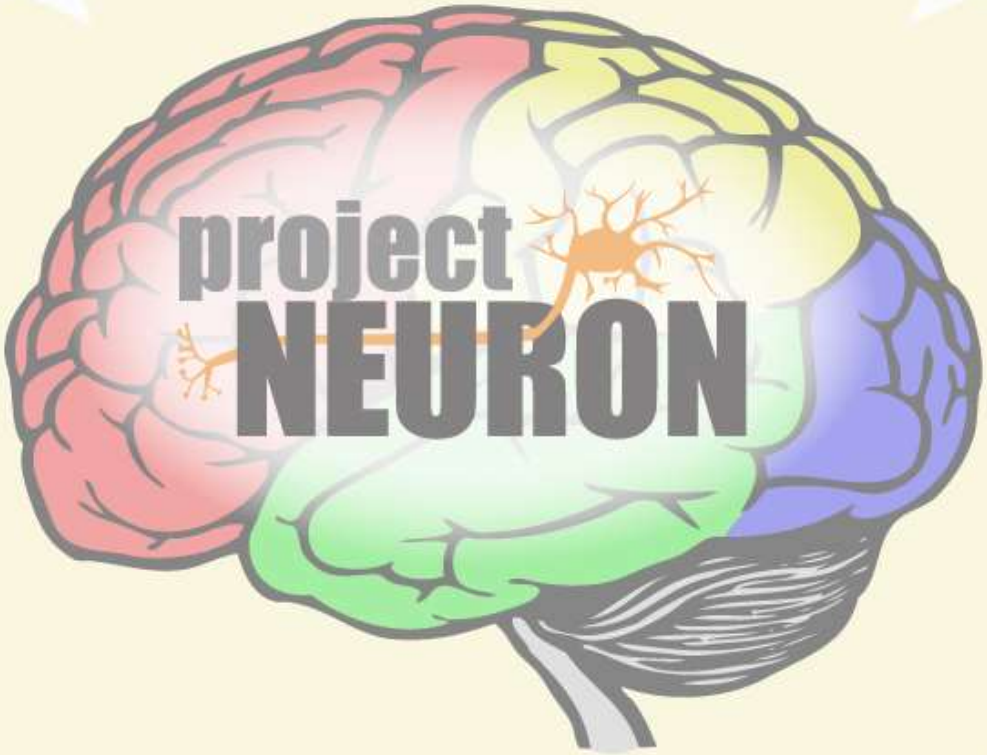
Dynamic nature of science: Discovering the tree of life



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University of Illinois

National Institutes of Health

SEPA SCIENCE EDUCATION PARTNERSHIP AWARD

Supported by the National Institutes of Health

What is Project NEURON?

