Photosynthesis lesson plan pdf free

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In any introductory biology class, photosynthesis is a big topic—that's hardly surprising, given just how important photosynthesis is to all life on Earth! It can also be challenging to teach, since there's so much information students need to not just memorize but understand, from plant structures to chemical equations. Fortunately, Visible Biology's got you covered! Today, we'll walk you through a free lesson plan and set of lab activities on photosynthesis. Ultimately, after finishing the lesson and labs, students should be able to answer these three questions: What are the reactants and products of photosynthesis? What is the photosynthesis equation? Why is photosynthesis important for a plant's survival? What are the main steps in the process of photosynthesis? 1. Introduce the reactants and products of photosynthesis Our lesson plan begins with a zoomed-out view of photosynthesis—identification of the reactants and products. If you want to assign some before-class reading on this topic, the Reactants and Products article on Visible Body's Biology Learn Site and the Photosynthesis Overview chapter of OpenStax's Concepts of Biology are both good resources. You can have students use the Photosynthesis interactive simulation in Visible Biology to identify the following: carbon dioxide (CO_2) molecules a glucose ($C_6H_{12}O_6$) molecule oxygen (O_2) molecules photons of light water (H_2O) molecules Photosynthesis models and simulations in the Energy Unit in Visible Biology. These animated 3D models show how each reactant enters the plant, and what happens to each (by)product. A preview of the photosynthesis simulation models in Visible Biology. 2. Walk through the roles of plant structures involved in photosynthesis Next, use the dicot leaf 3D model in Visible Biology to show students the leaf structures they'll need to know: The upper and lower epidermis that contain the stomata and their guard cells The palisade and spongy mesophyll, where photosynthesis takes place The phloem and xylem, which move nutrients and water through the plant. For more information on these structures, students can read the Leaf Structures Involved in Photosynthesis article on the Biology Learn Site. The dicot leaf model in Visible Biology. The palisade mesophyll, spongy mesophyll, xylem, and phloem are labeled with tags and the spongy mesophyll is highlighted. 3. Get into more detail with light-dependent and light-independent reactions inside the chloroplast For those instructors who want to give students a more detailed look at the chemical reactions taking place during photosynthesis, the chloroplast simulation in Visible Biology shows the light-dependent and light-independent reactions of photosynthesis, as well as the internal structures of the chloroplast where these reactions occur. Students will be able to identify the following: The reactants and products of photosynthesis as well as chlorophyll The inner and outer membrane of the chloroplast The stroma Thylakoids, organized into grana They will also be able to see how oxygen is produced when water molecules are broken down in the light-dependent reactions, and how the light-independent reactions use carbon dioxide to produce glucose. Video footage of the chloroplast simulation in Visible Biology. Students can brush up on their knowledge of these structures and processes by reading the Light-Dependent and Light-Independent Reactions of Photosynthesis article on the Biology Learn Site. The Light-Dependent Reactions of Photosynthesis and Calvin Cycle chapters of OpenStax Concepts of Biology are also great background reading. If you want to introduce students to how photosynthesis compares to and relates to cellular respiration, check out this post from the Visible Body Blog. 4. Check students' knowledge with Lab 1: Plant Structures, Reactants, and Products of Photosynthesis Now that your students have completed the introductory lessons and readings, it's time to assess their understanding of photosynthesis with this first lab. The official Visible Biology lab contains five activities, which take about 45 minutes total to complete. There is also a set of more general background questions, which could be assigned as pre-lab homework along with the reading and structure identification lessons. Students can conveniently access the photosynthesis models for help during the lab activities with the Study tab in Visible Biology. The photosynthesis simulations and models students will need for the photosynthesis lab activities are located in the Lab Activities section under the Study tab in Visible Biology. In Lab 1, students will review what they learned about products and reactants and plant structures from the reading and from the 3D models and simulations. They will need to label the following: The reactants and products of photosynthesis The leaf structures involved in photosynthesis A chloroplast within a plant cell The internal structures of a chloroplast They will also be asked to match different plant structures to their roles in photosynthesis and to complete a chart detailing each product, reactant, and step of photosynthesis. 5. Observe photosynthesis with Lab 2: Floating Leaf Disk Experiment Once students have a thorough understanding of the reactants and products of photosynthesis, as well as the structures of the plant that allow it to occur, the floating leaf disk experiment will show them photosynthesis in action and lead them to deduce the conditions under which it can occur. Check out this video to see an overview of the procedure for the floating leaf disk experiment activity. In this lab, students will submerge leaf disks in different solutions and environments (a bicarbonate solution in light conditions, a bicarbonate solution in dark conditions, and distilled water in light conditions). They will then measure how many leaf disks sink and how many remain floating at the end of each minute for 20 minutes. Afterwards, they will graph their results and answer several short answer questions to evaluate their significance. 