

Photosynthesis Lab

by C. Kohn, Waterford WI



Name: _____ Hour _____ Date: _____

Date Assignment is due: _____ Why late? _____ Score: + ✓ -
Day of Week Date If your project was late, describe why

Lab Overview

In this lab, you will be conducting multiple experiments to test ideas about photosynthesis. During the week, you will investigate plant cells under a microscope and test photosynthesis on leaf disks in a syringe.

Needed Materials

Tap water, spinach leaves, paper punch, a syringe (10 CC or greater), 0.2% sodium bicarbonate (baking soda) solution, light sources, microscope and slides, thermometer, misc. supplies for student experiments (as indicated by students and agreed on by the instructor).

Itinerary

Monday: Review of photosynthesis in groups; class discussion

Tuesday: Leaf microscopy

Wednesday: Leaf Disk Experiment

Thursday: Leaf Disk Experiment Independent Experiments

Friday: Designing a "Super Crop"

Expectations

1. This is a lab that involves live materials and sensitive equipment. You'll need to pay attention, use your brains, and stay smart to avoid accidents and problems.
2. This lab requires you to follow instructions; all instructions are clearly written in this packet. Consult your directions first, and then ask your instructor if you still have questions.
3. You will have to understand and think about the unit content to complete this activity. Use your brains! They exist for a reason ;)

Day 1: Review of Material

Score _____ /15

Directions: work with your group members to complete this sheet. Questions will be graded in class.

1. What is the job of light during photosynthesis? _____

2. How is H₂O used during photosynthesis? _____

3. How is CO₂ used during photosynthesis? _____

4. What two products are produced by photosynthesis? _____ & _____
5. What is a chloroplast? _____
6. What specific processes occur in the thylakoids? _____
7. What processes occur in the stroma? _____
8. What happens during the Light Cycle? _____

9. What happens during the Calvin Cycle? _____

10. What is RuBP? _____

11. What is G3P? _____

12. What is the job of the Electron Transport System? _____
13. What is the job of NADP⁺? _____
14. What is the job of chlorophyll? _____

Day 2: Spinach Leaf Microscopy

Overview

In this lab, you will be examining spinach cells under a microscope at varying magnifications. You will try to identify as many structures as you can. You will then test how cells respond to a saltwater solution.

Materials needed per group of 4

A light microscope, microscope slides, spinach leaves, table salt, small cups or graduated cylinders

Complete these blanks before beginning...

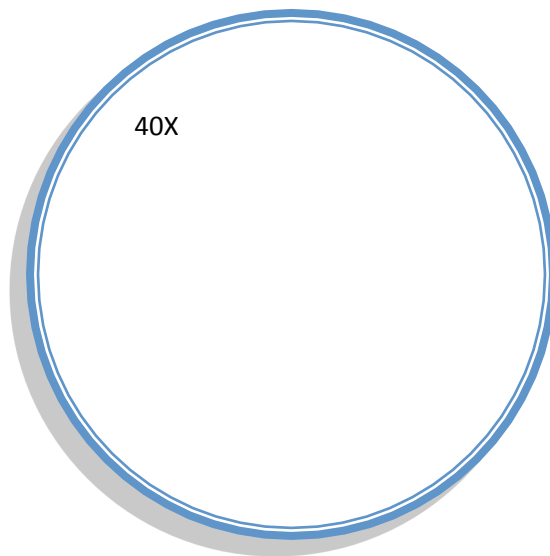
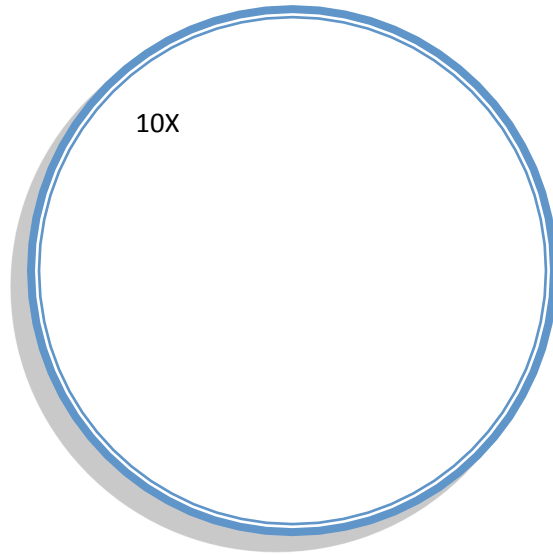
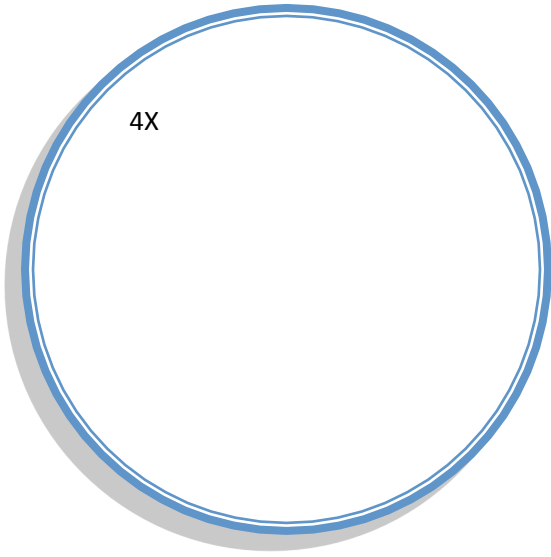
- a. Where does your instructor want you to get your microscopes from? _____
- b. How should you carry your microscopes? _____
- c. Where has your instructor placed your needed materials? _____
- d. What do you need to do to prevent damage to the microscope while working? _____

