Teacher Resource for:

Emergence of Individuality in Genetically Identical Mice

Using This Teacher Resource

Table of Contents:

GENERAL USE OF Science in the Classroom

Student Learning Goals:

Current views of science education emphasize that “one fundamental goal for K-12 science education is a scientifically literate person who can understand the nature of scientific knowledge.” (From *A Framework for K-12 Science Education*, National Research Council, 2012).

The U.S. National Academy of Sciences defines science as: “Any new finding requires independent testing before it is accepted as scientific knowledge; a scientist is therefore required to honestly and openly report results so that they can readily be repeated, challenged, and built upon by other scientists. Proceeding in this way over centuries, the community effort that we call science has developed an increasingly accurate understanding of how the world works. To do so, it has had to reject all dogmatic claims based on authority, insisting instead that there be reproducible evidence for any scientific claim.”

A very important student learning goal, central to any understanding of “the nature of scientific knowledge,” is to give each student an appreciation of how science is done.

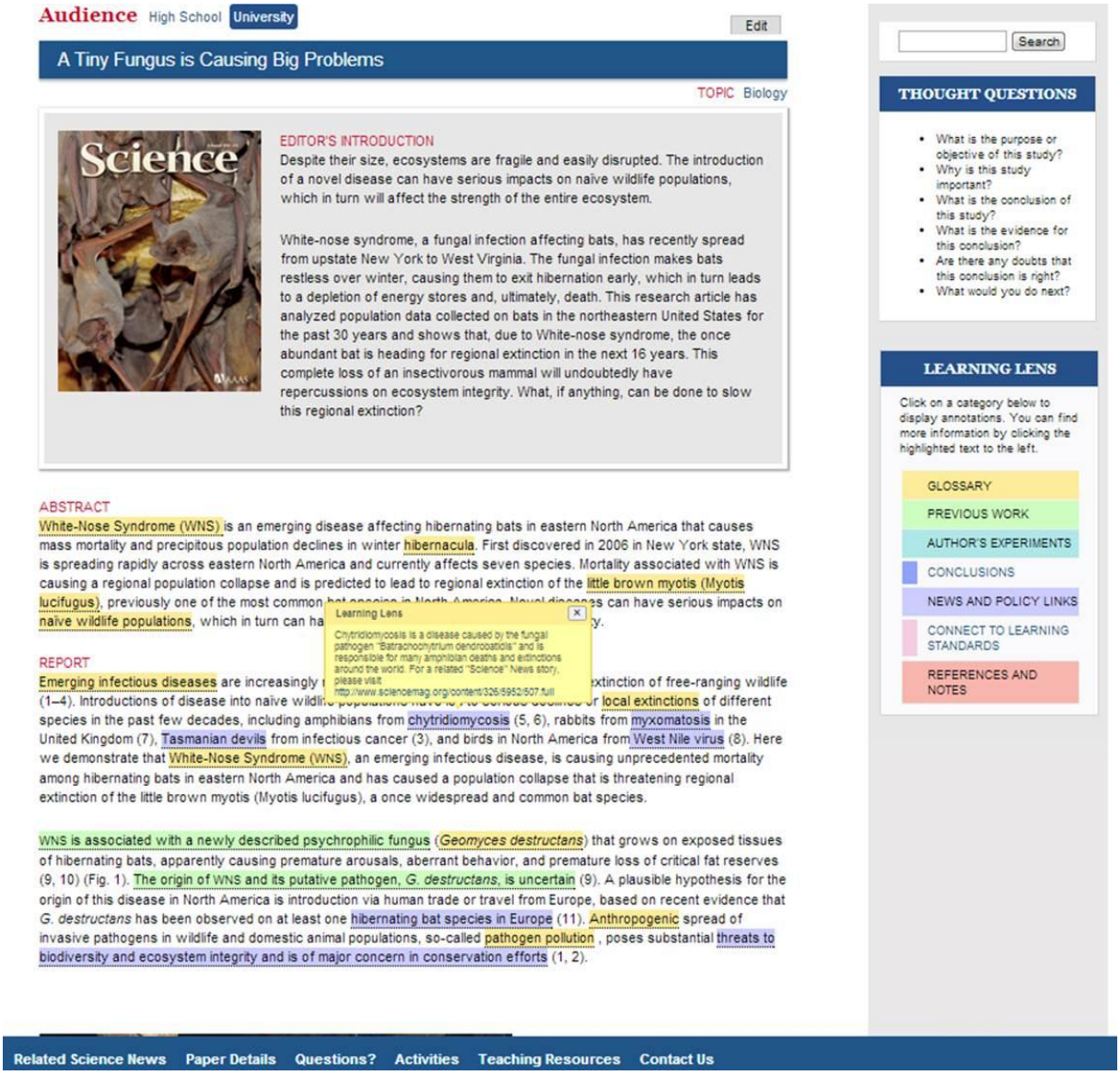
This includes knowing why:

- Scientists must be independent thinkers, who are free to dissent from what the majority believes.
- Science can deal only with issues for which testable evidence can be obtained.
- All scientific understandings are built on previous work
- It is to be expected that one scientist’s conclusions will sometimes contradict the conclusions of other scientists.
- Science is a never-ending venture, as the results from one study always lead to more questions to investigate.

Using This Resource

Learning Lens:

The Learning Lens tool can be found on the right sidebar of each resource and is the source of annotations. Clicking on any of the headings will result in corresponding text of the research article being highlighted. A second click on the highlighted text will produce a text box containing more information about that particular piece of text. Below is an example of the Glossary function of the Learning Lens in use.



