Teacher Resource for:

An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species

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.

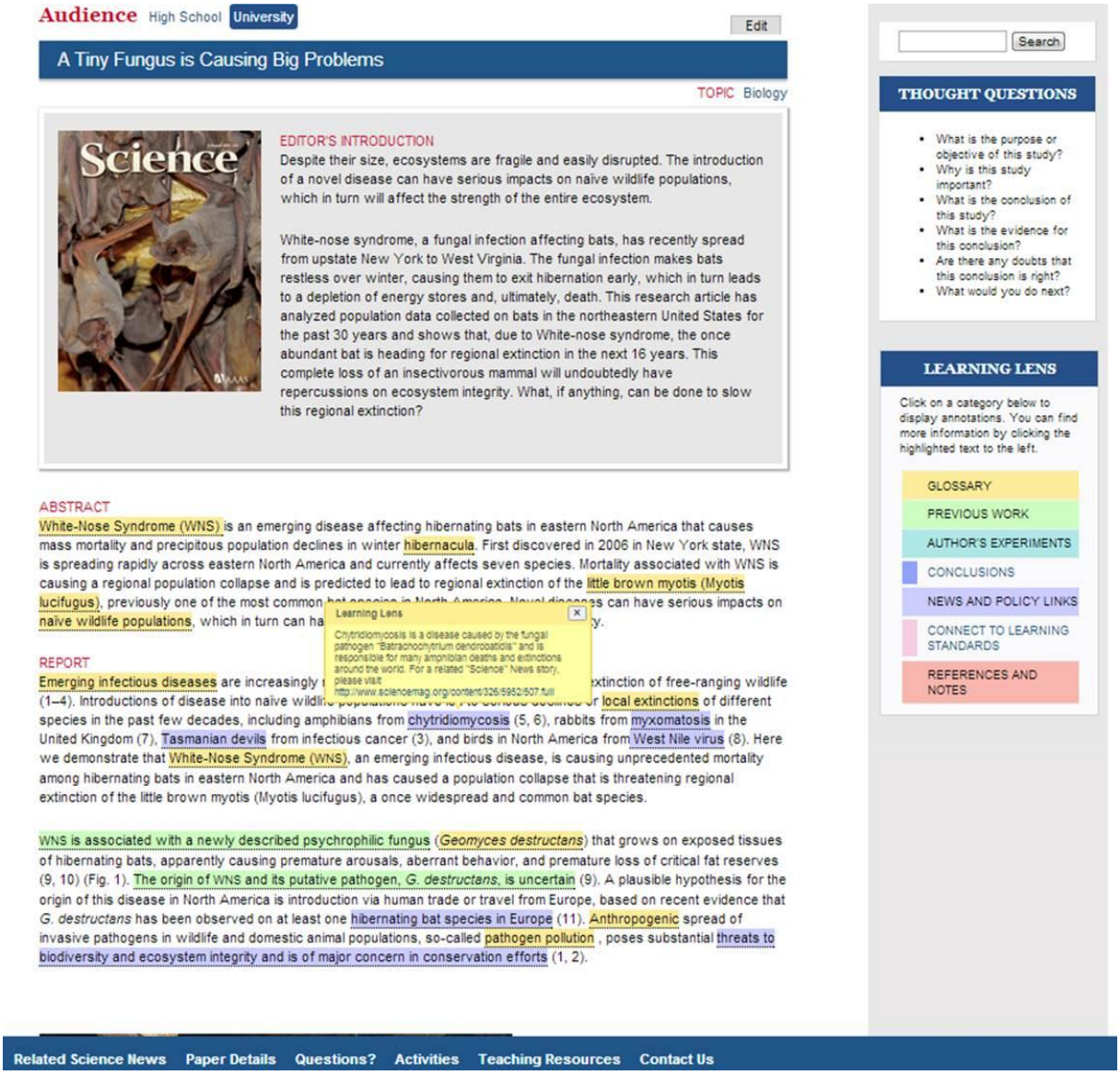
This includes knowing why:

- 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
    - How does the health of one member of an ecosystem impact the ecosystem as a whole?
    - Can damage to an ecosystem be reversed?

- The importance of this scientific research
    - Loss of a species of bat

- The actual science involved
    - free energy transfer
    - interaction among members of an ecosystem
    - infectious disease
    - hibernation
    - population dynamics

Connect to Learning Standards:

This resource connects to four sets of learning standards:

Discussion Questions related to these standards are found in Resources for Interactive Engagement

1. The AP Bio Standards

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

- Essential Knowledge 1.C.1: Speciation and extinction have occurred throughout the Earth's history. (page 25 of the AP Biology Course and Exam Description)
- Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis. (page 39 of the AP Biology Course and Exam Description)
- Essential Knowledge 1.C.1: Speciation and extinction have occurred throughout the Earth's history. (page 17 of the AP Biology Course and Exam Description)
- Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy. (page 87 of the AP Biology Course and Exam Description)
- Essential knowledge 4.A.5: Communities are composed of populations of organisms that interact in complex ways. (page 86 of the AP Biology Course and Exam Description)
- Essential knowledge 4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem. (page 96 of the AP Biology Course and Exam Description)
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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:
Despite their size, ecosystems are fragile and easily disrupted. The introduction of a novel disease can have serious impacts on naïve wildlife populations, which in turn will affect the strength of the entire ecosystem.

