What's the Glow About? The Science Behind Why Things Glow

(7-9 Class Periods)

Authors

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SUBJECT/GRADE LEVEL

Subject Area: Biology

Grade Level: High School 9-12

Materials

Engagement:

- Video clips/images of biofluorescent organisms
- UV/blue light flashlight (450–470 nm)
- Fluorescent household items (tonic water, highlighters, minerals)
- Question Board

Exploration:

GloFish® Fluorescent Fish Video! (Includes our new Gl..

Lab Station Instructions.docx

Digital Versions- Lab Stations

Printable Lab Station Versions

- UV flashlight (450-470 nm)
- Tonic water
- Highlighter ink
- Laundry detergent (with whitener added)
- Fluorescent white paper
- Vaseline
- Toothpaste (with whitener added)
- Uranium glass
- Chlorophyll extract
- Fluorescent dye/paint
- Fluorescent rock
- Dark viewing box
- Observation sheet
- Data sheet
- UV-vis spectrophotometer
- Fluorescein stock solution

- Multiple highlighter ink extracts (yellow, green, pink, orange, blue, etc.)
- Distilled water
- Cuvettes
- Graduated cylinder
- Pipettes
- Test tubes (Eppendorf tubes or something similar)
- Kimwipes
- Data sheet
- 3 glow sticks of same size and color
- 3 250 mL beakers (or cups- hot, room temp, ice water)
- Water
- Ice
- Electric kettle, microwave, hot plate, etc. to obtain “hot” water
- Timer
- Thermometer
- GloFish © tank or GloFish video
- UV flashlight or fish tank blacklight
- Observation sheet
- Liquid Chalk Markers

Explanation:

Card Sorting Cards.docx

Card Sorting Worksheet.docx

Explanation Student Sheet.docx

Elaboration:

Student Directions_ Glow Comparison Carousel Activi…

Lesson 4 glow comparison lab sheet.docx

Evaluation:

Formative Assessment Plan_ “Glow It Up.docx

Extension:

- GloFish Punnett and Chi Square.docx
- Extension Teacher Instructions.docx
- GloFish Mendelian Genetics & Chi-Square Investigatio...
- GloFish Genetics Investigation Teacher.docx

STANDARDS

Next Generation Science Standards

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-LS1.2 Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

HS-LS1.3 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

HS-LS4.1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

HS-LS4.2 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

HS-LS4.3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

HS-LS4.4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

HS-LS4.5 Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

Mathematics Standards | Common Core State Standards

Mathematical Practice

MP.1 Make sense of problems and persevere in solving them: Students will need to interpret information about bioluminescence and fluorescence, analyze data, and solve problems related to genetic probabilities.

Mathematical Standards

HSS.CP.A.1: Describe events as subsets of a sample space (the set of all possible outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events ("or," "and," "not").

- Application: Offspring of a dye injected glo fish with a natural glo fish, what is the outcome?

HSS.CP.A.4: Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities.

English Language Arts Standards | Common Core State

CSS.ELA-Literacy.RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts.

Application: Students will read articles/websites about bioluminescence, fluorescence, and GloFish genetics. They should be able to identify and quote specific sentences or phrases that answer questions about these topics. (e.g., "According to the article, bioluminescence occurs when...")

CCSS.ELA-Literacy.RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

Application: Students will summarize the key differences between bioluminescence and fluorescence, or the main points about how GloFish are genetically modified.

CCSS.ELA-Literacy.RST.6-8.3: Follow precisely a multi-step procedure when carrying out experiments, taking measurements, or performing technical tasks.

Application: When conducting the "Explore" activities with glow sticks, black lights, and fluorescent materials, students will follow step-by-step instructions.

Craft and Structure:

CCSS.ELA-Literacy.RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context.

Application: Students will learn and use vocabulary such as "bioluminescence," "fluorescence," "genetics," "GMO," "DNA," "gene," "protein," "phenotype," "genotype," "allele," "dominant," "recessive."

CCSS.ELA-Literacy.RST.6-8.5: Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.

Application: Students might analyze how a scientific article about GloFish is structured (e.g., introduction to the fish, explanation of the modification process, ethical considerations).

