best for odors?
6. Which treatment method worked best for lowering turbidity? Which was least effective?
7. What was the effect of treatment on pH?
8. Compare the results obtained with your custom-designed filtration process to those from the individual filter media. Be sure to make comparisons regarding the rate of filtration. (Why might this be important?)
9. Based on your results and those of your classmates, which combination of treatment processes produced the best results? Explain, using your data to support.
10. Suppose you had to design a system to treat for human consumption a large amount of the type of wastewater used in this activity. What treatment methods would you include? Explain.?

FRESHWATER QUALITY MONITORING

Driving Question

What impacts may agriculture have on water quality in our watershed?

Materials and Equipment

- Temperature Sensor
- Conductivity Sensor
- pH Sensor
- Dissolved Oxygen Sensor
- Turbidity sensor with interface (optional)
- pH calibration buffers, pH 4 and 10
- 5-gallon bucket, plastic, small
- Water sampling bucket or extension rod
- Labels and pens

Background

Water quality maybe affected by current agricultural practices. Run-off, as well as poor soil management may elevate concentrations of nutrients, fecal coliforms, and sediment loads. Over reliance or improper application of synthetic fertilizers could also lead to the degradation of our watersheds. Grazing and other agriculture practices may intensify erosion processes by raising sediment input into nearby water sources. Increased sediment loads make drinking water treatment more difficult while also affecting fish and macroinvertebrates.

Procedure

1. Select a site in a local watershed that has a creek or drainage ditch. Connect to the barometer sensor.

2. Open the AGR03 Water Quality.spklab lab file.

    - If the configuration file is not available create a digits display for each measurement shown in Table 1 after connecting the sensors.

3. Connect sensors (pH, conductivity, temperature, dissolved oxygen, and turbidity) and calibrate them according to the product manual.

4. Place the sensors into the water using the rod or collect a water sample using a 1-2L bucket and conduct the measurements onshore. Try to sample at least one meter from shore to avoid contaminating samples.

5. At site 1, place the sensors into the sample and allow 2-3min for the measurements to stabilize, then record the measurements in Table 1.

6. Repeat the steps for additional test sites. Follow the previous instructions and record your measurements.

Table 1: Site measurements and observations

Test	**Temp (°C)**	**pH**	**Conductivity (µS/cm)**	**Dissolved Oxygen (mg/L)**	**Turbidity (NTU)** *Optional*
Site 1:					
Site 2:					
Site 3:					

Analysis

1. Dissolved oxygen levels below 3 mg/L indicate low water quality for many aquatic animals. Do you think the water you tested had enough dissolved oxygen to support most aquatic animals? Explain.

2. An acceptable range of pH for freshwater is 6.0–9.0. Does your body of water fall into this acceptable range?

3. Conductivity is a measure of salts dissolved in the water. Conductivity levels in a surface water body above 200 to 300 µS/cm may indicate pollution by runoff from cities or agricultural regions. Does your water body show signs of pollution? If so, what do you think might be contributing to this pollution?

4. In the United States, turbidity levels higher than 1 nephelometric turbidity unit (NTU) in drinking water are unlawful, and the World Health Organization recommends levels lower than 1 NTU for drinking water. If the body of water you investigated served as a drinking water source, would the water have to be filtered to remove suspended solids? Explain.

WATER AND PH

Driving Question

What levels of acid rain or fog do we have in our local watersheds?

Materials and Equipment

- pH sensor
- Conductivity sensor
- Marking pen
- Beaker, 250-mL (4)
- Graduated cylinder, 100-mL
- Small container (for distilled vinegar solution)
- Stirring rod
- White vinegar, 250 mL
- Water sample, 250 mL (3)
- Distilled water, 250 mL
- Labels or tape
- pH calibration buffers 4, 10

Background

Acid rain can occur when precipitation occurs in the presence of aerosol chemicals like sulfur dioxides and nitrogen dioxides, commonly released during the processing and burning of fossil fuels like gasoline. Acid rain can directly impact agriculture by harming plant tissues, decreasing soil and water quality, and consequently reducing yields. One way to investigate the impacts of acid rain is to examine the buffering capacity of water sources. Water with dissolved ions like $CaCO_3$, often found in areas with limestone has very high buffering capacity and is less susceptible to acid rain.

Procedure

1. Collect three water samples from your home or neighborhood, for instance, from ponds, rivers, wells, and tap water. Label each water sample.

2. Connect to the pH and conductivity sensor and open the AGR 04 Water and pH.spklab file.

    - If the file is not available create a data table to record the conductivity and pH of the water samples. Use manual sampling mode to collect the data.

3. Measure and pour 200 mL of distilled water and 200mL of vinegar into separate 250-mL beakers

4. Rinse the pH sensor with distilled water and calibrate it according to the product manual

5. Place the pH sensor and conductivity sensor into the beaker of vinegar. Wait until the pH reading stabilizes and record the reading in Table 1. Rinse the sensors with distilled water.

6. Place the pH sensor and conductivity sensor into the beaker of distilled water. Wait until the pH reading stabilizes. Rinse the sensors with distilled water.

7. Measure the pH and conductivity of the three water samples and record the measurements in Table 1. Be sure to rinse the sensors with distilled water between samples.

8. Using the pipet, add 1 mL of vinegar to each water sample, gently stir the sample and wait for 3min before proceeding.

9. Rinse the sensors with distilled water., Measure and record the pH and conductivity for the each of the three water samples with vinegar added. Record the data in Table 1 in the column entitled “With Acid”.

