Fossil Forests Teacher Guide

Note: This kit is intended for students 6th grade and higher in a supervised classroom setting. It is strongly recommended that instructors try the kit themselves before using it with students. This kit covers the scientific practices of Analyzing & Interpreting Data; Using Mathematics & Computational Thinking; Constructing Explanations & Designing Solutions; and Engaging in Argument from Evidence. (https://www.nap.edu/read/13165/chapter/7#50)

Unpacking Instructions

One classroom set of 15 kits is inside one large case. Also included is a teacher's kit (different color) with extra supplies in case they are needed.

This kit is for 30 students working in groups of 2.

Kit Contents

Each individual kit should contain:

- Sample of Fossil Wood (Red Bag)
- 3 Blocks of Wood (softwood, palm, hardwood) and Cards (Green Bag)
- Fossil Wood ID Chart
- Magnifier
- 50 mL Beaker
- 3 Wood Thin Sections
- Microscope
- 2 Eyepiece Objectives
- Light Box
- Jar of Fossilization Sand Mixture
- Jar of Straws
- Jar of Clay
- Fossil Wood Sorting Cards
- Transverse Section Template
- Square Petri Dish
- Modern Climates Chart
- AAT of WY Fossil Wood Data Table
- Wooden Spoon
- Ruler
- Brush
- Templates

  Colored Pencils

Major Concepts	Scientific Inquiry Skills
1. Tree anatomy 2. Wood anatomy of softwoods, hardwoods, and palm “wood” in transverse view. 3. Wood petrifaction or mineralization 4. Identification of fossil softwood, hardwood, and palm 5. Using nearest living relatives to infer past ecosystems and climate. 6. Interview with Paleobotanist	1. Data collecting and graphing 2. Developing and Using Models 3. Analyzing and Interpreting Data 4. Constructing Explanations 5. Using scientific notebooks
Vocabulary	**Prior Concepts/Skills**
1. Transverse section 2. Vascular Tissue 3. Nearest Living Relative 4. Average Annual Temperature 5. Average Annual Precipitation 6. Eocene 7. Hardwood 8. Palm 9. Conifers	1. Focusing a Microscope 2. Using a hand lens

Fossil Forests Kit Alignment to Next Generation Science Standards

Disciplinary Core Ideas

- MS-LS1.A: Structure and Function Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.
- MS-LS2.C: Ecosystem Dynamics, Functioning, and Resilience Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
- HS-LS1.A: Structure and Function Systems of specialized cells within organisms help them perform the essential functions of life.
- HS-ESS2.A: Earth Materials and Systems The geologic record shows that changes to global and regional climate can be caused by interactions among changes in the sun’s energy output or Earth’s orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of timescales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.

Science and Engineering Practices

- Developing and using models
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Obtaining, evaluating, and communicating information

Crosscutting Concepts

- Patterns
- Cause and Effect
- Scale, Proportion, and Quantity
- Systems and System Models
- Structure and Function
- Stability and Change of Systems

Room Setup

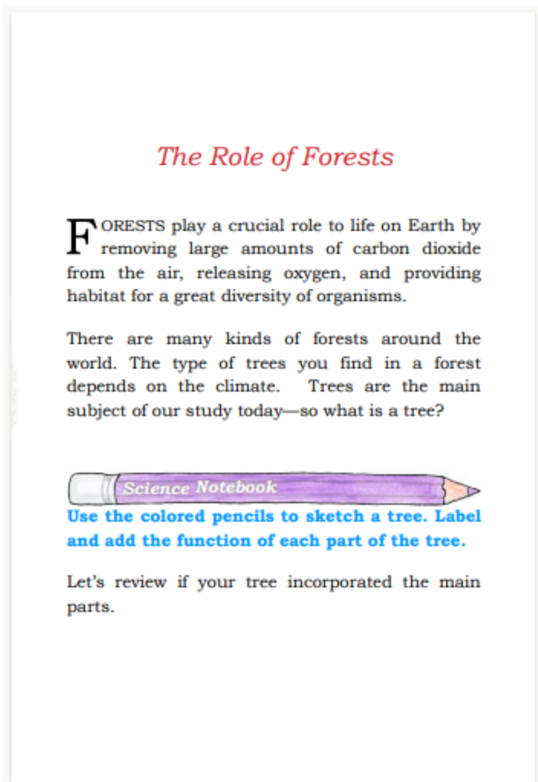
1. This lab is designed for students to work in groups of two.