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

Project NEURON Curriculum Units

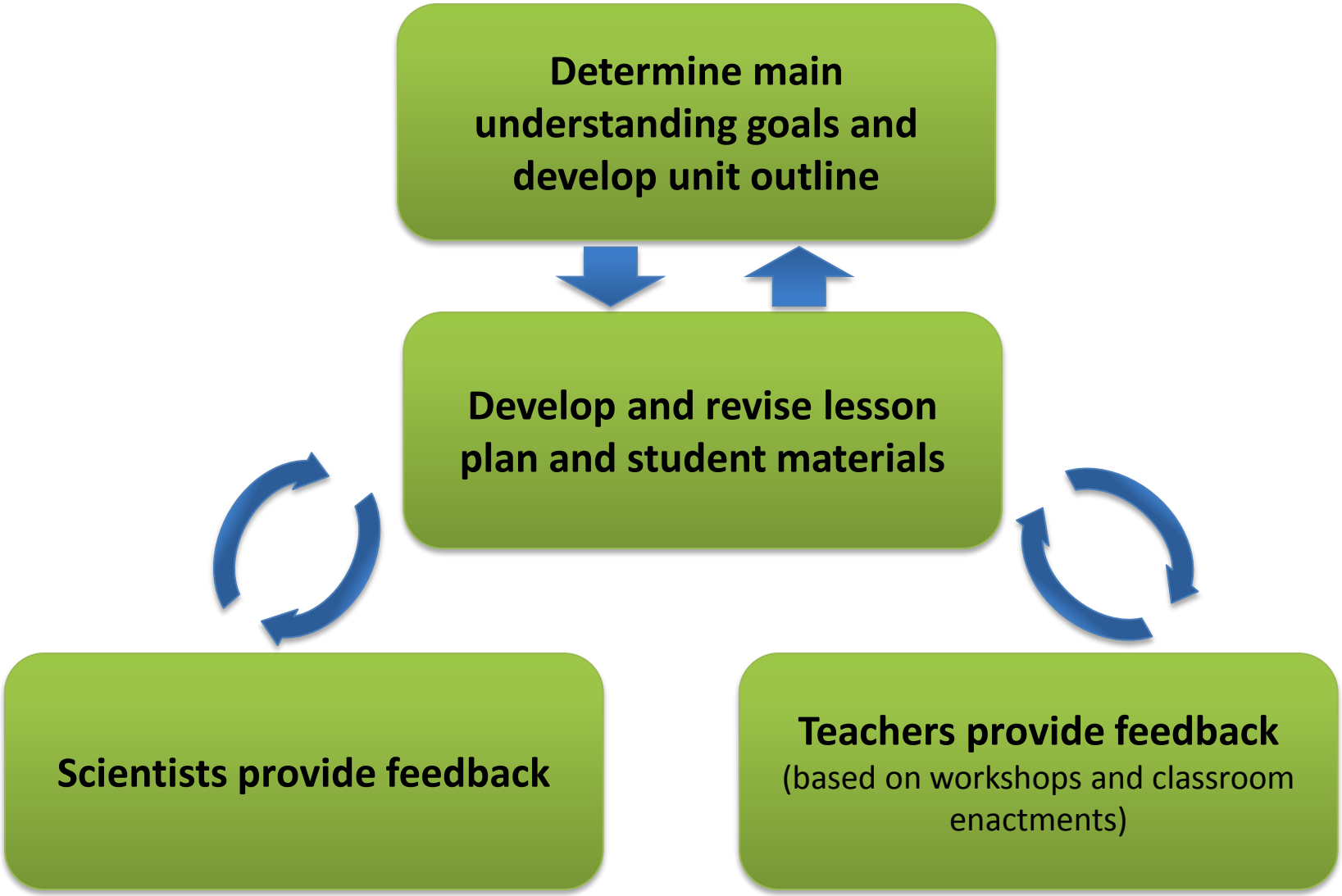
- **Do you see what I see?**
  - *Light, sight, and natural selection*
- **What can I learn from worms?**
  - *Regeneration, stem cells, and models*
- **What makes me tick…tock?**
  - *Circadian rhythms, genetics, and health*
- **What changes our minds?**
  - *Toxicants, exposure, and the environment*
  - *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

The Microbe Unit: A Collaborative Process

- Science Educators (Project NEURON)
  - Initial unit planning
  - Developing lessons
  - Modify/revise materials based on feedback
- Scientists (Whitaker Lab)
  - Initial unit planning
  - Provide feedback on lesson content
- Teachers (High School Science)
  - Initial unit planning
  - Enact lessons in the classroom
  - Provide feedback

An Iterative Development Process



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?

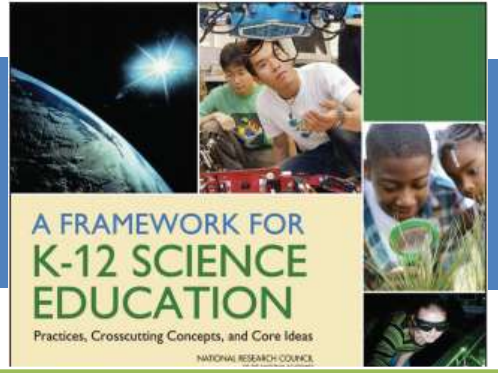
- Lesson 4:

  How do microbes interact with humans?

- Lesson 5:

  What happens when my microbiome is disturbed?

A Framework for K-12 Science Education



Dimension 1: Scientific & Engineering Practices	Dimension 2: Crosscutting Concepts	Dimension 3: Disciplinary Core Ideas
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	**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**	**Life Sciences:** • **Evidence of common ancestry and diversity** • **Interdependent relationships in ecosystems** • **Ecosystem dynamics, functioning, and resilience** • **Biodiversity and humans**

The Nature of Science in the NGSS

- The integration of scientific and engineering practices, disciplinary core ideas, and crosscutting concepts sets the stage for teaching and learning about the nature of science.
- The NOS Matrix
  - Learning outcomes for 8 major NOS themes
  - 4 link to practices (page 5)
  - 4 link to crosscutting concepts (page 6)
- Implementing Instruction
  - Students be metacognitive about NOS after doing the practices
  - Case studies from the history of science

The Curriculum Unit

How do small things make a big difference?

