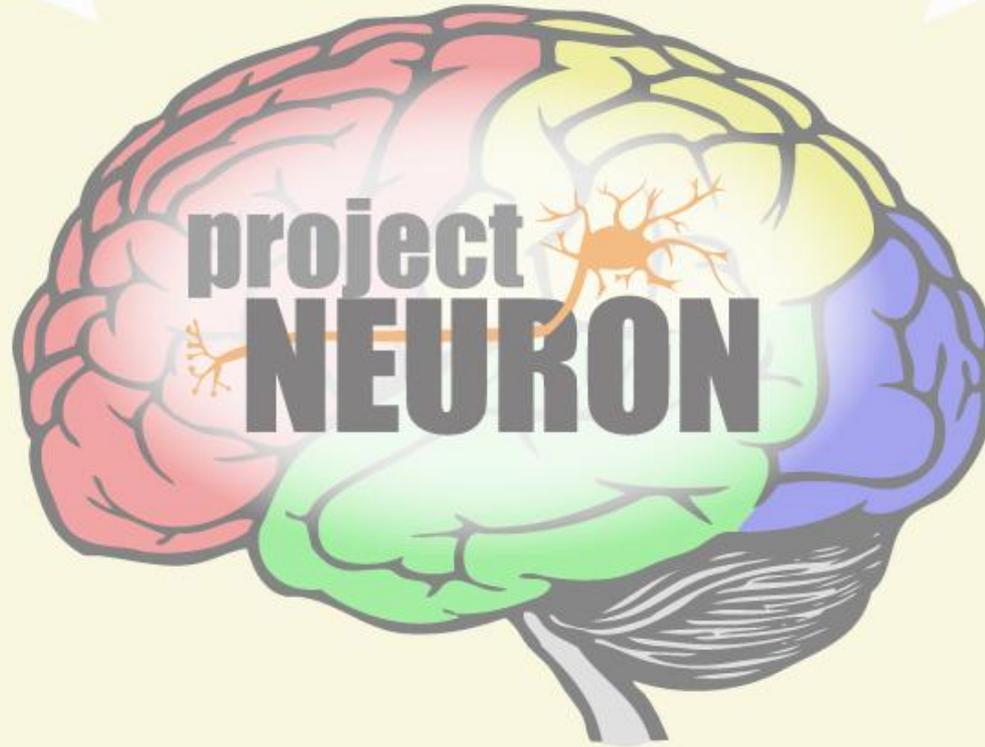


# Worms and cell biology: Connect students to scientists' work



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National Institutes  
of Health

**SEPA** SCIENCE EDUCATION  
PARTNERSHIP AWARD  
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# What is Project NEURON?

- At the University of Illinois
- Educators, scientists, and graduate students
- Curriculum development
  - Inquiry-based
  - Connect to standards
- Professional development
  - Summer institutes
  - Conferences



# Project NEURON Curriculum Units

- **Do you see what I see?**
  - *Light, sight, and natural selection*
- **What can I learn from worms?**
  - *Regeneration, stem cells, and models*
- **What makes me tick...tock?**
  - *Circadian rhythms, genetics, and health*
- **What changes our minds?**
  - *Toxicants, exposure, and the environment*
  - *Foods, drugs, and the brain*
- **Why dread a bump on the head?**
  - *The neuroscience of traumatic brain injury (TBI)*
- **Food for thought: What fuels us?**
  - *Glucose, the endocrine system, and health*
- **What makes honey bees work together?**
  - *How genes and environment affect behavior*
- **How do small things make a big difference?**
  - *Microbes, ecology, and the tree of life*

Available at:  
[neuron.illinois.edu](http://neuron.illinois.edu)

# An Iterative & Collaborative Development Process



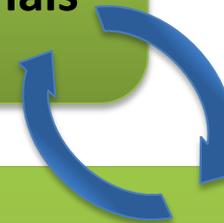
**Determine main understanding goals and develop unit outline**



**Develop and revise lesson plan and student materials**



**Scientists provide feedback**  
(Newmark Lab)



**Teachers provide feedback**  
(Based on workshops and classroom enactments)

# The Curriculum Unit

## What can I learn from worms?

*Regeneration, stem cell, and models*

- Lesson 1: What is regeneration?
- Lesson 2: How do planarians react to their environments?
- Lesson 3: How do planarians regenerate?
- Lesson 4: What happens in the worms' cells during regeneration?
- Lesson 5: How can we see the worms' cells during regeneration?
- Lesson 6: How do DNA and protein determine behavior?
- Lesson 7: What does planarian regeneration tell us about human regeneration?