- e. What should you do when you think you are done? _____

Methods, Part 1

1. Prepare a slide and place it on the stage of the microscope. To prepare a slide:
 - a. Take a glass microscope slide and make sure it is clean. If there is any debris or smudges, use soap and water to clean and wipe dry with a clean paper towel (be careful not to scratch the slide).
 - b. Acquire a plastic coverslip; keep in a safe place until you are ready to use it.
 - c. For the start of our lab, we will use a spinach leaf to acquire the cells that we will observe under the microscope. Obtain a sample of the plant material provided by your instructor.
 - d. Cut the leaf into a small piece (smaller than a postage stamp) and slice the sample into the smallest slivers that you can create. Place one of the slivers on the glass slide and dice the leaf smaller using a knife, scissors blade, or clean blunt object (such as a glass stirring rod or pestle).
 - i. Your goal is to make a uniform "paste" from the sliver of your spinach leaf.
 - e. Add a drop of water to your glass slide and place a cover slip over the water and leaf cells.
2. Using the 4x objective lens bring the specimen into focus using the coarse and fine adjustment knob. Draw what you see (in pencil) below in the appropriate circle.
3. Switch to the 10x objective lens and bring the specimen back into focus using the coarse and fine adjustment knobs. Draw what you see (in pencil) below in the appropriate circle.
4. Finally, switch to the high-power 40x objective lens and bring specimen into focus using ONLY the fine adjustment knob. Draw what you see (in pencil) below in the appropriate circle.
5. Turn off your microscope's light. Record observations on the next page.
6. Clean your glass slide using soap and water and dry with a paper towel.

Observations: Record your observations and make your drawings on this page. Label the following in your images below: cell wall, cell membrane, chloroplasts. Also label any other structures you can identify.



Written observations: describe what you saw below. Be sure to comment how the image changes as you progress from 4x to 10x to 40x magnification (*i.e.* what was visible at 40x that wasn't at 5x? What became more visible as the magnification increased? What couldn't you see even at 40x?).