2. The following supplies are not included in the kit but are required for this experiment:
   - Water (50.0 mL of water for each group)
   - Paper Towels
   - Science Notebook
   - Tape (for taping data tables into Science Notebooks)

Begin Lesson

1. Students should start by opening their science notebooks to a new page. Notebook should be labeled *"Fossil Forests!*" with the date and the name of their lab partner.

2. They should then open the kit and take out the *Fossil Forests*! booklet and begin reading on page 3.



The Role of Forests

FORESTS play a crucial role to life on Earth by removing large amounts of carbon dioxide from the air, releasing oxygen, and providing habitat for a great diversity of organisms.

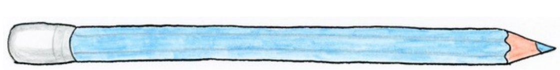
There are many kinds of forests around the world. The type of trees you find in a forest depends on the climate. Trees are the main subject of our study today—so what is a tree?

Science Notebook

Use the colored pencils to sketch a tree. Label and add the function of each part of the tree.

Let's review if your tree incorporated the main parts.

3. The words 'Science Notebook', accompanied by a pencil icon, are located throughout the booklet, which indicates that the students should **<u>stop and respond</u>** to the prompt in their notebooks.



3. Blank graph templates are supplied in the kit that can be used by the students and taped into their science notebooks in the appropriate place. Extra copies of the templates can be downloaded from the EOC website or found at the end of this document.

4. Pairs of students should be allowed to proceed at their own pace. Make sure to encourage students to read the text rather than just looking at the pictures.

5. Walk around the classroom and check on students, especially if they are younger. Clarify any parts that the students do not understand.

Part 1: The Role of Forests (pages 3–4)

- This section introduces students to the ecological importance of forests and activates their background knowledge about trees by having them draw and label their concept of a tree. Students then compare and revise their work with the help of a chart that summarizes the function of major tree parts. Estimated time: 10 minutes
- **Vocabulary**: Roots, trunk, branches, leaves, canopy/crown, flower, cone, fruit
- **Data Table/Template:** None
- **Handout**: None

Student Learning Objectives:
- Students can draw and label their concept of a tree and revise their work based on new information.
- Students can identify two crucial roles forests play for life on Earth.

Part 2: Amazing Wood (pages 5–8)

In this section students explore the wood of three major tree types (hardwoods, softwoods (conifers), and palms. Students learn to identify the three types of wood based on examining the vascular tissue arrangement in cross-section (transverse view). Students choose a microscopic view of a tree type and construct a model of the vascular tissue using clay and straws. The model is set aside for further use.

Student Learning Objectives:
- Students can distinguish between three tree types (hardwood, softwood, and palm) based on the organization of their vascular tissues.
- Students can build a model representing the vascular organization of either a hardwood, softwood, or palm.
- Students can explain the purpose of vascular tissue.

Tip: How to use the Hand Lens.

Many students struggle to use hand lenses. The best way to use it is to hold it away from the eye, at the tip of one's nose. Then move the object (ie, the fossilized wood) in and out of focus.

Students will remove the wood samples from the green pouch and match each wood block to the correct card.

Hardwood

Red Oak, *Quercus rubra*

Palm

Palm, *Cyrtostachys renda*

Softwood (conifer)

White Pine, *Pinus strobus*

Students will then use the clay to model the transverse section of vascular tissue in a tree. There are multiple ways for students to do this and the result is open to interpretation. Some students may use the straws as "cookie cutters" to poke holes in the clay but other students will use the straws as the vascular tissue.

