Teacher Resource for:
Cyclic Dynamics in a Simple Vertebrate Predator-Prey Community.

Using This Teacher Resource

Table of Contents:

I. GENERAL USE OF Science in the Classroom
   a. Student Learning Goals (general)
   b. Using this Resource
      i. Learning Lens
      ii. Learning Notes
      iii. References
   c. Suggestions for Classroom Use

II. ARTICLE-SPECIFIC MATERIALS
   a. Student Learning Goals (specific)
   b. Connect to Learning Standards
   c. Summary of the Article for the Teacher
   d. Resources for Interactive Engagement
   e. Discussion Questions Associated with the Standards
   f. Activities connecting to the data shown in the Article
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 rodent dynamics are regulated in a top-down manner
  - how to explain biogeographic variations in abundance and dynamics through species interactions and integration in ecosystems

- The importance of this scientific research
  - What are the ecological mechanisms that generate fluctuations in predator-prey cycles?
  - Are these ecological mechanisms unique to certain species or are they common to all cyclic populations?
  - Will understanding these mechanisms allow scientists to explain why some populations are cyclic whereas others are not?

- The actual science involved
  - Population density estimations
  - Nest counts
  - Daily predation rates
  - Predator and Prey density estimations
  - Regression analysis
  - Statistical analysis
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


Essential Knowledge 2.A.1: All living systems require constant input of free energy (page 23 of the AP Biology Course and Exam Description).

Essential knowledge 2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy (page 37 of the AP Biology Course and Exam Description).

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

http://www.nap.edu/openbook.php?record_id=13165&page=42

Practice 2: Developing and using models.

Practice 7: Engaging in argument from evidence

3. The Common Core English and Language Arts Standards

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

RST.11-12.4: Determine the meaning of symbols, key terms, and other domainspecific words and phrases as they are used in a specific scientific or technical context.

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.
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:**
Populations of small mammals rise and fall, and rise and fall again, yet population ecologists don’t know exactly why. There remain three main unanswered questions: what are the ecological mechanisms behind these population cycles, do these same mechanisms occur in all small mammal populations, and will an understanding of these mechanisms allow scientists to explain why some populations are regulated by non-cyclic patterns? This research focuses on a long-term field study of the cyclic dynamics of collared lemmings. Basic population counts are translated, using a mathematical model, to describe how population dynamics of the lemming are affected by predators.

**Topics covered:**
- Population density estimations
- Predator and Prey density estimations
- Regression analysis
- Statistical analysis

**Why this Research is Important:**
This study demonstrates how a simple predator-prey interaction leads to lemming cycles in northeastern Greenland, and how rodent dynamics are regulated in a top-down manner. Can scientists use data and findings from this simple, high arctic ecosystem to explore a more complex one, such as the Serengeti plains of Tanzania in East Africa?

**Methods used in the Research:**
- Population density estimations
- Nest counts
- Daily predation rates
- Predator and Prey density estimations
- Regression analysis
- Statistical analysis

**Conclusions:**
“The predicted population dynamics were generated by a combination of destabilizing predation by the stoat and strongly stabilizing predation by the three other species of predators. This is an example of cyclic predator-prey dynamics in which the prey dynamics are entirely determined by predation. If one of the avian predators is completely removed from the model, the dynamics change.”
Resources for Interactive Engagement:

1. Discussion Questions Associated with the Standards

The AP Bio Standards


Essential Knowledge 2.A.1: All living systems require constant input of free energy (page 23 of the AP Biology Course and Exam Description).

Essential knowledge 2.D.1: All biological systems from cells and organisms to populations, communities and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy (page 37 of the AP Biology Course and Exam Description).

What is considered to be free energy in this ecosystem? Food, lemmings, etc.

Can a member of the ecosystem both act as free energy and consume free energy at the same time? Yes, lemmings both consume free energy (their food) and act as free energy sources to their predators.

What happens to the free energy of this system if one member of the ecosystem is removed? This answer depends on what kind of free energy the student decides to remove.
The Science and Engineering Practices contained in the Next Generation Science Standards

http://www.nap.edu/openbook.php?record_id=13165&page=42

Practice 2: Developing and using models.

Does the model the authors built work like they had envisioned? Yes, the statistics fit their model almost perfectly.

What can we learn from this model? The simplest case of population dynamics.

If this model works, what is the next step? Applying this simple model to other complex ecosystems.

Why are researchers using this particular model for their experiments? It is simple and easy to track each member of this ecosystem.

Practice 7: Engaging in argument from evidence

Is there a part of this research that did not convince you? Why not? What would you have done instead?
RST.11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context.

A key term in this paper is “predator-prey community.” What does this term mean in this paper? Why is it used?

Another key term is “population density.” What does this term mean in regard to the lemming?

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.

Is there a part of this research that did not convince you? Why not? What would you have done instead?
2. Activities connecting to the data shown in the Article

The Activities are linked to in the right-hand sidebar found above the Learning Lens. Activities linked to this particular resource contain raw data from the authors that the students will be able to work with directly.