Methods, Part 2

1. Prepare a new slide and place it on the stage of the microscope. To prepare a slide:
 - a. Take a glass microscope slide and make sure it is clean. If there is any debris or smudges, use soap and water to clean and wipe dry with a clean paper towel (be careful not to scratch the slide).
 - b. Acquire a plastic coverslip; keep in a safe place until you are ready to use it.
 - c. For the start of our lab, we will use a spinach leaf to acquire the cells that we will observe under the microscope. Obtain a sample of the plant material provided by your instructor.
 - d. Cut the leaf into a small piece (smaller than a postage stamp) and slice the sample into the smallest slivers that you can create. Place one of the slivers on the glass slide and dice the leaf smaller using a knife, scissors blade, or clean blunt object (such as a glass stirring rod or pestle).
 - i. Your goal is to make a uniform “paste” from the sliver of your spinach leaf.
7. Mix 10 g of table salt in 100 ml of tap water (as a ballpark figure, this is about a teaspoon of salt per 1/3 a cup of water – this measurement does not have to be *exactly* right).
8. Add a drop of salt water to your glass slide and place a cover slip over the water and leaf cells.
9. Using the 4x objective lens bring the specimen into focus using the coarse and fine adjustment knob. Draw what you see (in pencil) below in the appropriate circle.
10. Switch to the 10x objective lens and bring the specimen back into focus using the coarse and fine adjustment knobs. Draw what you see (in pencil) below in the appropriate circle.
11. Finally, switch to the high-power 40x objective lens and bring specimen into focus using **ONLY** the fine adjustment knob. Draw what you see (in pencil) below in the appropriate circle.
12. Turn off your microscope’s light. Record observations on the next page.
13. Clean your glass slide using soap and water and dry with a paper towel. Answer the questions below:

Questions

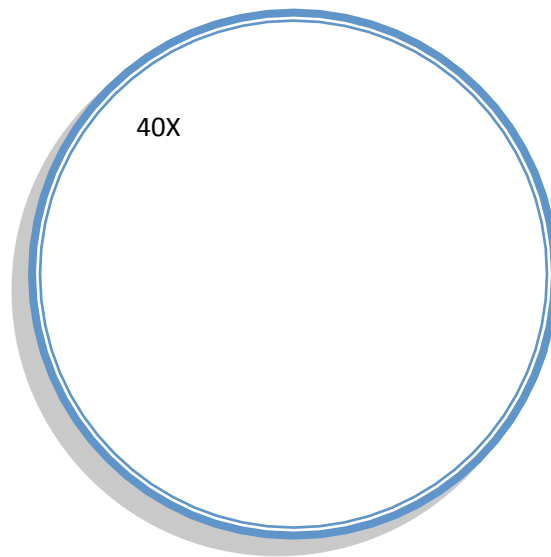
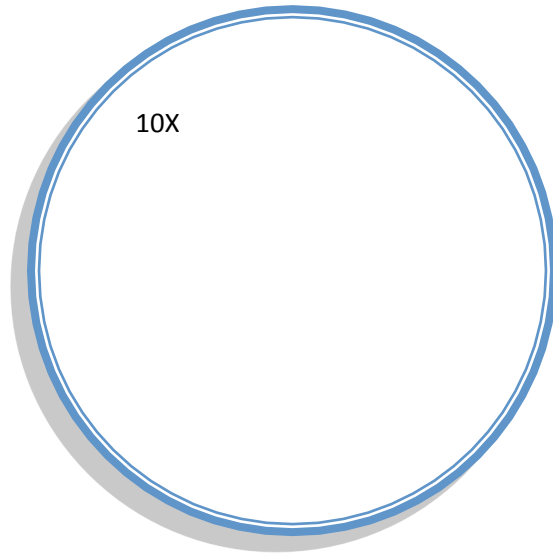
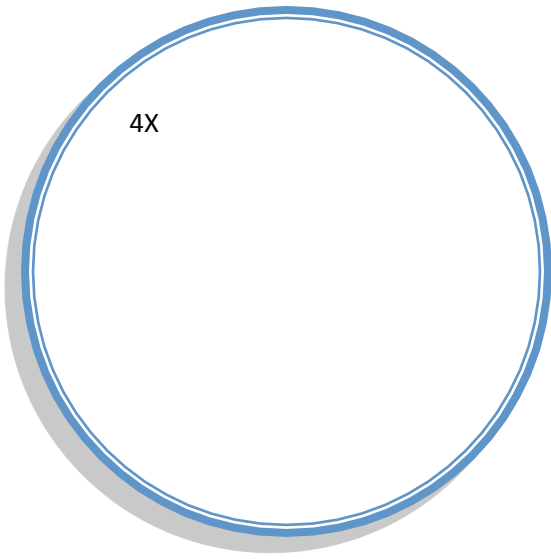
1. How did your cells change from your first trial with tapwater to your second trial with salt water?

