RESET | Bioluminescence

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TEACHER

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Phoebe Lawing: Facilitator

SUBJECT/GRADE LEVEL

Subject: Biology
Grade: High School

Materials

- Goggles
- Gloves
- Apron
- Glowing Jellyfish Bacteria Kit
- Vibrio fischeri
- pDusk and pDawn plasmids
- *E. coli* (non-human pathogen)
- LB Kanamycin
- Agar plates
- glass beads
- Glowstick
- Beaker
- Liquid detergent with whitener
- Incubator
- UV light

STANDARDS

Next Generation Science Standards

- HS-PS1-4 Chemical Reactions: Many substances react chemically with other substances to form new substances with different properties. This change in properties results from the ways in which atoms from the original substances are combined and rearranged in the new substances.
- HS-PS4-2 Electromagnetic Radiation: Objects can be seen if light is available to illuminate them or if they give off their own light.
- HS-LS1-1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
- HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations

Mathematics Standards | Common Core State Standards

- CCSS.MATH.CONTENT.HSF.LE.A.2: Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).
- CCSS.MATH.CONTENT.HSF.LE.A.3: Observe using graphs and tables that a quantity increasing exponentially eventually exceeds a quantity increasing linearly, quadratically, or (more generally) as a polynomial function.

English Language Arts Standards | Common Core State

- CCSS.ELA-LITERACY.SL.11-12.1: Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.
- CCSS.ELA-LITERACY.W.11-12.1.E: Provide a concluding statement or section that follows from and supports the argument presented.
- CCSS.ELA-LITERACY.W.11-12.10: Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

LESSON OBJECTIVE(S)

Students will investigate the interaction(s) between cells and light which create the effects of bioluminescence and biofluorescence and explain at least two ways in which the ability to produce light may be useful to terrestrial and ocean organisms. Students will perform a bacterial transformation process in which the new cell exhibits characteristics of the inserted plasmid.

CAREER CONNECTION(S)

Mentor Background: Alex Tobias: I am a Biotechnology technical professional experienced with leading teams and prosecuting academic, industrial, and government research in the lab. My proudest accomplishments have been (1) the enzyme engineering work I performed on the DuPont/BP Butamax joint venture to develop an isobutanol-producing yeast, (2) the successful push to commercialize 24 ELISA assays as part of the V-PLEX team at Meso Scale Diagnostics, and (3) earning my doctorate as part of the laboratory of Frances Arnold (2018 Nobel Laureate in Chemistry) at Caltech.

I have always taken an inclusive, relationship-building approach to project inception and advancement, and have helped develop team members for successful promotion to greater responsibilities. I enjoy writing and editing technical papers & reports and have done so for large international teams.

STEM Careers: Chemical Engineer-Biotechnology technical leader: Assays, Automation, Protein & Strain Engineering, Synthetic Biology

ENGAGEMENT

Classroom	Virtual
Teacher Actions: • Students will see the word bioluminescence broken down on the board like this: Bio - Luminescence. Students will be asked "What does bio mean? What does illuminate mean?" After students answer these questions, they'll be presented with the definition of bioluminescence. • The teacher will ask students "What organisms have you seen with bioluminescent properties?" • Next, students will be shown pictures of several organisms displaying bioluminescence. • Ask students "What is the purpose of bioluminescence?" Then show them the Finding Nemo - Angler Fish Scene. Ask students "What did the angler fish use its bioluminescent properties for?" Then students can take notes on the different functions of bioluminescence in their notebooks. The notes and pictures will be shown on the Bioluminescence google slides **Student Actions:** • Students will define bioluminescence, verbally answer questions from the teacher, and take notes on the functions of bioluminescence in animals.	**Teacher Actions:** • Instruct students to click on **Bioluminescence Padlet*** and create a note explaining what you think bioluminescence means based on the pictures. • Next, students will watch the video **Finding Nemo - Angler Fish Scene** and think about how the fish uses its bioluminescence. **Student Actions:** • Click on **Bioluminescence Padlet** and create a note explaining what they think bioluminescence means based on the pictures. • Watch the video **Finding Nemo - Angler Fish Scene** and think about how the fish uses its bioluminescence. ***Click here if the link of padlet does not work for an example of the set up.**

