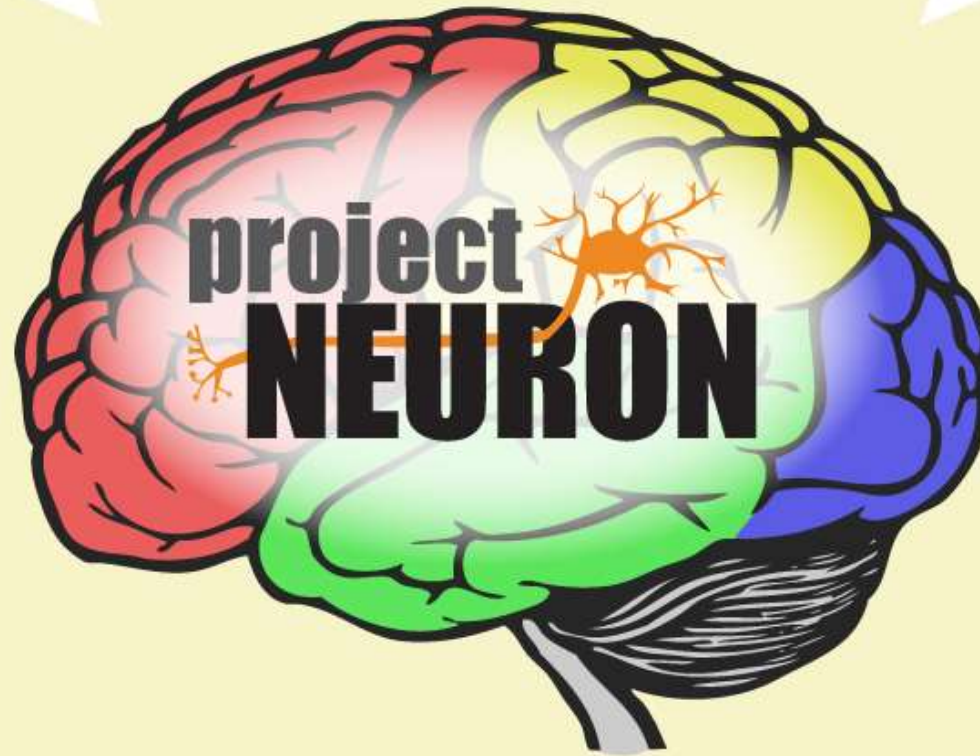


# Exploring Human-Microbe Interactions



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*University of Illinois*

*NABT Atlanta, GA*



# What is Project NEURON?

- NIH, SEPA
- Educators, scientists, and graduate students
- Curriculum development
  - Inquiry-based
  - Connect to standards
- Professional development
  - Summer institutes
  - Conferences



# Project NEURON Curriculum Units

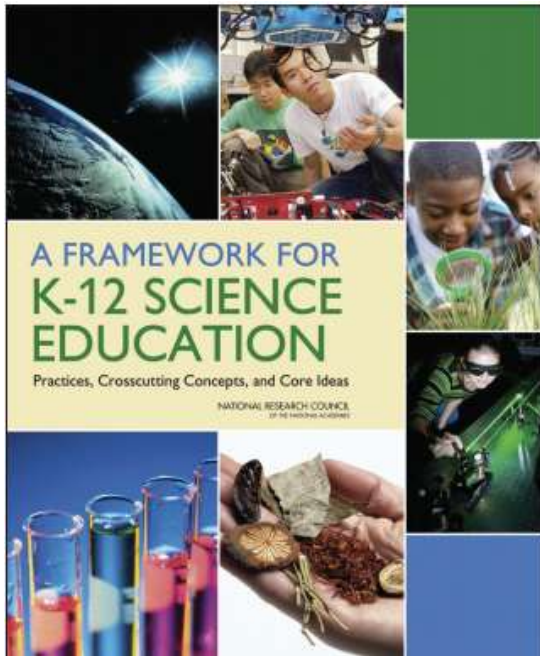
- **Do you see what I see?**
  - *Light, sight, and natural selection*
- **What can I learn from worms?**
  - *Regeneration, stem cells, and models*
- **What makes me tick...tock?**
  - *Circadian rhythms, genetics, and health*
- **What changes our minds?**
  - *Toxicants, exposure, and the environment*
  - *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 microbes make a big difference?**
  - *Microbes, ecology, and the tree of life*

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

# How do small microbes make a big difference?

- **Lesson 1:**  
How did the tree of life change through history?
- **Lesson 2:**  
What is the current tree of life model?
- **Lesson 3:**  
What do microbial communities look like?
- **Lesson 4:**  
How do microbes interact with humans?
- **Lesson 5:**  
What happens when my microbiome is disturbed?