CCSS.ELA-Literacy.RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

Application: Students can discuss why a certain website or article presents information about GloFish the way it does (e.g., is it promoting GloFish, warning about them, or just explaining the science?).

Integration of Knowledge and Ideas:

CCSS.ELA-Literacy.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Application: This is crucial for the genetics component. Students will interpret diagrams of DNA and genes, and use Punnett squares (a visual/mathematical representation) to understand genetic crosses. They should be able to explain the information from these visuals in words.

CCSS.ELA-Literacy.RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

Application: Especially when discussing the ethics of GMOs or the potential impact of GloFish, students will need to differentiate between scientifically proven facts, expert opinions, and unsubstantiated claims.

CCSS.ELA-Literacy.RST.6-8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

Application: Students will compare their observations of real GloFish (or videos) with what they read about their genetics and glowing properties. They will compare information from different sources (e.g., a scientific journal article vs. a news report about GMOs).

LESSON OBJECTIVE(S)

At the end of this lesson, students will be able to:

- Define and differentiate between biofluorescence, bioluminescence, and general fluorescence based on their light source, mechanism, and whether external light is required.
- Identify examples of organisms and materials that exhibit these various forms of light production.
- Explain the molecular basis of biofluorescence, specifically the role of genetically encoded fluorescent proteins (like GFP) in absorbing and re-emitting light at different wavelengths.

- Describe the genetic pathway (Central Dogma) from DNA to RNA to fluorescent protein, demonstrating how biofluorescence is an inherited trait.
- Compare and contrast natural biofluorescence with artificially induced glowing (e.g., dyed organisms, genetically engineered GloFish), emphasizing the heritability and permanence of the trait.
- Analyze the ethical considerations surrounding genetically modified organisms, particularly in the context of commercial applications like GloFish.
- Apply probability concepts (e.g., sample space, Punnett squares, theoretical vs. empirical probability) to predict and analyze the inheritance patterns of the fluorescent trait in organisms like GloFish.
- Discuss the ecological roles and potential evolutionary advantages of biofluorescence in various organisms.
- Describe methods used to study biofluorescence in organisms (e.g., UV-Vis spectroscopy, observation under UV light).

CAREER CONNECTION(S)

Mentor Background: Dr. Jesse Roberts: Dr. Roberts is a research chemical engineer within the Environmental Laboratory at the U.S. Army Engineering Research and Development Center (ERDC) in Vicksburg, MS. They provide solutions for tomorrow's environmental challenges by finding new ways to clean water and remediate environmental contaminants. His role focuses on developing and characterizing new materials for synthetic biology and environmental applications. Specifically, Dr. Roberts works with graphene nanomaterials to remove harmful cyanotoxins from water sources that pose a significant risk to human health. Dr. Roberts has a PhD in chemical engineering from the University of Arkansas where he focused on biomaterial development for tissue engineering and biosensing applications. His team serves to make the world better by developing and utilizing materials to provide sustainable water infrastructure through clean and safe water.

STEM Careers:

- Biologist
- Statistician
- Chemists
- Geneticist
- Medical Doctor

ENGAGEMENT

Brief Description:
Students will identify examples of biofluorescent organisms and formulate initial questions about their

ability to glow. Time Frame 1 Period

Lesson 1:

Materials:

- Video clips/images of biofluorescent organisms
- UV/blue light flashlight (450–470 nm)
- Fluorescent household items (tonic water, highlighters, minerals)
- Question Board or whiteboard/poster paper and markers

Procedures:
To begin the lesson, darken the room so that the observation can begin. Students are then shown the side-by-side organisms in both regular and UV light, revealing the hidden fluorescent glows. The continuation of this goes to demonstrate uv -induced with fluorescence with common items. Create the question board and introduce students to the term biofluorescence.

Specific Adaptations for Each Assessment Type:

Engage Phase: Think-Pair-Share and Question Board Analysis

- Adaptation: Provide visual cues or pre-selected images of glowing organisms to help prompt initial observations. For the Question Board, allow students to draw their questions or use a picture symbol if writing is a barrier. The teacher can transcribe their verbal questions.