6. Put it all together with Lab 3: Photosynthesis in the Chloroplast The final lab activity gives students the chance to demonstrate their knowledge of photosynthesis by drawing a chloroplast and illustrating the light-dependent and light-independent reactions. They will need to explain the process of photosynthesis and its equation in their own words, showing that they understand each component and step. All in all, Visible Biology's content and lab activities bring the process of photosynthesis to life and put students in the driver's seat, letting them manipulate 3D models and simulations to find the answers they need, helping them draw connections to other biology topics (like cellular respiration), and engaging their writing and critical thinking skills to explain what they've learned. You can download the lesson plan and lab activities here. For a free instructor trial of Visible Biology, contact our Education Team. Happy teaching! Be sure to subscribe to the Visible Body Blog for more anatomy awesomeness! Are you an instructor? We have award-winning 3D products and resources for your anatomy and physiology course! Learn more here. In order to help as many teachers as we can, we have cut our prices. For $59.00 US, you can download all of our editable lesson plans + answer keys + test questions. These high school biology lesson plans include DOCX, PPTX, and XLSX files. Our editable lessons help you transition your class for blended learning. Start Today Imagine a class where the science and engineering practices engage every student because curiosity and inquiry brings out the desire to learn, to be challenged, and to persevere. When students' curiosities are peaked, they will learn on their own, your job as the teacher is to scaffold to reach and inspire every one of your students. Science and Engineering Practices In everything we do, we believe in inspiring others. Imagine a science class where every student is engaged in hands-on science and motivated to discover the world around them. The way we inspire learning is to help teachers use inquiry-based instruction and scaffolded learning. We just happen to make great biology lesson plans! Free Biology Lessons Every lesson we wrote has been overhauled and rewritten to increase learning and curiosity. Membership now includes answer keys for the revised lesson plans and test question banks. You will be able to download all of our lesson plans for free or with a membership, you can have the editable files, answer keys, and test questions too. Join Today There are a thousand ways of implementing the science and engineering practices into your curriculum as the practices are only about what the students are expected to do, not how they learn the practices. The NGSS standards are built around the idea that one practice is the focal point for each content standard (DCI). Of course you have probably already noticed that the science and engineering practices build off of each other. Below are a few of the best science and engineering practices that incorporate both the NGSS and the Common Core. Asking questions (for science) and defining problems (for engineering): Getting all of your students to ask scientific questions is very difficult, especially if they are not used to being asked to ask scientific questions. Student generated questions are by far the most powerful questions to base your curriculum off of. If a majority of your students are not used to asking scientific questions, then when a student asks a question, you could say "I don't know, that is a good question". Your goal after class is to now either make a one day experiment, demo, or research project based on that question. The next day you have that student repeat the question and suddenly you start a demo, start a structured inquiry lab, or start a one day research project. If you do a demo, afterwards you are going to transition this activity into building a conceptual model (explained in constructing explanations). If you do a lab, your focus will be on analyzing the data to determine the answer. If you do a research project, make sure to find grade level resources ahead of time; textbook page numbers, web addresses, etc. Your goal is to spotlight the question. Several of the NGSS standards focus on designing a solution. You can do this by creating many projects based upon solving student chosen problems. An example combining the science and engineering practices is where students define an environmental problem and then design a solution to solve this environmental problem. Developing and using models: There are many types of models including diagrams, pictures, physical replicas, mathematical representations, concepts, analogies, & computer simulations. [6] All models are used to represent a system (or parts of a system) that predict phenomena. Basic models include pictures, diagrams and physical replicas. Most teachers already have students develop diagram and picture models. The carbon cycle is great example of a diagram / picture model. Higher DOK level models are usually abstract and may include mathematical representations or a concept. Concept maps are a great pre-writing assignment, [3] especially for EL students. Give students 5-10 main keywords that represent a concept. Students are to organize the words and link them with arrows (cross-links). The next step is critical. Have students then write connecting words on each of the arrows. The connecting words can be later used to form sentences in an essay. A conceptual model can include engineering design models but also a collection of the statements that are used to predict phenomena. Students can develop a conceptual model using teacher lead instruction. Once the conceptual model has been developed, it provides students a scaffold for linking scientific concepts to applied writing. Planning and carrying out investigations: The investigations practice is all about experimentation