10. Calculate the change in pH and conductivity after the acid was added to each sample.

Table 1: Stabilized pH and conductivity readings for water samples before and after applying "acid rain"

Sample	Initial Reading (control)		With Acid		Change	
	pH	Conductivity	pH	Conductivity	∆**pH**	∆**Conductivity**
Vinegar			NA	NA	NA	NA
Distilled Water						
1:_____						
2:_____						
3:_____						

Analysis & Questions

1. Compare the change in pH for each sample. Using the distilled water as a control, did the samples you collected show a greater or smaller change in pH?

2. Which water samples seemed to show the least amount of pH change when the acid was added? Why do you think these samples were resistant?

3. Runoff from our lawns and golf courses often contains soil and dissolved fertilizers. What might be the consequences of this runoff to the river water?

4. In some high mountains regions, especially on coastal forests polluted air results in fog with a low (acidic) pH. What might be the consequences to the trees as well as the creeks as the fog passes through the ecosystem?

RESPIRATION OF GERMINATING SEEDS

Driving Question

Why do seeds have optimal temperature ranges in order to germinate?

Materials and Equipment

- CO_2 sensor
- Beaker, 1000-mL
- Sampling bottle (included with sensor)
- Spring water, 500mL
- 30 dry pea or bean seeds
- 30 germinating pea or bean seeds
- Ice, cubed or crushed, 500mL

Background

In the state of California, USA, seed sales and exports generate $2.9 billon USD, nearly 3% of the states total agricultural economy. In order to produce high quality seed crops we must provide them with ample sun, water and nutrients so that the seeds themselves have enough stored resources to germinate and thrive until they can germinate. Seeds, although dormant, still maintain some cellular functions which require enzymes. Enzymes are complex proteins which catalyze chemical reactions and are often sensitive to changes in the environment, specifically temperature and pH. All enzymes have an optimal temperature where they most efficiently catalyze chemical reactions. In this activity, you will investigate whether dry seeds or germinating seeds have the higher rate of cellular respiration as indicated by CO_2 production, and you will then determine whether temperature affects the rate of respiration for the germinating seeds.

Procedure

1. Connect to the CO_2 sensor.
2. Open AGR 05 Respiration of Seeds.spklab file.
    - If the file is not available create a graph display of CO_2 (ppm) versus time.
3. Calibrate the CO_2 sensor as directed in the product manual.
4. Place 30 dry dormant seeds into the sample bottle and insert the CO_2 sensor into the bottle.
5. Start data recording. Adjust the scale of the graph to show all data. After 10 minutes, stop data recording.
6. When data collection has finished, record the initial and final values for the dry/dormant seeds in Table 1. Empty and rinse the sample bottle.
7. Place 30 germinating seeds into the sample bottle and insert the CO_2 sensor into the bottle.
8. Start data recording. Adjust the scale of the graph to show all data. After 10 minutes, stop data recording.
9. When data collection has finished, record the initial and final values for the germinating seeds in Table 1. Empty and rinse the sample bottle.
10. Place approximately 400 mL of cubed or crushed ice into the 1000-mL beaker. Add 400 mL of water into the 1000-mL beaker.
11. Place 30 germinating seeds into the sampling bottle and insert the CO_2 sensor.

12. Put the sampling bottle into the 1000-mL beaker and make sure it is nested into the ice bath. Do not let the sensor get wet.
13. Start data recording. Adjust the scale of the graph to show all data. After 10 minutes, stop data recording.
14. When data collection has finished, record the initial and final values for the germinating seeds in Table 1. Empty and rinse the sample bottle.
15. Calculate the change (Δ) in CO_2 concentration for each run and the rate of CO_2 production per minute.

Table 1: Data table

Run	Initial CO_2 Concentration (ppm)	Final CO_2 Concentration (ppm)	ΔCO_2 Concentration (ppm)	Time (min)	Rate of CO_2 Production (ppm/min)
Dry dormant seeds					
Room-temperature germinating seeds					
Cold germinating seeds					

Analysis

1. How does the rate of CO_2 production for germinating seeds compare with the rate of CO_2 production for the dry, dormant seeds?

2. How does the rate of CO_2 production for cold, germinating seeds compare with the rate of CO_2 production for the room-temperature, germinating seeds?

3. What other factors might affect the rate of rate of cellular respiration by the germinating seeds?

4. What is the chemical equation for cellular respiration? Where does cellular respiration occur in the cell?

5. Judging from this expression, what gaseous molecule would you expect to be produced during cellular respiration?

6. Explain why plants and seeds need to perform cellular respiration, even though they are photosynthetic organisms.

PLANT PIGMENTS AND PHOTOSYNTHESIS

Driving Question

How do we know what the different photosynthetic pigments are and how can photosynthesis be measured?

Materials and Equipment

- Chromatography solvent, 5 mL
- Colorimeter sensor with interface
- Cuvettes (5)
- Glass jar, 10 to 12 cm tall
- Disposable graduated pipet (2), 1-mL
- Chloroplast suspension, 2 mL
- 0.1 M phosphate buffer, 4 mL
- DPIP in small amber bottle, 3 mL
- #1 Whatman® chromatography paper
- Spinach
- Quarter or other coin
- Kimwipes® or other lint-free tissue
- Distilled water, 13 mL
- Floodlight, 100 watt
- Heat sink (large beaker or flask filled with water)
- Aluminum foil
- Cheesecloth
- Ice

Background

Plants are photosynthetic organisms, able to harness light energy from the sun to convert carbon dioxide gas from the atmosphere into sugar through photosynthesis as follows:

$$6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2.$$

The photosynthetic pigments absorb light energy from the sun. As light hits the chloroplasts, electrons are excited and passed along an elaborate electron transport chain within the thylakoid membrane of the chloroplasts. The electrons eventually reduce the molecule nicotinamide adenine dinucleotide phosphate ($NADP^+$) to form NADPH.

