

Teacher Resource for:
Stop codon reassignments in the wild



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](#)
 - iv. [Thought Questions](#)
 - c. [Suggestions for Classroom Use](#)

- II. ARTICLE-SPECIFIC MATERIALS
 - a. [Specific to this *Science* article](#)
 - b. [Connect to Learning Standards](#)
 - c. [Summary of the Article for the Teacher](#)
 - d. [Discussion Questions](#)

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

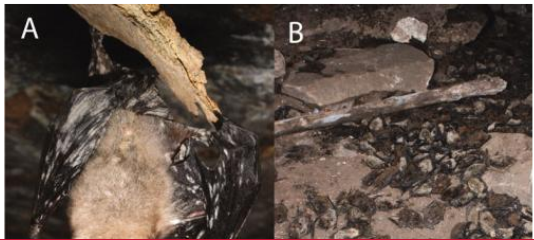
Learning Lens:

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.

ABSTRACT
[White-Nose Syndrome \(WNS\)](#) is an emerging disease affecting hibernating bat mortality and precipitous population declines in winter [hibernacula](#). First discovered spreading rapidly across eastern North America and currently affects seven species, WNS is a regional population collapse and is predicted to lead to regional extinction of the [little brown myotis \(Myotis lucifugus\)](#), previously one of the most common bat species in North America. Novel diseases can have serious impacts on [naive wildlife populations](#), which in turn can have substantial impacts on ecosystem integrity.

REPORT
[Emerging infectious diseases](#) are increasingly recognized as [direct and indirect agents of extinction](#) of free-ranging wildlife (1–4). [Introductions of disease into naive wildlife populations](#) have led to serious declines or [local extinctions](#) of different species in the past few decades, including amphibians from [chytridiomycosis](#) (5, 6), rabbits from [myxomatosis](#) in the United Kingdom (7), [Tasmanian devils](#) from infectious cancer (3), and birds in North America from [West Nile virus](#) (8). Here we demonstrate that [White-Nose Syndrome \(WNS\)](#), an emerging infectious disease, is causing unprecedented mortality among hibernating bats in eastern North America and has caused a population collapse that is [threatening regional extinction](#) of the little brown myotis (*Myotis lucifugus*), a once widespread and common bat species.

[WNS is associated with a newly described psychrophilic fungus \(*Geomyces destructans*\)](#) that grows on exposed tissues of hibernating bats, apparently causing premature arousals, aberrant behavior, and [premature loss of critical fat reserves](#) (9, 10) (Fig. 1). [The origin of WNS and its putative pathogen, *G. destructans*, is uncertain](#) (9). A plausible hypothesis for the origin of this disease in North America is [introduction via human trade or travel from Europe](#), based on recent evidence that *G. destructans* has been observed on at least one [hibernating bat species in Europe](#) (11). [Anthropogenic](#) spread of invasive pathogens in wildlife and domestic animal populations, so-called [pathogen pollution](#), poses substantial [threats to biodiversity and ecosystem integrity and is of major concern in conservation efforts](#) (1, 2).



Learning Lens

A species of bats:
http://www.mnh.si.edu/mna/image_info.cfm?species_id=199

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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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.

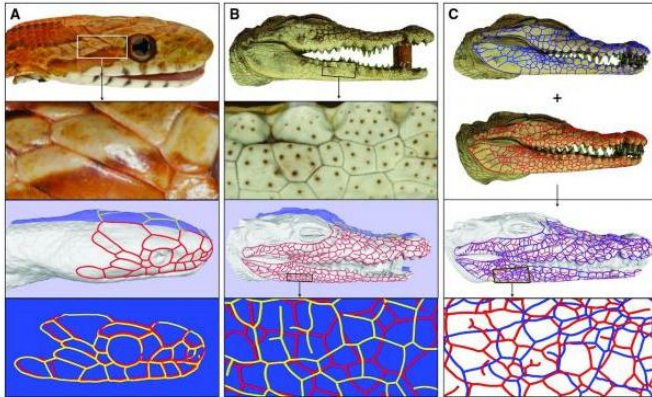


Fig. 1. Spatial distribution of head scales. (A) Head scales in most snakes (here, a corn snake) are polygons (two upper panels) with stereotyped spatial distribution (two lower panels): left (yellow) and right (red) scale edges overlap when reflected across the sagittal plane (blue). **(B)** Polygonal 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...>

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- REFERENCES AND NOTES

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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28. K. L. Jang, R. R. McCrae, A. Angleitner, R. Riemann, W. J. Livesley, Heritability of facet-level traits in a cross-cultural twin

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

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.

flexible use of spatially precise

brain plasticity. *Front Neurosci* 4,

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.