# Connections to Framework and NGSS



- **Disciplinary core ideas:**
  - Interdependent relationships in ecosystems
  - Ecosystem dynamics, functioning, and resilience
  - Biodiversity and humans

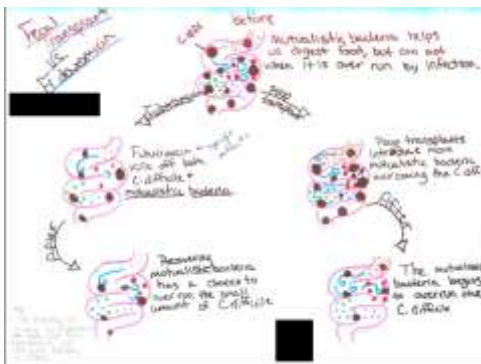
\*Note: This unit addresses these DCIs in the context of microbiology and human-microbe interactions.
- **Practices:**
  - Developing and Using Models
  - Analyzing and Interpreting Data
- **Crosscutting concepts:**
  - Cause and effect
  - System and system models
  - Stability and change



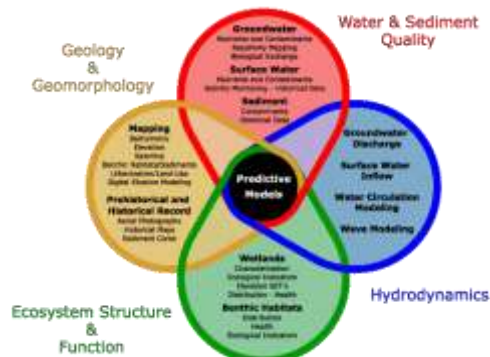
# What is modeling?

- Modeling...
  - is a way to represent a complex system.
  - is used to describe, explain, and/or make predictions
  - takes many forms
  - is a way to make student thinking visible
  - a process (model-ING)
  - opens opportunities for questioning, reasoning, advancing understanding

