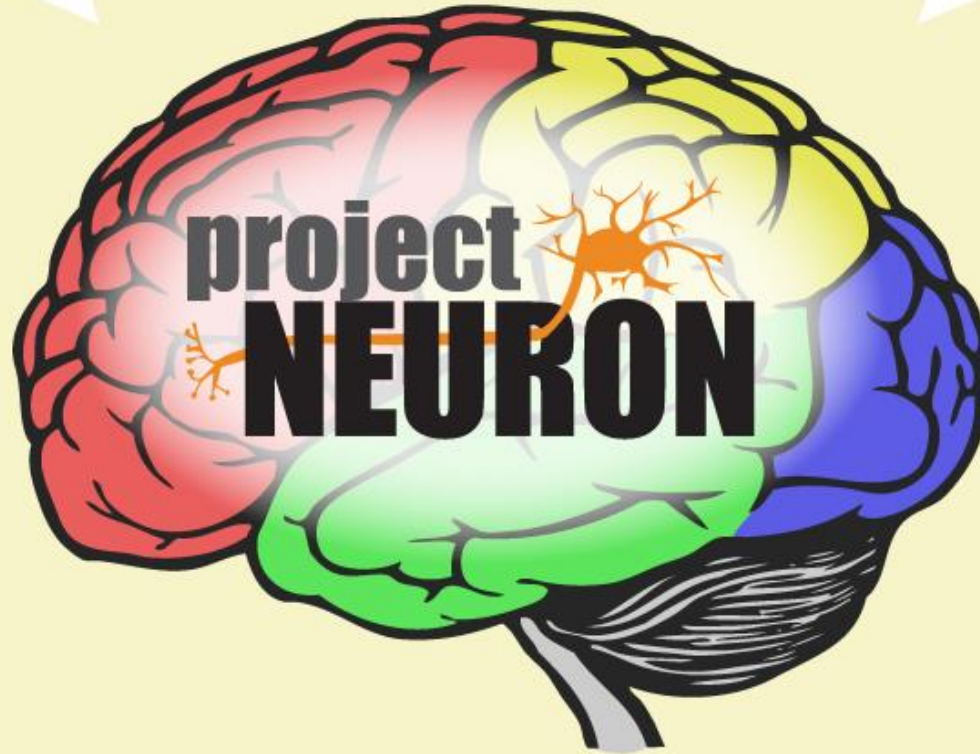


Modeling Using Digital Simulations



Robert Wallon, Hillary Lauren, & Barbara Hug
University of Illinois



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 microbes make a big difference?**
 - *Microbes, ecology, and the tree of life*

Available at:
neuron.illinois.edu



Session Goals

- Design experiments using a simulation
- Modify a simulation



Why use simulations?

- Effective for various science learning outcomes
 - Honey & Hilton, 2011
 - Smetana & Bell, 2012
 - D'Angelo et al., 2014



Framework and NGSS

Dimension 1: Science & Engineering Practices

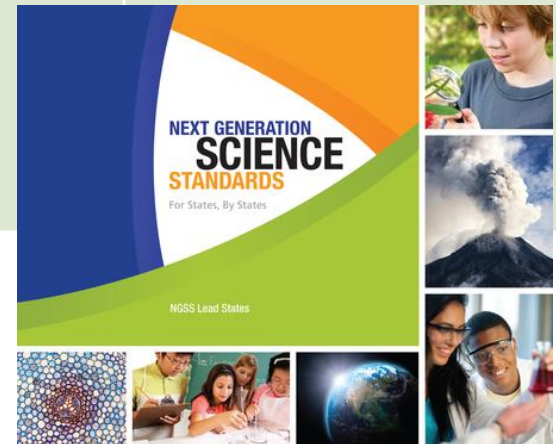
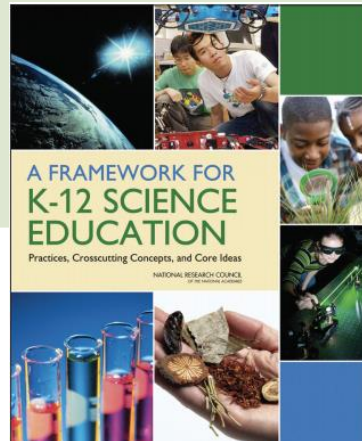
1. Asking questions
2. Developing/Using models
3. Planning/Carrying out investigations
4. Analyzing & interpreting data
5. Using math, information and computer technology, and computational thinking
6. Constructing explanations
7. Engaging in argument from evidence
8. Obtaining, evaluating, communicating information

