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| **TEAM Photosynthesis Lesson Plan** |
| Teacher: Dr. James Smart |
| Subject/Grade: Photosynthesis / Grade 7 |
| Lesson Title: Photosynthesis |
| **STANDARDS** | **Identify what you intend to teach.** State, Common Core, ACT College Readiness Standards and/or State Competencies; Enduring Understandings and Essential Questions. |
| Caution: This activity involves the use of sodium bicarbonate. See the Material Safety Data Sheet below: <https://fscimage.fishersci.com/msds/20970.htm> **7.LS1.9:** Construct a scientific explanation based on compiled evidence for the processes of photosynthesis, cellular respiration, and anaerobic respiration in the cycling of matter and flow of energy into and out of organisms. **7.LS2.1:** Develop a model to depict the cycling of matter, including carbon and oxygen, including the flow of energy among biotic and abiotic parts of an ecosystem. Crosscutting Concepts: Cause and effect relationships that can be explained through a mechanism, Energy and matter conservation through transformations that flow or cycle into, out of, or within a system SEPs: Planning and carrying out controlled investigations; using mathematics and computational thinking. 7.EE.B.4: Use variables to represent quantities in a real-world or mathematical problem and construct simple equations and inequalities to solve problems by reasoning about the quantities.7.SP.A.2: Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions. |
| **OBJECTIVE(s)/Sub-Objectives** | **Connect prior learning to new learning.** Clear, Specific, Observable, Demanding, High Quality, Measurable, Aligned to Standard(s), and Integrated with other subjects, build on prior student knowledgeStudent-Friendly (I Can Statement) |
| I can distinguish between heterotrophs and autotrophs. I can observe evidence for photosynthesis in leaf tissue samples. I can determine the conditions necessary for photosynthesis to occur. I can observe and predict the effects of external stressors on the photosynthetic process. I can understand the transformation of molecules within a closed system.  |
| **MATERIALS AND RESOURCES**  | **Content-related:** Clearly supports lesson objective(s); rigorous & relevant; Incorporates multimedia & resources beyond the textbook.  |
| **Resources**This activity requires 10-15 minutes of sample preparation and 30 minutes of observation (split into five-minute intervals- students will be partially engaged during this time). To conserve class time, samples could be prepared before class, allowing students to focus on collecting data. The activity requires 4 electrical outlets for lamps. Do not overload electrical circuits. **Materials** White board/marker/eraserClock or timer, (kitchen timer or smart phone timer) Distilled water (1 Liter)Dish detergent (four drops)Sodium bicarbonate (baking soda) (2 grams)BalancesWeighing paper4 120V lamps, with one each of Red, Green, Blue, and white incandescent bulbsPer group for 4 groups: 2 worksheets , approximately 10 fresh spinach leaves, 2 Drinking straws, 1 Sharpie®, 1 30mL syringe, 1 250 mL plastic beaker. For group 4 only, piece of aluminum foil (10cm x 11cm)**Routine for distributing materials:** Place distilled water, dish detergent, sodium bicarbonate, and balances in a central location. Place lamps at a separate central location. Individual students or pairs of students will come from each group to collect/measure out materials and use balances. Place group supplies at a lab table for each group.  |
| **ACCOMMODATIONS/ADAPTATIONS** | **Learning styles and interests.** Anticipate learning difficulties, regularly incorporate student interests & cultural heritage; differentiate instructional methods. |
| **Modifications/Plans for Diverse Learners** **Differentiation****\_\_x\_\_ Content** For some students the goal will be to correctly observe/count the floating disks and to understand that photosynthesis produces the gas to causing the leaves to float. Other students will be more engaged with deeper questions as listed in the questions section.  **\_\_x\_\_ Process** It may be necessary to punch leaf disks for students. It may also be appropriate to pre-mix the sodium bicarbonate solution. **Accommodations**If any student is color-blind, place labels on the lamps to indicate the color of their bulbs.  |

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| **MOTIVATING STUDENTS/ANTICIPATORY SET** | **“Hook”: Engage students’ attention and focus on learning.** Personally meaningful and relevant. |
| Show time-lapse video of plant growing such as “Top 8 Plant Growing Time Lapses of 2020 – 384 Days in 8 minutes” <https://www.youtube.com/watch?v=uSOOO3KBKDY> ( A good 1-minute segment is from 0:52 to 1:53 ) How does the plant grow without eating? Energy is required to lift its mass above the soil.  Discuss autotrophs vs. Heterotrophs- making their own food, sugar...“Wouldn’t it be nice to make your own food?”   |
| **INSTRUCTIONAL PROCEDURES** | **Step-by-Step Procedures-Lesson Sequence: Basic to Complex.** Lesson includes visuals, modeling, logical sequencing and segmenting (beginning, middle, ending); essential information; concise communication; grouping strategies; differentiated instructional strategies to provide intervention & extension; seamless routines; varied instructional strategies; key concepts & ideas highlighted regularly. |