EXPLORATION

Brief Description: Students will observe fluorescence in a variety of materials and make connections to the scientific method. (Time Frame: 2-3 periods)

Procedures:

Lab Station Instructions.docx

Digital Versions- Lab Stations

Printable Lab Station Versions

Station 1: Fluorescent Funhouse

Objective: Observe how different materials fluoresce under UV light.

Materials:

- UV flashlight (450-470 nm)
- Tonic water
- Highlighter ink
- Laundry detergent (with whitener added)
- Fluorescent white paper
- Vaseline
- Toothpaste (with whitener added)
- Uranium glass
- Chlorophyll extract
- Fluorescent dye/paint
- Fluorescent rock
- Dark viewing box
- Observation sheet

Instructions:

1. Place each object into the dark box.
2. Shine the UV light on the object and observe.
3. Record the color of the object under normal light and under UV light.

Station 2: GloFish © Observation

Objective: Examine GloFish © under normal and UV light

Materials:
GloFish © tank or GloFish video
UV flashlight or fish tank blacklight
Observation sheet

Instructions:

1. Observe the fish under normal lighting.
2. Turn off overhead lights and use UV flashlight or turn on the blacklight on the fish tank hood if included.
3. Note what colors appear and where.
4. Record the colors of the fish under normal light and under UV light as well as glow location or pattern.
5. Choose a second fish and repeat the procedure.

Station 3: UV-Vis Spectroscopy

Objective: Investigate how fluorescent molecules absorb and emit light using UV-Vis equipment.

Materials:

- UV-vis spectrophotometer
- Fluorescein stock solution
- Multiple highlighter ink extracts (yellow, green, pink, orange, blue, etc.)
- Distilled water
- Cuvettes
- Graduated cylinder
- Pipettes
- Test tubes (Eppendorf tubes or something similar)
- Kimwipes
- Data sheet

$M_1 \times V_1 = M_2 \times V_2$

M_1 = initial molarity (final concentration)
V_1 = volume of stock solution used
M_2 = final molarity (final concentration)
V_2 = final volume of diluted solution

Instructions:

1. Turn on the UV-Vis spectrophotometer and allow it to warm up.
2. Create two 10 mL dilutions of fluorescein (e.g. 1:10 and 1:100) Label your tubes.
    a. Label the test tubes including the following information: concentration (e.g. “0.1 M fluorescein”), date, and your initials or group number
    b. Use the dilution formula to determine the amount of each substance that you will need.
    c. Use a graduated cylinder or pipette to measure the calculated volume (V_1) of stock solution.
    d. Pour it into a clean test tube.
    e. Add enough distilled water to reach the final volume (V_2).
    f. Gently swirl or stir with a clean stirring rod. (Or cap and invert the test tube several times to ensure mixing.)
    g. Repeat the procedure with one highlighter color of your choice.
3. Rinse and fill a cuvette with distilled water to use as your blank. Wipe with a Kimwipe and zero the spectrophotometer.
4. Test each fluorescein dilution (1:1, 1:10, and 1:100). Rinse a cuvette with the sample, fill it, wipe it, and scan from 35-700 nm.
5. Record the peak absorbance wavelength and intensity.
6. Repeat the process with the chosen highlighter dilution series.
7. Test each additional highlighter color extraction (not diluted). Rinse a cuvette with the sample, fill it, wipe it, and scan from 35-700 nm.
8. Record the peak absorbance wavelength and intensity.
9. Compare how emission intensity changes across the different substances.

Station 4: Glow Stick Temperature Experiment

Objective: Test how temperature affects chemiluminescence

Materials:
3 glow sticks of same size and color
3 250 mL beakers (or cups- hot, room temp, ice water)
Water
Ice
Electric kettle, microwave, hot plate, etc. to obtain “hot” water
Timer
Thermometer (optional)

Instructions:

1. Activate (snap) each glow stick at the same time.
2. Shake glow sticks for 30 seconds.
3. Place 200 mL of “hot” water into one beaker.
4. Place 200 mL of room temperature water into a second beaker.
5. Place 200 mL of ice water into a third beaker.
6. Place one glow stick into each cup and start the stopwatch.
7. Record observations every 5 minutes for a total of 20 minutes.

Station 5: Light Interaction Model

Objective: Model how electrons interact with light by absorbing and releasing energy.