EXPLORATION

Classroom	Virtual
Teacher Actions: ● Tell students that they will conduct activities to compare the similarities and differences among other forms of luminescence. ● Have students complete Activity 1 and Activity 2 worksheet. ● Ask students ○ Does the light or glow spread to the rest of the stick, or does it remain focused on the part of the stick that was bent? Link ○ What will happen if students shake the light stick? ○ How the laundry detergent could glow? Link ○ What causes some of these other objects to appear as if they are glowing? ○ How is this type of luminescence different from what the students observed during the prior activity? **Student Actions:** ● Students will follow the teacher's instructions and will complete the Activity 1 and 2 worksheet. Extension: ● Do you want to know more about different ways that we can use bioluminescence? Follow the instructions in this worksheet and come prepared to discuss.	**Teacher Actions:** ● Discuss with the students Part 1A of the worksheet and begin conducting their experiment. Once students complete Part 1A (while waiting for 20 minutes), they can proceed with Part 1B. ● Complete Part 2A and 2B independently. ● Discuss with the class the following: ○ What are some examples of fluorescent things? Name examples of fluorescence in your day-to-day life. ○ Identify two organisms that fluoresce. ○ What special set of conditions does biofluorescence require in order to occur? ○ Do you think the mechanism of fluorescence in the video is the same as you observed in the spinach experiment? ○ How is cracking a glow stick similar to the chemical reaction of bioluminescence? **Student Actions:** ● Follow the teacher's instructions and start Part 1A experiment. ● While waiting for the 20 minutes Part 1A experiment watch Fluorescence video and answer the questions using the Edpuzzle. ● Proceed to Part B Bioluminescence video. ● Come prepared to the virtual class to discuss the worksheet. Extension: ● Do you want to know more about different ways that we can use bioluminescence? Follow the instructions in this worksheet and come prepared to discuss.

EXPLANATION

Classroom	Virtual
Teacher Actions: • Discuss with the students the Google slides and use the worksheet • Have each student research a bioluminescent animal and create a presentation that includes its habitat, diet, and how it uses its bioluminescent ability to survive. Include photos or illustrations of the bioluminescent animal to share with the rest of the class. • Create a mural of an underwater or terrestrial scene that represents a variety of bioluminescent organisms. Have students design the layout in which the organisms are found, and use paint that glows in the dark to represent the parts of the animals' bodies that emit light. Make sure to review with students the difference between paint that glows in the dark (a type of phosphorescent material) and bioluminescence, which is caused by a chemical reaction. **Student Actions:** • Take this worksheet and follow the class discussion. • Research a bioluminescent organism and create a presentation that includes its habitat, diet, and how it uses its bioluminescent ability to survive. Include photos or illustrations of the bioluminescent organism to share with the rest of the class.	**Teacher Actions:** • Discuss with the students the Google slides and use the worksheet • Have each student research a bioluminescent animal and create a presentation that includes its habitat, diet, and how it uses its bioluminescent ability to survive. Include photos or illustrations of the bioluminescent animal to share with the rest of the class. • Create a mural of an underwater or terrestrial scene that represents a variety of bioluminescent organisms. Have students design the layout in which the organisms are found, and use paint that glows in the dark to represent the parts of the animals' bodies that emit light. Make sure to review with students the difference between paint that glows in the dark (a type of phosphorescent material) and bioluminescence, which is caused by a chemical reaction. **Student Actions:** • Take this worksheet and follow the class discussion. • Research a bioluminescent organism and create a presentation that includes its habitat, diet, and how it uses its bioluminescent ability to survive. Include photos or illustrations of the bioluminescent organism to share with the rest of the class.