Dimension 2: Crosscutting Concepts

1. Patterns
2. Cause and Effect
3. Scale, Proportion, and Quantity
4. Systems and System Models
5. Energy and Matter
6. Structure and Function
7. Stability and Change

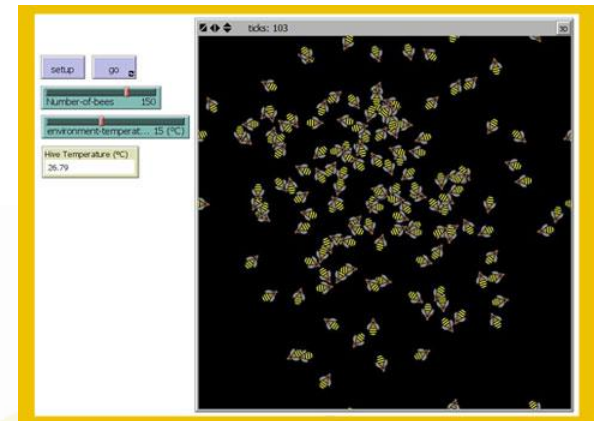
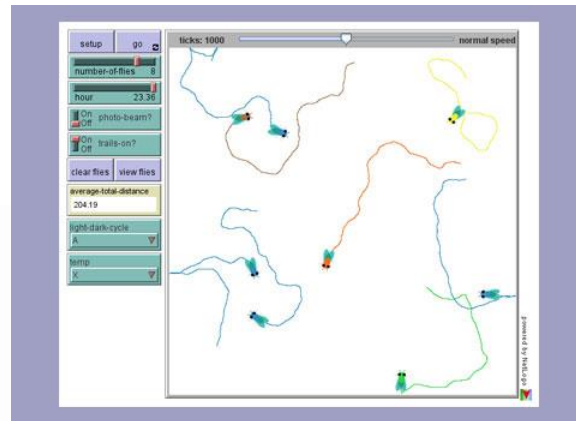
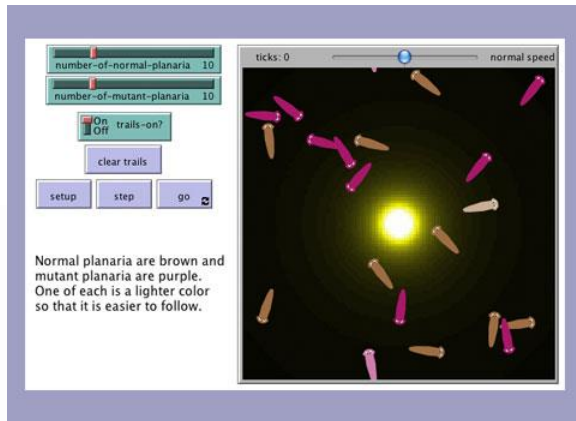
Dimension 3: Disciplinary Core Ideas

