Teacher Resource for:

Long-term measles-induced immunomodulation increases overall childhood infectious disease mortality

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GENERAL USE OF *Science* in the Classroom

Student Learning Goals:

"One fundamental goal for K-12 science education is a scientifically literate person who can understand the nature of scientific knowledge."[1]

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."

An 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:

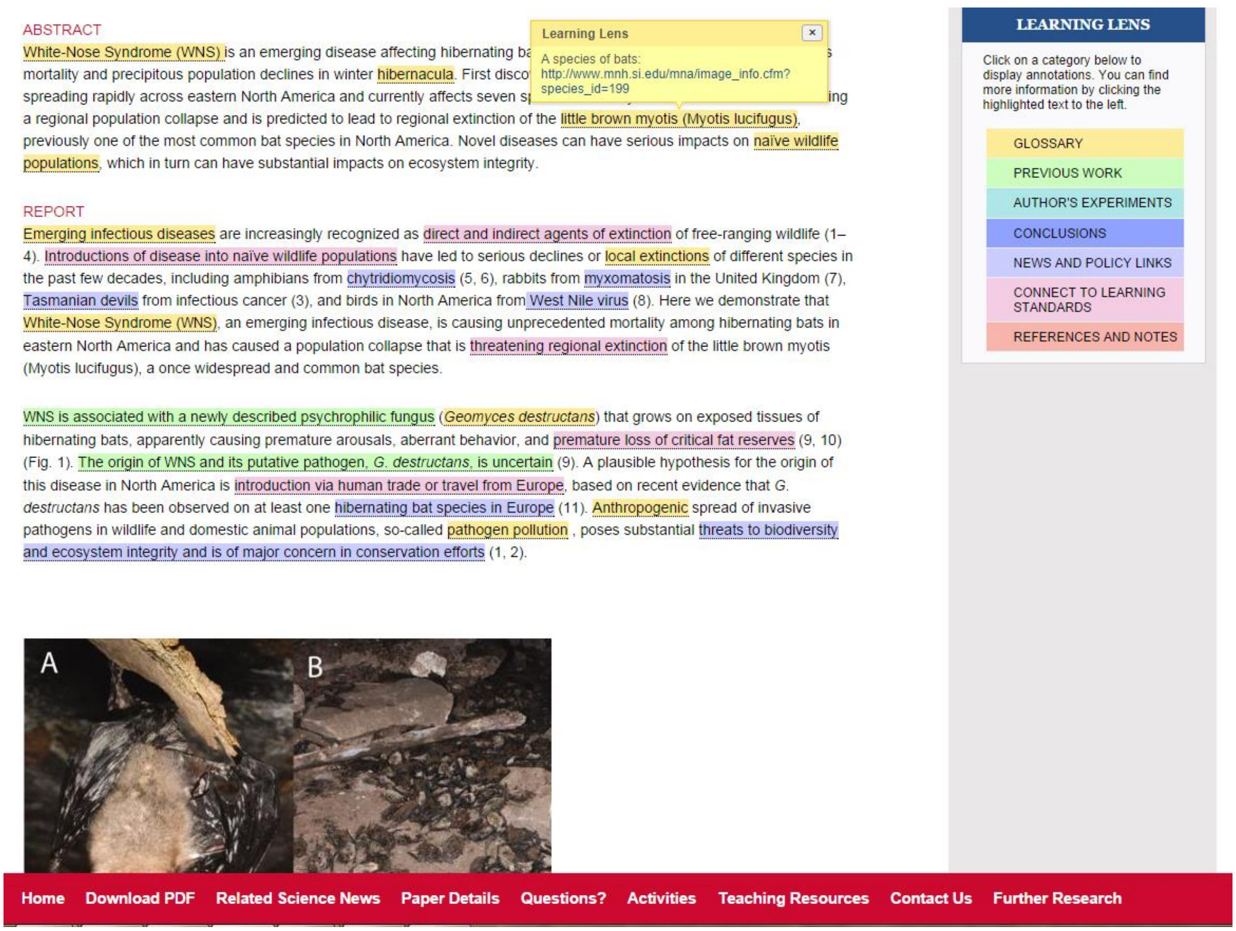
- Scientists must be independent thinkers, who are free to dissent from what the majority believes.
- Science can deal only with issues for which testable evidence can be obtained.
- All scientific understandings are built on previous work
- It is to be expected that one scientist's conclusions will 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.