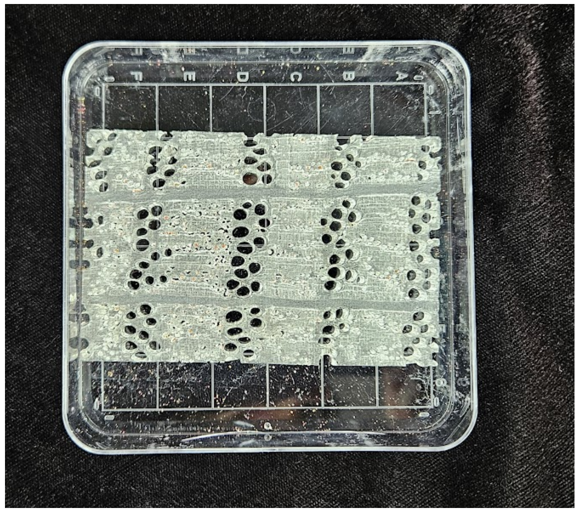
Part 3: Wood Over Time

- **Estimated time**: 10 minutes
- **Vocabulary**:
- **Data Table/Template:** Trunk Transverse Template

Student Learning Objectives:

- Students can explain how fossilization occurs.
- Students can compare their model of fossil wood mineralization with what happens in nature.

Students will "fossilize" a transverse section of a tree. Students will use the jar labeled *Sediments* and then use sink water.



Note: The sediment should “grow/expand” once it is combined with water. If the sediment does not expand, then there are not enough white particles on the transverse section. Instruct the students to shake their sediment jar and add another scoop with more white particles. The white particles are sodium polyacrylate—the same absorptive polymer found in diapers.

Teacher notes on the model of wood petrifaction or mineralization

In the student model an acrylic template of *Quercus rubra* (red oak) magnified at 10x is buried in a feldspar sand mixture that contains a small amount of sodium polyacrylate. SAP is non-toxic and is available commercially as instant “snow.” When water is added to the mixture the sodium polyacrylate absorbs the water.

SAP is a sodium salt consisting of long coiled chains of polyacrylate. Carboxylic acid groups line the long chains and ionically bond to the sodium. Water is attracted to the carboxylic acid groups and displace the sodium. As this happens the polyacrylate chains unwind allowing even more water molecules to hydrogen bond with exposed carboxylic groups. In this way the SAP can absorb water over 500 times its own weight. See the following website to view a gif. of the reaction:

https://www.dynamicscience.com.au/tester/solutions1/chemistry/chemicaldemos/sodiumpoly.html

Petrified wood that is preserved with silica is thought to form by a templating process. Silica, often from a volcanic source, is carried in groundwater as silicic acid. As the groundwater permeates buried wood the silicic acid forms hydrogen bonds with hydroxyl groups exposed on the cellulose making up the cell wall. The silicic acid polymerizes into opal and eventually into silica minerals. If there is a balance between wood degradation and silica emplacement this templating process can preserve wood structure down to the subcellular level (Leo and Barghoorn, 1976; Mustoe, 2017).

Students may note that their model is made of plastic, not of wood, that an artificial sand mixture is being used and that the process occurs in seconds. They may also note that wood mineralization in nature may take much longer, thousands of years and that the wood is eventually "replaced" by the silica through a templating process. They may also note that in both processes the wood or acrylate wood replica are buried and that when water is added the wood is saturated with water carrying sediment. In each case, the initial "mineralization" occurs in empty spaces, much of which is associated with the water conducting tissue of the wood.

While reaction of the feldspar sand SAP mixture with water is very different than the silica bonding to cell wall components at an atomic level, at a macroscopic level they look very much alike. Students might like knowing that artificial mineralization is being studied materials scientists as a way to make new materials that are light weight and have large surface areas (Dietrich, Viney, Lampke, 2015). Students might also like researching different uses for SAP and other related hydrogels.

References

Dietrich, D., Viney, M. Lampke, T. 2015. Petrifactions and wood-templated ceramics: Comparisons between natural and artificial silicification. *IAWA* 36(2): 167–185.

Leo, R. F. and Barghoorn, E. S. 1976. Silicification of Wood. *Botanical Museum Leaflets, Harvard University* 25(1): 1–47.

Mustoe, G. 2017. Wood Petrifaction: A New View of Permineralization and Replacement. *Geosciences* 7(4): 1–17.

Transverse Section Clean up

Instruct students to scrape the excess sediment directly into the trash. It is easiest if the teacher then has a large bin to soak the transverse tree sections. Students also have a scrub brush to remove any particles stuck in the transverse section's spaces. The sodium polyacrylate will float to the top of the bin. All the sediment, including sand and sodium polyacrylate, can be put in the trash.