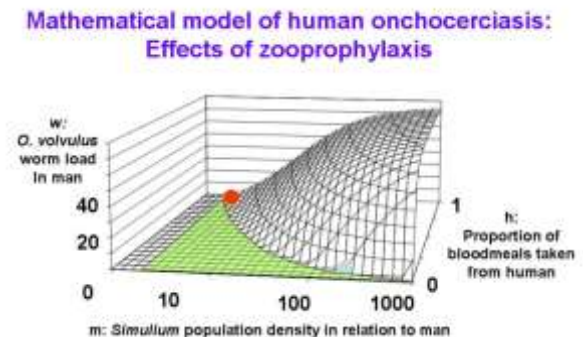
Diagram/Drawing



Conceptual

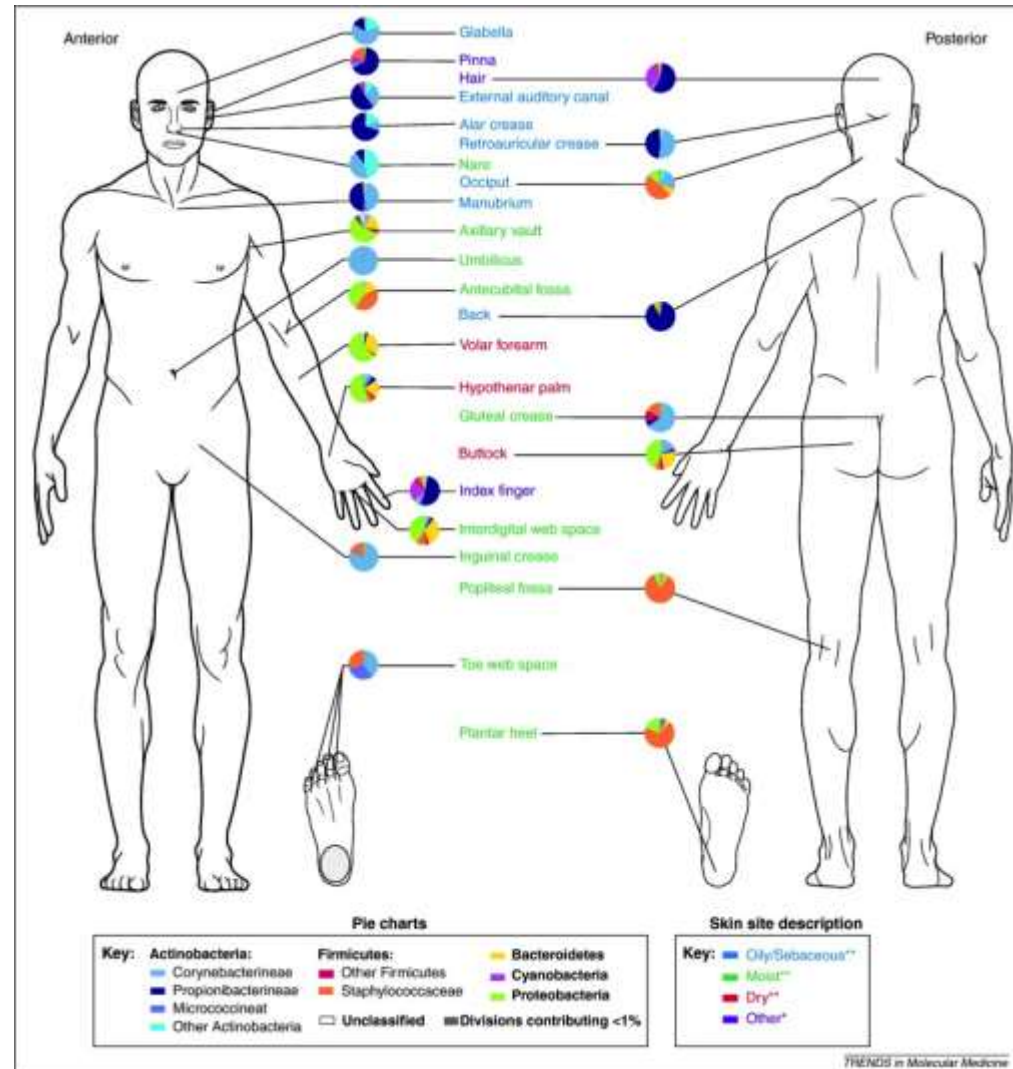


Mathematical



# Analyzing & Interpreting Data

- Data from published science papers
- Experience with primary literature
- Analyzing and interpreting data – an authentic experience



Kong, H.H. (2011). Skin microbiome: Genomics-based insights into the diversity and role of skin microbes. *Trends in Molecular Medicine*. 17(6): 320-328.

## Lesson 4:

# How do microbes interact with humans?

Working in groups of 4-6...develop a model of the human microbiome.

How would you answer this question?

How would your students answer this question?