1. Physical Sciences
2. Life Sciences
3. Earth and Space Sciences
4. Engineering, Technology and Applications of Science



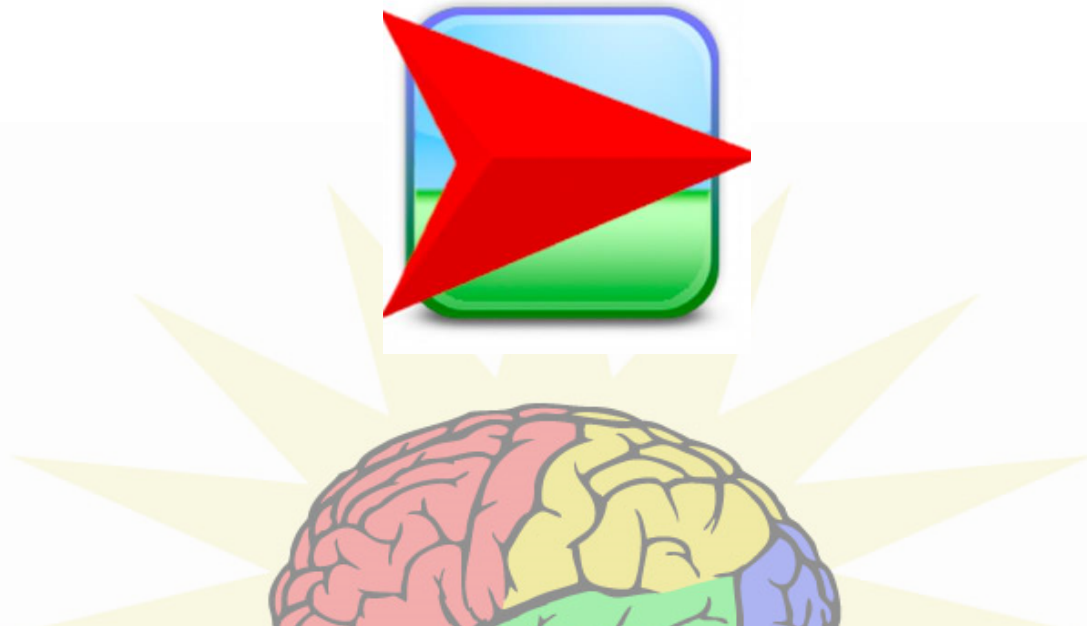
Project NEURON Simulations

- Planarians – RNAi
- Fruit flies – circadian rhythms
- Honey bees – hive thermoregulation



NetLogo

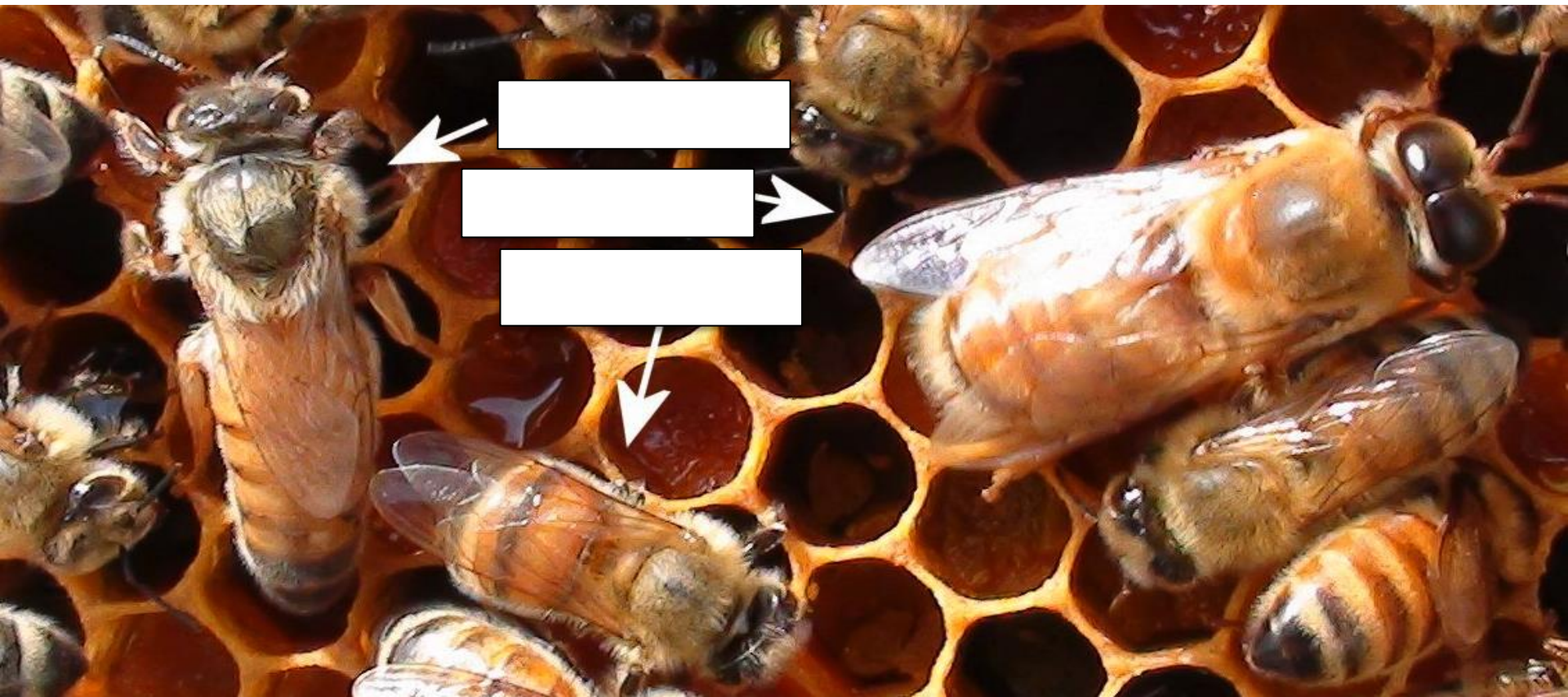
- “A multi-agent programmable modeling environment”
- Free software available from <https://ccl.northwestern.edu/netlogo/>