and the levels of inquiry. We advocate for the use of structural, guided and open inquiry based experiments. Planning an investigation involves guided and open inquiry and of course carrying out the investigation is included in all levels of inquiry. Confirmation inquiry is at the DOK 1 [7] level since students already know what the end result should be. Structural inquiry is at the DOK 2 [7] level since it mainly requires students to analyze the data to explain phenomena in terms of concepts. Guided inquiry is at the DOK 3 [7] level as it requires students to design and conduct an investigation for a specific purpose or research question. Open inquiry is at the DOK 4 [7] level since students need to conduct an investigation, from specifying a problem to designing and carrying out an experiment, to analyzing its data and forming a conclusion. Analyzing and interpreting data: One crucial skill all students need to have in order to do science is data analysis and interpretation. This includes graphing, tabulation, finding trends, patterns and relationships. For the more advanced students, they should be able to calculate the slope, intercept, and correlation coefficient for linear fits. Using mathematics and computational thinking: This practice is integrated with the analyzing and interpreting data practice. Students should be able to create and analyze a graph, and make and use mathematical models. A great example of a mathematical model is Mendel's Punnett squares. Graphs can also be a part of a mathematical model. All students should be able to do simple statistical analyses like ratios, rates, percentages, and unit conversions. For the more advanced students, complex statistical analysis like standard deviation, standard error and chi-square can and should be introduced. Constructing explanations (for science) and designing solutions (for engineering): Students make a claim and then apply scientific reasoning, theory, and/or models to link their evidence to the claim. Students should also be able to identify, use, and argue theories and laws in their explanations. Projects are a great tool for students to design solutions to real world problems by combining several science and engineering practices. Fun engineering projects include: design a solution to the water crisis for a city nearby, design better lab equipment for the classroom, or design a house that reduces water, waste or energy. Engaging in argument from evidence: A socratic seminar is a safe and powerful way to get student to argue and support their claim with other students. The goal of the socratic seminar is to let students learn from each other and to discover how well they can support their claim. The teacher's job is to be the facilitator of the argument and not let a student dominate the discussion or go off topic. The socratic seminar safely [8] requires students to advance and defend their ideas while simultaneously having students evaluate competing arguments or design solutions. Obtaining, evaluating, and communicating information: This practice is more closely aligned to the Common Core than any other practice. This is the practice where students to read and interpret scientific literature, though not at the level of scientific journals. Scientific literature can come from textbooks, science-related trade books, websites and popular articles about science. [9] Students should be exposed to multiple opportunities to write which include journaling, written reports, research projects and presentations. [9] Before students give a presentation or write a report, they should be given examples of previously written reports. This may mean you need to write a report yourself to provide as an example. The main goal of science education is for students to transfer their knowledge to new situations. In order to promote transference in your teaching, students need to solve problems about different topics during the same lesson. What links those different topics together is a crosscutting concept. The benefit of using the crossingcutting concepts and the science and engineering practices are that they discourage rote learning about one topic. Since a crossingcutting concept takes content from several disciplinary core ideas, students experience the crossingcutting concept through several different examples. By using different examples, the students need to rely on using a crosscutting concept to solve problems from different topics. [5] The purpose of crosscutting concepts is to help reduce shallow learning through rote learning (memorizing). Patterns. Guide students to organize and classify information, and how that information is related. Cause and effect: Mechanism and explanation. Experimentation allows students to practice cause and effect. For example, a hypothesis involves a cause and predicted effect. Students can argue the causes of some event (the effect). Scale, proportion, and quantity. When considering phenomena, students should analyze how changes in size, time, and energy can affect that phenomena. Systems and system models. Make complex ideas simple; models and defining systems allows students to limit variables to test their ideas through experimentation. Energy and matter: Flows, cycles, and conservation. Identifying changes of energy and matter into, out of, and within a system can help students understand the possibilities and limitations of that system. Structure and function. Shape determines function. Stability and change. Stability is when a system is unchanging. The dynamic equilibrium of stability and change is important to understanding systems. The Common Core and NGSS are focused on "what needs to be taught", not how it is taught. Curriculum is one of the most important aspects of any class as it combines the what you teach with how you teach it. Lessons that integrate the science and engineering practices like inquiry, prior knowledge, & various learning styles while capturing students' curiosity, have the greatest impact on learning. The Next Gen standards incorporate