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Wear safety glasses and lab coats or aprons.
- Due to the volatility of the chromatography solvent, ensure all containers remain tightly sealed.

Procedure

1. Connect to the colorimeter sensor.

2. Open the AGR 06 Plant Pigment and Photosynthesis.spklab file.

3. Prepare the incubation area. You will need a flood light and a heat sink (a large beaker or flask filled with water). Place the flood light directly in front of the heat sink. The heat sink will absorb the heat from the flood light while still allowing light to pass through to the cuvettes that are placed a few inches behind the flask.

4. Obtain five cuvettes and label the tops from "1"to "5". Obtain five cuvettes and label the tops from "1"to "5". Fill each of the cuvettes according to Table 4.1 below, <u>but do not add either the unboiled or boiled chloroplasts</u> yet.

Table 4.1: Setup for photosynthesis experiment

Contents	Cuvette 1 Blank (no DPIP)	Cuvette 2 Unboiled chloroplasts (Dark)	Cuvette 3 Unboiled chloroplasts (Light)	Cuvette 4 Boiled chloroplasts (Light)	Cuvette 5 No chloroplasts (Light)
Phosphate buffer	1 mL	1 mL	1 mL	1 mL	1 mL
Distilled water	4 mL	3 mL	3 mL	3 mL	3 mL + 3 drops
DPIP	None	1 mL	1 mL	1 mL	1 mL
Unboiled chloroplasts	3 drops	3 drops	3 drops	None	None
Boiled chloroplasts	None	None	None	3 drops	None

5. Add 3 drops of the unboiled chloroplast suspension to cuvette 1 (blank no DPIP). Screw the lid onto the cuvette and mix by inverting the cuvette several times. Wipe the sides of the cuvette gently with a Kimwipe® or other lint-free tissue.

6. Insert the cuvette into the cuvette holder on the colorimeter and close the colorimeter lid tightly. Calibrate the colorimeter. This step is added to help calibrate the sensor and establish a baseline.

7. Remove the cuvette. Do not replace the aluminum foil.

8. For cuvette 2 add 3 drops of the unboiled chloroplast suspension.

9. Remove the aluminum foil from the cuvette, and insert into the cuvette holder on the colorimeter. Close the colorimeter lid tightly.

10. Display % Transmittance in a digit display. Start recording data. Record the % Transmittance value in Table 4.2.

11. Remove cuvette form the colorimeter.

12. Recover the cuvette with foil.

13. For cuvettes 3-5 add the prescribed drops of unboiled or boiled chloroplasts listed in table 4.1. **Note**: for cuvette 5 add 3 drops of distilled water instead of chloroplasts.

14. Repeat steps 9-11. Note: for cuvettes 3-5 don't recover with foil.

15. Place all cuvettes in the incubation area. Note the time that the cuvettes are put in the incubation area.

16. Measure the % Transmittance of cuvettes 2-5 again at 5 minutes, 10 minutes and 15 minutes then record the data in Table 4.2.

Table 4.2: % Transmittance

Cuvette	Conditions	% Transmittance (Initial)	% Transmittance (5 min)	% Transmittance (10 min)	% Transmittance (15 min)
#2	Unboiled, Dark				
#3	Unboiled, Light				
#4	Boiled, Light				
#5	No Chloroplasts, Light				

17. Obtain a piece of chromatography paper about as long as the height of the glass jar. Cut one end of the paper into a point and draw a line in pencil across the width of the paper 1.5 cm above the point.

19. Lay a spinach leaf on the paper above the pencil line. Deposit the plant pigments onto the paper by firmly rolling the edge of a quarter over the leaf about 15 times until a heavy green line appears on the paper.

20. Lower the paper into the jar ensuring that only the tip of the paper touches the solvent. The green line must be above the solvent. Tightly close the lid of the jar.

21. When the solvent has traveled to about 1 cm below the top of the paper, remove the paper from the jar.

22. Using a pencil, quickly mark the location of the solvent's furthest point of travel before the solvent evaporates. Measure the distance the solvent traveled (the distance between the two lines) and record this value in Table 4.1

23. On the paper, mark the location of the top of each of the pigments. Measure the distance each pigment traveled from the origin to the top of each band. Record these measurements in Table 4.3.