Method 1

Materials:
Beads, buttons, pom-poms (or something else to represent electrons)
Paper plate or printed diagram for electron shells
String, pipe cleaners, or yarn (represent energy movement)
Markers or sticky notes for labeling
Tape
Atom diagram template (optional)

Instructions:
Step 1: Build your atom model

1. Use your materials to create a nucleus in the center
2. Add one electron on the first energy level (this is the ground state).
3. Label the nucleus and ground state with sticky notes

Step 2: Model Excitation

1. Show the electron absorbing energy from a light source (like a photon)
2. Move the electron to a higher energy level (choose an outer ring).
3. Use string or a labeled arrow to show the direction of movement.

4. Add a label: “Electron absorbs energy -> moves to excited state”.

Step 3: Model Emission

1. Show the electron releasing energy by falling back to the ground state.
2. Attach a new arrow pointing back to the original energy level.
3. Label it: “Electrons release energy as light (emission)”.
4. Add a small paper circle or drawing to represent the photon being released.

Method 2

Materials:
Liquid chalk markers

Students can use the steps listed for method 1 but draw and label the models on the lab benches using the liquid chalk markers.

Specific Adaptations for Each Assessment Type:

Explore Phase: Observation Charts, Group Discussions, and "3-2-1 Summary" Exit Ticket

- Adaptation for Charts: Offer simplified observation charts with fewer blanks or pre-filled sections. Use a clear, large font. For students with fine motor difficulties, ensure tools (e.g., larger markers) are available.
- Adaptation for Discussions: Pair students strategically (e.g., a strong peer with a peer who needs support) to facilitate discussion. Provide specific roles within groups to ensure participation.
- Adaptation for Exit Ticket: As mentioned above, provide sentence starters or allow verbal responses if writing is challenging.

EXPLANATION

Brief Description: Students explain the role of biofluorescent proteins and understand how DNA leads to protein expression. (Time Frame: 2 class Periods)

Procedures:
Objective: Students will explain how biofluorescent proteins function and describe how DNA leads to the creation of these proteins.

1. Review lab findings (from Exploration)
    a. Briefly discuss what students observed in the previous lab stations (light emission, light absorption, highlighters, fluorescein, concentration differences, why some items fluoresce while others do not, natural light versus UV light, glow patterns in fish, temperature changes, etc.)

b. Ask:
    i. What did you observe glowing under UV light?
    ii. Did anything glow without needing UV light?
    iii. What could cause these differences?
    iv. What do you think causes the glow in some organisms?

2. Transition "Today we'll explore two natural ways organisms glow–biofluorescence and bioluminescence–and how both are connected to the genetic code."
3. Introduce GFP (Green Fluorescent Protein)
    a. Show images or video clips of jellyfish, corals, or axolotls expressing GFP.
    b. Explain the GFP is a naturally occurring biofluorescent protein that absorbs UV/blue light and emits it as green visible color.
    c. GFP has a special chromophore that performs the biofluorescence process.
        i. **Light absorption:** A molecule called a fluorophone inside the organism absorbs high-energy photons (e.g., UV or blue light).
        ii. **Relaxation:** Almost immediately (within nanoseconds), the excited electrons begin to lose some energy (as heat or vibration).
        iii. **Emission of Light (Fluorescence)**: The electrons return to their ground state by releasing a photon. This emitted photon has less energy (i.e., a longer wavelength) than the absorbed one–often appearing as green , orange, or red light.
    d. Emphasize: This protein is made because of instructions in the organism's DNA.
4. Use visuals to explain light interactions
    a. Show a simple visual:
        i. Photon in (UV or blue light) -> Electron excited -> Photon out (green light)
    b. Connect to students' lab experiences with GloFish © and UV light.
5. Connect to DNA

Biofluorescence Example (GFP)

a. Display and explain: DNA -> RNA -> Protein
b. DNA contains the gene for Green Fluorescent Protein (GFP)
c. The gene is transcribed to RNA
d. RNA is translated into a biofluorescent protein
e. The protein becomes part of the organism's cells and causes the visible glow under UV light.
f. Ask students: "How do you think this ability could be passed from one organism to another?"