# Lesson 4: How do microbes interact with humans?

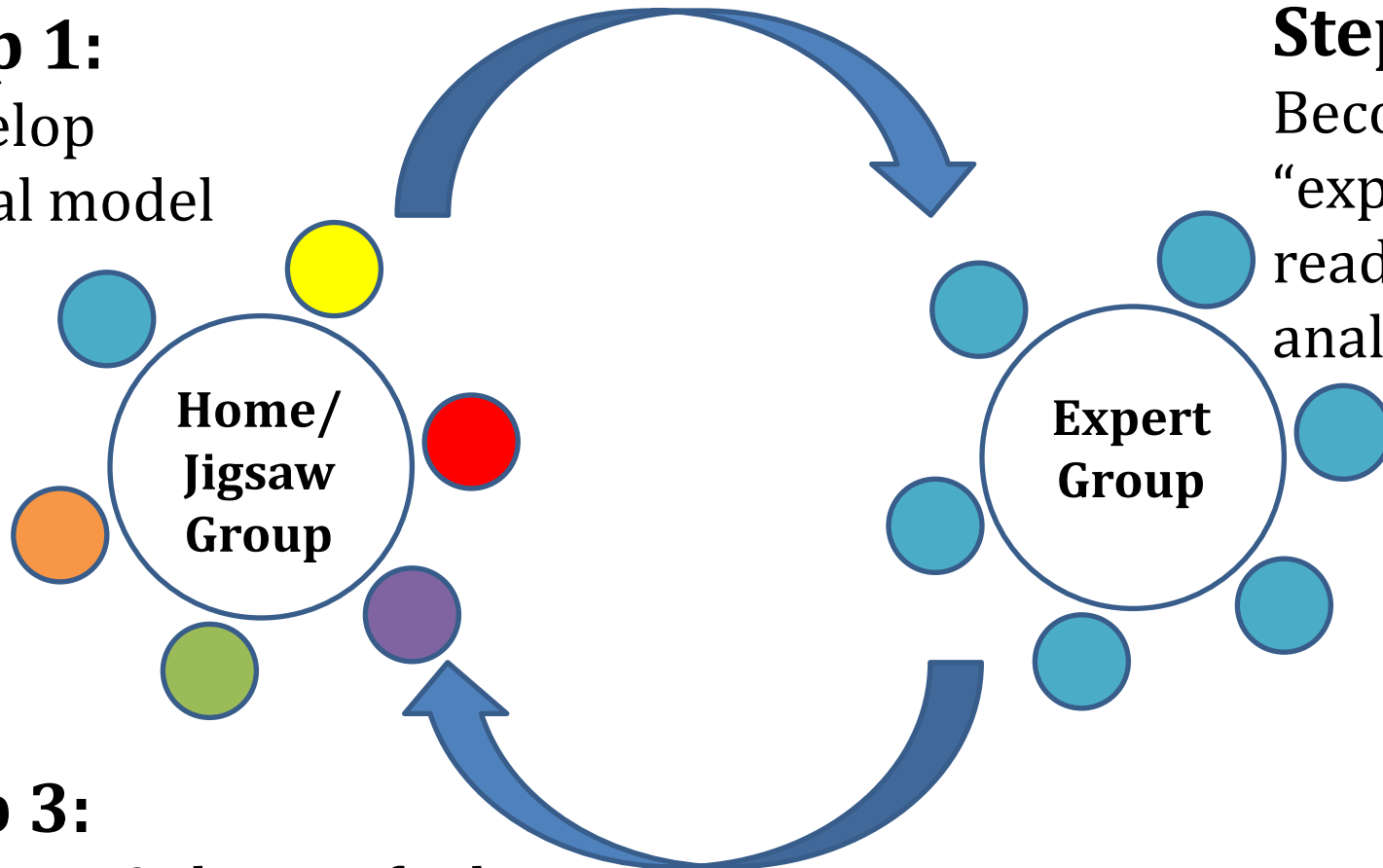
## Objectives:

- Explain why the diversity of microbes in/on the human body is important.
- Describe how microbes can protect humans.
- Discuss the mutualistic relationships between microbes and humans.
- Analyze and interpret data from recent scientific research.
- Construct a model of the human microbiome.

# Lesson 4: How do microbes interact with humans?

## Step 1:

Develop initial model



## Step 2:

Become “experts” by reading and analyzing data

## Step 3:

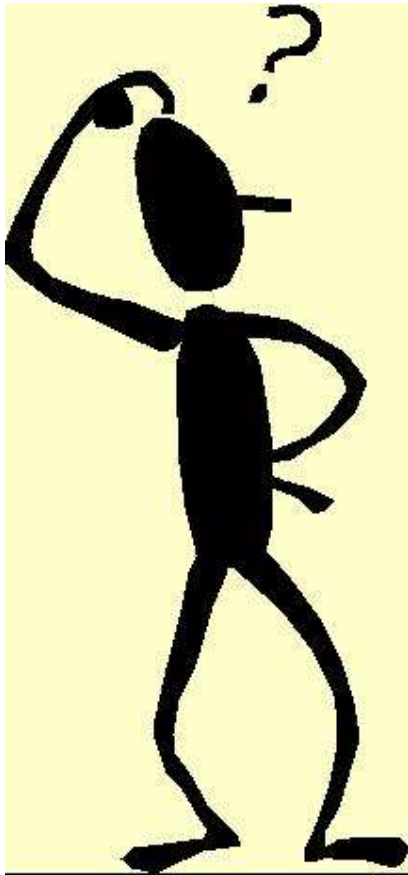
- Report & discuss findings
- Develop revised model based on new information

# JIGSAW ACTIVITY

# Jigsaw Activity: Today

- Become an expert! Each person pick a different reading.
  - Microbes that affect our body weight
  - Our skin microbiome
  - Microbes educate immune cells
  - Intestinal microbiota development in infants
  - Microbes and the blood-brain barrier
  - Using microbes as treatment of bacterial infection
- As you read think about...
  - What roles do microbes play in/on our bodies?