What makes honey bees work together?

- Lesson 1:
What do honey bees do?
- Lesson 2:
Why do honey bees have different jobs?
- Lesson 3:
How do honey bees heat the hive?
- Lesson 4:
What is the genetic basis for the evolution of eusocial behavior?







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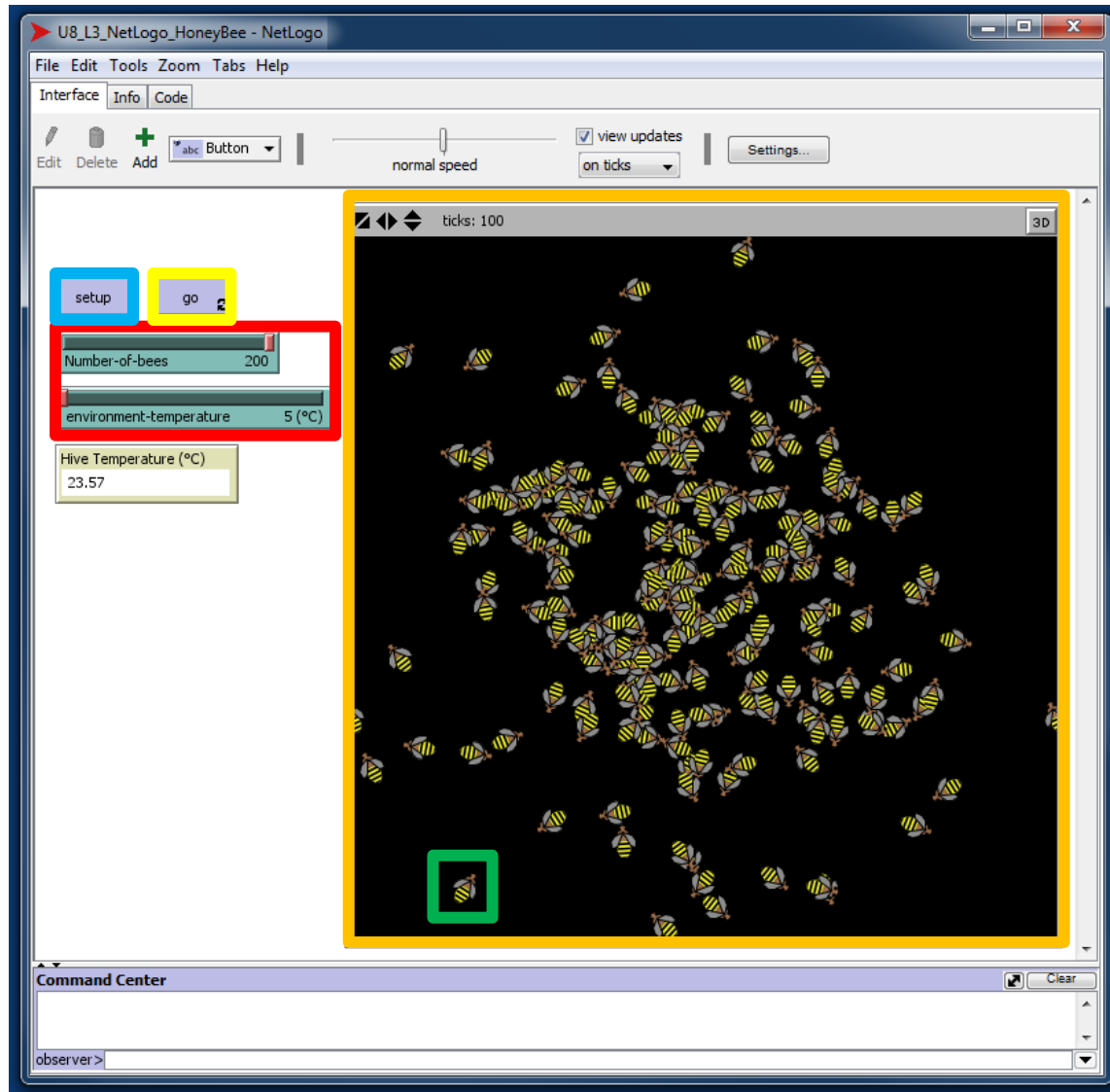