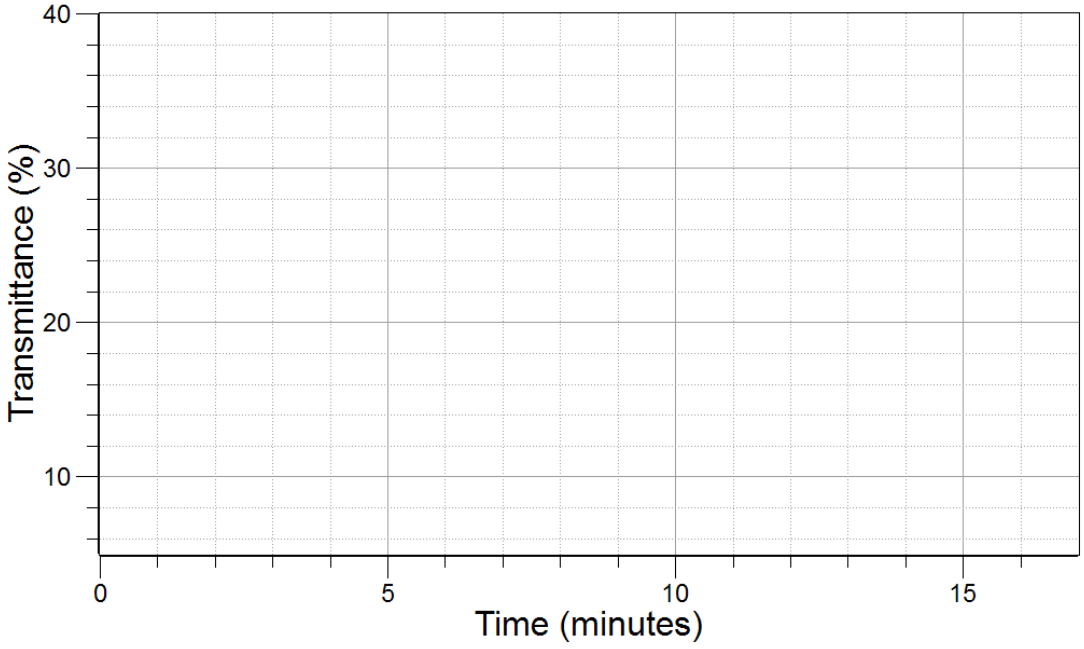
24. Measure the distance each pigment traveled from the origin to the top of each band. Record these measurements in Table 4.3.

Table 4.3: Distance moved by pigment bands (millimeters)

Band Number	Distance (mm)	Band color	R*f*
1			
2			
3			
4			
5			

Analysis & Questions

graph of % Transmittance versus Time



1. Which of the pigments that you observed in the chromatography experiment is most easily dissolved by the solvent? How do you know?

2. How would the *Rf* value change if a different solvent were used?

3. What is the role of DPIP in this experiment? What would happen to your results if you forgot to add the DPIP to cuvette #3?

4. Compare the % Transmittance in cuvettes #3 and #4.

5. Explain in your own words why the colorimeter was used in this lab. What data did it help you collect?

6. Relate leaves changing color in the fall to the accessory pigments.

NAME PERIOD DATE

PLANT RESPIRATION AND PHOTOSYNTHESIS

Driving Question

Do plants perform cellular respiration, in addition to performing photosynthesis?

Materials and Equipment

- CO_2 sensor with sampling bottle
- Aluminum foil, 1 ft.
- Distilled Water
- Fresh spinach leaves (2), or similar
- Lamp (CFL or LED, 1000 lumens or higher)
- Cotton Ball

Background

Since CO2 is produced during cellular respiration, an increasing CO_2 concentration inside a mini-terrarium when no light is present is evidence that cellular respiration is occurring. Cellular respiration occurs constantly in plants as in animals, the cells need to be active to sustain life and grow. However, when light and water are available, photosynthesis is possible. The balance between CO_2 production (respiration) and consumption (photosynthesis) depends on many factors but it is easy to determine the dominant process with a CO_2 sensor.

Procedure

1. Connect to the CO_2 sensor.

2. Open the AGR 07 Plant Respiration and Photosynthesis.spklab lab file.

   - If the file is not available create a graph display showing CO_2 concentration (ppm) versus time (min).

3. Gently put two leaves of spinach into the sampling bottle. Arrange the stems so that the majority of the leaves face in the same direction and do not overlap significantly. Soak a cotton ball in 5 mL of water and place it into the to the sampling bottle. This will ensure the humidity is near 100% and the leaves stomata will stay open for gas exchange.

4. Calibrate the CO_2 sensor according to the product manual. Place the CO_2 gas sensor into the sampling bottle so that the rubber stopper plugs the end of the bottle.

5. What do you think will happen to the CO_2 level in the bottle while the plant is in the light? Explain your answer.

6. Place the lamp 30-40cm away from the sample bottle so that it is facing the top surface of the leaves and turn it on.

7. Begin data collection and continue for 10 minutes.

8. Stop data collection after 10 minutes has passed and turn the light off. Wrap the bottle in a piece of tinfoil to completely block out the light.

10. What do you think will happen to the CO_2 level in the bottle while the plant is in the dark? Explain your answer.

12. Using the analysis tools, determine the intial, final, and change (Δ) in CO_2 levels for each trial. Record your data summary in Table 1 on the next page.

Table 1: The change in the CO_2 level inside the mini-terrarium in darkness and in light

Light Condition	Initial CO2 Level	Final CO_2 Level	Change in CO_2
Light			
Darkness			

Analysis & Questions

1. What happens to the level of carbon dioxide gas when the plant is in darkness? Why does this happen?
2. What happens to the level of carbon dioxide gas when the plant is in bright light? Why does this happen?
3. Was there a greater change in the level of carbon dioxide in darkness or light?
4. Which part of the activity shows the effect of cellular respiration on CO_2 levels in the chamber?
5. Write a conclusion for this experiment based on the following hypothesis, "If plant in a closed environment is exposed to light then the CO_2 level will rise when compared to its initial CO_2 level."
6. Answer the driving question, “Do plants perform cellular respiration, in addition to performing photosynthesis?

