What can I learn from worms?

Stem cells, regeneration, and models

Lesson 7: What does planarian regeneration tell us about human regeneration?

I. Overview

In this lesson, students use the information that they have acquired over the past six lessons to explain the importance of studying planarians and how it can help scientists understand human diseases and biological processes. Students are presented with a scenario, where a family member has read an article in the local newspaper about the discovery of several genes in the planarian that control the migration and division of stem cells. This begins a conversation where the student explains to the family member why this discovery is important and what implications it has for human stem cell research.

Crosscutting Concepts: System and System Models

In previous lessons students have focused on the system of planarians. This lesson aims to compare and contrast the planarian system with the human system. Through reading, discussion, and communication students analyze the properties of these systems as they relate to stem cells. Although humans and planarians are extremely different, there are fundamental aspects of each system that are similar; understanding this relationship can provide students with the knowledge of implications planarian research can have on humans.

Connections to the driving question

This lesson connects to the driving question by explicitly examining how findings about planarian regeneration can be used to better understand regeneration in humans.

Connections to previous lessons

In this lesson, students generate a claim that they support with evidence they have encountered in all previous lessons in the unit.

II. Standards

National Science Education Standards

- Content Standard A: Abilities necessary to do scientific inquiry. Communicate and defend a scientific argument. Students in school science programs should develop the abilities associated with accurate and effective communication. These include writing and following procedures,
expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments. (9-12 A:1/6).

- Content Standard C: The cell. Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multicellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues and organs that comprise the organism. This differentiation is regulated through the expression of differentiated genes. (9-12 C: 1/6)

- Content Standard C: 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**

Critical Response Skills

- Insist that the key assumptions and reasoning in any argument—whether one’s own or that of others—be made explicit; analyze the arguments for flawed assumptions, flawed reasoning, or both; and be critical of the claims if any flaws in the argument are found. 12E/H4

**Cells**

- Within the cells are specialized parts for the transport of materials, energy capture and release, protein building, waste disposal, passing information, and even movement. 5C/H2a

- In addition to the basic cellular functions common to all cells, most cells in multicellular organisms perform some special functions that others do not. 5C/H2b

### III. Learning Objectives

<table>
<thead>
<tr>
<th>Learning Objective</th>
<th>Assessment Criteria</th>
<th>Location in Lesson</th>
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<tbody>
<tr>
<td>Explain how regeneration is similar and/or different between planarians and humans</td>
<td>By referring to previous lessons and in the CERR Worksheet/Discussion students may respond</td>
<td>Activity 1 &amp; 2: Discussion and CERR Worksheet</td>
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<tr>
<td></td>
<td>• Many genes are similar between humans and planarians, so knowledge gained from planarian experiments can be used to investigate human stem cell regeneration</td>
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[SEPA SCIENCE EDUCATION PARTNERSHIP AWARD]

[project NEURC]
### Analyze a newspaper article to identify the major findings of a primary research article

- In the evidence part of the CERR Worksheet/Discussion:
  - Many regenerative genes have been identified in planarians
  - On a molecular level these genes may be very similar to humans

### Identify reasons why the findings of the study presented in the newspaper article are important to the scientific community

- In the CERR Worksheet/Discussion will explain:
  - Although stem cells show promise, there are still many problems associated with their application in medicine.

### Describe the greater human societal implications of the findings described in the newspaper article and how someone might react to the newspaper article if they did not understand planarian regeneration

- In “Reasoning” and/or “Rebuttal” part of the CERR Worksheet/Discussion:
  - Due to the planarian’s regenerative capabilities and easy maintenance of the planarians, along with the ability to label planarian stem cells, scientists can study regeneration in planarians and then use these findings to study human regeneration.

### Create a response using the Claim, Evidence, Reasoning Framework to present to a family member in response to questions on why planarian regeneration research is important to understand possible human regeneration using stem cells

- See the “CERR Framework” in Activity 2
IV. Adaptations and Accommodations
If this is the first time the students have constructed a scientific argument using the Claim, Evidence, Reasoning Rebuttal framework, it might be helpful to practice constructing these types of responses using activities done earlier in the year so students can become familiar with how to construct a scientific explanation. Through a whole class discussion, the teacher can articulate what these terms mean as connected to a scientific explanation: claim refers to a conclusion about a problem, evidence is the scientific data that is appropriate and sufficient to support the claim, while the reasoning is a justification that shows why the data counts as evidence to support the claim and includes appropriate scientific principles. With this in place, the teacher can review previous activities and/or units and the students can practice developing and writing CER responses to a question related to previous material. This can also be used as a way to review previous content and check for understanding. Once the students have had practice writing the CER, they can begin to explore the CER response for this lesson, given the appropriate opening and introduction to the prompt.

