**Lesson 4: Applications and Ethical Considerations for Optogenetics Technology**

**Author:** Janhavi Gupta, Science Teacher, Union County Vocational Technical Schools - Magnet High School (Scotch Plains, NJ) and 2021 Research Experience for Teachers program participant

**Date:** August 2021

**LESSON OVERVIEW**

**Activity Time:**

Two 50 minute class periods. Additional time for finishing group presentations as homework if needed.

**Lesson Plan Summary:**

In this lesson, student groups will choose a short science article on recent findings in the field of optogenetics. Students will use the [BRAVE Technical Reading Rubric](https://docs.google.com/document/d/1l1T8tqvdVYZrcDVV_483gOGMRb4Nd6Il/edit) to understand and present the information to the class. Students will be encouraged to explore any ethical considerations which may arise and elaborate on them during their presentations.

**STUDENT UNDERSTANDINGS**

**Investigative Phenomenon/Problem:**

* **Description of Phenomenon/Problem:** Ongoing research in new technologies such as optogenetics can help us answer fundamental questions. These technologies are being applied in various ways to solve real world problems, such as curing blindness.
* **Driving Question:** How is solving real world problems an endeavour needing concerted effort and creativity from many different disciplines of sciences?

**Learning Objectives:**

*Students will know…*

* About different applications of optogenetics technology and how it can be applied in different scenarios, sometimes as a cure for blindness.

*Students will be able to…*

* Understand how one principal technology can be applied in many different ways.
* Reflect on ethical considerations which need to be evaluated before implementing any new technological applications.

**Vocabulary**:

* **Bioethics:** A specialization within the field of ethics that is concerned with the societal issues surrounding biomedical research, new scientific techniques, and new biomedical technologies, devices, and treatments. Bioethicists consider the ethical, legal, and social implications of research, treatments, and technologies. The study of bioethics includes three main principles: *respect for persons*, *maximizing benefits/minimizing harm*, and *justice*.
* **Ethics:** A system of moral principles. Rules or standards that govern thinking, decision making, and behavior, in particular for how humans think and act in regards to others.
* **Neural engineering:** An engineering discipline that uses concepts from math and science to connect to and interact with the nervous system. Neural engineering is based on the loop between the sensory information that is received by the brain, information that the central nervous system (CNS) sends out, and computers/machines that receive input and produce outputs that feed back into the CNS.
* **Neuroethics:** The study of philosophical issues related to neurotechnologies; a sub-specialty within the study of bioethics. Neuroethics combines an understanding of neuroscience, philosophy, and the legal system. Neuroethical issues can arise during the design of a neurologically-focused device, drug, or therapy, all the way to the impacts it has once used with patients. Neuroethics deals with complex philosophical issues, such as *identity*, *security*, *privacy*, *autonomy*, *fairness*, and *justice*. Questions include the ethics of the methodology of research studies, accessibility of devices, legality of rights and patents, and delineating the line between human/animal consciousness, volition, and computer/machine influence.
* **Optogenetics (optical stimulation):** A technique used by neuroscientists that uses both light and genetic manipulation to control neurons. Neurons are genetically manipulated to be light-sensitive, thus enabling light to cause neurons to fire.
* **Technology:** Equipment, machinery, devices, or computer programs that are developed through a knowledge of science and/or engineering.

**Next Generation Science Standards:**

This lesson builds toward the following Performance Expectation (PE) and its integrated three dimensions of learning. Additional dimensions are denoted with an asterisk (\*).

| **High School Performance Expectations** | | |
| --- | --- | --- |
| [**HS-LS1-1**](https://www.nextgenscience.org/pe/hs-ls1-1-molecules-organisms-structures-and-processes) **From Molecules to Organisms: Structures and Processes**  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**](https://www.nextgenscience.org/pe/hs-ls1-2-molecules-organisms-structures-and-processes) **From Molecules to Organisms: Structures and Processes**  Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms. | | |
| **Science and Engineering Practices (SEPs)** | **Disciplinary Core Idea(s)** | **Crosscutting Concepts (CCCs)** |
| Constructing Explanations and Designing Solutions    Developing and Using Models  \*Asking Questions and Defining Problems \**Connections to the Nature of Science*Scientific Investigations Use a Variety of Methods | LS1.A: Structure and Function  \*ETS1.A: Defining and Delimiting an Engineering Problem | Structure and Function  Systems and System Models  ***Connections to Engineering, Technology, and Applications of Science***  \*Science is a Human Endeavor |

**Common Core State Standards:**

* **CCSS.ELA-LITERACY.RST.11-12.7:** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
* **CCSS.ELA-LITERACY.RST.11-12.9:** Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
* **CCSS.ELA-LITERACY.RST.11-12.10:** By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.
* **WHST .11-12.8:** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively ; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding

plagiarism and overreliance on any one source and following a standard format for citation. (HS-LS1-3)

* **WHST .9-12.9:** Draw evidence from informational texts to support analysis, reflection, and research. (HS -LS1-1)
* **SL.11-12.5:** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings,

reasoning, and evidence and to add interest.

