Teacher Resource for:

Sleep promotes branch-specific formation of dendritic spines after learning

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. Student Learning Goals (specific)
- b. Connect to Learning Standards
- c. Summary of the Article for the Teacher
- d. Resources for Interactive Engagement
  - i. 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:

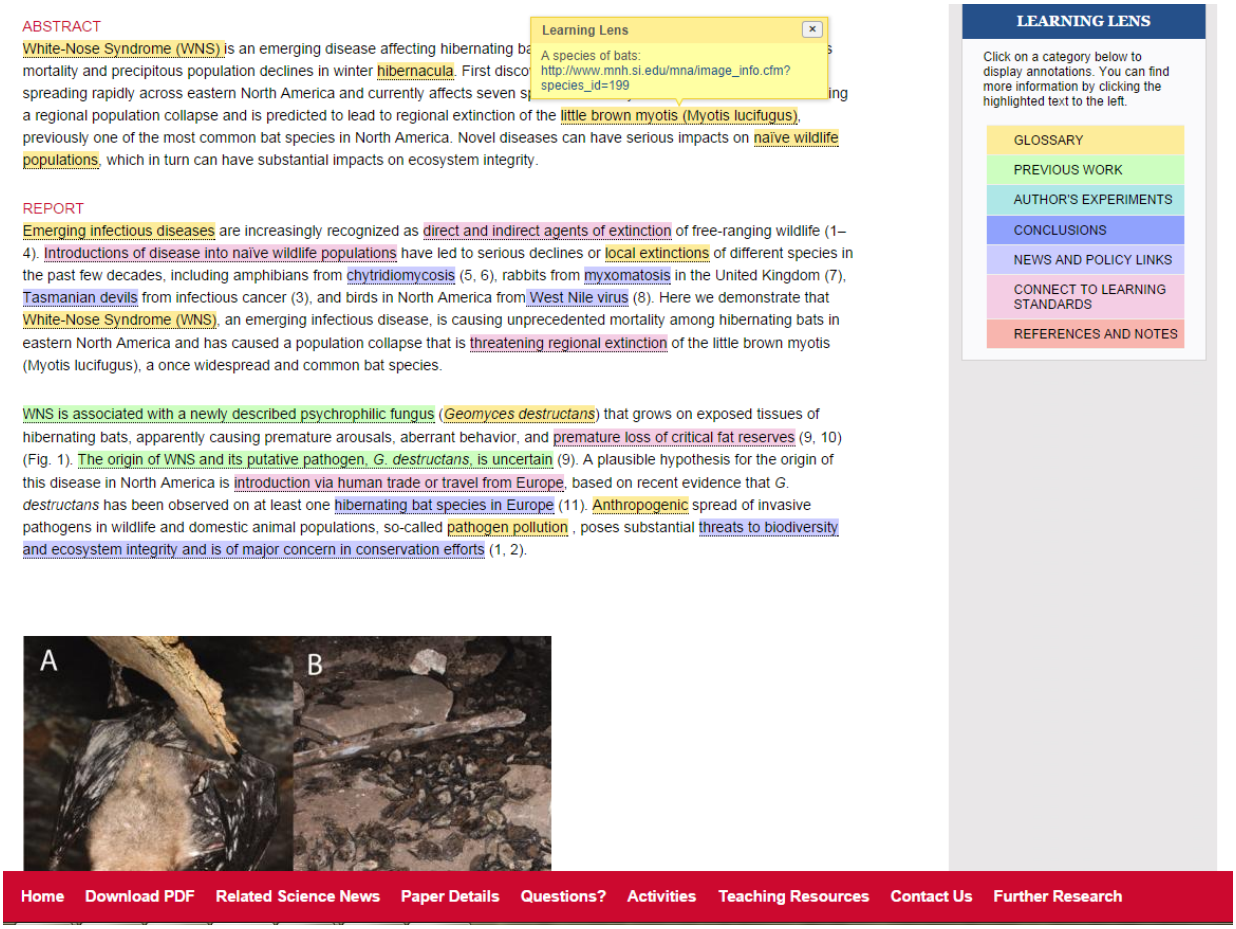
- Scientists must be independent thinkers, who are free to dissent from what the majority believes.
- Science can deal only with issues for which testable evidence can be obtained.
- All scientific understandings are built on previous work
- It is to be expected that one scientist's conclusions will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

<u>Learning Lens:</u>

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.