White-nose syndrome, a fungal infection affecting bats, has recently spread from upstate New York to West Virginia. The fungal infection makes bats restless over winter, causing them to exit hibernation early, which in turn leads to a depletion of energy stores and, ultimately, death. This research article has analyzed population data collected on bats in the northeastern United States for the past 30 years and shows that, due to White-nose syndrome, the once abundant bat is heading for regional extinction in the next 16 years. This complete loss of an insectivorous mammal will undoubtedly have repercussions on ecosystem integrity. What, if anything, can be done to slow this regional extinction?

Topics covered:
- free energy exchange
- population dynamics
- infectious disease spread
- ecosystem dynamics

Why this Research is Important:
The fitness of an ecosystem depends on the health of its individual members. If one member of an ecosystem becomes extinct, how does the rest of the ecosystem react?

Infectious disease is a real problem, and not just among human populations. How we learn to identify and respond to infectious disease, in human or animal populations, remains to be an unsolved scientific problem.

Methods used in the Research:
- Counting of populations
- Characterization of the spread of disease
- Population dynamics

Conclusions:
The little brown bat is headed for extinction unless a solution can be found to stop the spread of White Nose Syndrome.

Areas of Further Study:
How are bats in Europe immune to White Nose Syndrome? Can this be leveraged somehow to save the bats being infected in the US?

Resources for Interactive Engagement:

1. Discussion Questions Associated with the Standards

The AP Biology Standards

Essential Knowledge 1.C.1: Speciation and extinction have occurred throughout the Earth's history. (page 25 of the AP Biology Course and Exam Description)

The devastation of extinction can be felt throughout an ecosystem. What are some previous examples of how extinction changed an ecosystem forever? **Dinosaur extinction.**

Why are bats in Europe immune to WNS while bats in the US are susceptible to the fungus?

Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis. (page 39 of the AP Biology Course and Exam Description)

Essential knowledge 4.A.5: Communities are composed of populations of organisms that interact in complex ways. (page 86 of the AP Biology Course and Exam Description)

Essential knowledge 4.C.4: The diversity of species within an ecosystem may influence the stability of the ecosystem. (page 96 of the AP Biology Course and Exam Description)

If bats become extinct, what other members of their ecosystem will also be affected? **Bugs, plants, birds, any animal that preys on bats…**

Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy. (page 87 of the AP Biology Course and Exam Description)

When bats become infected with WNS, they eventually die (see figure 1). What happens to the free energy of the bat after its death? How did the bat amass this free energy while it was alive?

2. Discussion Questions Associated with Figures in the Article

Discussion Questions Associated with Figures in the Article are found within the Learning Notes. The symbol  denotes where in the text the discussion question fits best. We encourage teachers to present these questions to students for open- ended conversations about the data and research. Potential answers (although not the only answers) are provided in blue text when possible.

Discussion Questions associated with Figure 1:

What could cause a loss of fat reserves? **Waking up from hibernation uses stored fat reserves.**

How would this affect hibernation? **When fat stores are depleted hibernation is ended.**

Describe how being in a state of torpor is often used to help animals survive during periods of colder temperatures. Torpor, or temporary hibernation, is a (usually short-term) state of decreased physiological activity in an animal, usually characterized by a reduced body temperature and rate of metabolism. Torpor is often used to help animals survive during periods of colder temperatures, as it allows the organism to save the amount of energy that would normally be used to maintain a high body temperature.

Besides WNS, what could be some other environmental factors leading bats to awake from torpor ahead of schedule? **Disruption from humans, noise, other external stimuli.**

Can you think of a way for bats to arouse from torpor while using less energy?

Discussion Questions associated with Figure 2:

There are certainly benefits to bats hibernating together in large groups. How does the emergence of WNS stand to threaten these benefits and how can the bat population respond to it? **In groups bats can share food, housing, and safety, yet it also makes it easier for *Geomyces destructans* to spread among them. Do the benefits outweigh the costs?**

Why are European bats not succumbing to Geomyces destructans in the same way that North American bats are? **One possibility is that G. destructans has been present in Europe for a long time, and European bat species have evolved immunity. Alternatively, perhaps the fungus evolved greater virulence after arriving in North America, a possibility that could be investigated with further**

sequencing. ****This question directly relates to the Science News article Europe's Bats Resist Fungal Scourge of North America, linked in the resource under "News and Policy links."

What are some reasons that only one county in Missouri and only six counties in Tennessee have been infected? *Geomyces destructans* is a cold weather fungus. The temperatures in Missouri and Tennessee may not be cold enough for the fungus to grow.

Discussion Questions associated with Figure 3:

Could the human presence occurring during hibernacula surveys have contributed to the spread of WNS? How? Humans could track the fungus from cave to cave.

What could be possible reasons for this? Age of the colony, other environmental factors, migration of the colony.

Does this panel provide enough evidence to say definitively that WNS is responsible for deceases in bat populations? If not, what additional evidence is needed?

Discussion Questions associated with Figure 4:

Why do you think the authors chose the rates of 45, 20, 10, 5, and 2%? What rates would you have chosen?

What are some factors, both positive and negative, that can impact the rate of population decline in bats infected with WNS? Will bats ever be able to relocate to temperatures where WNS cannot grow?

On average, bats eat 600 mosquitoes per hour. Starting with a bat population of 1000 and assume that bats are awake and hunting for 8 hours a day, that summer lasts for 90 days, and that there is a population decline of 45%, what will the increase in mosquito population be the following summer? + 194,400,000 mosquitoes.

What will it be the summer after that? + 106,704,000 mosquitoes.

How will this affect the ecosystems where bats live? Human residents annoyed by bugs, crops affected, disease could spread….

3. Activities connecting to the data shown in the Article

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

We especially recommend “A chance to work with Dr. Frick’s data” which will allow students to work with actual bat population counts.