**TEACHER PREPARATION**

**Materials:**

| **Material** | **Description** | **Quantity** |
| --- | --- | --- |
| Classroom Computer | Teacher computer with projector, speakers, and internet connection to project slideshow and videos | 1 |
| Supplies | Student chromebooks/devices with internet and access to powerpoint or google slides.  [Genetic Engineering and Biotechnology News - Optogenetics](https://www.genengnews.com/category/optogenetics/) website  Laser pointer for students use if available (1 per class) | 1 per lab student |
| Documents | [Student Handouts 4: BRAVE Technical Reading Guide](https://docs.google.com/document/d/1MfaGTig9CnMHirfkdvF250E0xHSMjpfBdzDcRbkPn3g/edit#)  (Additional resource available at: <https://uw.pressbooks.pub/yspreach2020/back-matter/appendix/>)  [Student Handout 4: Ethical Decision-making Framework](https://www.nwabr.org/sites/default/files/DMFSinglepage.pdf) from NWABR.org  [Student Handout 4: Topics List for Bioethics](https://www.nwabr.org/sites/default/files/TopicsList.pdf) from NWABR.org | All student handout - 1 per student |
| Resource | [Teacher Resources 4\_Decision Making Framework Background](https://www.nwabr.org/sites/default/files/DMFBackground.pdf) from NWABR.org | For teacher use |

**Preparation:**

1. Make copies of [Student Handout 4: Ethical Decision Making Framework](https://www.nwabr.org/sites/default/files/DMFSinglepage.pdf) /per student
2. Make copies of [Student Handouts 4: BRAVE Technical Reading Guide](https://docs.google.com/document/d/1sQJ1Yq0a_oTO8Hn4m7KLAXCF7NZ2wBmc/edit). If students need additional support, they can access the following resource:

How to Read an Article from an Academic Journal (Bergsman & Chudler, 2020)

<https://uw.pressbooks.pub/yspreach2020/back-matter/appendix/>

1. Make copies of [Student Handout 4: Topics List for Bioethics](https://www.nwabr.org/sites/default/files/TopicsList.pdf).

**PROCEDURE**

**Activity 1: Background Reading (5 min)**

1. Assign students to read an article about how epigenetics was used to restore a man’s vision. (Note: This could be assigned as homework prior to launching the lesson).

**Injection of Light-sensitive Proteins Restores Blind Man’s Vision**

Sara Reardon, Nature May 24, 2021

<https://www.nature.com/articles/d41586-021-01421-0>

**Activity 2: Article Review & Presentation Preparation (45 min)**

1. Students will break out into groups of 2-3. Each group needs to choose one science article from the following website. There are many articles to choose from; teacher is encouraged to guide the student groups in choosing unique articles to avoid repetition during presentations the next day.

**Genetic Engineering and Biotechnology News - Optogenetics** website

<https://www.genengnews.com/category/optogenetics/>

1. Students will use the [Student Handouts 4: BRAVE Technical Reading Rubric](https://docs.google.com/document/d/1sQJ1Yq0a_oTO8Hn4m7KLAXCF7NZ2wBmc/edit)  to understand the technical information in the article. They also need to prepare a presentation on their chosen article.

**Note:** Additional resources for students on how to read a technical article are available at: <https://uw.pressbooks.pub/yspreach2020/back-matter/appendix/>

1. As they are reading the article, encourage students to reflect on ethical considerations related to the technology featured in their article. Students can be guided by using [Student Handout 4: Ethical Decision Making Framework](https://www.nwabr.org/sites/default/files/DMFSinglepage.pdf) and [Student Handout 4: Topics List for Bioethics](https://www.nwabr.org/sites/default/files/TopicsList.pdf) from the Northwest Association for Biomedical Research. Students should be encouraged to incorporate a discussion of ethical considerations into their presentations.
2. Beyond the provided article, students can be encouraged to use relevant scientific publications and resources to gain a firm understanding of their chosen optogenetics application news.

**Activity 3: Student Group Presentations (50 min)**

1. Allow time in class for each group to present on their article. Encourage students to act as active audience members, including asking questions at the end of each presentation.
2. The teacher can use any rubric recommended by their school district or use the [BRAVE Rubric](https://docs.google.com/document/d/1xdOR63o591z0-fyu-WJRCCjbwfYKqb9W/edit) to grade student presentations and give feedback to the students.
3. An Exit Ticket can be assigned to capture students’ reflection of their learning after engaging in this lesson sequence.

**STUDENT ASSESSMENT**

**Assessment Opportunities:**

Student group presentations provide an opportunity for assessment, using any rubric recommended by their school district or use the [BRAVE Rubric](https://docs.google.com/document/d/1xdOR63o591z0-fyu-WJRCCjbwfYKqb9W/edit) to grade student presentations and give feedback to the students.

**DIFFERENTIATION FOR INCLUSIVE INSTRUCTION**

**Adaptations for Remote Learning Environments:**

| **Name of Activity** | **Remote Adaptations** |
| --- | --- |
| **Activity 1** | Give students the URL for the Do Now [article](https://www.nature.com/articles/d41586-021-01421-0) to access asynchronously. |
| **Activity 2** | Use breakout rooms on Zoom/Google Meet to facilitate student collaboration in their groups and provide them one-on-one help when needed. Alternatively, make the article review assignment an independent (rather than group) assignment. |
| **Activity 3** | Allow student groups to present during a class meeting on Zoom/Google Meet. Alternatively, students can upload videos of their presentations to a FlipGrid or your LMS. |

**Adaptations for Learners’ Needs:**

* Learners with special needs can have more words on the slide or use Newsela to find resources at appropriate levels.
* Additional resources for students on how to read a technical article are available at: <https://uw.pressbooks.pub/yspreach2020/back-matter/appendix/>

**Extension Activities to Build on Student Interest and Expertise:**

* Student groups can present a research paper instead of short science articles on application of optogenetics.

**TEACHER BACKGROUND & RESOURCES**

**Background Information:**

Visit these websites for more information on teaching about bioethics and neuroethics.

Northwest Association for Biomedical Research - Teacher Center

<https://www.nwabr.org/teacher-center>

Neuroethics & Philosophy Teaching Resources - Center for Neurotechnology

<https://centerforneurotech.uw.edu/education-resources-teachers/neuroethics-philosophy>

**Additional Resources:**

If students want to explore research papers, try <https://pubmed.ncbi.nlm.nih.gov/>

This works like a Google search and students can choose free articles to present.