MODELING AN ECOSYSTEM

Driving Question

What makes up an agroecosystem and how does it fit in with other ecosystems?

Materials and Equipment

- Oxygen gas sensor [1]
- Carbon dioxide sensor[1]
- Temperature sensor[1]
- pH sensor [1]
- Conductivity sensor[1]
- Weather sensor[1]
- Dissolved Oxygen sensor
- Water quality colorimeter[1] and sample vials
- Plant seeds or seedlings, or moss
- Senor Interface or data logger
- Sensor extension cable
- EcoZone™ System
- Different types of living organisms
- Strong incandescent or full-spectrum fluorescent
- Compost or soil
- Pollution source
- Water, dechlorinated (quantity depends on design)

[1]These are a sample of the sensors for this student-designed activity. Not all are needed for a successful experiment.

Background

In this activity, you will be asked to design 3 individual chambers, which will be interlinked. There are many types of environments you could attempt to emulate including aquatic, decomposition, and agro-ecosystem. You can add living organisms to your design, including plants, fish, and insects and you can use different soil types and organic material in the different chambers.

Procedure

1. Write a brief outline of the procedure you will use to set up the EcoZone chambers and collect data. Include the following information:

   - What are your principle design considerations (what is the goal of your experiment)?
   - What are the independent variables? What are the dependent variables? What are you keeping the same? What parameters will you measure?
   - What are the biotic and abiotic components you are adding to each chamber?
   - Draw a diagram of the experimental setup you will use. Be sure to label the biotic and abiotic materials in each chamber and the sensor or sensors that will be in each chamber.

2. Will the system remain closed? Will you open the system periodically to water plants or feed organisms? How will you account for your influence on the system if it is opened? Use your knowledge about the trophic levels of ecosystems, food webs to design your new world.

3. Add the materials to each chamber. Seal the chambers so they are airtight. **Hint:** One way to be sure that the terrarium is airtight is to exhale several times into the empty chamber to raise the CO_2 level of the air in the terrarium relative to the room air. Then seal the terrarium and monitor the CO_2 level for several minutes with a carbon dioxide gas sensor. After the reading stabilizes, the level should not drop. If it does, you probably have a leak. Once you have learned how to make the terrarium airtight.

4. Insert the sensors and begin collecting data. Collect data for at regular intervals such as once a week for 6 weeks or longer. **Note:** Take detailed notes about the status of your chambers, including the live organisms, daily. Do not wait for an organism to begin dying to intervene – you can manipulate the chambers as you see fit during the experiment as long as it is properly documented. Before you introduce fish or any other animal or insect make sure your Eco-Zone system is stable in terms of its oxygen, CO_2 and temperature.

5. Create a table below that displays data you feel is relevant for others to know about the experiment Below the table, add comments regarding the conditions in the chambers throughout the course of the experiment.

6. Consider making a google form or spreadsheet that students use to record their weekly measurements and observations. Here is list of possible parameters you could record:

Air and water Temperature	Carbon Dioxide gas (ppm)
Soil and water pH	Turbidity
DO (dissolved Oxygen)	Odor scale 1-5
Water Conductivity	Aquatic Fauna (live or dead)
Oxygen Gas (%)	Terrestrial Fauna

Analysis & Questions

1. Describe any significant changes you observed in the chambers during the course of the experiment

2. Agricultural farming typically requires fertilizer to be added to the soil to ensure high quality crops. Rain and runoff wash excess fertilizers into local waterways. Based on your experience, what type of positive and negative consequences could result from this runoff?

3. What parameter changed the most over the time you observed? What is the significance of this?

4. Which ecosystem provided the most CO2? Which one water? Which one oxygen?

GREENHOUSE GASES

Driving Question

What are greenhouse gases and how do they interact with the atmosphere and cause a change in our climate

Materials and Equipment

- Temperature sensor
- EcoChamber with stoppers or large flask
- Plastic wrap
- Stoppers to seal EcoChamber or large flask
- Dark aquarium rocks or dark sand (200g)
- Heating lamp (Lamp with 100W incandescent bulb)
- Ring stand
- Balance (1 per class)
- Canned keyboard duster (fresh)

Background

Carbon dioxide and methane are greenhouse gases – atmospheric gases that absorb reradiated energy from the earth's surface and trap heat in the atmosphere. Solar radiation from the sun passes through the atmosphere and is partially absorbed by the earth's surface. Some of this radiation passes through the atmosphere and into space, while greenhouse gases absorb the remainder, trapping heat in the atmosphere. This is called the greenhouse effect that can affect climate change. Climate change affects agriculture in a number of ways, including through changes in average temperatures, rainfall, and climate extremes (e.g., heat waves); changes in pests and diseases; changes in atmospheric carbon dioxide and ground-level ozone concentrations which also could disrupt food availability, reduce access, as well as food quality. To create a model of greenhouse gases we'll be using difluoroethane instead of CO_2 or methane. Difluoroethane is also carbon based but as a larger molecule is a much stronger greenhouse gas.

Procedure

1. Connect temperature sensor.

2. Open the AGR 09 Greenhouse Gases.spklab file.

    - If the file is not available create a graph display of temperature (°C) versus time (min).

3. Place the temperature sensor inside the EcoChamber or flask, the tip of the temperature sensor should be in the mid-point of the chamber.