2. Why do you think these changes occurred? _____

3. Why would your answer above make sense? _____

4. How do you think these changes would affect Light Reaction and the Calvin Cycle? _____

5. Observations: Record your observations and make your drawings on this page. .



If you have extra time, continue to exam other leaves under the microscope. Try to find the following:

- Structures underneath the leaf that open and close in order to allow carbon dioxide in and oxygen out. These structures look like to half-moons pushed together and are called stomata.
- Protective structures such as hairs, spines, wax, etc.
- Veins and other vasculature that enable a plant to move sugars back and forth to other cells.
- Differences in the amount of chloroplasts in cells on top of the leaf vs. underneath the leaf.

Day 3: Rates of Photosynthesis in Leaf Disks

Based on the lab by [John S. Olson](#)

Overview

In this lab, you will be using disks punched out of spinach leaf cells and a syringe full of water to measure rates of photosynthesis. The syringe will be used to change the pressure inside the chamber in order to pull out the oxygen found inside. As the oxygen is pulled out of the leaf disks, they will sink to the bottom. As the plants photosynthesize, they will produce oxygen, causing the leaf disks to become more buoyant. The faster the leaf disks rise to the top of the syringe, the greater the rates of photosynthesis.

Materials needed per group of 4

A 10⁺ cc syringe, tap water, spinach leaves, paper punch, 20% sodium bicarbonate (baking soda) solution, light source, ruler

Complete these blanks before beginning...

- a. Where does your instructor have your materials for this lab? _____

- b. What should you do before beginning this lab? _____

- c. Where should you squirt out the fluids when you are finished with them? _____

- d. What should you do with your materials when you are finished? _____

- e. What should you do when you think you are done? _____

Methods

1. Prior to this lab, your instructor should soak the spinach leaves in water overnight in a refrigerator. Fresh, dark green spinach leaves will work best. Your instructor will also need to prepare a 20% sodium bicarbonate solution by mixing 20 g of baking soda in one liter of water.
2. Using a paper punch, cut out 10-20 leaf disks from the freshest portions of the spinach leaves (extras are good to have in case you need them). Try to avoid veins, stems, and other non-leafy portions.
3. Add 10 leaf disks to your 10 cc syringe (if it is larger than 10 cc's, that is ok). Suck up 10 cc's of the sodium bicarbonate solution your instructor has provided.
4. Hold your finger over the end of the syringe. Pull back on the plunger as far as you reasonable can; you are creating a vacuum to suck the air out of the inside of the leaf disks. You should be able to visibly see air coming out of the disks.
 - a. As you are sucking the air out, sodium bicarbonate is going into the spongy layer of the leaf cells. This is how the cells will get the carbon dioxide needed for photosynthesis

5. Gently squirt out the sodium bicarbonate solution into a sink or beaker (whichever your instructor has provided). Suck up 10 cc's of water.
 - a. Make sure the leaf disks sink in the water. If not, remove the water and repeat the steps on the previous page until they do.
6. Move your syringes to a well-lit location. Record the start time here: _____
7. While you are waiting, start the questions below. Lightly turn or agitate your syringe from time to time.
8. Record the time at which at least half of the disks have floated halfway to the top of the syringe (i.e. the time at which at least 5 disks are at 5 cc's or higher).

 Time: _____ Total time elapsed from start to this time: _____ min
9. If time allows, repeat this experiment with a second set of 10 disks newly punched from the spinach leaves your instructor has provided.
10. Record the start time for your second trial of spinach leaf disks here: _____
11. Record the end time at which 5 or more disks reached 5 cc's or higher here: _____
12. Record the total time elapsed here: _____ min
13. Finish the questions for this lab.

Questions

1. Why was the 20% sodium bicarbonate solution necessary? _____

2. What would happen if the sodium bicarbonate was not used? What specific part of photosynthesis would be affected?

3. What made the leaf disks rise? _____
4. How do you think the following scenarios would impact the rate at which the leaf disks rise? Write "faster" or "slower" next to each scenario:

 Increased light intensity: _____ Increase the sodium bicarbonate concentration: _____

 Raise the temperature: _____ Lower the pH (inc. H^+ ions in the solution): _____

Day 4: Rates of Photosynthesis in Leaf Disks, Part 2

Based on the lab by [John S. Olson](#)

Overview

For the second part of this lab, you will be testing the impact of a specific independent variable of your choosing and measuring how a particular factor affects the rates of photosynthesis as determined by how fast the disks rise. For this lab, you have a few choices for your independent variable, including...