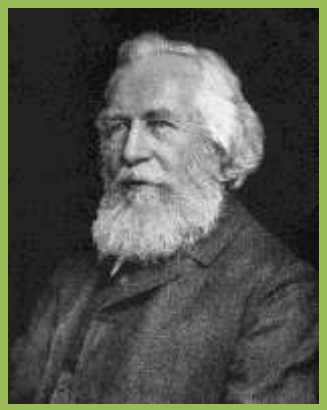
Microbes, ecology, and the tree of life

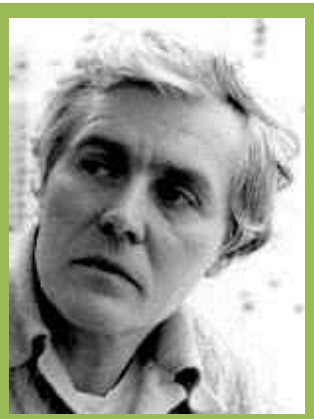
- Lesson 1: How did the tree of life change through history?
- Lesson 2: What is the current tree of life model?
- Lesson 3: What do microbial communities look like?
- Lesson 4: How do microbes interact with humans?
- Lesson 5: What happens when my microbiome is disturbed?

Lesson 1: How did the tree of life change through history?

Learning Objectives

- Explain how and why scientific models can change over time (within the context of the tree of life model case study)
- Explain the role of technology in the advancement of science
- Explain how the model of the tree of life changed throughout history



Activity: Tree of Life Timeline

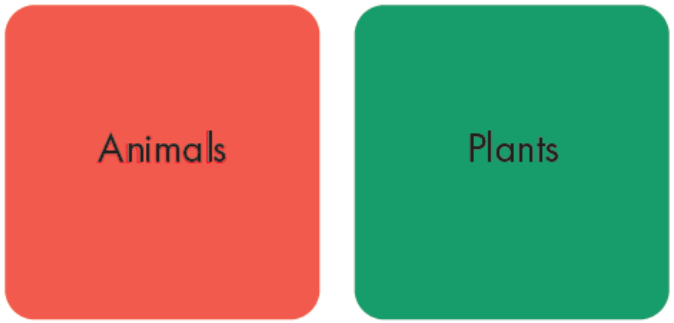
Step 1: 1758 A ⟶ 1758 B

Step 2: 1866 A ⟶ 1866 B

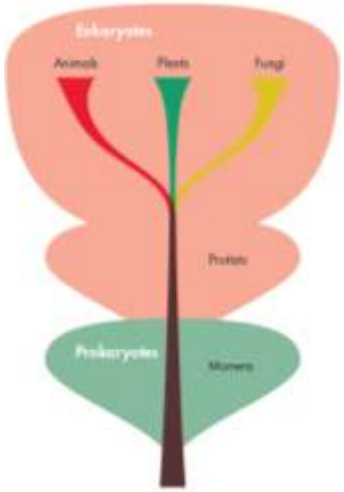
Step 3: 1969 A ⟶ 1969 B

Step 4: 1990 A ⟶ 1990 B

Tree of Life Timeline: Discussion

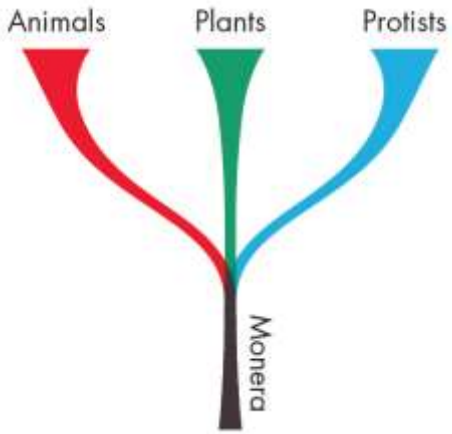


Linneaus (1758)