4. Place approximately 200 grams of aquarium rocks or enough to cover the bottom of each chamber.

5. Seal the openings using rubber stoppers and plastic wrap.

6. Position the heating lamp 40-50cm away from the chamber, angled slightly downward to increase the amount of solar radiation hitting the rocks. Do not turn the light on yet.

7. Turn on the lamp and begin recording data after 5 minutes, turn the lamp off and continue to record data for 5 more minutes. After 10 minutes has elapsed, stop recording data. Use the graph analysis tools and determine the initial temp, final temp, increase in temperature (max temp minus initial), and decrease in temperature (max temp minus final temp).

8. Open the EcoChamber and allow it to cool completely. You may want to replace the rocks with room temperature rocks, but use the same mass of rocks as you did before.

9. Replace the lid on the EcoChamber. Ensure that the temperature probe is placed as it was in the first trial, and that the lamp and the chamber are positioned exactly as they were in the first trial.

10. Crack the stopper or poke a small hole in the plastic wrap to insert the straw of the keyboard duster into the hole. Fill the chamber with difluoroethane by pulling the trigger on the can in a series of short bursts (eight 1-sec bursts). Keep the can upright while dispensing. Reseal the chamber and wait three minutes.

11. Turn on the light and begin data recording. Collect data for 5 minutes under the lamp. Then, turn off the light and continue to collect data for an additional 5 minutes while the chamber cools. Stop data recording.

12. Repeat the analysis described in step 7 for this run of data.

Table 1: Temperature data

Chamber	Initial Temp. (°C)	Final Temp. (°C)	Increase in Temp. (°C)	Decrease in Temp. (°C)
Control (air)				
Experimental 1 gentle burst of breath.				

Analysis & Questions

1. How significant are the differences that you observed in heat retention and maximum temperature?

2. In analyzing this data, which of the following is more valuable to compare: the overall change in temperature, the heating change in temperature, the cooling change in temperature, or the difference in maximum temperatures? Explain your reasoning.

3. In what ways does this demonstration fail to predict what effect this gas would have on the atmosphere?

4. In what ways will climate change effect agriculture's ability to feed developing nations?

5. How can agriculture help limit the impact of climate change worldwide?

ENERGY CONTENT OF FOOD

Driving Question

Which type of foods contain the most energy per gram?

Materials and Equipment

- Temperature sensor
- Aluminum Foil
- Graduated cylinder, 100-mL
- Rod or other attachment
- Cardboard Square (10cm x 10cm)
- Large marshmallow (1)
- Tape
- Aluminum cans (2)
- Centigram Balance
- Ring stand
- Large paper clips (2)
- Whole cashew or peanut (1)
- Matches
- Wooden Splint (3)

Background

Plants use photosynthesis to convert the sun's energy into chemical bond energy stored in carbohydrates, proteins, and fats. Energy from chemical bonds is released during respiration, which is very similar to combustion or burning reaction. Respiration occurs more slowly than combustion because it is controlled by enzymes, but the reactions are essentially the same.

$$carbon\ based\ fuel + O_2 \rightarrow CO_2 + H_2O + Energy$$

Calorimetry is a method used to calculate energy released based on heat exchange during a chemical reaction. You will burn different kinds of food and calculate the amount of energy released based on temperature change in water. Energy released by the burning food is equal to the energy absorbed by the water and the surrounding environment.

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Use appropriate caution with burning and hot materials, such as matches, starter wands, and foods.
- Conduct the lab in a well-ventilated area, preferably outside or under a ventilated hood.

Procedure

1. Put on your safety goggles.
2. Connect the temperature sensor.
3. Open the *AGR 10 Energy Content of Food* lab file.
    - If the configuration file is not available, create a graph display of temperature versus time. Set the sample rate to 1hz.

4. Use a paperclip, cardboard, and tape to construct a food stand similar to the diagram. Cover the cardboard with foil.

5. Tape the wooden splint to the sensor so the stick extends ~1/2 inch (~1 cm) past the metal shaft.

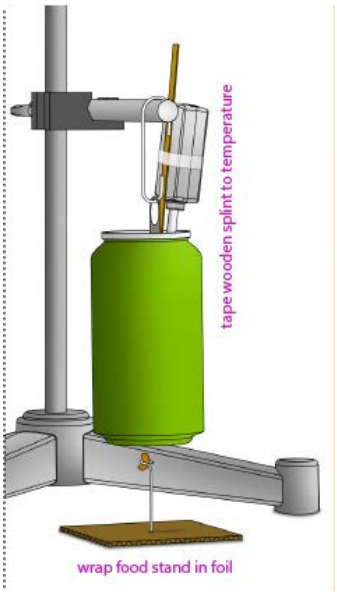
6. Rinse a can with water. Fill it with 100 ml of water. Place the temperature sensor in the can. The wooden splint should help the sensor contact only water for greater accuracy.

7. Record the mass of the nut on a piece of paper. Use the same paper to record data throughout the experiment.

6. Place the nut in the foil stand as illustrated and record the mass of both items together.

7. Use a paper clip to suspend the can from a ring stand attachment.

8. Place the foil stand under the can. Adjust the can height so the nut is 1 inch (2.5 cm) or less below the bottom of the can.



9. Start collecting data.

10. When the temperature stabilizes, use a wooden splint to ignite the nut from the bottom. Move the foil stand to center the flame beneath the can.

11. Stop collecting data when the nut completely loses its flame.

12. Remove the temperature sensor from the can and dry it.

13. Record the combined mass of the nut and stand after burning, then dispose of the nut remains.

? 14. What changes are visible on the can after burning the nut?