Design an experiment

- Question 1: How does the internal temperature of a bee colony change as the environmental temperature changes?
- Question 2: How does the number of bees in a group affect the response to environmental temperature?



How to use NetLogo



Design an experiment

- Question 1: How does the internal temperature of a bee colony change as the environmental temperature changes?
- Question 2: How does the number of bees in a group affect the response to environmental temperature?
- Groups of 2-3
- We will regroup in ~25 minutes



Framework and NGSS

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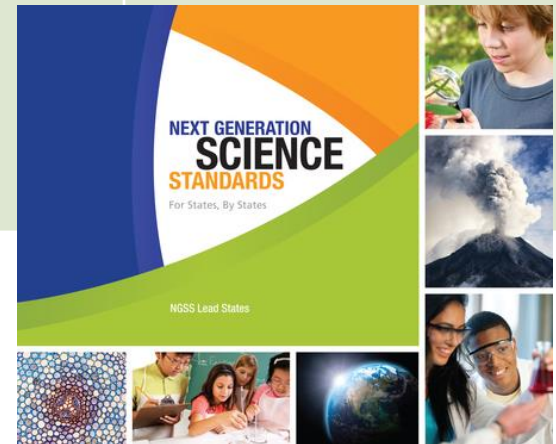
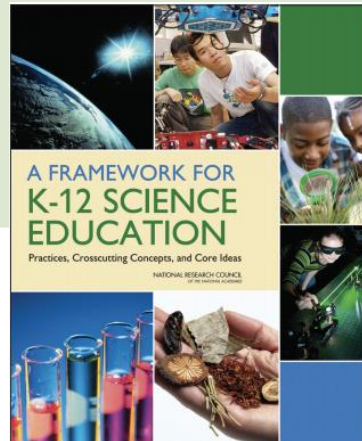
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Discussion

“Although models do not correspond exactly to the real world , they bring certain features into focus while obscuring others” (NGSS Appendix F).

- Which features were in focus? Which features were obscured?
- In what ways would you change the simulation to improve the model?