# Connections to NGSS

Performance Expectation: Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms (HS-LS1-4).

DCIs	Practices	Crosscutting Concepts
LS1.B Growth and development of organisms	Developing and using models Planning and carrying out investigations Analyzing & interpreting data Constructing explanations	Patterns Cause and effect System and system models

# Unit beginnings

**Lesson 1: What is regeneration?**

**Lesson 2: How do planarians react to their environment?**

# Connections to Scientists (1890s)

## Lesson 3



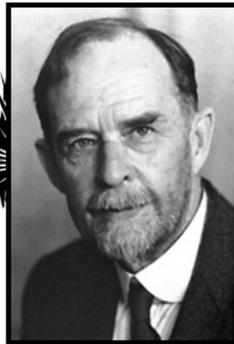
### Cool Scientists: Randolph and Morgan

In the early development of most animals, an individual begins its life as a single cell. This cell divides and becomes two cells, then four, then eight and so on. Over time, a complex individual forms with billions of cells that have very different functions and appearances. One may wonder how all those cells manage to develop and organize themselves into the familiar shapes of animals. Why aren't there a lot of cats with six toes or turtles with two heads running around? And if we do see these individuals, we wonder what went wrong? In other words, how do cells in an embryo "know" that they should form a leg, a brain, or an artery?

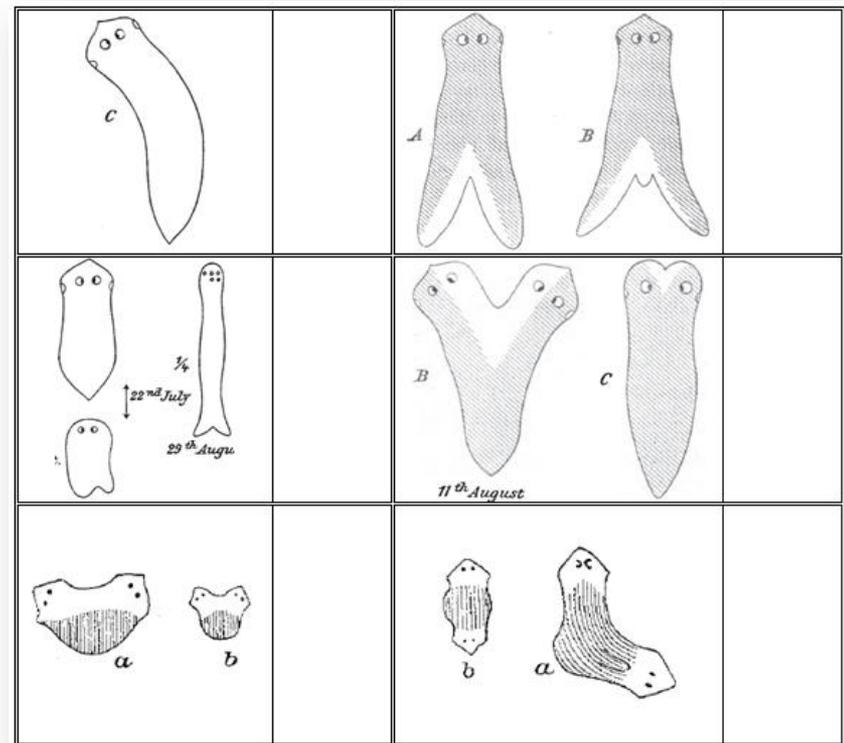
These are questions that scientists have been asking for hundreds of years and are still trying to solve today. You will have the

opportunity to conduct experiments similar to those performed on planarians over a hundred years ago by scientists like Harriet Randolph and Thomas Hunt Morgan.