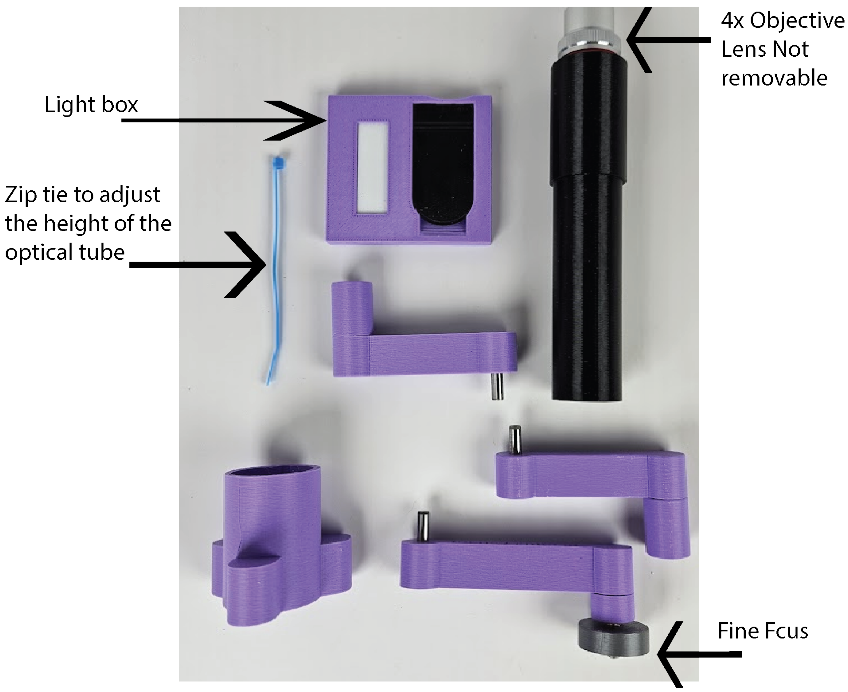
Part 4: Paleobotany

- **Estimated time**: 20 minutes
- **Vocabulary**: conifers, hardwoods, and palms
- **Data Table/Template:** Sample Identification Template

Student Learning Objectives: Students will identify three different species of trees based on their understanding of formation of vascular tissue.

Constructing the Microscope

Students will construct microscopes. The microscopes are intuitive to construct, but the order that students construct them does matter.



1. Construct the base

2. Insert the Eyepiece lens into the Optical Tube BEFORE inserting the Optical tube in the purple base

3. Insert the Optical Tube and the into the purple holder.

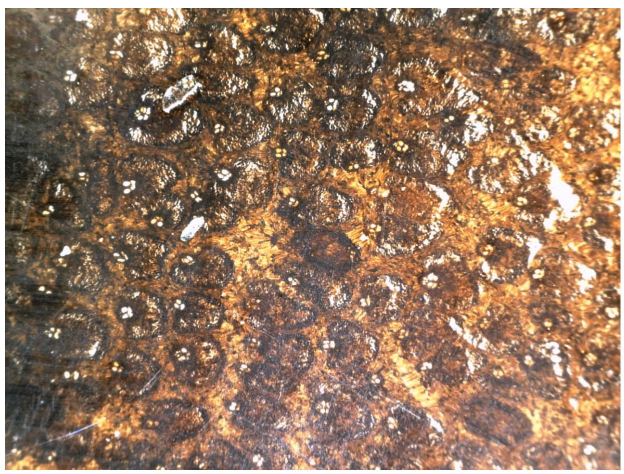
Once in the purple holder, adjust the height of the Optical Tube moving it up and down. Once in focus, insert the blue zip tie to ensure the tube no longer moves up and down.

Turn on the light box and place it underneath the microscope. The light needs to be directly under the optical tube. Place one of the three tree samples on the light box. Move the Optical Tube up and down until the slide is mostly in focus. Once the image is mostly in focus, students can then rotate the *Fine Focus* leg to enhance the focus.