# Lesson 4: Putting the pieces together



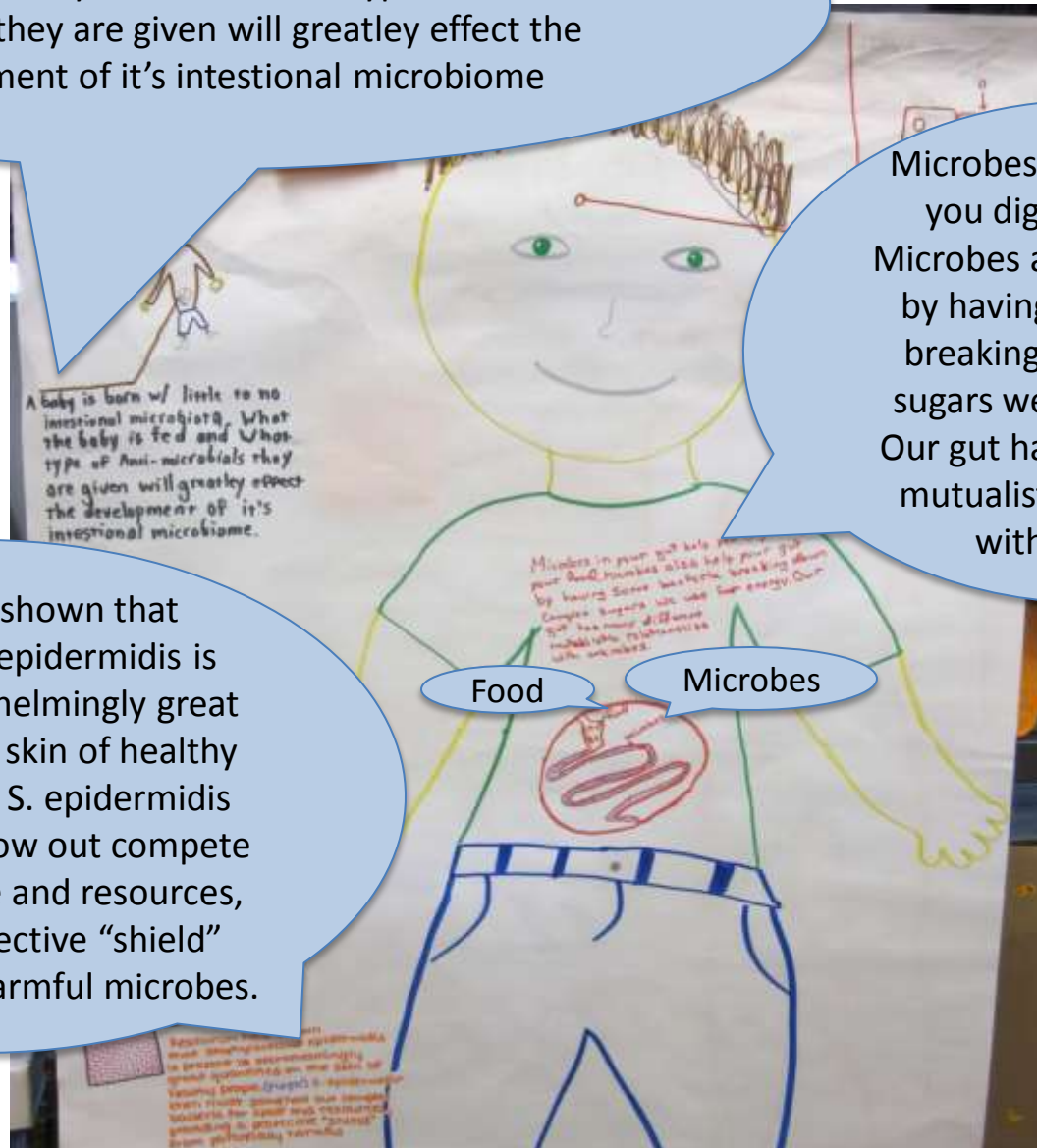
What roles do microbes play in/on our bodies?

- Report and discuss your articles' findings.
- Using this new information, how would you revise your model of the human microbiome?

A baby is born w/ little to no intestinal microbiota. What the baby is fed and what type of Anti-microbials they are given will greatly effect the development of it's intestinal microbiome

Microbes in your gut help you digest your food. Microbes also help your gut by having some bacteria breaking down complex sugars we use for energy. Our gut has many different mutualistic relationships with microbes.