Bioluminescence Example (Firefly and deep-sea anglerfish)

g. DNA contains genes for luciferase (an enzyme)
h. RNA is transcribed
i. Protein (luciferase) is made and catalyzes a chemical reaction with luciferin, oxygen, and ATP

j. Light is emitted as a result of the reaction
k. Ask students: “How are these glowing traits inherited? What are the similarities between biofluorescence and bioluminescence at the genetic level?”

6. Emphasize the Genetics Basis
   a. Both processes are encoded in DNA.
   b. Through transcription and translation, organisms create specialized proteins–biofluorescent or bioluminescent–that give them the ability to glow.
7. Reasons for bioluminescence and biofluorescence- camouflage, communication, mating, or UV protection
8. Recap- Distinguish between Biofluorescence vs. Bioluminescence

Feature	Biofluorescence	Bioluminescence
Light source	Requires external light (e.g. UV)	Produces light through internal chemical reactions
Process Type	Light absorption -> emission	Chemical reaction (luciferin + oxygen + luciferase)
Energy Source	Light energy	Chemical energy (ATP)
Organisms	Corals, GFP in jellyfish, some fish, amphibians, GloFish, parrots	Fireflies, deep-sea fish, some fungi, bacteria
Gene-Based?	Yes, gene codes for fluorescent proteins	Yes, gene codes for luciferase and associated enzymes

9. Students will then use **Card Sorting Cards.docx** to strengthen understanding of the information presented to them.

Card Sorting Worksheet.docx

10. Students will be able to complete the **Explanation Student Sheet.docx** by viewing the provided video clips.
11. **Specific Adaptations for Each Assessment Type:**

    Explain Phase: "Natural Fluorescence Explained" Worksheet

    - Adaptation: Provide partially completed diagrams for labeling, or a cut-and-paste activity for the flow chart instead of requiring students to write everything from scratch. Offer multiple-choice options for some conceptual questions if open-ended responses are too challenging.

Understanding Biofluorescence

1. **National Geographic – Biofluorescent Creatures**
   Stunning underwater footage of glowing marine organisms like corals, sharks, and fish under UV light.
   National Geographic - Bioluminescent Creatures - Documentary 2016 HD 1080p

2. **GFP: The Protein That Changed Biology (HHMI Biointeractive)**
   A short animation explaining how Green Fluorescent Protein (GFP) is used in research.
   Visualizing Gene-Expression Patterns

3. **Aequorea victoria and GFP (minutephysics-style animation)**
   Explains where GFP comes from and how it fluoresces.
   GFP and Jellyfish | Green Fluorescent Protein & Aequorea victoria - YouTube

Understanding Bioluminescence

4. **What's Behind the Fireflies Glow? What's Inside?**
   Zooms into fireflies' light-producing organs and explains luciferin-luciferase chemistry.
   What's Behind the Fireflies Glow? What's Inside?

5. **Bioluminescence Explained – TED-Ed**
   Illustrated video explaining the chemical process and why bioluminescence evolved.
   The brilliance of bioluminescence - Leslie Kenna

6. **How Glow-in-the-Dark Organisms Work – IFL Science**
   Compares biofluorescence vs. bioluminescence clearly with visuals.
   Biofluorescence vs Bioluminescence

DNA → RNA → Protein (Central Dogma)

7. **The Central Dogma of Biology – Amoeba Sisters**
   Engaging cartoon-style explanation of transcription and translation for high schoolers.
   Amoeba Sisters – Central Dogma

8. **Protein Synthesis Animation – BioMan Biology**
   Step-by-step animation showing transcription and translation in action.
   BioMan Biology – Protein Synthesis Game & Animation

Application in Genetic Engineering

9. **How Scientists Use GFP**
   Short video showing how GFP is used as a "tag" in genetic engineering.
   GFP and its application in biomedical research | Visualizations of cell using the GFP reporter

10. **Developing GFP as a Biological Marker**
    Nobel Prize in Chemistry 2008- For developing GFP as a biological marker
    Martin Chalfie (Columbia University): Developing GFP as a Biological Marker

ELABORATE

Brief Description: Students compare natural biofluorescence to artificial methods such as dyes and GloFish genetic engineering.
1-2 Class Periods Lesson 4