[1] *A Framework for K-12 Science Education*, National Research Council, 2012

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. Click on the headings to highlight portions of the text of the corresponding research article. A subsequent 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.



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.

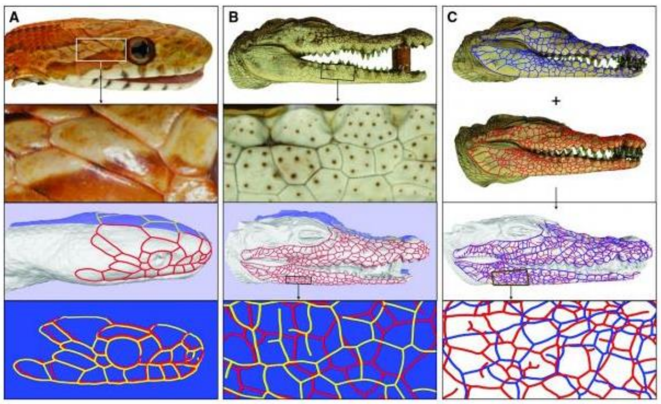


Fig. 1. Spatial distribution of head scales. (A) Head scales in most snakes (here, a corn snake) are polygons (two upper panels) with stereotyped spatial distribution (two lower panels): left (yellow) and right (red) scale edges overlap when reflected across the sagittal plane (blue). (B) Polygonal head scales in crocodiles have a largely random spatial distribution without symmetrical correspondence between left and right. (C) Head scales from different individuals have different distributions of scales' sizes and localizations (blue and red edges from top and bottom crocodiles, respectively).

Method: 3D geometry and color-texture reconstruction | Panel A | Panel B | Panel C

The authors took 120 color pictures of each animal to create detailed, three-dimensional models of reptile heads. Watch this video in which the authors further explain their modeling methods:

http://www.sciencemag.org/content/suppl/2012/11/29/science.1226265.DC1/1...

LEARNING LENS

Click on a category below to display annotations. You can find more information by clicking the highlighted text to the left.

- GLOSSARY
- PREVIOUS WORK
- AUTHOR'S EXPERIMENTS
- CONCLUSIONS
- NEWS AND POLICY LINKS
- CONNECT TO LEARNING STANDARDS
- REFERENCES AND NOTES

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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.

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24. K. Friston, M. Breakspear, G. Deco, Perception and self-organized instability. Front. Comput. Neurosci. 6, 44 (2012).
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> **Learning Lens** ×
> This paper showed that while both physical activity, like running, and living in an enriched environment can result in the generation of new hippocampal neurons in mice, a combination of the two activities leads to even greater rates of neurogenesis.