The screenshot displays the 'Science in the Classroom' website interface. At the top, the site title 'Science in the Classroom' is accompanied by the tagline 'A collection of annotated research papers and accompanying teaching materials'. The page is categorized for 'Audience' as 'High School' and 'University', and the 'TOPIC' is 'Biological'. The main resource title is 'Lemmings: They're What's for Dinner'. The resource content includes a cover image of 'Science' magazine with the headline 'Brain Disease', an 'EDITOR'S INTRODUCTION' by Gilg et al. titled 'Cyclic Dynamics in a Simple Vertebrate Predator-Prey Community', and an 'ABSTRACT' discussing lemming population dynamics in Greenland. The right sidebar features a search bar, social sharing options, and a 'THOUGHT QUESTIONS' section with six numbered questions. Below this is a 'LEARNING LENS' section with a category selector and a list of links: GLOSSARY, PREVIOUS WORK, AUTHOR'S EXPERIMENTS, CONCLUSIONS, and NEWS AND POLICY LINKS. A red navigation bar at the bottom contains links for Home, Download PDF, Related Science News, Paper Details, Questions?, Activities, Teaching Resources, and Contact Us.

Science in the Classroom
A collection of annotated research papers and accompanying teaching materials

Audience: High School University

Edit TOPIC Biological

Lemmings: They're What's for Dinner

Science
Brain Disease

EDITOR'S INTRODUCTION
Cyclic Dynamics in a Simple Vertebrate Predator-Prey Community.
Gilg et al.

Scientific studies often involve more than one discipline. In this case of lemming population dynamics, scientists use both ecology-related methodology to collect data in Greenland, and mathematical equations to construct a predictive model. Similar to the cyclic dynamic described in this study, this interdisciplinary research would not have been complete if one of these two scientific disciplines had been missing.

annotated by Fanny Bernardon
original paper published 10/31/2003
annotations posted on 1/31/14

THOUGHT QUESTIONS

1. Why is this study important?
2. What is the objective?
3. What are the conclusions?
4. What is the supporting evidence?
5. Are there any doubts that this conclusion is right?
6. What would you do next?

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LEARNING LENS

Click on a category below to display additional information and more information by clicking the highlighted text to the left.

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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

Scientists are looking for connections between various microbe environments. In this study, the scientists collected samples from aquatic and terrestrial environments as well from microbiomes of human mouth, stools, and throat in order to compare and contrast the genetic material found within these microcosms.

The importance of this scientific research

The scientists performed an extensive survey of environmental data to study the reassignment of genetic codes. They investigate the effect of such reassignment in genetically recorded organisms and also in viral resistance.

The actual science involved

The scientists undertook a massive bioinformatic analysis of 5.6 trillion base pairs of metagenomic data for stop codon reassignment events.

Connect to Learning Standards:

Next Generation Science Standards 8 practices:

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

1. Asking questions (for science) and defining problems (for engineering)
4. Analyzing and interpreting data
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

AP Biology

<http://media.collegeboard.com/digitalServices/pdf/ap/ap-biology-course-and-exam-description.pdf>

Essential Knowledge 2.D.2: Homeostatic mechanisms reflect both common ancestry and divergence due to adaptation in different environments.

Common Core English Language Arts Standards:

<http://www.corestandards.org/ELA-Literacy/RST/11-12/2/>

Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.

Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

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:

In most animals, babies sleep more than adults. This is true in humans, mice, and even all the way down to fruit flies (*Drosophila*). The authors of this paper discovered that the reason newborn flies sleep more than adults is because they have less of a chemical called dopamine. This chemical is a neurotransmitter, which means it is used for neurons to communicate with one another. In the fly, less dopamine causes a brain region called the dorsal fan-shaped body (dFSB) to become more active, which causes young flies to sleep more. The researchers also found that young male flies need sleep in order to court female flies when they are older. The reason for this appears to be related to another region of the brain called the VA1v. This study is important because it shows that the consequences of sleep deprivation during development may carry over into adulthood.

Topics Covered:

- CRISPR
- Genetically recorded Organisms
- Viral resistance
- Genetic code and their reassignments

Methods used in the Research:

- bioinformatics
- analysis tools such as Prodigal

Conclusions:

This research showed that codon reassignment is diverse and abundant in prokaryotes and phages.

Areas of Further Study:

- Genetically Recorded Organisms
- Viral resistance and alternative genetic codon

Resources for Interactive Engagement:

Discussion Questions

1. What is the genetic code and why it is universal?

The genetic code is set of rules for information flow from DNA (or RNA) to proteins. It suggests which three nucleotides code which amino acids. It is universal as it is optimum and selected for better information flow from DNA to proteins.

2. Is there any alternative assignment for genetic code that is different than universal?

There are alternative assigned for many codon in different organisms. For example in *Mycoplasma capricolum*, codon UGA is assigned for tryptophan instead of its universal role in termination signal.

3. What are tools for gene prediction?

There are several bioinformatics tools like Prodigal, GSFinder, TiCO, Glimmer, GenemarkHMM and Easygene.

4. Do stop codons code for amino acids or not?

Yes. For example in *Mycoplasma capricolum*, codon UGA is assigned for tryptophan instead of its universal role in termination signal.

5. Does difference in codon usages cause protection of host from virus infection?

It is one of the antiviral hypotheses but this paper shows that phages infect bacteria even if there is difference in codon usage.

6. What is CRISPR?

This is a newly discovered pathway in bacteria and archaea that protects cells from phages and conjugative plasmids.