15. Discard the can.

16. Repeat steps 4 through 14 with a new can and a marshmallow.

? 17. What changes are visible on the can after burning the marshmallow?

Analysis

1. Use Show Statistics to get the minimum and maximum temperatures. Record these values in table 1.

2. Repeat with marshmallow run.

3. Calculate change in temperature for each food by subtracting minimum temperature from maximum temperature. Your answer should be a positive number. Record the answers in Table 1.

4. Calculate change in mass for each food (initial mass of food+holder minus final mass of food+holder). Record your in Table 1.

5. Calculate the change in mass using the following formula

$$EnergyPerGram = (100 \times \frac{\Delta T}{\Delta M})$$

Table 1: Mass, temperature and energy data for food samples

Food	Initial Mass (g)	Final Mass (g)	**ΔMass** (g)	**ΔTemp** (°C)	Energy per Gram (cal/g)
Peanut					
Marshmallow					

6. What happens to the mass that appears to be lost during burning? Use observations from your experiment to support this claim.

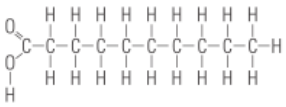
7. Using only temperature change to compare energy released for each food is an unfair comparison. Why?

8. Which type of food contains more energy per gram: a fat (nut) or carbohydrate (marshmallow)? Use multiple lines of evidence from your experiment to support your answer.

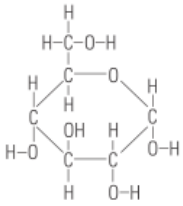
9. Do the structural differences between fat and carbohydrate molecules support your answer to the pervious question? Why or why not?

10. Summarize the flow of energy from the sun to the energy in your body.

FAT



CARBOHYDRATE



DIFFUSION

Driving Question

♦ What is diffusion and which molecules in pickle juice can diffuse across a dialysis membrane?

Materials and Equipment

- Conductivity sensor
- pH sensor
- Colorimeter
- Lint-free tissue
- Disposable pipet (4)
- Cuvettes (2)
- 400-mL beaker or similar-sized cup
- 50-mL beaker or similar-sized cup (2)
- Pickle juice containing FD&C yellow dye # 5, 50 mL
- Soaked dialysis tubing 28 cm
- Squirt bottle of water and cup or beaker
- Paper towels
- Plastic wrap
- Labeling marker
- Distilled water
- Scissors

Background

All living plant cells have permeable membranes that allow them to absorb and secrete ions, thus causing them to uptake minerals and water. The ions cause a negative potential that osmotically passes water to the Xylem. Generally speaking, diffusion is the random movement of molecules from an area of higher concentration of those molecules to an area of lower concentration. Diffusion is driven by the concentration gradient of the molecule, the difference that exists when there is a difference in the concentration of a substance in a given area. Through diffusion, molecules will move down their concentration gradient until a dynamic equilibrium is reached.

Procedure

1. Connect to the pH and Colorimeter sensors.

2. Open the Diffusion lab file.

3. Create a digit display of pH and set the conductivity probe to a measurement range of 0 to 100,000 (the wave button), and connect a 10X probe to the sensor. Create a digit display of conductivity. Set the colorimeter to measure absorbance. Create a digit display of Blue Absorbance.

4. Pour approximately 50 mL of pickle juice into one of your 50-mL beakers. Label this beaker "pickle juice". Fill a clean cuvette with pickle juice using a clean pipet, and screw the cap on the cuvette. Do not dispose of the pickle juice.

5. Fill the other 50-mL beaker with distilled water. Label this beaker "distilled water". Using a clean pipet, fill the second cuvette with distilled water and screw the cap on the cuvette. Do not dispose of the distilled water.

6. Start recording data and use the pH and conductivity probes to measure the pH and conductivity of the pickle juice. Repeat for the pH and conductivity probes to measure the pH and conductivity of the distilled water. Write the results in Table 1.

7. Do not dispose of the pickle juice or the distilled water. Clean the outside of the cuvette with lint free tissue. Calibrate the colorimeter with the cuvette of distilled water.

8. Insert the cuvette into the colorimeter, close the top, measure the absorbance of blue light, and record the data in Table 1. Stop data recording.

9. Obtain a piece of dialysis tubing soaking in water. Tie a half-knot in one end. Open the other end of the dialysis tubing by rubbing it back and forth between your wet fingers. Be patient. Once you get the tube open, hold it open.

10. Using a disposable pipet, fill the dialysis bag with 15 to 20 mL of pickle juice. Be sure to leave enough room in the bag for expansion.

11. Tie off the open end of the bag with another half-knot. If any excess dialysis tubing is exposed above or below your knots, cut it off with scissors. You should have 0.5 cm of dialysis tubing above and below each knot.

12. Place the bag containing pickle juice into the beaker or cup of water, and allow it to soak for 30 to 45 minutes (depending upon your teacher's instructions).

13. What do you think will happen to the pH of the solution in the dialysis bag and the solution in the beaker?

14. Allow the incubation to finish and then remove the dialysis bag from the water. (Do not dispose of the water in the cup.) Hold the dialysis bag over the "pickle juice" beaker, and carefully cut the bag open so the contents empty into the beaker.

15. Using a clean pipet, fill a cuvette with soaking fluid from the cup. Screw on the cap and clean the outside of the cuvette with lint free tissue. Using a clean pipet, fill another cuvette with fluid from the dialysis bag. Screw on the cap and clean the outside of the cuvette with lint free tissue.