| ***Introductio*n**With the whole group’s attention, explain what is going to happen. There will be four groups. The students are going to prepare a solution, prepare spinach leaf disks, suspend the leaf disks in solution within syringes, pull the air out of the leaf disks, and place the syringes in front of different light sources. For ½ hour, every five minutes students will count the number of disks which are floating. After making observations the whole class will discuss what they have seen. Demonstrate cutting leaf disks with a straw. Demonstrate placing disks into a syringe and placing the plunger back into the syringe. Demonstrate drawing solution into a syringe and demonstrate creating a vacuum in the syringe. Separate the students into four groups and number the groups 1 through 4. Ensure that each group knows its group number. Have students record their names on their worksheets. Have them follow the instructions on the worksheet. Observe weighing and solution mixing, assisting as needed. Have each group show their sunken leaf disks. Have students place their syringes in front of the lights. Ask students to predict what will happen, that is, to make a hypothesis. Note the time or set a timer for five minutes, and turn the lights on. **Middle**While waiting for the timer, designate one group member to count and record the number of leaf disks. In Group 4, designate a second person to unwrap and re-wrap the syringe. Ensure that students understand that they will record numbers for each syringe, not just their own. Between observations, gain the whole group’s attention and discuss the following: Discuss the vocabulary words **autotroph** and **heterotroph**. Autotrophs are organisms that can produce their own food. Heterotrophs are organisms that cannot produce their own food. Autotrophs are producers, and heterotrophs are consumers. In this activity, spinach is an autotroph. We are heterotrophs. Discuss **photosynthesis**. Photosynthesis is a process that converts light energy into food. Light is absorbed by photosynthetic pigments in the chloroplast and used to convert carbon dioxide and water into glucose, a sugar. Photosynthesis also produces oxygen, a gas. Carbon dioxide usually comes from the air and water from soil through a plant’s roots. In this activity, the carbon dioxide and water come from the sodium bicarbonate solution. Discuss the **observations**. We usually cannot see carbon dioxide or oxygen, so it is hard to see photosynthesis. In this activity, we exposed the leaf discs to a vacuum. That removed any air trapped in the leaves so that they would sink. When we see the leaf disks float again, it means that gas has replaced the air we removed. This gas is oxygen, which gives us evidence that photosynthesis has taken place. Show the **equations**. Write out the chemical equation for photosynthesis. 6CO2 + 6H2O + light energy à C6H12O6 + 6O2Notice that the equation is balanced. Every atom on the left matches an atom on the right. Ask students how many of each type of atom are on each side of the equation (There are 6 carbon atoms on the left, and 6 carbon atoms on the right. There are 18 Oxygen atoms on the left, and there are 18 oxygen atoms on the right. There are 12 hydrogen atoms on the left, and 12 hydrogen atoms on the right.) Discuss the **van Helmont experiment**. About 200 years ago, Jan Baptista van Helmont did experiments on the nature of photosynthesis. He wanted to know where plants get the materials necessary to grow. He planted a tree seedling weighing 5 pounds in a barrel filled with 200 pounds of soil. He watered the tree regularly. Five years passed. Then van Helmont weighed the tree and the soil. The tree weighed 169 pounds, 3 ounces. The soil weighed 199 pounds, 14 ounces. Because the tree gained so much weight, and the soil lost so little, he concluded the tree had gained all its weight by absorbing water he added to the barrel. Given what you know about photosynthesis, why was he misguided? What really happened? **End/Closure**:  After recording all observations, each group should designate a member to begin cleanup, disposing of leaf disks and solutions and rinsing syringes and beakers. The remaining students should answer the questions on their worksheets within their groups. Regain the whole group’s attention. Ask students to explain why some leaves are floating and others are not. Ask them about the purpose of the sodium bicarbonate solution. Ask them which colors of light plants absorb. Finally, ask them why photosynthesis is important to us (humans). Collect the worksheets. **Motivating Students** \_x\_ Relate to Real World: We get our food from photosynthesis.  \_x\_ Verbal Reinforcement: The teacher will monitor students’ work throughout the activity to provide reinforcement. **Presenting Instructional Content** \_x\_ Hands on: Students are interacting with the plant samples, running every step of the experiment themselves. \_x\_ Modeling: The teacher will demonstrate how to cut leaf disks and how to operate the syringes\_x\_ Discussion: Students will discuss answers to questions on their worksheets in their small groups. The whole group will discuss the results and the effects of the different colors of light. ***Instructional strategies:*****Modeling and Guided Practice *–*** The teacher will demonstrate techniques used such as using a balance, cutting leaf disks, and pumping the syringe. The teacher will monitor students’ work and ask questions to prompt them if they are stuck.  **Check for Understanding (CFU) –** ***What am I doing for students that progress at different rates?*** Encourage students to help each other. Faster students can help others with cutting their spinach or preparing their syringes. ***What do I do if they get it?*** Discuss why it is important to study plant processes such as photosynthesis- for growing food, conserving ecosystems, identifying chemical signatures of life on other planets, etc. Discuss other important chemical processes in living organisms, such as cellular respiration, digestion, and nitrogen fixation. ***What do I do if they don’t get it?*** Run the experiment with only one or two syringes- a white light syringe and a dark syringe, for example.  |