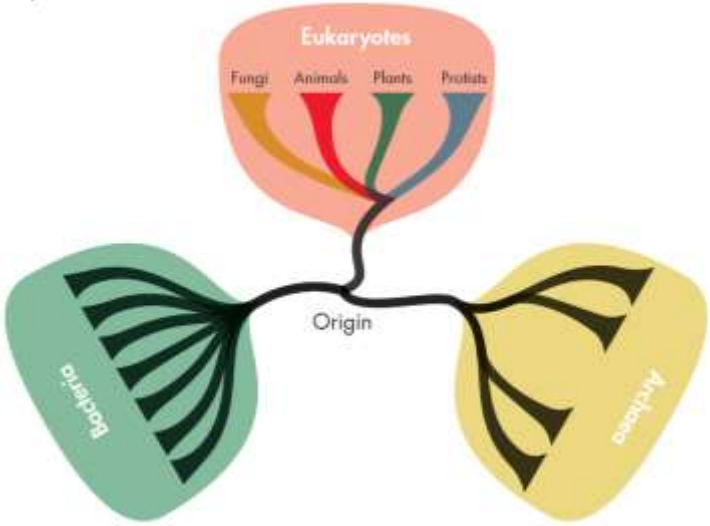


Whitaker (1969)

Haeckel (1866)



Woese (1990)



Linneaus

1735

CLASSIFICATION:

Includes Plants (Vegetabilia) and Animals (Animilia). Determines based off of what was seen with the naked eye weither or not an organism was a plant or animal.

Example of model:

Animilia →

Vegetabilia →

Darwin

1850

Darwin played a role in changing the way people thought and has influenced classification. Because of his theory of evolution, Darwin made people aware that organisms have a much broader way of existing. Thus many ways of classifying.

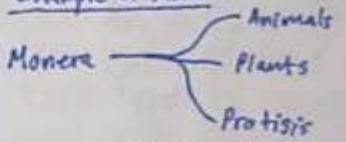
Hackel

1866

CLASSIFICATION:

Includes Plants, Animals, and Protists. Created a new kingdom that is neither plant nor animal. Shows microscopic organisms that cannot be seen without a microscope.

Example of model:



Shows they all have a common ancestor: monera

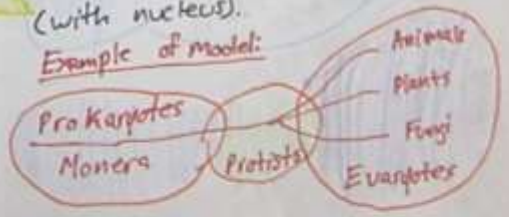
Whitaker

1969

CLASSIFICATION:

He added a new level of classification. This new level includes weither or not the cells have a nucleus. Main groups in this was prokaryote (without nucleus) and eukaryote (with nucleus).

Example of model:

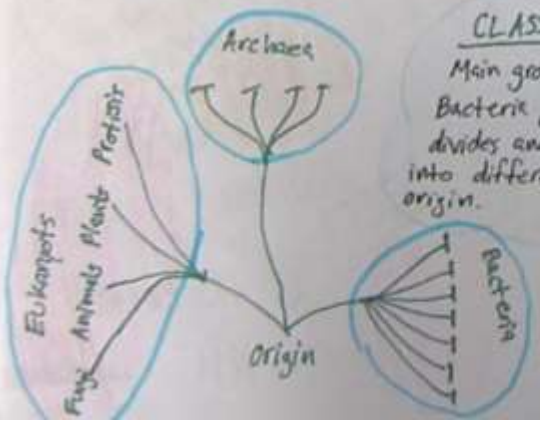


Woese

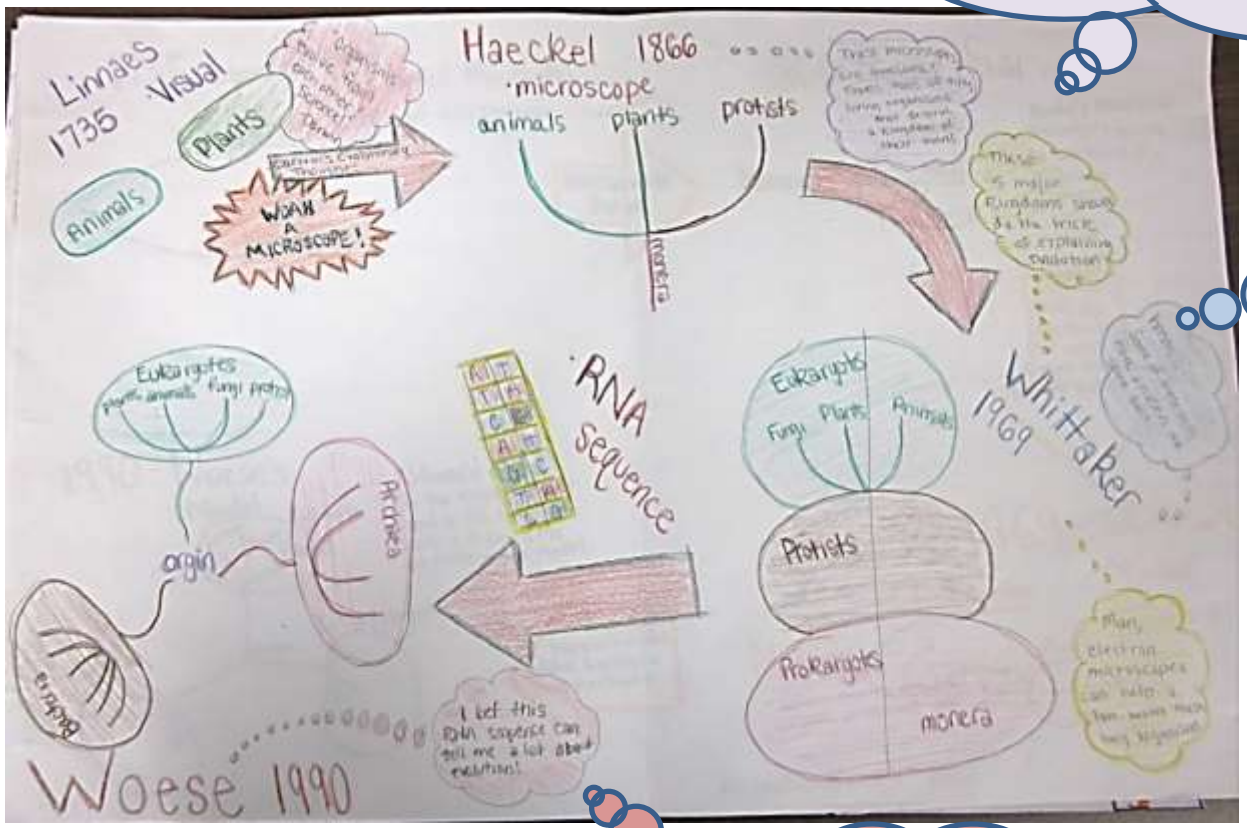
1990s

CLASSIFICATION:

Main groups are Archaea, Bacteria, and Eukarya. Woese divides and classifies the organisms into different groups but with the same origin.



These microscopes are awesome! There's tons of tiny living organisms that deserve a kingdom of their own!



Hmm…Some of these cells have a nucleus and some don't…

I bet this RNA sequence can tell me a lot about evolution!

Discussion

- Where might your students struggle?
- How could you support them?

- How can you move to align student thinking with NGSS?
  - Revising models based on new evidence?
  - Nature of Science concepts?

The Curriculum Unit

How do small things make a big difference?

Microbes, ecology, and the tree of life

- Lesson 1: How did the tree of life change through history?
- Lesson 2: What is the current tree of life model?
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- Lesson 5: What happens when my microbiome is disturbed?

Lesson 2: What is the current tree of life model?

Learning Objectives

- Draw and label an accurate sketch of the current molecular tree of life indicating the three domains and their evolutionary relationships
- Explain how Woese's discovery affected the scientific community
- Explain the major concepts of molecular methods and how they work
- Construct an argument regarding the use of the term "prokaryote" and its implications