A look behind the scenes...

```
U8_L3_NetLogo_HoneyBee - NetLogo (C:\Users\rwallon2\Desktop)
File Edit Tools Zoom Tabs Help
Interface Info Code
Find... Check Procedures Indent automatically

globals [ temp-contribution beedistance ]

to setup
  clear-all
  create-turtles Number-of-bees [ setxy random-xcor random-ycor ]
  ask turtles [
    set shape "honeybee"
    set size 2
    create-links-with other turtles
    layout-spring turtles links 500 beedistance 1
    set beedistance (environment-temperature / 2)
  ]
  reset-ticks
end

to go
  move-bees
  heat-hive
  tick
  if ticks >= 100 [ stop ] ;; Only run for 100 ticks
end

to move-bees
  ask turtles [
    right random 360
    forward 1
  ]
end

to heat-hive
  ask turtles [
    if environment-temperature >= 5 and environment-temperature < 7.5 [
      if Number-of-bees >= 10 and Number-of-bees < 25 [ set temp-contribution ( Number-of-bees * 0.5666666666 )
      if Number-of-bees >= 25 and Number-of-bees < 50 [ set temp-contribution ( 0.132 * Number-of-bees + 10.5 )
      if Number-of-bees >= 50 and Number-of-bees < 100 [ set temp-contribution ( 0.088 * Number-of-bees + 12.5 )
      if Number-of-bees >= 100 and Number-of-bees <= 200 [ set temp-contribution ( 0.023 * Number-of-bees + 14.5 )
    ]
    if environment-temperature >= 7.5 and environment-temperature < 12.5 [
      if Number-of-bees >= 10 and Number-of-bees < 25 [ set temp-contribution ( 0.28 * Number-of-bees + 8.7 )
      if Number-of-bees >= 25 and Number-of-bees < 50 [ set temp-contribution ( 0.128 * Number-of-bees + 12.5 )
      if Number-of-bees >= 50 and Number-of-bees < 100 [ set temp-contribution ( 0.1 * Number-of-bees + 13.5 )
      if Number-of-bees >= 100 and Number-of-bees <= 200 [ set temp-contribution ( 0.027 * Number-of-bees + 15.5 )
    ]
    if environment-temperature >= 12.5 and environment-temperature < 17.5 [
      if Number-of-bees >= 10 and Number-of-bees < 25 [ set temp-contribution ( 0.1 * Number-of-bees + 17.5 )
      if Number-of-bees >= 25 and Number-of-bees < 50 [ set temp-contribution ( 0.048 * Number-of-bees + 18.5 )
      if Number-of-bees >= 50 and Number-of-bees < 100 [ set temp-contribution ( 0.072 * Number-of-bees + 17.5 )
      if Number-of-bees >= 100 and Number-of-bees <= 200 [ set temp-contribution ( 0.039 * Number-of-bees + 19.5 )
    ]
    if environment-temperature >= 17.5 and environment-temperature < 22.5 [
      if Number-of-bees >= 10 and Number-of-bees < 25 [ set temp-contribution ( 0.086666666667 * Number-of-bees + 17.5 )
      if Number-of-bees >= 25 and Number-of-bees < 50 [ set temp-contribution ( 0.048 * Number-of-bees + 18.5 )
      if Number-of-bees >= 50 and Number-of-bees < 100 [ set temp-contribution ( 0.072 * Number-of-bees + 17.5 )
      if Number-of-bees >= 100 and Number-of-bees <= 200 [ set temp-contribution ( 0.039 * Number-of-bees + 19.5 )
    ]
  ]
end
```