• Create a mural of an underwater or terrestrial scene that represents a variety of bioluminescent organisms. Design the layout in which the organisms are found, and use paint that glows in the dark to represent the parts of the animals' bodies that emit light. Make sure to review with the teacher the difference between paint that glows in the dark (a type of phosphorescent material) and bioluminescence, which is caused by a chemical reaction. • Use the Living Light Bioluminescence and Scientific Posters Inquiry Guide > Open with Annotate with Kami as a guide for your bioluminescence research project.	• Create a mural of an underwater or terrestrial scene that represents a variety of bioluminescent organisms. Design the layout in which the organisms are found, or use paint that glows in the dark, Padlet, Google Drawings, or any other virtual site to represent the parts of the animals' bodies that emit light. Make sure to review with the teacher the difference between glow organisms in the dark (a type of phosphorescent material) and bioluminescence, which is caused by a chemical reaction. • Use the Living Light Bioluminescence and Scientific Posters Inquiry Guide > Open with Annotate with Kami as a guide for your bioluminescence research project.

ELABORATION

Classroom	Virtual
Teacher Actions: ● Show students individually samples of cultures containing pdawn and pdusk. Ask students to predict what will happen with each one when a black light is applied. Shine the light on the samples. The pDawn should glow . Now turn down/off the lights and shine the light on the samples. After students answer the questions, go over how pdawn and pdusk are regulated by blue light sensors to control expression of a fluorescent protein, blue light activates one while turning off the other. ● Ask students: ○ What are the benefits of things that "glow"? ○ Is the glowing based on living or nonliving means? ○ Why do you think we put aluminum foil around one sample of each of the pDawn and pDusk? ● Pass out the instructions for the glowing jellyfish experiment. Tell students that they need to read the instructions and then take the prelab assessment. **Student Actions:** ● Students will discuss with their partner(s) the benefits of things that glow. ● Students will read the lab instructions and complete the prelab assessment.	**Teacher Actions:** ● Instruct the students to watch the five following videos: ○ Bacterial Transformation ○ Glow in the Dark Mushrooms ○ What Makes Some Animals Glow? ○ Glow in the dark sharks and other sea creatures ○ How deep sea creatures emit their own light ● Instructs students that upon completion of watching the videos, they should provide a "3-2-1 reflection" as it relates to specific resources in this list. Tell us: ○ 3 things you learned ○ 2 things you liked ○ 1 question you have OR 1 concept you would like to explore further. **Student Actions:** ● Students will create a document and provide a "3-2-1 reflection" as it relates to specific resources in the video list. Tell us: ○ 3 things you learned ○ 2 things you liked ○ 1 question you have OR 1 concept you would like to explore further. ● Students will submit the "3-2-1 reflection" document when it is completed.

EVALUATION

Classroom	Virtual
Teacher Actions: • Prelab- Prepare all the materials needed to complete the lab activity. • Discuss the lab instructions and ask if there are any questions. • Monitor students as they are completing the lab activity. **Student Actions:** • Students will follow the instructions for the jellyfish bacteria activity. • Students will write all information down in their journal. • Students will complete the end of the activity questions. • Students will submit a completed formal lab report and their end of the activity questions when completed.	**Teacher Actions:** • Instruct the students to click on the video and write down the lab instructions and results in their online lab journal. • Instruct students to complete a formal lab report and to answer the end of the activity lab questions. **Student Actions:** • Students will watch the video about the transformation of jellyfish bacteria. • Students will write the results down in their journal, pausing the video as needed. • Students will complete the end of the activity questions. • Students will submit their online lab journal, a formal written lab report, and their end of the activity questions when completed.
Extension Suggestions • Using pDawn and/or pDusk incubated in a broth, have students create a new culture every day from the latest culture. Students will collect data and will determine at what point the GFP plasmid is no longer expressed. Students can create timelines and/or graphs of their data. This activity serves as an evolutionary timeline. More detailed instructions can be found here. • Another extension to the lesson. Submit a sample of the pDawn/pDusk plasmid(s) and obtain sequencing to **Interpretation of Sequencing Chromatograms | Sanger Sequencing/Fragment Analysis FAQs**. • The following resources may aid you in planning additional extensions. ○ **Genewiz** ○ **Integrated DNA technologies** ○ **The Sanger Method of DNA Sequencing** ○ **From Dusk till Dawn**	**Extension** • Example Graph can be found in the online lab journal

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