Real DNA Sequences - 16SrRNA

CLUSTAL 2.1 MULTIPLE SEQUENCE ALIGNMENT

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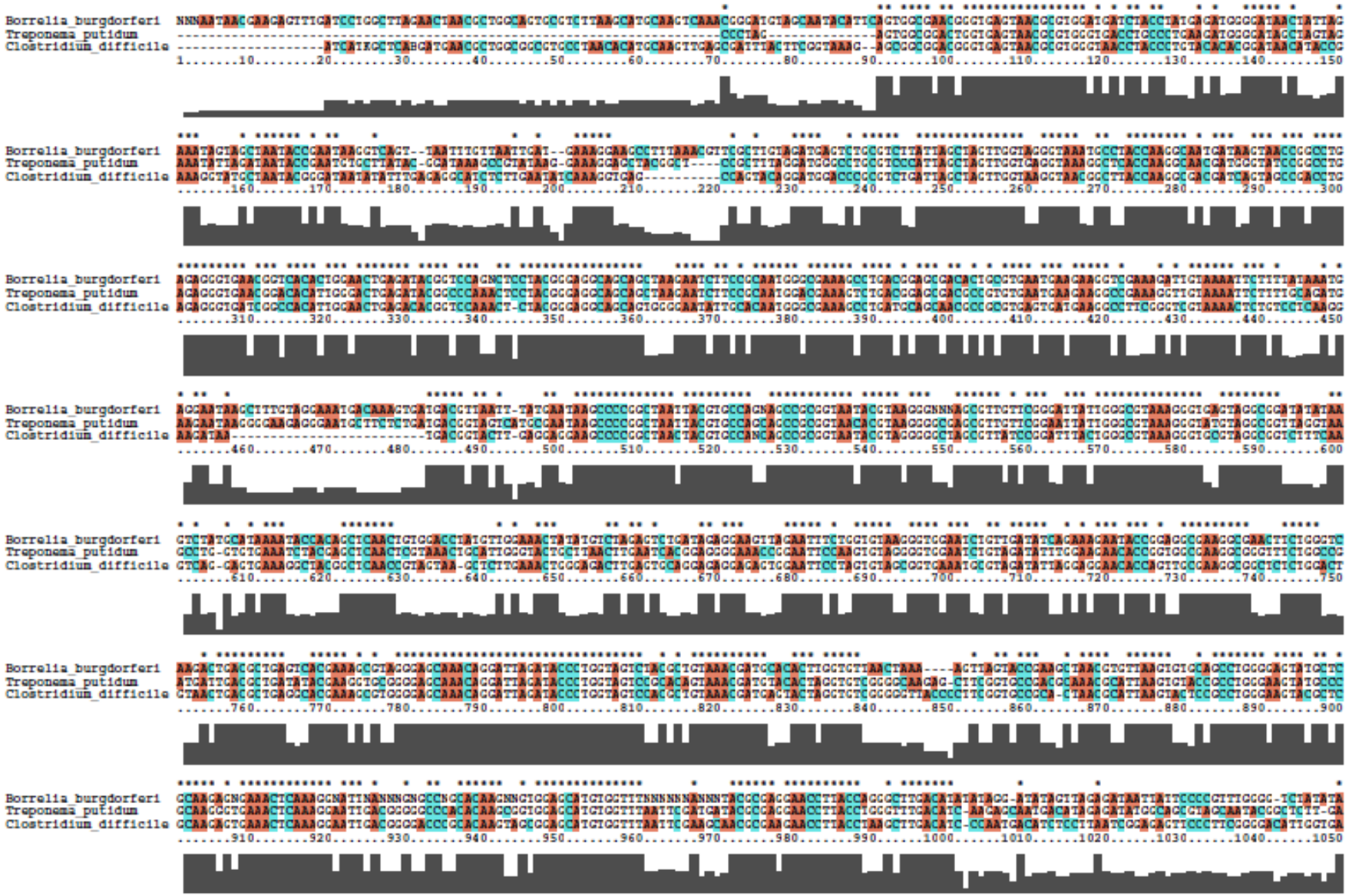
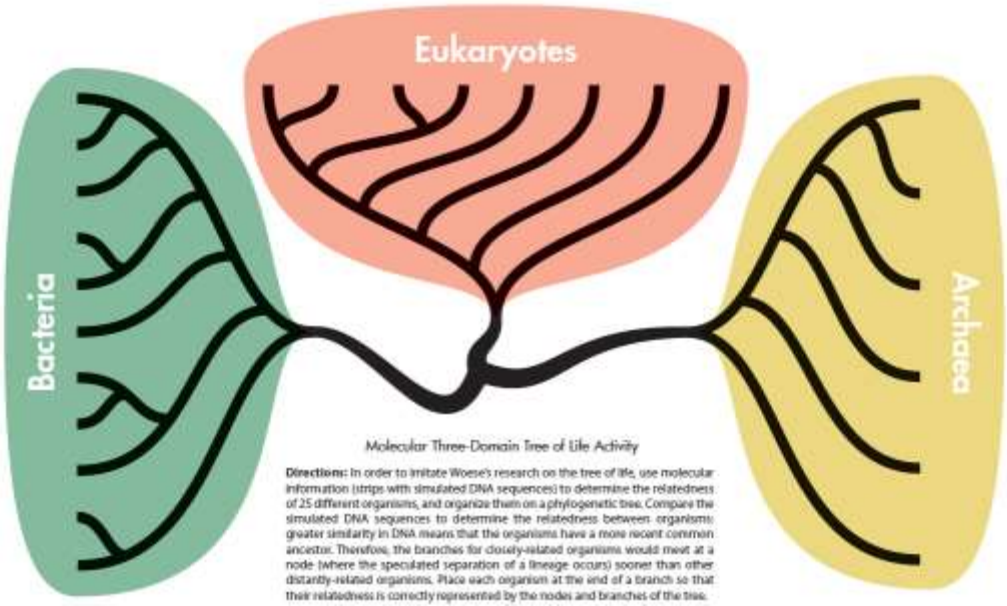