**Harriet Randolph** was born in Pennsylvania and had a late start in her science career, graduating from the women's college Bryn Mawr at age thirty-three. She was trained by Edmund Beecher Wilson, the famous cell biologist who discovered that females and males have distinct sex chromosomes. Randolph received her Ph.D. in Zurich, Germany, while researching the reproductive cells of insects. She returned to Bryn Mawr as a lecturer for biology classes and studied planarians during the summer at the Marine Biological Laboratory in Woods Hole, Massachusetts.



Early planarian experiments  
by Harriet Randolph and  
Thomas Hunt Morgan



# Planarian Experiment: How do planarians regenerate?

- 1) Develop hypothesis
- 2) Design experiment
- 3) Perform cuts
- 4) Observe sample cut planarians

(20 minutes)



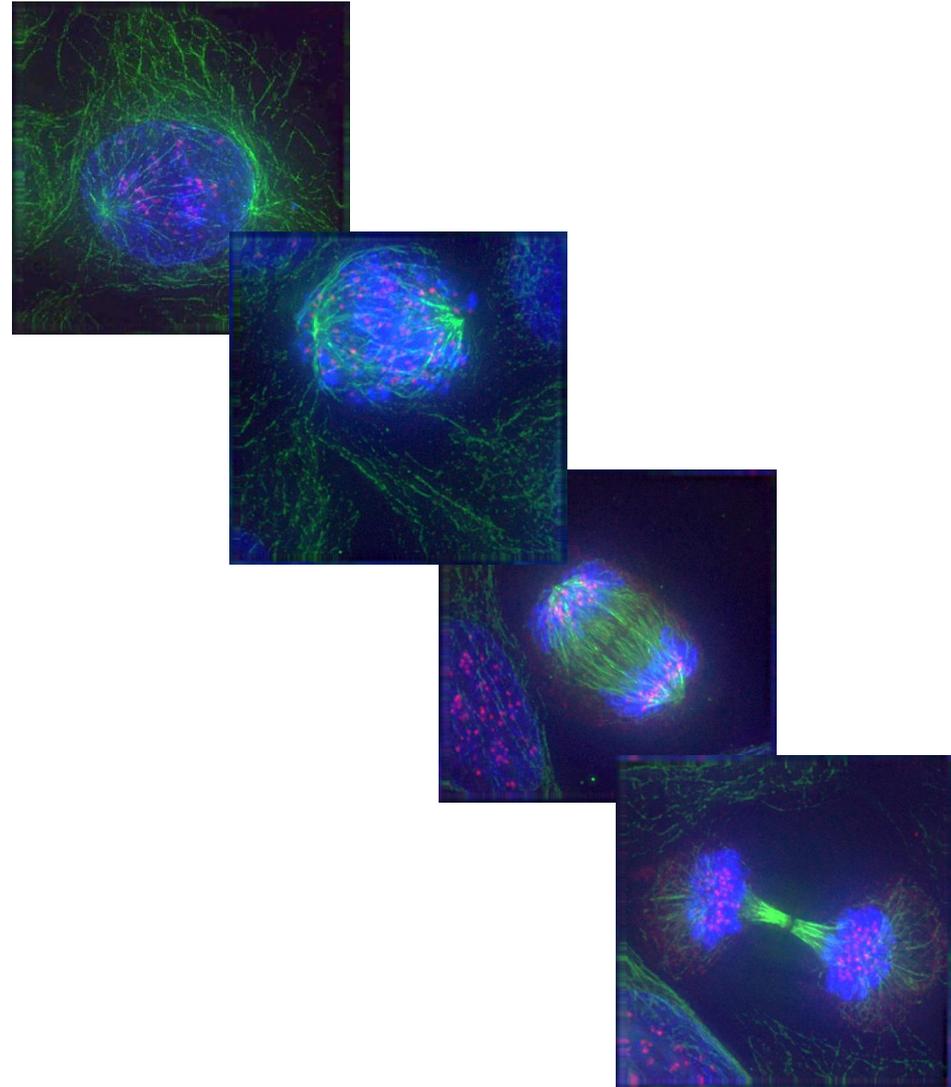
# Planarian Experiment: Discussion

- What did you do?
- What did you find?
- What are your initial thoughts about this experiment?

