Lesson 1: What is regeneration?

I. Overview
This introductory lesson motivates the unit by asking the question “What is regeneration?” Through this lesson, the unit’s driving question is introduced and examined. The lesson activities stimulate student interest in learning about what the term regeneration means by providing a series of science articles on regeneration and healing in humans and other species. Students generate questions about regeneration that will be investigated throughout the unit. Students are introduced to the idea of model organisms, which provides the rationale for studying planarians in this unit. Students are also introduced to the scientific practice of modeling, which is emphasized throughout the unit.

Connections to the driving question
In this unit students will learn how planarians regenerate and what this tells scientists about regeneration in general.

II. Standards

National Science Education Standards
- Science as Inquiry. Identify questions and concepts that guide scientific investigation (9-12 A: 1/1).
- The Behavior of Organisms. Multicellular animals have nervous systems that generate behavior. Nervous systems are formed from specialized cells that conduct signals rapidly through the long cell extensions that make up nerves. The nerve cells communicate with each other by secreting specific excitatory and inhibitory molecules. In sense organs, specialized cells detect light, sound, and specific chemicals and enable animals to monitor what is going on in the world around them (9-12 C: 6/1).

Benchmarks for Science Literacy
The Nature of Science: The Scientific Enterprise
- Current ethics in science hold that research involving human subjects may be conducted only with the informed consent of the subjects, even if this constraint limits some kinds of potentially important research or influences the results. 1C/H5a*
### III. Learning objectives

<table>
<thead>
<tr>
<th>Learning objective</th>
<th>Assessment Criteria</th>
<th>Location in Lesson</th>
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</thead>
<tbody>
<tr>
<td>Synthesize and summarize information from a 1-2 page article</td>
<td>Summaries should be accurate, succinct, and reflect the ideas expressed in the respective articles students read.</td>
<td>Activity 1: Jigsaw about science of regeneration</td>
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<td>Generate questions to guide inquiry about a specific topic</td>
<td>Questions should relate to regeneration.</td>
<td>Activity 2: Generation of regeneration questions</td>
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<td>Define regeneration</td>
<td>Definition can include:</td>
<td>Opening of lesson discussion</td>
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<td></td>
<td>• Process in which damaged tissue grows again</td>
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<td>Identify key concepts in the field of regeneration</td>
<td>Key concepts include:</td>
<td>Activity 1 jigsaw group discussions</td>
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<td>• Stem cells are the source of new cell growth that allows for regeneration.</td>
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<td>• Some organisms (i.e. salamanders and planarians) have the ability to regrow whole body parts because of stem cells.</td>
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<td>• Humans have limited regeneration ability but future technologies may increase the extent of humans’ ability to regenerate.</td>
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<td>Articulate the similarities/differences between human and model organisms’ abilities to regenerate.</td>
<td>Responses can include:</td>
<td>Discussion during conclusion of lesson</td>
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<td></td>
<td>• Stem cells are involved in both</td>
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<td>• Human regeneration is more limited than planarian regeneration</td>
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<tr>
<td>Define and explain what a model organism is.</td>
<td>Definitions can include:</td>
<td>Discussion during conclusion of lesson</td>
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<td></td>
<td>• Organisms used by scientists to study questions that cannot easily, practically or ethically be investigated using other approaches</td>
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### IV. Adaptations/Accommodations

SEPA SCIENCE EDUCATION PARTNERSHIP AWARD
For students with lower reading abilities, the articles can be adapted to decrease the advanced scientific vocabulary yet retain the overall ideas related to stem cells and regeneration. This lesson can also be scaffolded such that more visual aids can be used to describe some of the scientific terms (stem cells, gene) that students might not be familiar with. Students can also take on different roles in the group, one as the “leader” who leads the discussion, one who is the “reader” who reads the articles aloud to other group members, and one or two who are “recorders” that write down the answers to what people say for the rest of the group. Students who are interested in the topic or have advanced reading skills can read the original articles located in the “Additional Resources” folder provided.