Student Directions_ Glow Comparison Carousel Activity - Genetics Focus.docx

Lesson 4 glow comparison lab sheet.docx

Procedures: Glow Comparison Carousel Activity: Station (Lab Stations)
Materials:

1. Natural Biofluorescent Fish (e.g., coral reef fish) Glow in the dark sharks Glowing animals: understanding bioluminescence and biofluorescence
2. GloFish science and genetic engineering background How Glo Fish are made
3. DNA vs. Dye comparison (inherited vs. temporary glow)Inherited Glow Dye injected fish

Instructions for Lab:

2. **Form Your Group:** Work in your assigned groups. Each member is responsible for contributing to the discussion and completion of the lab sheet.
3. **Read the Introduction:** Before you begin, carefully read the "Introduction" section on your lab sheet. This will provide an overview of the activity and its main focus.
4. **Station Rotation:**
    - You will rotate through three different stations. Your teacher will tell you the order in which your group should rotate.
    - You will have a designated amount of time at each station (e.g., 10-15 minutes). When your teacher signals, you will move to the next station.
    - **Focus on the genetic aspects** at each station as you gather information.
5. **At Each Station:**
    - **Read the Station Description:** Familiarize yourself with the materials and guiding questions for the current station.
    - **Observe and Analyze:** Carefully observe the images, videos, and information provided at the station. Discuss your observations and the provided text with your group members.
    - **Complete the Lab Sheet:** Answer all questions for that station directly on your lab sheet. Make sure your answers are thorough and address the genetic focus of each question. Use complete sentences and provide explanations where asked.
6. **Class Synthesis (After Station Rotations):**
    - Once your group has completed all three stations, return to your original work area.
    - **Venn Diagram:** Work together to complete the Venn diagram on the "Class Synthesis" section of your lab sheet. Categorize the characteristics of Natural Biofluorescence, GloFish (Genetic Engineering), and Dyes (Temporary), paying close attention to the genetic basis and heritability.

- **Discussion Questions:** Discuss the "Discussion Questions" with your group. Formulate thoughtful answers that integrate the information you gathered from all three stations, especially concerning inheritance, gene expression, and ethical implications.

7. **Review and Submit:** Before submitting, review your entire lab sheet to ensure all questions are answered, your explanations are clear, and your Venn diagram is complete. Make sure everyone in your group understands the concepts.

EVALUATION

Brief Description: To ensure all students can demonstrate their understanding of bioluminescence, fluorescence, and the genetics of GloFish

Demonstrating Biofluorescence Mastery

Objective: Students will demonstrate their comprehensive understanding of biofluorescence, its mechanisms, and the distinction between natural and artificial forms.

Materials:

- Assessment: Scenario Analysis & Diagram Labeling Assessment.docx
- Rubric for the assessment. Rubric for Demonstrating Bioflurescence

Assessment Plan:

Part 1: Natural Fluorescence Explained Worksheet

- **Worksheet:**
  - **Section A: Define & Describe**

    1. Define biofluorescence in your own words.

    2. What are fluorescent proteins, and what is their role in biofluorescence?

    3. How does light absorption and re-emission occur in biofluorescence? Use terms like "excitation" and "emission."

    4. Explain the relationship between DNA, genes, and fluorescent proteins.

  - **Section B: Diagram Analysis**

        - Provide a simplified diagram of a cell with a nucleus, ribosomes, and a fluorescent protein being synthesized. Ask students to label: DNA, gene, mRNA, ribosome, fluorescent protein. Explain the process shown in the diagram.
    - **Section C: Short Answer**

        5. Describe two potential ecological advantages for a fish that can be biofluorescent.

        6. Give an example of an animal (other than a fish) that exhibits biofluorescence and describe how it might use this ability.

Part 2: Biofluorescence Comparison & Scenario Assessment (In-class, 30 minutes)

- **Scenario A: The Deep-Sea Dragonfish**
    - Scientists discover a new species of deep-sea dragonfish that glows red when exposed to certain blue light. They find that this glow is consistent across generations. Genetic analysis reveals that the fish naturally produces a unique red fluorescent protein.
    - **Questions:**

        7. Is this phenomenon biofluorescence or bioluminescence? Justify your answer.

        8. Explain the likely mechanism by which this fish produces its red glow, including the role of the fluorescent protein.

        9.Why is the glowing trait passed on to the offspring? Connect your answer to DNA.