Research has shown that staphylococcus epidermidis is present in overwhelmingly great quantities on the skin of healthy people. (purple). S. epidermidis then must somehow out compete bacteria for space and resources, providing a protective "shield" from potentially harmful microbes.



Food

Microbes



# Lesson 5: What happens when my microbiome is disturbed?

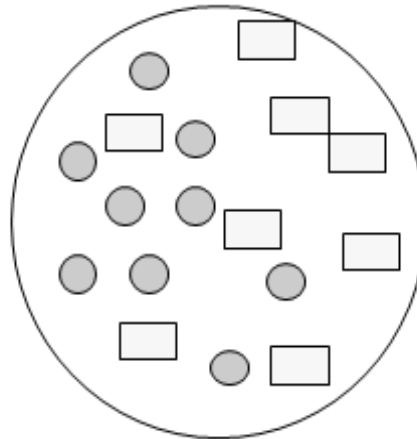
## Objectives and activities:

- What is a microbiome disturbance?
  - Introduce ecological disturbances and modeling
- Case study of recurrent *C. difficile* infections
  - How do microbial communities recover?
  - Analyze data to develop models and make predictions about affects of disturbance on microbiome
  - Determine and defend a treatment plan
- Comparison of treatment methods
  - Analyze information and construct an explanation
  - Microbiome's resilience is linked to diversity

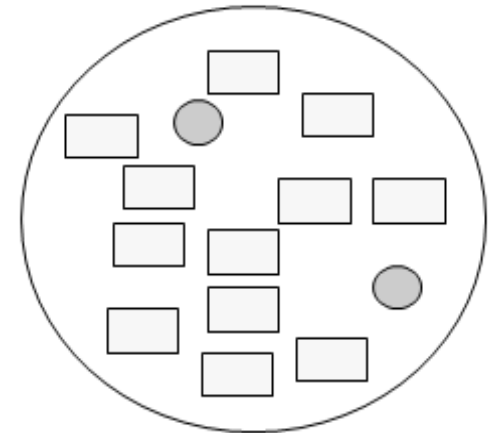
# Activity 1: What is a Microbiome Disturbance?

- Introduce ecology concepts
- Analyze data
- Create models

Before the antibiotic



After the antibiotic



● Microbes that need thiamine

□ Microbes that make their own thiamine

# Case Study Overview

- Students become interns at CMW Hospital
  - High number of patients with recurrent *C. difficile* infections
- Students help researchers analyze the data from a clinical trial of a new antibiotic
- Students choose an antibiotic for the hospital
  - Argue from evidence
- Students educate administrators on the effectiveness of different *C. difficile* treatments

# Activity 2: Case Study

## Goals:

- Students analyze real data from a clinical trial
- Students use the data to develop and revise a model of antibiotic effects on the gut microbiome
- Students use the model to support a claim