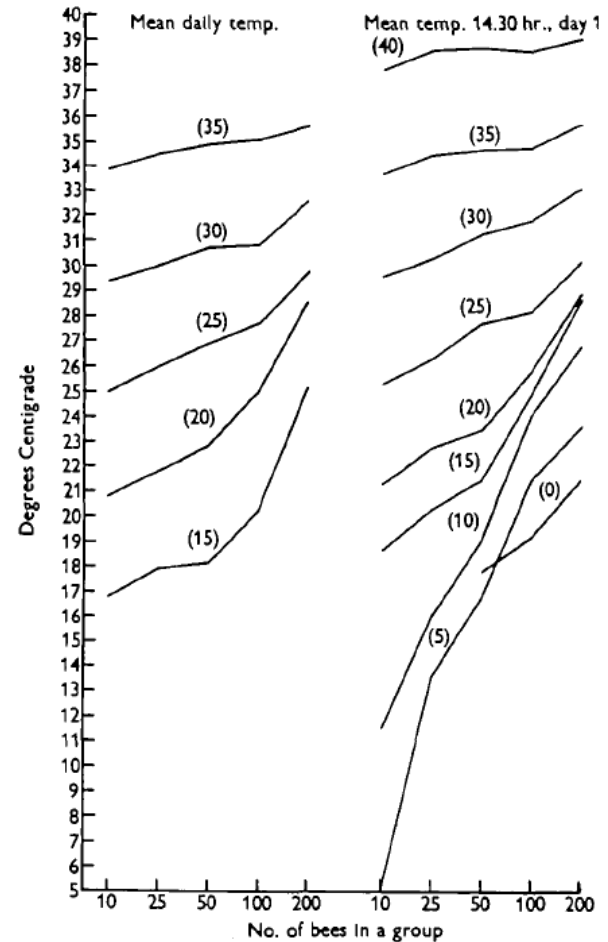


Fig. 1. Temperatures of groups at various environmental temperatures (environmental temperatures in parentheses).

Modify a simulation

- Groups of 2-3
- We will regroup in ~20 minutes



Discussion

- What worked well while modifying your simulation? What challenges did you experience?
- What additional support would you need to modify or create your own simulations?
- Under what circumstances would you ask your students to modify or create their own simulations?



Where to find more simulations

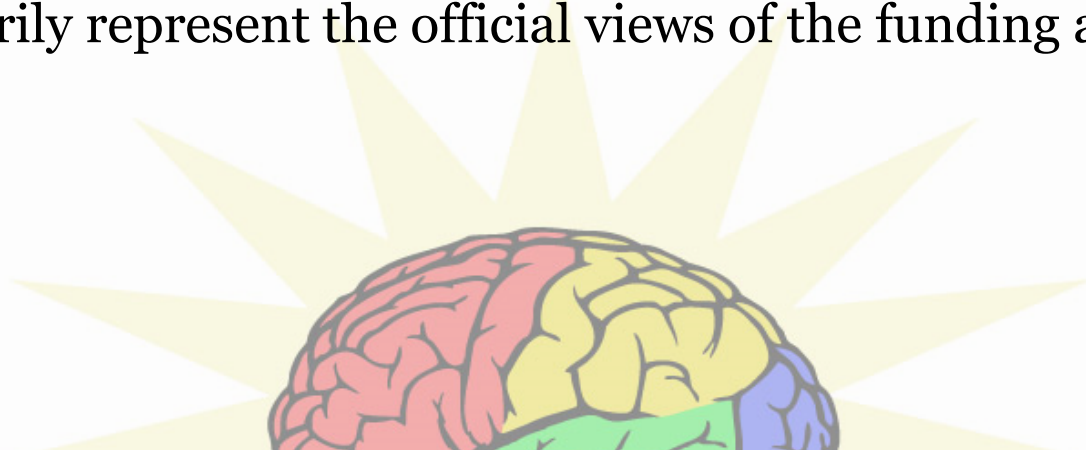
- Project NEURON Curriculum Materials
- NetLogo Models Library (File>Models Library)
- Concord Consortium
(<http://concord.org/>)
- PhET (<http://phet.colorado.edu/>)