**Safety**
There are no additional safety concerns associated with this lesson.

**V. Timeframe for lesson**

**Opening of Lesson**
- Video clip and discussion of prior knowledge about regeneration – 10 minutes

**Main Part of Lesson**
- Activity 1: Jigsaw reading about science of regeneration – 25 minutes
- Activity 2: Regeneration question generation – 5 minutes

**Conclusion of Lesson**
- Summary discussion of regeneration and model organisms – 10 minutes

**VI. Advance prep and materials**

**Opening of Lesson**

**Materials:**
- Computer with internet access for online video

**Preparation:**
- Load the video ahead of time. Consider downloading it if you have a slow internet connection.

**Activity 1: Jigsaw reading about science of regeneration**

**Materials:**
- 4-6 articles about regeneration and handouts of associated guided reading questions. Materials provided include:
  - Planarian regeneration reading and questions
  \[(U2_L1_ReadingAndQuestions_StemCellPoweredWorm.docx)\]
Activity 2: Regeneration question generation

Materials:
- Large paper for recording questions (or board space, or projected list on computer)

Conclusion of Lesson

Materials:
- Dry erase board or chalk board

Preparation:
- Practice writing the example model out one step at a time.

Homework and Assessments

Materials:
- Summary of common model organisms used in research with guided reading questions
  (U2_L1_Homework_ModelOrganisms.docx)
- Additional reading and questions on phantom limb syndrome research
  (U2_L1_Supplement_PhantomLimbStudy.docx)

VII. Resources and references

Teacher resources
- Video about spinal cord injury, regeneration, and brain-machine interfaces:
  http://www.youtube.com/watch?v=cDiWFcA0gaw
- The website for the Neural Engineering Center for Artificial Limbs at the Rehabilitation Institute in Chicago (http://www.ric.org/research/research-centers--programs/bionic-medicine/) is a good online resource for information in the latest technology on reinnervation and limb loss. There are videos of patients with prostheses that use reinnervation technology to move their artificial limbs along with information about “sensory reinnervation” that students may want to explore. In addition, there are links from that page to information about rehabilitation for other neural injuries, such as stroke recovery.
References

VIII. Lesson Implementation

Opening of Lesson:
Open the lesson by asking the following questions in order to have students participate in a whole-class discussion where they develop an initial definition of regeneration:

- What happens when you get hurt? When you bruise your arm? What about when you bruise your brain? Can you think of different effects that brain injuries can have on a person?
- Have you heard the term “regeneration” before? In what context?
- Is it possible for humans to regenerate? What about other organisms?
- How can we define the term “regeneration”? What are some key characteristics of something that has regenerated?

Show a video about spinal cord injury, regeneration, and brain-machine interfaces. The video provided below illustrates the limited ability of the human nervous system to regenerate and new directions in medical research and development. The video can be accessed at: http://www.youtube.com/watch?v=cDiWFcA0gaw

After showing the video, revisit the questions that opened the discussion to see if students’ responses have changed. Alternatively, show the video first and follow with the questions. Use this opening discussion to tell the students that they will be starting a unit that focuses on using model organisms to study complex behaviors like neuroregeneration.

Use the video to engage the students in the unit. Ask students:

- How might scientists study neuroregeneration? What types of models might be used to study the spinal cord injuries featured in the video?
- Are there any animals that you know of that could be used to study regeneration?

After students have shared their ideas, share with the students that they will study regeneration using the planarian as a model organism. The planarian is a flatworm that has been used since the late 1800s to study how tissue can grow once it has been removed or injured.

Main Part of Lesson

Activity 1: Jigsaw reading about science of regeneration
In this activity, groups of students are assigned specific readings about regeneration. After reading their individual story, students are asked to share their understanding of the readings to other group members who read a different story. Students need to become “experts” for the reading in order to explain to other students what they learned.
Assign students to a group in which each student receives the same article. In this group, have students read and discuss the article. Here, the students become “experts” by working through the article and answering the guiding questions together. Readings provided include:

- Planarian Reading and Questions (U2_L1_ReadingQuestions_Planarian.docx)
- Salamander Reading and Questions (U2_L1_ReadingQuestions_Salamander.docx)
- Brain Injury Reading and Questions (U2_L1_ReadingQuestions_BrainInjury.docx)
- Phantom Limb Syndrome Readings and Questions (U2_L1_ReadingQuestions_Phantom.docx)

After becoming experts, divide students into a new group, the jigsaw group, where each member has read a different article. Here, have students share with and teach the other students in the group what s/he learned about their original specific article. Each student will complete the “Group Discussion” student sheet to facilitate the jigsaw group discussion.