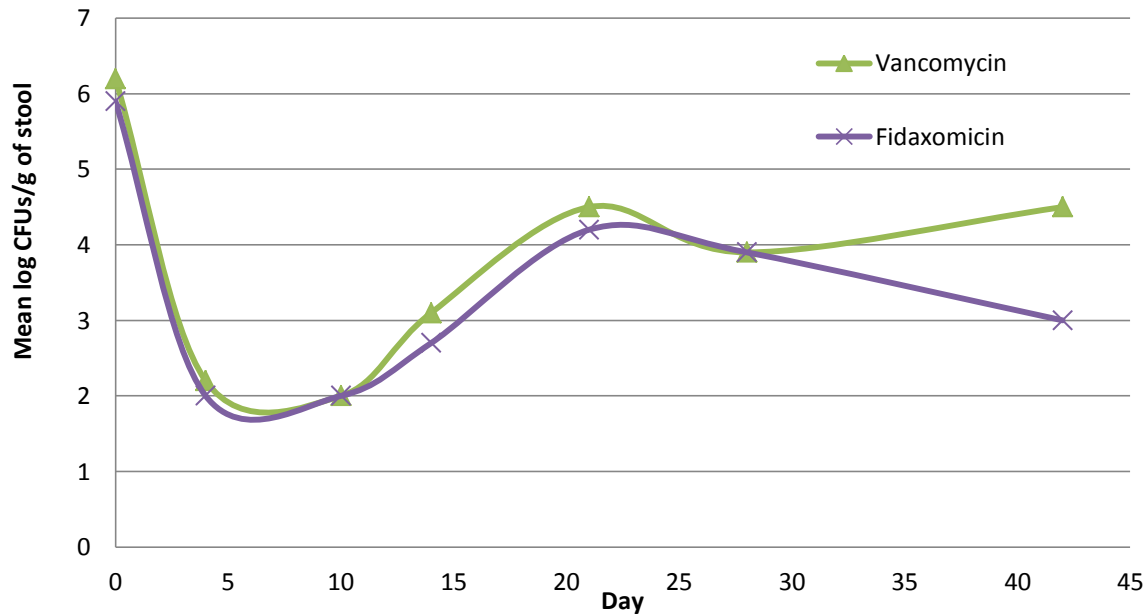


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Central Midwest Hospital

# Activity 2: Scientific Practice: Data Analysis

Comparison of *Clostridium difficile* counts before, during, and after antibiotics



Source: Louie T.J. et al(2012). Fidaxomicin preserves the intestinal microbiome during and after treatment of *Clostridium difficile* infection (CDI) ... Clin Infect Dis. 55 Suppl 2:S132-42.

*Looking at the graphs, suggest an explanation for why researchers saw higher levels of recurrence in the Vancomycin group compared to the Fidaxomicin group.*

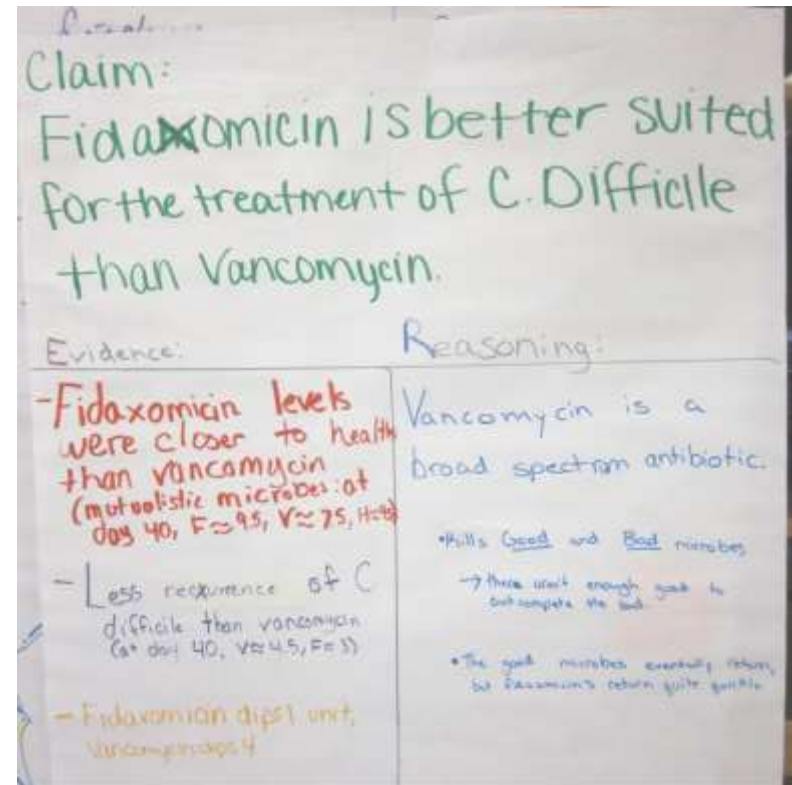


# Activity 2: Scientific Practice: Arguing from Evidence

## Claim, Evidence, Reasoning

- An explicit process where students make a claim, support it with evidence and link the two through reasoning

McNeill and Krajcik (2012), *Supporting grade 5-8 students in constructing explanations in science: The claim, evidence, and reasoning framework for talk and writing.*



Claim:

Fidaxomicin is better suited for the treatment of C. Difficile than Vancomycin.

Evidence:

- Fidaxomicin levels were closer to health than vancomycin (mutualistic microbes: at day 40,  $F \approx 9.5$ ,  $V \approx 7.5$ ,  $H \approx 9.5$ )

- Less recurrence of C. difficile than vancomycin (at day 40,  $V \approx 4.5$ ,  $F \approx 3$ )

- Fidaxomicin dips 1 unit, Vancomycin dips 4

Reasoning:

Vancomycin is a broad spectrum antibiotic.