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

V. Timeframe for lesson

Opening of Lesson
• Discuss the previous lesson and connect to the driving question – 5-10 minutes

Main Part of Lesson
• Activity 1: Article and background reading on stem cell research – 10 minutes
• Activity 2: Constructing an argument for a parent or family member – 30-35 minutes

Conclusion of Lesson
• Discussion of CER responses – 5-10 minutes

VI. Advance prep and materials

Activity 1: Article and background reading on stem cell research
Materials:
• Student readings, investigation sheets, and other student materials from lessons 1-6
• “Planarian Gene” article (U2_L7_Reading_PlanarianGene.pdf)

Activity 2: Constructing argument for a parent or family member
Materials:
• Student materials from lessons 1-6
VII. Resources and references

Teacher resources


References

VIII. Lesson Implementation

Opening of Lesson
Begin the lesson by asking students what they learned about RNAi in Lesson 6:
- How does RNAi work and what is its purpose? Why do scientists use it?
- What could we observe in planarians dosed with RNAi in both experiments 1 and 2? How was this different from the normal or wild type planarians?
- Is it possible to use RNAi in humans? Why/why not could we use it in humans?

Explain to students that in today’s lesson, the focus will shift from only planarians to examining how planarian and human research intersects. Ask students to recall why planarians are used as a model system for studying regeneration instead of humans:
- What differences in anatomy and physiology between planarians and humans account for their different regenerative potentials?
- What cellular regenerative mechanisms do planarians have that humans do not?

Although humans do not possess the range of regenerative capabilities that other species do, ask the students if they think that some type of regeneration is possible in humans.

An additional follow up question might include:
- What sort of regeneration is possible in humans? Have they ever “regenerated” themselves in any way? Examples of a cut healing itself or broken bone healing after being placed in a cast might be mentioned.

Main Part of Lesson

Activity 1: Article and background reading on stem cell research
Explain to students that they will learn more about a gene recently discovered in planarians involved in neoblast regeneration, Smed-soxP-1. Students should remember this gene was introduced in the “Journey to Neoblast Division” reading in Lesson 4. Ask students what the role of the protein was in cell division. Follow up with a question about how they think this protein is involved in regeneration based on what they know already know.

Scientific Practices: Communicating Information
Scientists publish their research findings in peer-reviewed journals, complete with their initial ideas, experimental procedures, data/observations, and conclusions based on their data, along with future questions they wish to pursue. These articles are intended for other scientists that are highly familiar with the authors’ techniques and concepts they use in their experiments, and are often difficult to read for the average person. Thus, both print and on-line newspapers and magazines publish reports on these
recent findings and adapt the language such that the “average” reader will understand the importance and implications of the research. Students should understand that the newspaper reports are summaries of the research and are written by people who are not part of the research team, interpreting the research based on their own understanding of the research.

Hand out the “Planarian Gene” article with associated guided reading questions. Place students in groups of 4 to encourage group work. The students will work in these groups to read the articles and then answer the guiding questions associated with both human stem cell regeneration articles. Students can work in groups to answer the questions, but each student should record his/her own answers.

After students have had time to discuss the articles and answer the guiding questions, have a whole class discussion about the ideas presented in the article as well as why this type of article might be published in more mainstream publications.

Ask students:
- Why do you think Science Daily published the results of this study? Why are scientists excited about this discovery?
- What are some of the main points you and your group took away from this reading?
- How do you think someone without your knowledge of planarians might interpret this article? Would he/she have the same reaction to it as you?

Following this discussion, explain to the students that they will write a scientific explanation as if to a parent or a family member who has just read the article that they have read and has questions about the story. It is their responsibility to create a scientific argument that will clearly articulate the purpose of the scientific research. This family member does not have the background in planarian biology or scientific techniques used to study them.