# Lesson 4: What happens in worms' cells during regeneration?

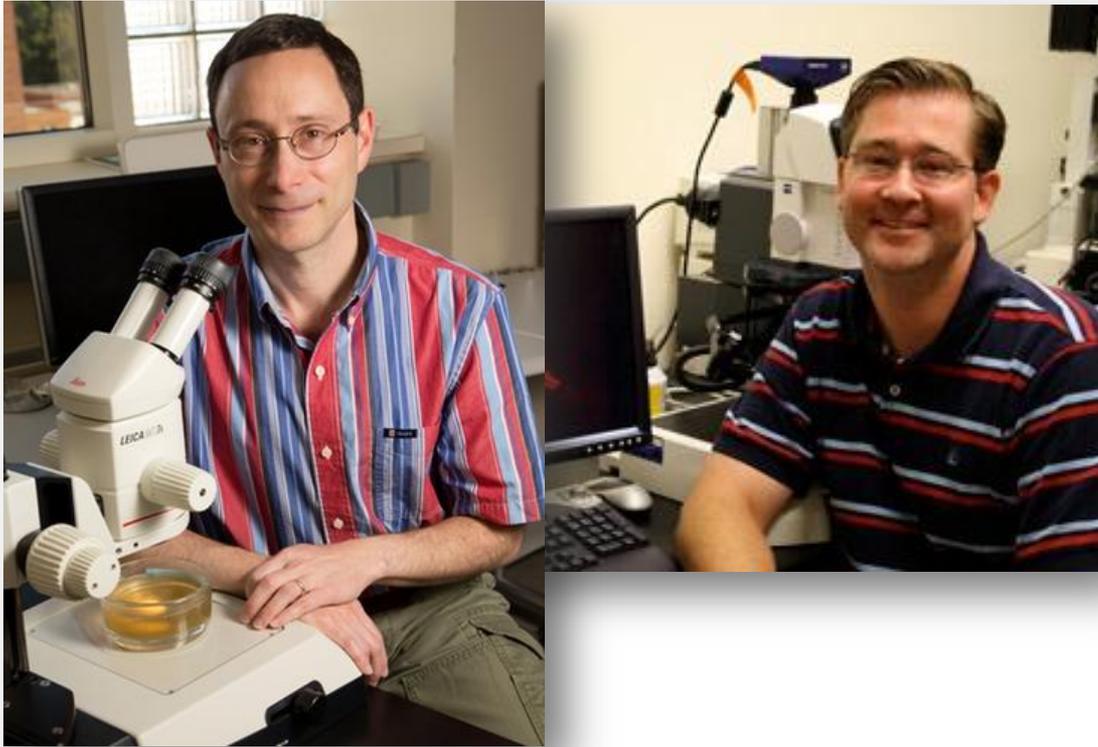
Students learn about cell division within the context of their planarian experiment:

- The story of Planarian Paolo
- Cell images of mitosis



# Connections to Current Scientists

## Lesson 5

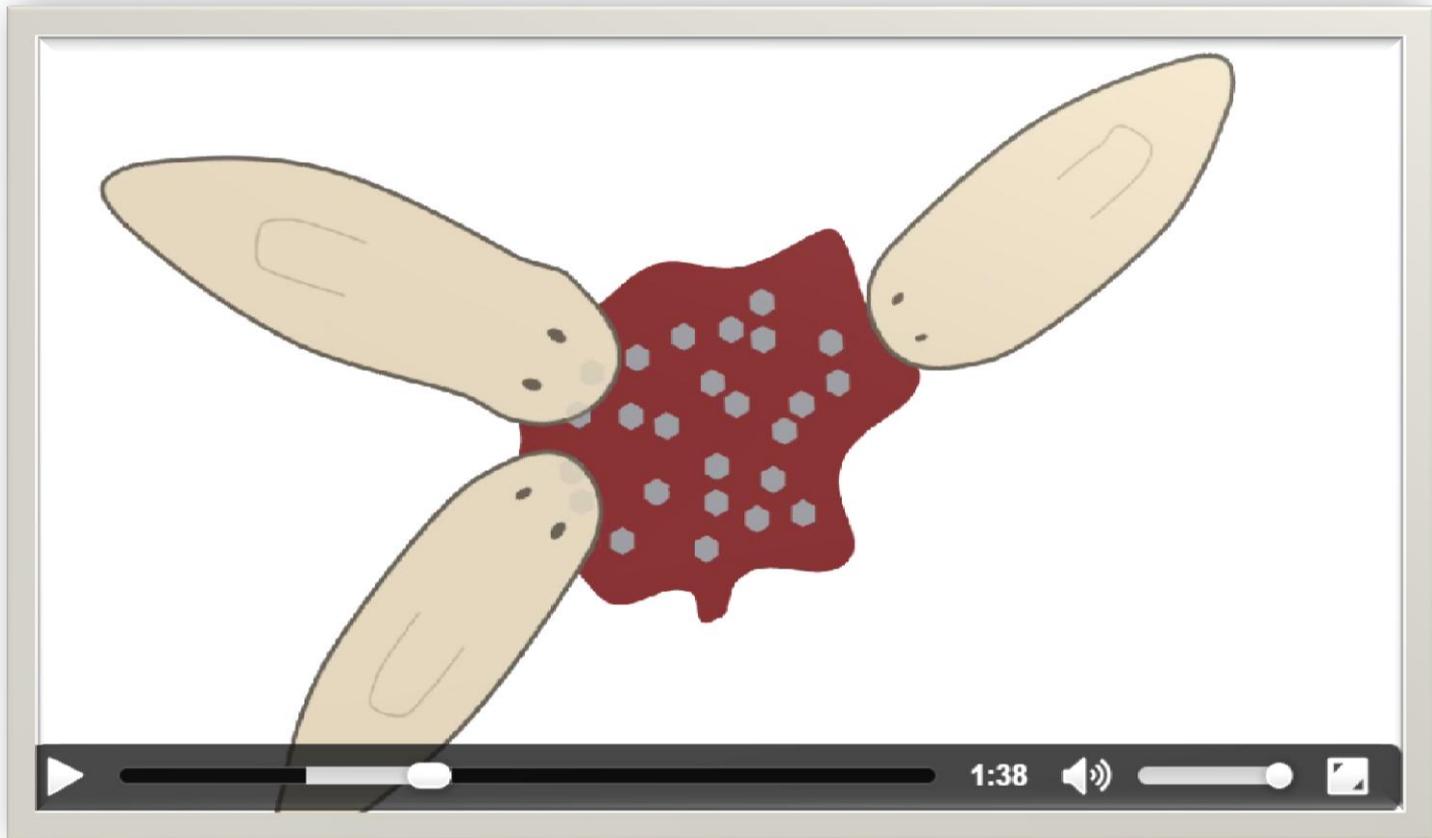


**Newmark Lab**  
**Planarian Regeneration**  
**University of Illinois**



Newmark & Sánchez, 2000

# Video: How do scientists visualize the regeneration of cells?



<https://neuron.illinois.edu/videos/brdu>

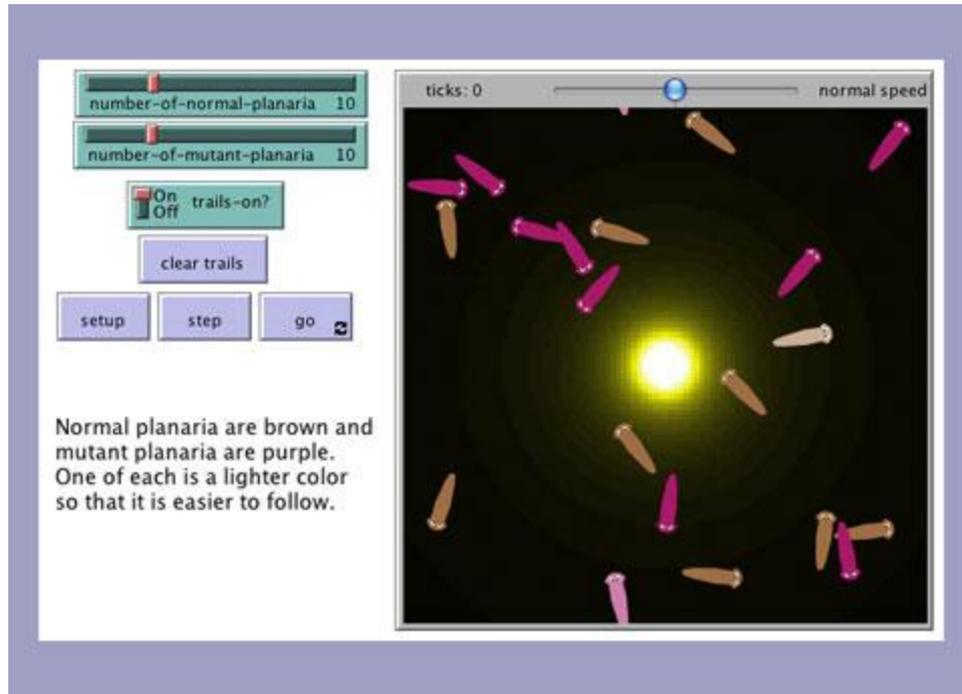
# Analyzing a scientist's data

Students learn more about how a planarian regenerates using published scientific data from the Newmark lab

- Students can apply new understanding of scientific principles to their explanation of why their planarians are regenerating.

# Netlogo Simulation

How do DNA and protein determine behavior?



- What is RNAi?
- Propose an experiment (1-normal & mutant)
- What protein is altered? (2-RNAi experiment 1)
- What does siRNA show? (3-RNAi experiment 2)

**Lesson 6** (20 min)

# Discussion:

## BrdU Video, Reading & RNAi Simulation

- In groups, compare and contrast the content presented in the video, reading with that in the Netlogo simulation.
- How can you incorporate this information to develop a stronger model of cell division and differentiation?
- How does the new information affect your explanation for your planarian experiment?

# Discussion

- How would you use these lessons in your classroom?
- What is the value of connecting to real scientists' work?
- What is the value of using planarians to teach cell division and differentiation?

# Acknowledgements

- NIH, SEPA
- University of Illinois
  - Project NEURON