1. How different intensities of light affect rates of photosynthesis
2. How different colors of light affect rates of photosynthesis
3. How different temperatures affect rates of photosynthesis
4. How different pH levels affect rates of photosynthesis
5. Alternate option of your choosing (requires approval by your instructor)

Materials needed per group of 4

A 10⁺ cc syringe, tap water, spinach leaves, paper punch, 20% sodium bicarbonate (baking soda) solution, light source, ruler, additional supplies needed for each selection of independent variables

Methods

1. As a group, decide what experimental option most interests you. If you are selecting an option not listed above (i.e. the alternate option), speak with instructor and get their approval before continuing.
2. Complete the questions on the next page. Answer them as a group.
3. When you have completed these questions, speak with your instructor. If they are with another group, patiently wait until they are done.
 - a. It would be a good idea to review your questions and plan if you are waiting to make sure you haven't made any mistakes or left out any details.
 - b. Make sure that everyone is clear on what their responsibilities will be when you conduct the experiment and that everyone agrees to these plans.
4. After you receive instructor approval, you can begin your experiment. Conduct your experiment using the protocols agreed on by your group and your instructor.
5. After completing your experiment, clean up your area and complete the Results questions.
 - a. If you do not finish in class, you will need to finish these questions outside of class.

Pre-Experiment Questions (answer BEFORE asking for instructor approval)

1. Fully describe what you intend to do in this experiment: _____

2. What is your research question for this experiment? Write it below:

We are unsure if _____

3. What is your hypothesis for this experiment? Write it below:

We predict that _____

4. What is your rationale for your hypothesis? *We think that that this will happen*

because _____

5. What is your independent variable (the thing you purposely changed) for this experiment? Write it below:

Our independent variable is _____

6. What is your dependent variable (the thing you measure) for this experiment? Write it below:

Our dependent variable is _____

7. How will you measure your dependent variable? _____

8. What is your control for this experiment? _____

9. What materials do you need for this experiment? List ALL supplies and materials needed below: _____

Hint: you may want to look at the materials used earlier in this packet for guidance

10. What are your methods for this experiment? Write them below in a “cookbook” step-by-step style:

Hint: you may want to look at the methods used earlier in this packet for guidance

11. What will be the role of each person during this experiment?

Person 1: _____ Responsibilities: _____

Person 2: _____ Responsibilities: _____

Person 3: _____ Responsibilities: _____

Person 4: _____ Responsibilities: _____

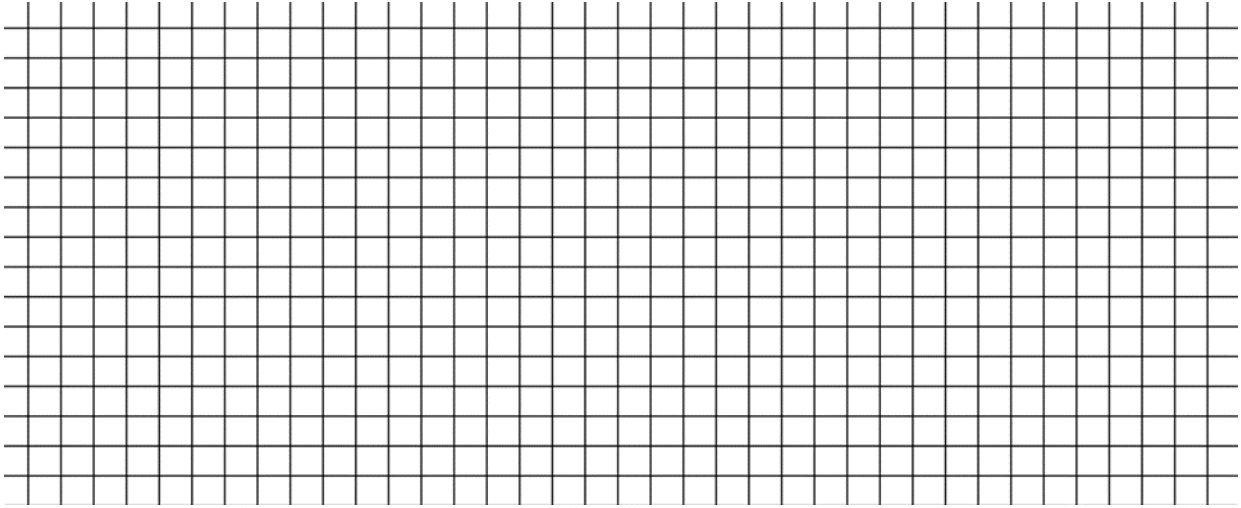
Instructor's Signature of Approval: _____ **Date:** _____