LEARNING LENS

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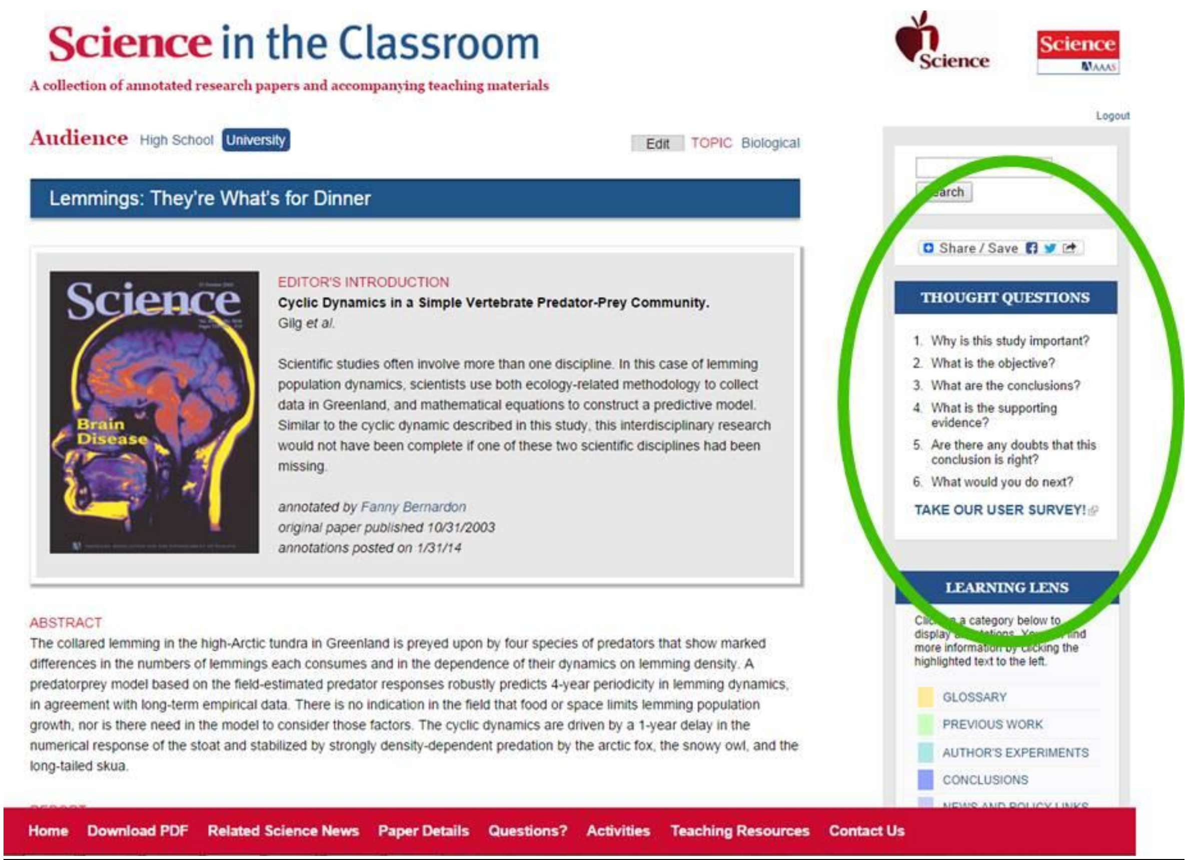
- REFERENCES AND NOTES

Thought Questions

Thought Questions are located above the Learning Lens in the right sidebar of each resource. These questions were written to be universal and applicable to any primary research paper. Thought questions do not have a single answer, or a correct answer for that matter, and can be used to stimulate discussion among students.



Suggestions for Classroom Use:

In addition to the thought questions discussed above, other resources are provided for use in the classroom. These can be found toward the end of the teacher guides associated with each specific article and include:

1. Discussion questions specific to the article, related to the standards, and/or associated with the figures.

2. Activities tied to the articles.

Some ways to use the *Science* in the Classroom articles:

1. Assign to student groups to read and discuss during class.

2. Assign small sections of the article to student groups to read and discuss during class, with the expectation that they will present or use jigsaw to teach the entire class what is in their part of the article.

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

4. Assign reading as an extra credit project.

Some ideas for interactive student engagement after reading the article:

1. 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 understood by their peers.

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

4. Have students, 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

Connections to the nature of science from the article

- Why do scientists want to study a disease that is preventable by vaccination?
- Is it reasonable that the authors chose to study vaccination using population-level data?

The importance of this scientific research

- Understanding how the prevention of human infectious disease can impact human health in a broader sense than previously understood
- Importance of vaccination

The actual science involved

- Virology
- Statistics

Connect to Learning Standards:

The Next Generation Science Standards

- Science and Engineering Practice 6: Constructing explanations and designing solutions
  - This paper deals with a topic that has been well researched in the past; in order to understand this work students must understand the previous theories and how the authors' theory of using high-income country data provides a new explanation on previous observed phenomenon.

The AP Biology Standards

- Practice 6: The student can work with scientific explanations and theories.
  - See above

Common Core English Language Arts

- 11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
  - This article requires students to follow a process that analyzes data based on four stages of testing to evaluate a conclusion.