| **QUESTIONING/THINKING/PROBLEM SOLVING (embedded throughout)** | **Balanced mix of question types.** Utilizes Blooms Taxonomy/Webb’s Depth of Knowledge; high frequency; purposeful & coherent; require active responses; balance based on volunteers/non-volunteers, ability, & gender; lead to further inquiry & self-directed learning.  **Implement four types of thinking (Analytical, Practical, Creative, & Research-based) & Teach/Reinforce problem-solving types**. Provide opportunities for students to generate ideas & alternatives; analyze, evaluate & explain information from multiple perspectives& viewpoints. |
| **Questioning:** These questions will occur throughout the activity as prompts based on groups’ or individual students’ progress. **Knowledge:**What do plants take in during photosynthesis? (carbon dioxide, water, light energy)What do plants produce during photosynthesis? (sugar, oxygen)Are most plants autotrophs or heterotrophs? (autotrophs)Are animals autotrophs or heterotrophs? (heterotrophs)What colors of light do plant leaves absorb? (red and blue) What is the difference between a producer and a consumer? ( a producer can create its own food, a consumer cannot)**Comprehension:** Where do we see photosynthesis happening in our lives? (growing plants) Which are we, producers or consumers? (consumers) Are plant leaves undergoing photosynthesis in the fall after their leaves change color? (no) Why do some of the leaf disks float (photosynthesis produces oxygen)Which component of the photosynthesis equation is the baking soda providing? (carbon dioxide) **Application:**How can we describe photosynthesis to someone who has never heard of it before? (Discuss the ways we can feel energy- feeling the heat of the sun on our face- segue into seeing that life energy- moving, talking, etc. comes from food we eat, which comes from plants that absorb light energy)Do mushrooms undergo photosynthesis? ( no ) What color would plats be if they absorbed all visible light wavelengths equally? (black) Would frozen spinach leaves work as well as fresh leaves? (No. The freeze/thaw expansion will destroy the membranes needed to insulate the proton gradient that photosynthesis produces. That is, burst open cells & chloroplasts means no photosynthesis).Would cooked spinach leaves work as well as raw fresh leaves? (No. Proteins in the thylakoid membrane in the chloroplasts would be denatured by heat and therefore non-functional.) What was wrong with van Helmont’s conclusion about weight gain through water absorption? How did van Helmont’s tree actually grow? **Analysis:** What are some slight modifications we could make to this experiment to understand more about photosynthesis? ( Use different colored lights such as yellow or purple, use water in the syringe instead of sodium bicarbonate solution. Use a bleach solution instead of water. Cook the spinach first. Freeze the leaf disks before using them) Why do we study photosynthesis? **Synthesis:****Evaluation:** **Thinking**  \_x\_ **Practical** – Photosynthesis is constant, abundant, and applicable to everyone. \_x\_ **Creative**– Students can propose variations for future experiments. \_x\_ **Analytical** – Students must interpret differences in results in terms of the colors of light (or lack of light) on the syringes.  \_x\_ **Research-based** – Students form hypotheses before making observations, and test the hypotheses against the results. **Problem Solving** **\_x\_\_** **Observing and Experimenting**. This activity is an experiment in which students observe changes in leaf disks in a syringe. **\_x\_\_ Predicting Outcomes** Students predict whether leaf disks will float or not. **\_x\_\_ Drawing conclusions** Students should conclude that plants use some colors of light and not others in photosynthesis, and should also conclude that light is necessary for the process.  |
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| **GROUPING** | **Maximize student understanding & learning** Varied group composition (race, gender, ability, & age); clearly understood roles, responsibilities & group work expectations; accountability for group & individual work; student opportunities for goal setting, reflection & evaluation of learning. |
| * Whole group discussion; heterogeneous groups of 6 to 7 students conduct the experiment.
* Group roles include: Reader/Leader (keeps everyone on task), Recorder (fills in the table and records the group’s answers on worksheet) , leaf disc cutter, syringe operator, foil unwrapper/re-wrapper (in Group 4 only), counter (counts the floating leaf disks and tells recorder), timekeeper (prompts counter to count floating leaf disks), cleaner (disposes of used leaf disks/solution, rinses syringes and beakers)
* Product. Groups will produce a completed worksheet
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| **ASSESSMENT** | **Formative and/or summative assessment.** A variety of assessments, including rubrics, measure achievement of objectives and informs instruction.  |
| **\_\_x\_ Teacher Made Test:** In a future assessment the teacher can ask students to differentiate between heterotrophs and autotrophs, or list requirements necessary for photosynthesis to take place. **\_\_x\_ Observation:** The teacher will directly observe if the students are drawing correct conclusions from the leaves’ behavior. **\_\_x\_ Worksheet:** The teacher will grade the worksheets.  |
| **CLOSURE** | **Reflection/Wrap Up.** Summarizing, reminding, reflecting, restarting, connecting. |
| Regain the whole group’s attention. Ask students to explain why some leaves are floating and others are not. Ask them about the purpose of the sodium bicarbonate solution. Ask them which colors of light plants absorb. Finally, ask them why photosynthesis is important to us (humans). Collect the worksheets. ***Reflection: You must reflect on every lesson you teach.*** |

**NOTES:**

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