three main ideas: 1) Science and Engineering Practices, 2) Content Knowledge, 3) Integrate Concepts. How you structure your curriculum is important to being successful with implementing the three main ideas of the NGSS along with the Common Core. Below is one possible way of integrateing the NGSS into your classroom. Implementing NGSS with CCSS Question: Always start a lesson with a hook. A teacher demo, a story that creates tension, history of how the concept was discovered or a video from YouTube is great way to get students to become curious about what you are teaching. The goal of the hook is to get your students asking questions (what caused that, how did that happen). Analysis: Have students conduct a structured inquiry experiment to collect data. The data should be organized in a data table and graphed. The important aspect of this step is to have students analyze their data to find trends. While this may seem counter intuitive to have students immediately start with a higher DOK level, this requires students to apply their prior knowledge and analytical skills. Do not include lab questions or the lab background as the goal is to get students to analyze their data. Answering questions and being correct is not the goal at this point, data analysis is. Trial and error is a major component to the scientific method. [1] You may need to help students / groups with finding trends and relationships. Before finishing with data analysis, have students discuss their analysis in a small group and then as a class discussion. The teacher will collect the main ideas and maybe introduce new ones. Lastly, have all the students vote publicly on which ideas they think is correct. Clear Expectations: Provide students with examples of what you want them to accomplish by the end of the unit. [12] If you are giving students a test, provide students with the study guide for that test. Then provide students an example test wheere students take it or analyze the test using the study guide. You could have students identify on the example test where each part of the study guide is being used. This concept of clear expectations truely helps when your test requires students to transfer their knowledge and skills to a new, not taught topic. At the ned of the test review, students will know what the test will look like, type of questions it will ask (modeling, multiple choice, claim evidence reasoning paragraphs, etc.), and what they will be expected to do / know. DO NOT provide students with the actual test; think of the example as a pre-test. This concept of clear expectations should also be used with projects. Provide students a rubric and several example projects (hopefully saved from previous years). Students then analyze the rubric by grading the project examples based on the rubric. Students should be encouraged to compare how they graded each example with their peers. Lastly, the teacher then asks the class how they would grade it, and offer advice. The goal is so students clearly know what they will be expected to know and do by the end of the unit. Vocabulary: Now is the time you introduce both academic and scientific vocabulary. Using a graphic organizer, students write the word, synonym of the word, definition of the word, and a sentence using the word. To speed up the process, provide students with this graphic organizer with the vocabulary word filled in, sentence frame for the how the word is used, and an image for the word. [2] This is a good spot to introduce the crosscutting concept to your students. Academic Speech: Students write how they talk. It is critical to have students practice saying complete sentences with the academic and content vocabulary. Students choral read the sentence with their partner. Then the teacher introduces new sentences that use the academic and scientific vocabulary and the class repeats those sentences. While this takes valuable time, your students are building their academic oral language that will be used in their applied writing. [2] Content Instruction: The goal of this instruction is to guide students to discover separate pieces of information. Do not integrate the concepts for the students as they need to make these connections themselves later. You can guide students to collect the disintegrated facts through small group discussions based on prior knowledge, reading the textbook, or through teacher-led direct instruction. As a formative assessment, you may choose to use DOK 1 level multiple choice questions to check for their understanding. Concept Integration: Reintroduce to your students the crosscutting concept. Next, have students build a concept map of the main keywords and then have them cross-link the keywords using arrows. [3] On each arrow, students need to write words that explain how one keyword relates to the other keyword. Remember that we did not ask lab questions previously; this is the time to ask those types of questions. Students should have the concept map in front of them when they are writing the answers to the lab questions. Their answers need to include both academic and content vocabulary and be written in complete sentences. Do not provide students with a multiple choice style assessment as they need to synthesize the information themselves. The goal is to guide students to integrate the concepts taught with previous taught concepts and the crosscutting concept. Claim, Evidence, Reasoning: This is the time when students answer the question. You can have students write the claim evidence reasoning paragraph as their conclusion of the experiment. Present the question again to the students. Have the students write a claim to what they think is the answer to the question. They need to back up their claim with experimental evidence (from data table) and explain how that evidence supports the claim. If your students are new to claim, evidence, and reasoning, then you should provide sentence frames for each section. [2] If your students are more advanced, you can have them write a DOK 4 essay with the