- **Scenario B: The "Sparkle" Aquarium Fish**
    - A new type of "Sparkle" fish is sold in pet stores. It glows bright blue under normal aquarium lights. Upon investigation, it's revealed that the fish were created by injecting a gene from a jellyfish into the eggs of a common guppy.
    - **Questions:**

        10. Is this an example of natural biofluorescence? Explain why or why not. (4 points)

        11. Compare and contrast the "Sparkle" fish's glow with the deep-sea dragonfish's glow. Focus on the *origin* of the glowing ability and its *heritability*.

        12. If someone simply injected a blue dye into a guppy, how would its glow differ from the "Sparkle" fish's glow?

Student Adaptations for the assessment:

To ensure all students can demonstrate their understanding of bioluminescence, fluorescence, and the genetics of GloFish, here are some adaptations for the formative assessment plan:

General Adaptations for All Assessments:

- Extended Time: Provide additional time for students who process information or complete tasks more slowly. This can be for worksheets, lab observations, or any written response.
- Reduced Workload/Chunking: Break down larger tasks or worksheets into smaller, manageable sections. For example, instead of completing an entire lab handout at once, focus on one section at a time.
- Preferred Format for Responses: Allow students to respond in various ways beyond traditional writing, such as:
    - Verbal Explanations: Students can explain their answers or observations aloud to the teacher, a small group, or a peer.
    - Drawing/Diagramming: Encourage the use of diagrams, flowcharts, or concept maps with labels, even if minimal text is included. This is especially helpful for visual learners or those with writing difficulties.
    - Dictation: For students who struggle with handwriting or typing, allow them to dictate their answers to a teacher, aide, or use speech-to-text software.
- Sentence Starters/Sentence Frames: Provide sentence starters or frames for written responses, especially for students who struggle with initiating writing or structuring their thoughts.
    - *Example for "3-2-1 Summary":* "Three things I observed were... / Two new terms I learned are... / One question I still have is..."
    - *Example for "Natural Fluorescence Explained" worksheet:* "Light is absorbed by the protein, which causes it to..." or "The ability to glow is inherited because..."
- Word Banks: Offer word banks for key vocabulary terms (e.g., excitation, emission, wavelength, protein, DNA, inherited) to aid in recall and accurate usage in written responses.
- Access to Notes/Resources: For formative assessments, allow students to use their class notes, lab handouts, or the comparison chart. This reduces the burden of memorization and focuses on comprehension and application.
- Check-ins and Scaffolding: Increase the frequency of one-on-one or small-group check-ins during work time. Provide guiding questions, rephrase instructions, or offer hints to help students progress.

Specific Adaptations for Each Assessment Type:

Evaluate Phase (Formative "Mini-Scenario Application"):

- Adaptation: Offer the scenarios read aloud multiple times. Provide simplified language in the scenarios. Include multiple-choice options for the answer choices, along with a space for a brief explanation. For students who struggle with written explanations, accept bullet points or a verbal justification.

EXTENSIONS

GloFish Punnett and Chi Square.docx

Extension Teacher Instructions.docx

GloFish Mendelian Genetics & Chi-Square Investigation.docx

GloFish Genetics Investigation Teacher.docx

Transformation of E. coli with Green Fluorescent Protein (Edvotek Lab)

REFERENCES

- Amoeba Sisters- Proteins
- Biofluorescence vs Bioluminescence
- BioMan Biology – Protein Synthesis Game & Animation
- The brilliance of bioluminescence - Leslie Kenna
- Chi Square Test: AP® Biology Crash Course | Albert.io
- GFP and its application in biomedical research | Visualizations of cell using the GFP reporter
- GFP and Jellyfish | Green Fluorescent Protein & Aequorea victoria - YouTube
- GloFish
- GloFish® Fluorescent Fish Video! (Includes our new GloFish Tetras!)
- Martin Chalfie (Columbia University): Developing GFP as a Biological Marker
- National Geographic - Bioluminescent Creatures - Documentary 2016 HD 1080p
- Protein Synthesis Race
- Visualizing Gene-Expression Patterns
- Zebrafish in the Classroom

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