**Scientific Practices: Engaging in argument from evidence.**

“Arguing” might have a negative connotation for students but in science, argumentation is an important facet of presenting scientific explanations. Students should be encouraged to “argue” their points with their classmates, using the evidence they have collected for their CERR to strengthen their own argument and refute claims of other students. A key practice in the Framework for K-12 Science Education is “Engaging in argument from evidence” where students are able to discuss their CERR responses with their classmates and discuss ways of improving their explanations.
Ask the students to take out the materials they have from Lesson 1-6 that can be used as resources to construct their explanation to a family member.

Teacher Pedagogical Content Knowledge
This last lesson serves as a synthesis of the concepts and ideas the students have been exploring in Lessons 1-6 by creating a CERR scientific explanation. Each lesson provides bridges to both the previous and the subsequent lesson and at this point, the students should be able to recognize what these bridges are and how the lessons fit together. It might be a good idea to have the students work in groups, or as a whole class, decide how the lessons fit together and what “story” the unit tells about stem cells, regeneration, and models.

Activity 2: Constructing an argument for a parent or family member
Using the resources from the unit, the students will construct a scientific explanation using the “Claim, Evidence, Reasoning and Rebuttal” (CERR) framework. With this, the students will state their claim, or their main hypothesis to answer the questions the family member asks:

- Why is this research published in the newspaper?
- What is so important about this discovery?
- I always hear about stem cell research in humans-can this discovery help to cure human diseases?

Teacher Pedagogical Content Knowledge
At this point, students have gathered a variety of first-hand and second-hand evidence to support their claim and construct their scientific reasoning(s) that support their claim for this final CERR exercise of the unit. To bolster their explanation, and teach a valuable skill in rebutting a claim, have students add a rebuttal to their explanation. This rebuttal will offer why the opposing claim to their own is not valid due to evidence and reasoning that is present in the unit.

To support their claim, the students will use evidence collected over the unit to support their claims to the three questions. This might be data collected throughout the unit, or other observations they have made in the class activities/homework reading. Then, the students will link the claim and evidence with an accepted scientific reason. A simple example of the CERR Framework is:

- **Claim:** This research was published in the newspaper because planarians are good model organisms to study human regeneration.
- **Evidence:** (previous lessons’ regeneration experiments and observations, BrdU labeling of cell migration, RNAi technique to study regeneration, other examples pulled from unit activities/discussion/readings)
• **Reasoning:** Due to the planarian’s regenerative capabilities and easy maintenance of the planarians, along with the ability to label planarian stem cells, scientists can study regeneration in planarians and then use these findings to study human regeneration.

• **Rebuttal:** The idea that planarians are not a worthwhile model organism to study regeneration because they are too dissimilar to humans is unfounded. Many genes are similar between humans and planarians, so knowledge gained from planarian experiments can be used to investigate human stem cell regeneration.

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**Teacher Pedagogical Content Knowledge**

A great resource to support teachers in facilitating the construction of scientific explanations is the book Supporting Grade 5-8 Students in Constructing Explanations in Science: The Claim, Evidence, and Reasoning Framework for Talk and Writing by Katherine L. McNeill and Joseph S. Krajcik (2012). This text provides an introduction to the CER framework as well as ideas for using this as an assessment tool and designing rubrics to evaluate students’ CER responses. While the title indicates the text is for use by middle school teachers, it provides a wealth of ideas and pedagogical knowledge for high school teachers, too.

Individually, students will construct their CERR responses. There are suggestions to support students in the “Adaptations and Accommodations” section regarding the construction of their CERR responses. If desired, teachers can assign this as homework or allow students to work on their response in class. The students can also receive the rubric to help them develop their CERR.

The next day, ask students to read their CER responses aloud to groups of 4 students. Within these groups, the students could critique one another’s responses, asking their group members to clarify the responses or by adding additional information to support their claim. Once this has been accomplished, the student can then turn in the CER to the teacher for a grade.

**Conclusion of Lesson**

After students have discussed their initial CER in small group, ask the students to discuss as a whole class:

- What are some similarities/differences in CER responses between you and your group members? What kind of suggestions did you make to your group mates to improve their CER?
- In general, do you think that it is important for scientists to study planarian regeneration? Why or why not?
- How can the study of planarian regeneration help scientists discover more about human regeneration? What are some challenges to the study of human regeneration?

**Assessments**
The CER response can be used as a formal summative assessment to evaluate the students’ understanding of the planarian unit. A base rubric is found as U2_L7_Resource_BaseRubricCER.docx in the Lesson 7 folder as a guide to produce a more specific rubric for this CER response to guide students and help with evaluation of the CER assessment.