claim being the introduction paragraph, the evidence and reasoning being the body paragraphs, and a conclusion paragraph summarizing their findings or predicting a new solution. Assessment: Proof of understanding should be the main goal of your assesment. The assessment needs to have students use the concepts learned in the unit and apply those concepts to new, untaught situations. This is called transfer. Transfer is not the same as application. Transfer requires that you did not teach the situation and students have to use concepts taught in class to understand the new situation. There are many types of assessments you can use to test transfer. You can choose to use a DOK 2 and DOK 3 level multiple choice test with applied short response questions to make sure your students know of the content. You can also choose to make the experiment itself be the assessment with you mainly evaluating the analysis, claim evidence reasoning, and argument sections. With the use of rubrics for the three sections, students will demonstrate all four DOK levels. Section 1, students use prior knowledge and analytical skills. Section 2, students use their content knowledge and experimental data to support a claim. Section 3, flush out any misconceptions when student defend their claim and get students to ask scientific questions. Argumentation (Optional): Now is the time for students to try to show their mastery of what they have learned by having them argue their claim with their classmates. Socratic seminars (fishbowl) or circles are great for safely having students argue their claims or ideas with their peers. [4] Part of the students' grade for this section is to ask a scientific question about another group's claims, evidence, or reasoning. An example of a scientific question is for students to make a prediction based on another group's claim. An extention activity is to have student answer the prediction with more research or another experiment. Scientific inquiry is all about "how much information (e.g., guiding question, procedure, and expected results) is provided to students and how much guidance you will provide as the teacher." [10] The purpose of the inquiry-based science and engineering practices are for students to construct meaning of what is being taught. The 1st key ingredient to inquiry-based learning is to start with a question. The 2nd key ingredient is for students to engage with either hands-on learning or analyze data or text you provide. Only after students analyze the lab results / data / text is when you teach the content. Getting students to ask questions first, requiring students to integrate their prior knowledge with new information is paramount for scientific inquiry. " The most important single factor influencing learning is what the learner already knows. " Confirmation inquiry is all about the old ways of teaching science. First the teacher teaches a concept and then students do a lab that demonstrates the concept. The key feature of confirmation inquiry is that students are taught the content first. Structured inquiry requires the students to not know the answer in advanced. This means the teacher starts off with a question, and then the students follow a list of procedures to do an experiment. Guided inquiry is when the teacher poses a question but requires the students to figure out how to test their own hypothesis. Students design their own experiment to try to answer the question. A best practice for guided inquiry is for students to do a structured inquiry lab first and then in a second lab, manipulate a new variable. AP science labs focus on Guided Inquiry and Open Inquiry. [11] Open inquiry is like a science fair project. Students come up with the question, design how they are going to test their hypothesis, and discover the solution on their own. " Questioning and reflecting lead to long lasting learning. " There are many benefits to having great lesson plans in your biology classes. Biology can be many students' favorite subject. By the time students reach high school most have already developed their preferred learning styles. Students learn faster and retain more information when the educational curriculum matches their prior knowledge, preferred learning styles, & curiosity. Let us become your educational resource for high school, middle school, and elementary school science classes and blended learning. " Instructional strategies that emphasize relating new knowledge to the learner's existing knowledge foster meaningful learning. " Differentiation The integration of students' prior knowledge, preferred learning styles, & curiosities is the most important factor when differentiating instruction for every student. Writing high school science curriculum that incorporates different learning styles, different levels of prior knowledge, student interest, and the Common Core and NGSS standards is very difficult. Students who were formerly bored with biology may once again become interested in class, with student questions and curiosity driving their learning. When students are interested in a class, they earn a better grade, which, in turn, leads to higher self-esteem and a greater feeling of success. The student-teacher relationship improves when students are successful and take an active role in participation. more Our Vision Teach to Inspire Inspiring learning is the driving force behind everything we do. Science is the way we think about and question our world. NGSS Life Science offers life science teachers curriculums that are aligned to the Common Core (CCSS) and the NGSS. NGSS Life Science is a high school science education resource company dedicated to inspire learning based on the Common Core and NGSS. contact us References 1. Pease, C. and Bull, J. (2010) How Non-Scientists use the Scientific Method. University of Texas at Austin. 2. Kinsella, K. (2011) Brief Constructed Response Routines to Support Reluctant Writers. San Francisco State University. 3. Novak, J., Canas, A. 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