**Teacher Pedagogical Knowledge**

Use of the jigsaw reading strategy is one way to allow students to read something relevant to the discussion of regeneration and at the same time have a variety of readings done in a relative short amount of time. This type of activity requires students to become “experts” about the reading, and share their expertise with their peers.

**Activity 2: Regeneration question generation**

Using the final jigsaw discussion as a starting point, have students develop 3 questions on regeneration topics they hope to learn more about. Students report these questions through a whole-class discussion where the teacher creates a cumulative class list of questions on the board (or paper) to be displayed throughout the unit. This list of questions serves as a permanent reminder of student interests during the unit. These questions will be used throughout the unit to help facilitate class discussion about regeneration.

**Scientific Practices: Asking questions**

This is an opportunity to convey to students that science is not about simply about answers. Scientists need to use creativity and deep thinking in order to generate questions worthy of investigation.

**Conclusion of Lesson**

In this discussion, refer back to the different activities and briefly ask students to summarize each of the activities:

For the discussion, key points include:

- Why do spinal cord injuries produce such a disability?
• Scientists and physicians are developing new and better ways to help injured people. Name some of these new methods.
• What are stem cells?

For the jigsaw activity (Activity 1 and 2) key points include:
• Stem cell research may aid in treating some diseases
• Different species respond to injury differently
• Planarians are used in regeneration research

Emphasize that this unit will include developing models of regeneration. Inform students that this use of the term model means "external representations of mental concepts" (Krajcik & Merritt, 2012). Provide a simple example of a diagram model of regeneration, and highlight that a diagram is only one type of model. The image below provides a possible simplified model of planarian regeneration:

![Planarian Regeneration Model](image)

Point out that this model does not explain why each section of the planarian reforms into a complete planarian. Tell students that they will revise this model later in the lesson to add that explanation.

**Scientific Practices: Developing and Using Models**
Models can take a number of forms, including "diagrams, three-dimensional physical structures, computer simulations, mathematical formulations, and analogies" (Krajcik & Merritt, 2012).
Then, make connections to the next day’s planarian observations by having a short discussion about why scientists might use planarians in research. Ask:

- Why do scientists use planarians to study regeneration?
- Planarians are called a model organism. What do you think that means? (Have students brainstorm their ideas and write on board good definitions of model organism). Can you name other model organisms used in research?
- Why do we use model organisms in research? Why not use humans?

Teacher Content Knowledge
Model organisms are organisms used by scientists to study questions that cannot easily, practically or ethically be investigated using other approaches. Despite the apparent diversity within the animal kingdom, the degree of genotypic and phenotypic conservation seen across animals in different phyla often allows scientists to draw conclusions about one animal by studying another. Specific model organisms have features making them particularly suitable for answering a specific biological question or solving a problem. In biomedical research, model organisms are often used as a substitute for conducting experiments in humans. However, using models to avoid research with humans is only one reason for using models. Model organisms have been an indispensable part of scientific inquiry for hundreds of years.

The Model Organisms in Research reading can be assigned as homework if the students need additional support in understanding the role of model organisms in research. It also provides some background on the planarians they will be observing in Lesson 2. Interested students can be assigned the supplemental reading on phantom limb research.

Assessments
Informal assessment will be used throughout this lesson. Students’ understanding of the material in this lesson can be assessed by the responses that students give to the questions in the whole group discussions, both written and orally.

The guided questions from the news articles can also be used as a summative assessment, as well as the jigsaw group discussion questions. This lesson is meant to introduce various research topics in the field of regeneration so much of the assessment will revolve around whole-class and group discussions.