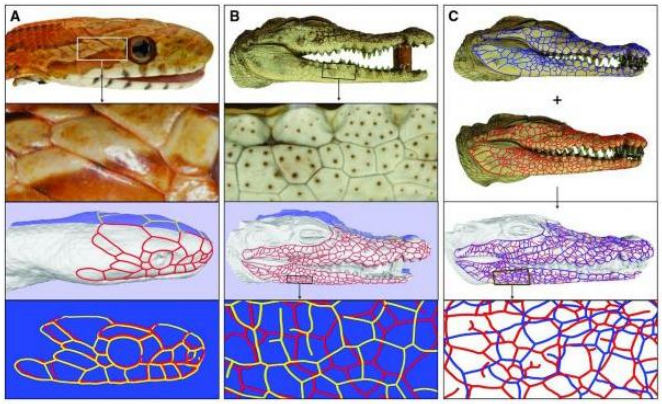


Fig. 1. Spatial distribution of head scales. (A) Head scales in most snakes (here, a corn snake) are polygons (two upper panels) with stereotyped spatial distribution (two lower panels): left (yellow) and right (red) scale edges overlap when reflected across the sagittal plane (blue). (B) Polygonal head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

Home Download PDF Related Science News Paper Details Questions? Activities Teaching Resources Contact Us

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.

6. L. Lewejohann, B. Zipser, N. Sachser, "Personality" in laboratory mice used for biomedical research: A way of understanding variability? Dev. Psychobiol. 53, 624 (2011).
7. G. Kempermann, The neurogenic reserve hypothesis: What is adult hippocampal neurogenesis good for? Trends Neurosci. 31, 163 (2008).
8. Lewejohann et al., Behavioral phenotyping of a murine model of Alzheimer's disease in a seminaturalistic environment using RFID tracking. Behav. Res. Methods 41, 850 (2009).
9. B. Steineret al., Differential regulation of gliogenesis in the context of adult hippocampal neurogenesis in mice. Glia 46, 41 (2004).
10. Garthe, J. Behr, G. Kempermann, Ad flexible use of spatially precise learning strategies. PLoS ONE 4, e54
11. G. Kempermann, New neurons for 'su 27 (2012).
12. G. Kempermannet al., Why and how brain plasticity. Front Neurosci 4, 189 (2010).
13. K. Fabelet al., Additive effects of physical exercise and environmental enrichment on adult hippocampal neurogenesis in mice. Front. Neurosci. 3, 50 (2009).
14. Amrein, H. P. Lipp, Adult hippocampal neurogenesis of mammals: Evolution and life history. Biol. Lett. 5, 141 (2009).
15. G. Kempermann, Why new neurons? Possible functions for adult hippocampal neurogenesis. J. Neurosci. 22, 635 (2002).
16. C. Crabbe, D. Wahlsten, B. C. Dudek, Genetics of mouse behavior: Interactions with laboratory environment. Science 284, 1670 (1999).
17. Lewejohann et al., Environmental bias? Effects of housing conditions, laboratory environment and experimenter on behavioral tests. Genes Brain Behav. 5, 64 (2006).
18. D. W. Bailey, How pure are inbred strains of mice? Immunol. Today 3, 210 (1982).
19. R. Lathe, The individuality of mice. Genes Brain Behav. 3, 317 (2004).
20. C. Julieret al., Minisatellite linkage maps in the mouse by cross-hybridization with human probes containing tandem repeats. Proc. Natl. Acad. Sci. U.S.A. 87, 4585 (1990).
21. R. P. Talenset al., Epigenetic variation during the adult lifespan: Cross-sectional and longitudinal data on monozygotic twin pairs. Aging Cell 11, 694 (2012).
22. P. B. Baltes, J. R. Nesselroade, S. W. Cornelius, Multivariate antecedents of structural change in development: A simulation of cumulative environmental patterns. Multivariate Behav. Res. 13, 127 (1978).
23. M.E. Raijmakers, P. C. Molenaar, Modeling developmental transitions in adaptive resonance theory. Dev. Sci. 7, 149 (2004).
24. K. Friston, M. Breakspear, G. Deco, Perception and self-organized instability. Front. Comput. Neurosci. 6, 44 (2012).
25. Van de Weerd et al., Effects of environmental enrichment for mice: Variation in experimental results. J. Appl. Anim. Welf. Sci. 5, 87 (2002).
26. D. P. Wolferet al., Laboratory animal welfare: Cage enrichment and mouse behaviour. Nature 432, 821 (2004).
27. K. Lewin, Dynamic Theory of Personality (McGraw-Hill, New York, 1935).
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

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.