An example of the resource with the Glossary, Previous Work, Author's Experiments, News and Policy Links, and References and Notes tools turned on. The Glossary tool is in use.

Learning Notes:

Learning Notes accompany each figure and are designed to help students deconstruct the methods and data analysis contained within each figure.

References:

The Reference section of each resource is annotated with a short statement about how or why each reference relates to the current research study.

Suggestions for Classroom Use:

Four alternative ways to use the SitC reading, questions, and activities:

1. Assign to small groups to complete during class

2. Assign different sections of the article to small groups to complete during class. Use class presentations or jigsaw to teach the entire class what is in the article.

3. Assign to individual students to complete during class or as homework.

4. Assign as an extra credit project.

Interactive student engagement ideas for use after reading the article:

1. Have students write answers to discussion questions (for example, those linked to the standards or those linked to the diagrams).

2. Go over the abstract, as well as information about the purpose and structure of an abstract, and have students write their own abstracts for the articles in language that could be best understood by their peers.

3. Have students edit the current version of the article, or parts of the article, to a simpler reading level.

4. Have students, working alone or in small groups, use the annotated list of references to explain how the scientists who wrote this article built on the published work of at least one independent group of scientists in making their discoveries. In the process, did they produce data that supports the findings of the earlier publication that they have cited in the text? In what way does this article support the statement that scientific knowledge is built up as a “community effort”?

5. Use the article and discussion questions linked to the standards and the diagrams for a teacher-led classroom discussion. The discussion can focus on the nature of science and scientific research, as well as on the science in the article itself.

6. Have students give a classroom presentation about the article, parts of the article, or their answers to discussion questions.

ARTICLE-SPECIFIC MATERIALS

Student Learning Goals:

- Connections to the nature of science from the article
    - What can we learn about human genetics and behavior from mice?
    - How can we design scientific experiments to understand subjective qualities, such as ‘individuality’ in model organisms?

- The importance of this scientific research
    - Understanding the connections between genetics and behavior.

- The actual science involved
    - Model systems
    - Immunocytochemistry and brain histology
    - Generating mathematical models and analyzing behavioral data

Connect to Learning Standards:

1. The AP Bio Standards

http://media.collegeboard.com/digitalServices/pdf/ap/2012advances/AP-Biology_CED_Fall2012.pdf

- Essential knowledge 2.C.2: Organisms respond to changes in their external environments.
- Essential knowledge 2.E.2: Timing and coordination of physiological events are regulated by multiple mechanisms.

2. The Science and Engineering Practices contained in the Next Generation Science Standards

http://www.nap.edu/openbook.php?record_id=13165&page=41

- Practice 1: *Asking questions.*
- Practice 8: *Obtaining, evaluating, and communicating information.*

3. The Common Core English and Language Arts Standards

http://www.corestandards.org/ELA-Literacy/RST/11-12

- RST.11-12.6: *Analyze the author's purpose.*

Summary of the Article for the Teacher:

It is recommended that this not be used by students in place of reading the article.

General Overview:
We have noticed for a long time that identical twins, who share the same genes and grew up in the same family, do not act exactly the same. But, since we also know that our environment and genetic makeup influence how our bodies and brains develop, where do these individual differences come from? When genetically identical mice live in the same environment for a long time, they develop individual patterns of exploring their home. How do you get unique behavior from the same DNA and the same environment?

Topics covered:
- Genomic DNA
- Animal behavior
- Adult neurogenesis

Why this Research is Important:
- It advances out understanding of the connections between genetics and behavior.

Methods used in the Research:
- Spatial and temporal behavior tracking
- Immunocytochemistry
- Body/brain weight measurements
- Mathematical modeling
- Statistical analysis: determining correlation of data

Conclusions:
Three months of living in a complex environment led to a massive magnification of individual differences in explorative behavior among genetically identical individuals over time, and these differences were related to adult hippocampal neurogenesis.

Areas of Further Study:
Exploring the causal relationship between correlated factors identified in this work (adult neurogenesis and exploratory behavior). Further testing to see whether adult neurogenesis is required for increased exploratory behavior, or just positively correlated.

Resources for Interactive Engagement:

1. Discussion Questions Associated with the Standards

The AP Biology Standards

- *Essential knowledge 2.C.2: Organisms respond to changes in their external environments.*
    - **What are some external stimuli that you could measure in your own life to see how you could respond to changes in your own environment?**

- *Essential knowledge 2.E.2: Timing and coordination of physiological events are regulated by multiple mechanisms.*
    - **What do you think is the evolutionary basis for this type of regulation?**

The Science and Engineering Practices that appear in the Next Generation Science Standards

- *Practice 1: Asking questions.*
    - **How is asking questions an important part of scientific research?**
    - **What are some other "big questions" in science? Select one of your "big questions" and narrow it down to a question that could be investigated.**

- *Practice 8: Obtaining, evaluating, and communicating information.*

- **Scientific findings are often communicated through a research paper. The abstract is a place where scientists briefly discuss the questions they were asking and the results they obtained while doing so. What is the purpose of an abstract in a research paper?**

- **How is an abstract useful to another researcher in the same field?**

The Common Core English and Language Arts Standards

- *RST.11-12.6: Analyze the author's purpose in the explanation, procedure, or experiment, and ID important issues that remain unresolved.*

    - **What were the author's trying to measure?**

    - **Did they succeed?**

    - **What additional evidence could have strengthened (or weakened) their claims?**

2. Activities connecting to the data shown in the Article

The Activities are linked to in red tool bar along the bottom of the website. Activities linked to this particular resource contain raw data from the authors that the students will be able to work with directly.