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# Thanks!

For additional information visit:  
**<http://neuron.illinois.edu>**

E-mail:  
**[neuron@illinois.edu](mailto:neuron@illinois.edu)**

The screenshot shows the Project NEURON website homepage. At the top left is the University of Illinois logo. In the center is a stylized brain with the text "project NEURON" overlaid. To the right of the brain is a search bar and a "Log in/Create account" link. Below the header is a navigation menu with links for "Curriculum Units", "Professional Development", "Games and Media", "Additional Projects", and "About". The main content area features the title "Project NEURON" and the subtitle "Novel Education for Understanding Research on Neuroscience". Below this is a section titled "Find out more about our 2013 Summer Professional Development!" followed by a paragraph of text. Another paragraph describes the core project's focus on curriculum units and professional development. A third paragraph notes the website's continuous improvement. A "News and Events" section lists three items: "Color Sorting Activity in The Science Teacher" (March 2013), "Color Sorting Game is Back Online" (February 20, 2013), and "Project NEURON at 2013 Public Engagement Symposium" (February 6, 2013). On the right side of the news section is a "Neuroscience Day" poster for two events: one at Marina Inn in Sioux City, NE on March 19, and another at Siena Gilleska in Mission, SD on March 20, both from 9:00 to 3:00 with lunch provided. The poster also features a small brain icon.