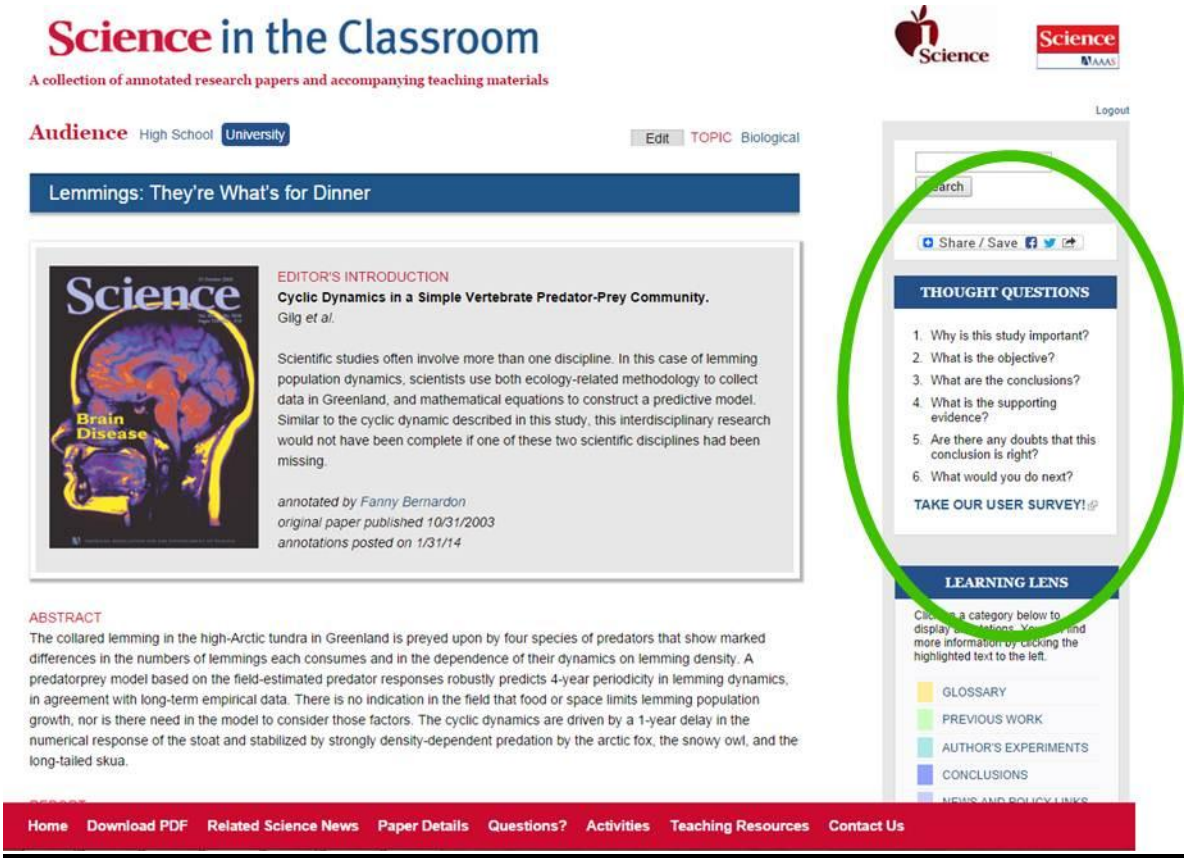
LEARNING LENS

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

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

- How exactly does sleep aid learning and memory formation?

The importance of this scientific research

- Sleep plays a key role in learning and memory formation, but the mechanisms of these processes remain elusive. This study establishes the mechanism that sleep promotes the formation and maintenance of learning-dependent, postsynaptic dendritic spines and contributes to memory storage.

The actual science involved

- Synaptic formation, maintenance, and elimination

Connect to Learning Standards:

- Connects to English Language Arts Standards, Science and Technical Subjects Standard CCSS.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."

- Connects to English Language Arts Standards, Science and Technical Subjects Standard CCSS.ELA-LITERACY.RST.11-12.6.

  Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved."

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

- Connects to Next Generation Science Standard Practice 1:

  Asking questions (for science) and defining problems (for engineering)

- Connects to Next Generation Science Standard Practice 4:

  Analyzing and interpreting data

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

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:
Scientists know that sleep is involved in learning and memory, however they don't know exactly how. In this study, scientists examine how the structure of a neuron changes after a task is learned. Using a mouse model, scientists were able to show the growth of small protuberances—or "spines"—that formed on dendrites of neurons after the mice learned a motor task. As the mice slept, the neurons retained these spines, as neurons what fired during the learning process also fired during sleep.

Topics Covered:

- Sleep in motor learning and memory
- Dendritic spine remodeling
- Neuronal reactivation during sleep

Methods used in the Research:

- Genetically and surgically modified mouse models
- Rotarod and treadmill motor training
- Transcranial two-photon microscopy
    - Yellow fluorescent protein tag
    - GCaMP6 calcium indicator
- EEG, EMG recording
- Drug administration
    - Corticosterone
    - N-methyl-D-aspartate receptor inhibitor MK801
- Statistical tests
    - Non parametric
    - One-way ANOVA

Conclusions:

Sleep promotes the formation and maintenance of synapses after learning on selected dendritic branches. This synaptic formation is aided by neuronal reactivation during nonrapid eye movement (NREM) sleep.

Areas of Further Study:

What are other ways in which sleep contributes to memory storage?

How does neuronal reactivation promote synaptic formation? (i.e. epigenetic regulation)

Resources for Interactive Engagement:

Discussion Questions

1. What is the goal of this study?
2. Why is this study important?
3. Are there any other explanations for the observed results?
4. Assuming this is the only reason connecting sleep to learning and memory, what advice would you give your friends regarding being able to learn?