Activity: Molecular Tree of Life

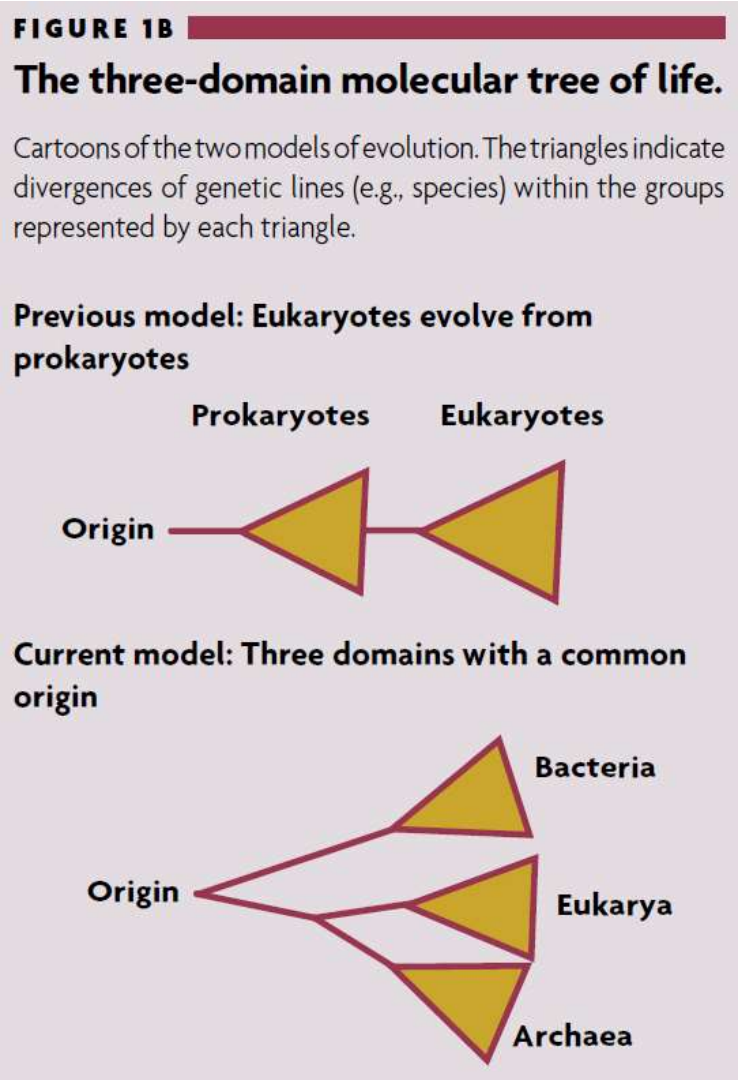


NYT Article

Questions for students:

- How did Woese identify archaea as a separate domain?
- How did the scientific community respond? Why?
- How did Woese's findings affect the world of microbiology?
- What is the role of microbes in this story?
- What is the importance of continuing to study microbes?