16. Start data recording. Insert the cuvette filled with soaking fluid into the colorimeter, close the top, measure the absorbance of blue light. Record the data in Table 1.

17. Insert the cuvette filled with soaking fluid into the colorimeter, close the top, measure the absorbance of blue light. Record the data in Table 1.

18. Remove the cuvette and replace with the cuvette filled with fluid from the dialysis bag. Close the top, measure the absorbance of blue light and record the data in Table 1.

19. Use the pH and conductivity probes to measure the pH and conductivity of the fluid in the beaker labeled "distilled water", and record the data in Table 2.

20. Use the pH and conductivity probes to measure the pH and conductivity of the fluid from the dialysis bag, and record the data in Table 2.

21. Stop data recording.

Analysis & Questions

Table 1: Pre-soak conditions

	pH	**Conductivity (µS/cm)**	**Abs Blue Light (480 nm)**
Distilled water			
Pickle juice			

Table 2: Post-soak conditions (30 minutes)

	pH	**Conductivity (µS/cm)**	**Abs Blue Light (480 nm)**
Contents of beaker			
Contents of dialysis bag			

1. Calculate the change in pH for the distilled water and the pickle juice. Show your work below and record your results in Table 3. Change = Final – Initial

2. Calculate the percent change in pH for the distilled water and the pickle juice. Show your work below and record your results in Table 3. Percent change = Change in pH X 100 / initial pH

Table 3 Change in pH & conductivity

	Initial pH	**Final pH**	**Change in pH**	**(%) Change in pH**	**Initial Conductivity (µS/cm)**	**Final Conductivity (µS/cm)**	**Change in Conductivity (µS/cm)**	**(%) Change in Conductivity**
Distilled Water								
Pickle juice								

Table 4: Change in absorbance of blue light

	Initial Absorbance	**Final Absorbance**	**Change in Absorbance**	**Change in Absorbance (%)**
Distilled Water				
Pickle juice				

3. Calculate the change in absorbance of blue light for the distilled water and the pickle juice. Show your work below and record your results in Table4. Change = Final – initial

4. Calculate the percent change in absorbance of blue light for the distilled water and the pickle juice. Show your work below and record your results in Table 4. Percent change = Change in absorbance X 100 / initial absorbance

5. Which molecules was the dialysis membrane permeable to? Which way did these molecules diffuse: from the bag into the beaker, or from the beaker into the bag? What evidence do you have to support your claims?

6. Was the membrane impermeable to any of the molecules? What evidence do you have to support your claims?

7. Did osmosis occur during the experiment? What evidence do you have to support your claim?

SOIL PH

Driving Question

Does soil taken from different locations have the same pH?

Materials and Equipment

- pH sensor
- Beaker, 250-ml (3)
- Graduated cylinder 100-mL
- Marking pens
- pH calibration buffers, 4 and 10
- Wash bottle
- Hand trowel or shovel
- Sealable plastic bag, quart/liter size (3)
- Distilled water, 400 mL

Background

pH is an abiotic factor in the agricultural ecosystem that must be monitored to keep crops healthy and productive. Chemically speaking, pH is the measure of hydrogen ions (H^+) in the soil. This scale ranges from 0 (highly acidic) to 14 (highly alkaline). Distilled water, with a pH of 7, is a neutral solution. Most crops prefer a neutral to slightly alkaline soil pH but there are exceptions, notably citrus trees, which prefer acidic soil conditions.

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Wear safety goggles at all times

Procedure

1. Put on your safety goggles.

2. Using a clean hand trowel dig at least eight centimeters deep. Collect three 60 mL soil samples. Place each sample into a sealed plastic bag.

3. Label the bags of soil with the location where each sample was collected.

4. Connect to the pH sensor and open the AGR 12 Soil pH.spklab file.

    - If the lab file is not available create a new experiment with a digits display of pH.

5. Crush the soil that is in the bag so there are no clumps, the sample should be as uniform as possible.

6. Place 60mL of each soil sample into each of the three 250 mL beakers. Label each beaker indicating the location it was collected.

7. Add 60mL of distilled water to each beaker, mix it, thoroughly. Let the samples stand for 10 minutes prior to data collection to promote hydrogen ion (H^+) dissociation and allow sediments to settle.

8. Calibrate pH sensor. Rinse the sensor with distilled water.

9. Place the sensor into the first beaker and monitor data without recording. Gently stir the mixture until the reading stabilizes (as much as 60 seconds). Make sure the sensor is in the mid-point of the water column, not resting in the sediment. Record the final value in Table 1.

10. Repeat step 9 for the remaining soil samples rinsing the sensor thoroughly between each sample.

Table 1: Stabilized pH readings for soil samples

	Soil sample location and observations	pH
1		
2		
3		

Analysis

1. Record your observations in table 1 as well as the pH. Your observations may show; soil color, texture, organism, rocks or anything that is unusual.

2. Why did we add water to the soil sample?

3. Why did we rinse the sensor with distilled water before testing each sample?

4. Why was the soil crushed?

5. Based on your pH results only, would any of the soil samples from your three collection sites be capable of supporting a healthy agricultural crop?

6. How could you safely alter your soil in order to improve it ability to support agricultural crops?

7. What did you notice about the different types and numbers of living organisms in your soil samples? What might this indicate about the health of soil in your area?

8. What evidence of human interaction or interference could you identify when collecting your samples? How do you think this interaction has altered the original condition of the soil?