Acknowledgements

- NIH, SEPA
- University of Illinois

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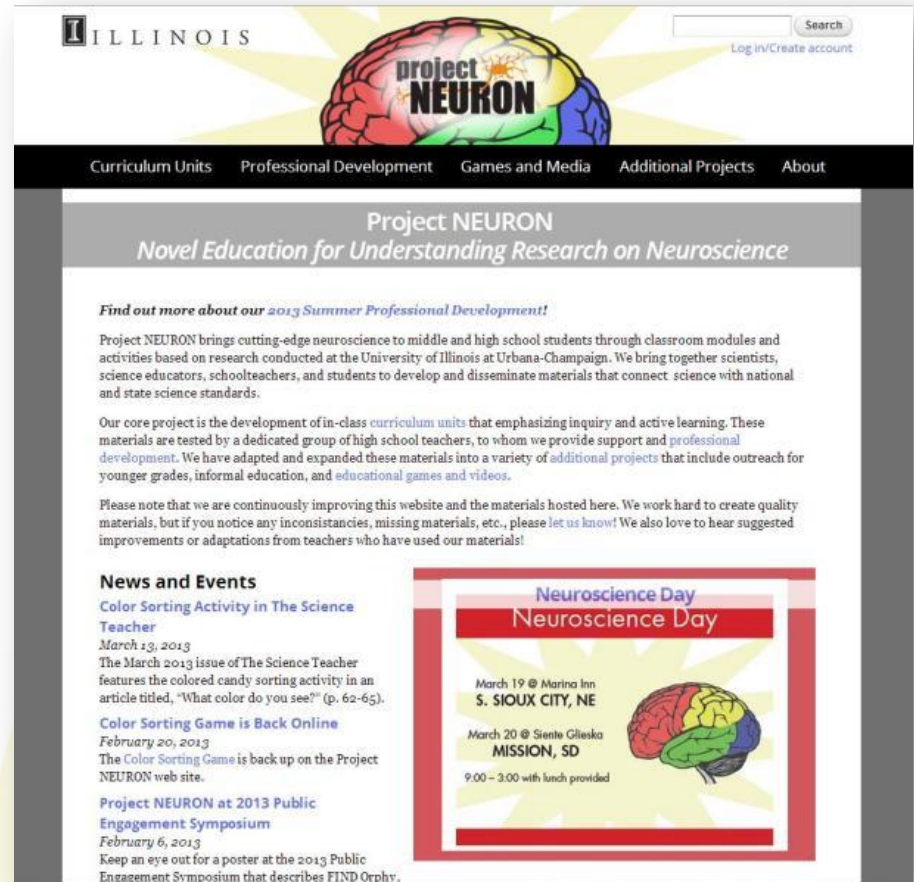
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Curriculum Units Professional Development Games and Media Additional Projects About

Project NEURON
Novel Education for Understanding Research on Neuroscience

Find out more about our 2013 Summer Professional Development!

Project NEURON brings cutting-edge neuroscience to middle and high school students through classroom modules and activities based on research conducted at the University of Illinois at Urbana-Champaign. We bring together scientists, science educators, schoolteachers, and students to develop and disseminate materials that connect science with national and state science standards.

Our core project is the development of in-class [curriculum units](#) that emphasizing inquiry and active learning. These materials are tested by a dedicated group of high school teachers, to whom we provide support and [professional development](#). We have adapted and expanded these materials into a variety of [additional projects](#) that include outreach for younger grades, informal education, and [educational games and videos](#).

Please note that we are continuously improving this website and the materials hosted here. We work hard to create quality materials, but if you notice any inconsistencies, missing materials, etc., please [let us know!](#) We also love to hear suggested improvements or adaptations from teachers who have used our materials!

News and Events

Color Sorting Activity in The Science Teacher
March 13, 2013
The March 2013 issue of The Science Teacher features the colored candy sorting activity in an article titled, "What color do you see?" (p. 62-65).

Color Sorting Game is Back Online
February 20, 2013
The Color Sorting Game is back up on the Project NEURON web site.

Project NEURON at 2013 Public Engagement Symposium
February 6, 2013
Keep an eye out for a poster at the 2013 Public Engagement Symposium that describes FIND Orphy.

Neuroscience Day
Neuroscience Day

March 19 @ Marina Inn
S. SIOUX CITY, NE

March 20 @ Siente Glieska
MISSION, SD

9:00 - 3:00 with lunch provided