Vision and Change Core Competencies and Disciplinary Practice

- Competency 1: Ability to apply the process of science
  - Students who read this article are being shown how scientists gather and analyze data to test a hypothesis and come to conclusions. They are then asked new questions based on those conclusions and evaluating the results.
- Competency 4: Ability to tap into the interdisciplinary nature of science
  - This paper relies heavily on the data collected by doctors and epidemiologists, their previous observations and research, and the ability of biostatisticians to analyze the data in new ways.

[*Common Core Statistics & Probability*]

- Calculate expected values and use them to solve problems
    - The authors have calculated the length of immunomodulation in this paper and used it as a model to understand the impact of measles on childhood infectious disease mortality; students have been able to follow that process in this paper.

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:

It has been observed that after the introduction of measles vaccination there was a drop in childhood death rates not entirely explainable by the prevention of just measles. Others have observed an immunosuppression effect after measles infection and attempted to study this via molecular virology/immunology as well as epidemiologically by studying measles incidence in low-income countries. This paper takes a unique approach to studying the phenomenon by examining high-income countries with overall lower incidence of infectious disease in an attempt to remove the complicating factors of increased childhood mortality in the low-income countries. By doing so the duration of immunomodulation (approximately 2.5 years) is revealed.

Topics Covered:

- Measles vaccination
- Immunosuppression
- Population statistics

Why this research is important:

This research is an important contribution to virology, epidemiology, and health sciences. With the determination of a 2- to 3-year-long immunomodulation following measles infection there is further support for the importance of measles vaccination, despite a vast reduction in the incidence of measles, especially in high-income countries. Understanding the long-term effects of measles incidence can also help when studying the incidence and prevalence of other childhood infectious diseases in the context of measles vaccination introduction.

Methods used in the Research:

- Population statistics
- Gamma-transformation
- Best-fit analysis

Conclusions:

- The immunomodulation effects of measles infection could be implicated in up to half of all childhood infectious disease deaths.
- Reduction of measles incidence due to vaccination was the cause of reduced overall childhood infectious disease mortality following introduction of vaccination.
- Strong correlations provide strong evidence that measles is responsible for the immune effect.
- Results are consistent with multiple immune-epidemiological and case-controlled studies performed by other researchers.
- Data collected support that measles vaccination is capable of producing strong herd immunity against the disease.
- These results suggest that there may be a greater positive effect of measles vaccination than previously thought.

Areas of Further Study:

- Knowing the duration of immunomodulation, can these data be transferred into low-income countries to confirm that this effect is a worldwide phenomenon?
- How is this immunomodulation caused by measles infection?

Discussion Questions:

1. Does this research change your view about whether vaccination against measles should be required for all children, or should it remain the choice of the parent?

2. Infectious diseases cause fewer childhood deaths in high-income countries than low-income countries. Does this influence your opinion on the validity of this approach to studying childhood infectious disease mortality as it relates to measles infection?

3. Are there any questions that still remain for you? Are there any additional studies you think should be done?

4. Would you expect measles vaccination to affect the incidence of noninfectious disease?

5. Why is herd immunity so important?

Additional Thought Questions:

1. **Why is this study important?** *This question is answered in paragraph or bullet form farther into this document.*
2. **What is the objective?** *To determine the duration of immunomodulation caused by measles infection by using nonmeasles infectious disease mortality data during the pre- and postvaccination era.*
3. **What is the supporting evidence?** *Population-level data from high-income countries were analyzed to compare childhood infectious disease mortality levels in correlation to measles disease levels. By contrasting the two a delay can be seen following high measles disease with an increase in nonmeasles infectious disease deaths of about 2 to 3 years.*
4. **What are the conclusions?** *Measles infectious disease causes immunomodulation in children of about 2 to 3 years in high-income countries.*
5. **Do you agree with the authors' interpretations of the presented data? Why or why not?** *Students may disagree because the data are done only using three high-income countries and do not include the low-income countries most impacted by childhood infectious diseases. They may agree because all three countries provide consistent results of immunomodulation between 2 to 3 years, which suggests the results are believable. The data are also consistent with previous studies on measles immunomodulation.*
6. **What would you do next?** *Transfer these data to low-income countries, or perhaps determine the mechanisms responsible for this immunomodulation phenomenon.*