Results: Data & Observations (complete after your experiment is finished)

1. What were the results of your experiment? _____

a. Why do you think this happened? _____

2. Create a graph in the space below comparing your results to the results of the control:



3. Write a caption for this graph (a caption should describe what the graph shows and what that means):

In this graph you can see that _____

Conclusion (complete after your experiment is finished)

1. What was your original hypothesis? *We predicted that* _____

2. What is your rationale for your hypothesis? *We thought that that this would happen because...*

3. What actually happened? _____

4. Was your hypothesis supported by your data? _____

5. If you repeated your experiment again, do you think you would get the same results? _____

Explain: _____

6. Why do you think you saw the results that you did? Answer by relating your tested variable to specific aspects of photosynthesis (such as Light Reaction, the Calvin Cycle, hydrogen concentrations in the thylakoids, etc.).

7. Complete the Peer Review below:

1. Group Member's Name: _____ Score: 1 2 3 4 5

Reason: _____

2. Group Member's Name: _____ Score: 1 2 3 4 5

Reason: _____

3. Group Member's Name: _____ Score: 1 2 3 4 5

Reason: _____

4. Your Name: _____ Score: 1 2 3 4 5

Reason: _____

Day 5: Designing a “Super Crop”

Overview

In this activity, you will work in teams of four to design a hypothetical “super corn” that has greater rates of photosynthesis in order to produce more sugars that can be converted into larger corn kernels.

Using your knowledge of how photosynthesis works, you will make hypothetical changes to the cell of your new corn plant. You will have to explain the changes you made and how they will improve the performance of your corn plant both in this worksheet and orally to the class after you and your group members have had some work time.

You may want to use some of the following as inspiration for your changes:

- Ability of the plant to absorb water
- Amount of light-absorbing pigments in the thylakoid
- Ability of the Electron Transport System to utilize electrons and move hydrogen into the thylakoid
- Amount of ATP Synthase on the thylakoid membrane
- Amount of NADP⁺ available to move hydrogen from the thylakoid to the stroma
- Amount of CO₂ that the plant can absorb
- Amount of RuBP available in the stroma

Don't worry about *how* these changes will be made (we have a scientific magic wand 😊) – instead focus on *why* we would want to make these changes and *what* the impact of those changes would be on the plant.

You will also be asked to determine what else would need to change inside the plant in order for this change to work. For example, it would not help the plant to increase the concentration of RuBP unless there was also more ATP available to power the Calvin Cycle (i.e. more RuBP without more ATP would not change the amount of G3P and glucose produced in the Calvin Cycle).

Change 1: _____

How would this affect photosynthesis? _____

How would this increase the production of glucose? _____

What else would have to change in order for this to increase the production of glucose? _____

Change 2: _____

How would this affect photosynthesis? _____

How would this increase the production of glucose? _____

What else would have to change in order for this to increase the production of glucose? _____

Change 3: _____

How would this affect photosynthesis? _____

How would this increase the production of glucose? _____

What else would have to change in order for this to increase the production of glucose? _____

Change 4: _____

How would this affect photosynthesis? _____

How would this increase the production of glucose? _____

What else would have to change in order for this to increase the production of glucose? _____

Change 5: _____

How would this affect photosynthesis? _____

How would this increase the production of glucose? _____

What else would have to change in order for this to increase the production of glucose? _____