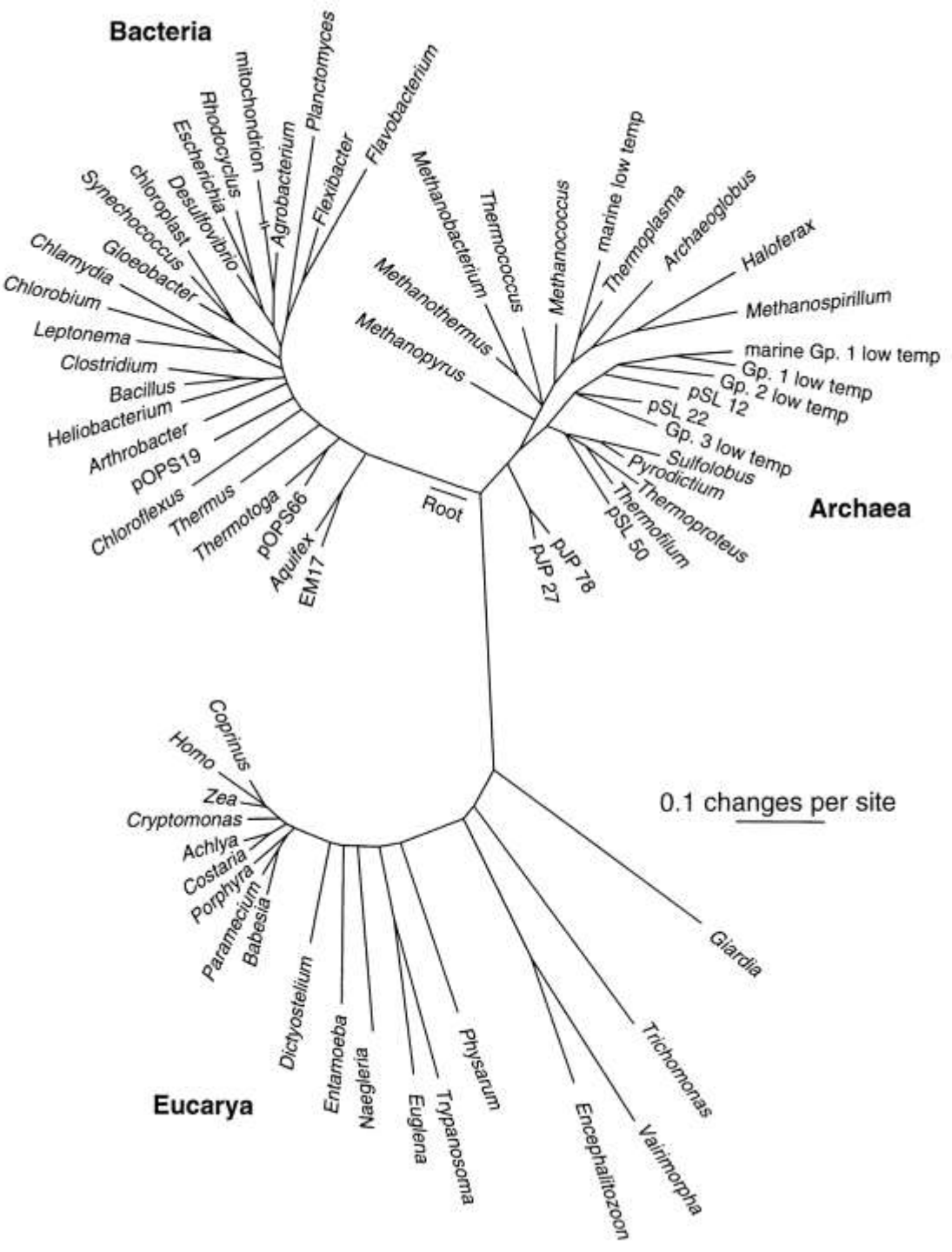
To use or not to use prokaryote?



Baumgartner, L.K. & Pace, N.R. (October 2007)

- Which model is more accurate? Why?
- What was the term "prokaryote" originally used for?
- How might changes in the tree of life model affect the use and meaning of the term?
- Where did archaea fit in the old model as compared to the new? How does this affect what "prokaryote" means?

How do you think Carl Woese's new tree of life model has affected microbiology research?



Pace (2007)

Discussion

- How could you use these lessons in your classroom?
  - To teach about the Nature of Science?
- How might you modify these materials to fit with your curriculum?

Acknowledgements

- NIH, SEPA
- University of Illinois
  - Project NEURON
  - Whitaker Lab (NSF Grant DEB-0816885)

This project was supported by SEPA and the National Center for Research Resources and the Division of Program Coordination, Planning, and Strategic Initiatives of the National Institutes of Health through Grant Number R25 RR024251-03. The contents of this presentation are solely the responsibility of Project NEURON and do not necessarily represent the official views of the funding agencies.

Thanks!

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