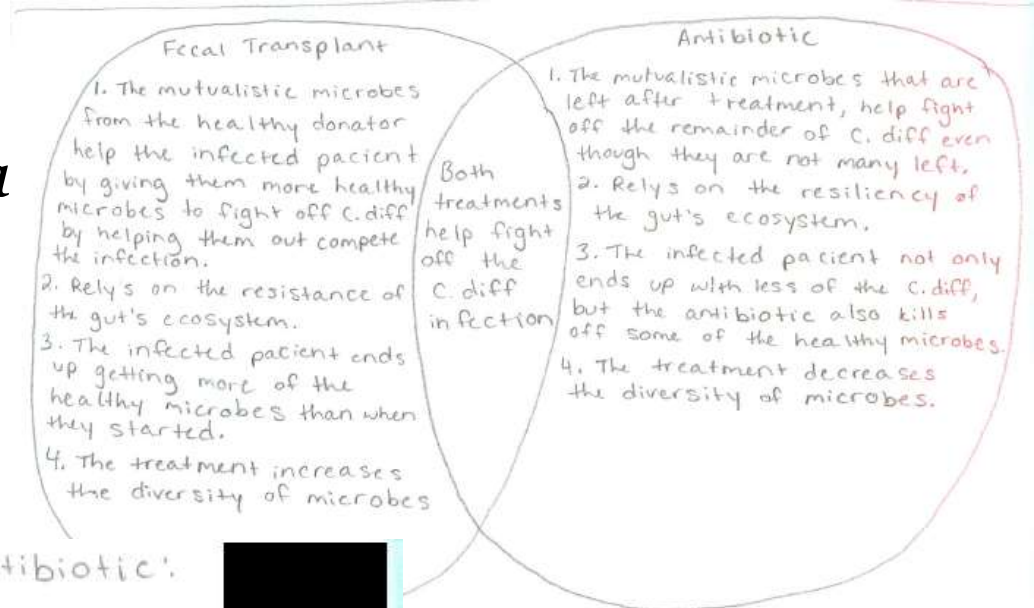
• Kills Good and Bad microbes

→ there aren't enough good to outcompete the bad.

• The good microbes eventually return, but fidaxomicin's return quite quickly.

# Activity 3: Treatment Comparison

*How does an antibiotic disturbance compare to a fecal transplant disturbance?*



Fecal Transplant:



→ transplant gives infected patient more healthy mutualistic microbes in order to out compete C. diff.

Antibiotic:



→ While antibiotic kills the C. diff infection off, it also kills some healthy mutualistic microbes in the process.

Disturbance of the ecosystems are not the same. Patients who will most likely have some kind of infection. The patient should consider is cost, whether or not due to certain antibiotics or microbes, and also if getting for the transplant is a good match for



# Fecal Transplant vs. Fidaxomicin



Mutualistic bacteria helps us digest food, but can not when it is over run by infection.



#16  
The disturbances caused by Fidaxomicin are bad, and fecal transplants just add more healthy microbes.



# Unit Discussion

- How would you support students in:
  - Explaining why diversity in a microbial community is important
  - Discussing the mutualistic relationships between microbes and humans
  - Analyzing and interpreting data
  - Constructing and revising models
- How could you use these lessons in your class?
  - To teach content?
  - To teach scientific practices?
  - To teach crosscutting concepts?
- How would you possibly modify it for your students?





# Acknowledgements

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- Sahid Rosado

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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, there is a navigation bar with the University of Illinois logo on the left, a search bar, and a 'log in/Create account' link. Below the navigation bar is a main header with the text 'Project NEURON' and 'Novel Education for Understanding Research on Neuroscience'. The main content area features several paragraphs of text, including a section titled 'Find out more about our 2013 Summer Professional Development!' and a 'News and Events' section. The 'News and Events' section lists several events, including 'Color Sorting Activity in The Science Teacher' (March 25, 2013), 'Color Sorting Game is Back Online' (February 20, 2013), and 'Project NEURON at 2013 Public Engagement Symposium' (February 6, 2013). A prominent red-bordered box on the right side of the page contains information about 'Neuroscience Day' events in S. SIOUX CITY, NE (March 19 @ Marquette) and MISSION, SD (March 20 @ Sierra Grande), both from 9:00 - 3:00 with lunch provided. A small brain icon is also visible in this box.