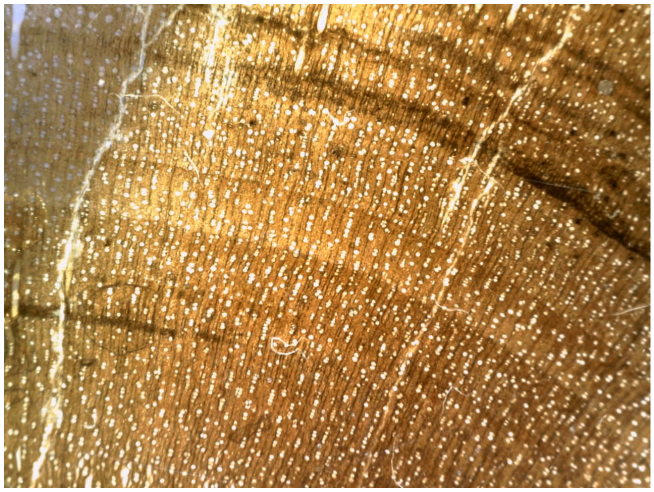
Deconstructing the Microscope

When taking the microscope apart, students **DO NOT** need to unscrew anything. If a student is unscrewing something (which will be the non-removeable 4x objective lens) they are doing it WRONG. **ONLY** the eye piece should be removed from the Optical Tube, and that is done by pulling it out of the tube.

Specimen A
Fossil conifer from Blue Forest Wyoming
Note very small tracheids (water conducting cells) in radial lines across the entire growth ring.



Specimen B
Fossil *Palmoxylon* (plam "wood") from Big Sandy Wyoming
Note scattered vascular bundles



Specimen C
Hardwood (*Schinoxylon*) from Blue Forest Wyoming
Note vessel grouped in radial multiples of 1 or more

Part 5: Ancient Ecosystems and Climate

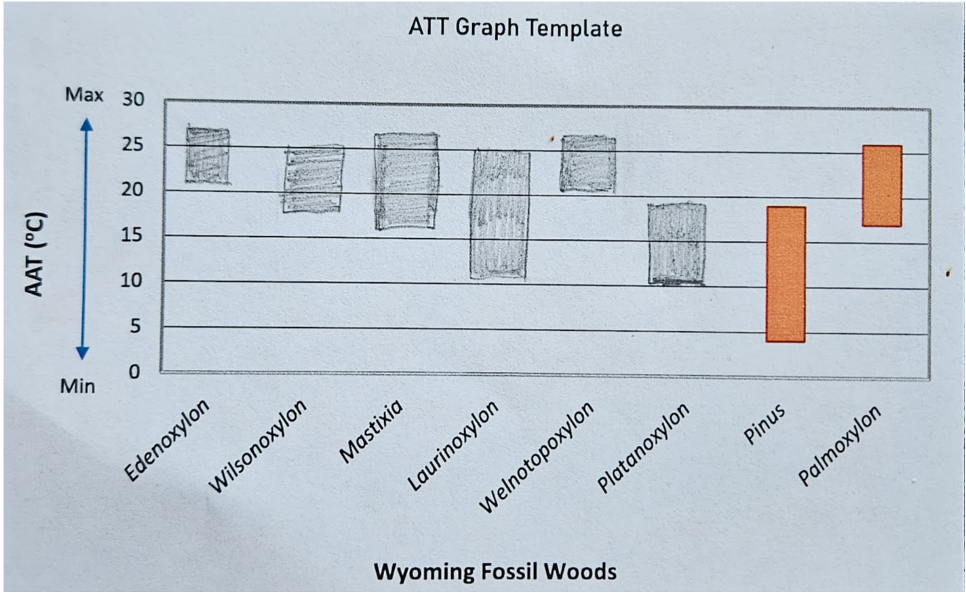
- **Estimated time**: 25 minutes
- **Vocabulary**: Nearest Living Relative (NLR), Average Annual Temperature (AAT), Average Annual Precipitation (AAP), and Eocene Era
- **Graphs/Handouts:** *Wyoming Fossil Wood & Nearest Living Relative Table*, *Modern Climate Chart*, *Time vs Average Global Temperature Graph*
- **Template:** ATT Graph Template x2

Student Learning Objectives: Students will use historical tree data to determine the climate of southwestern Wyoming during the early Eocene era.

Students will use the following table to complete the ATT Graph Template

Wyoming Fossil Wood & Nearest Living Relative (NRL) Table			
Fossil Wood	**Tree Type**	**NLR**	**AAT Range in °C**
Edenoxylon	Hardwood	Tapirira tree	22°C - 26°C
Wilsonoxylon	Hardwood	Canella tree	17°C - 25°C
Mastixia	Hardwood	Asian Dog Wood Tree	16°C - 26°C
Laurinoxylon	Hardwood	Laurel tree	11°C - 25°C
Welkoetoxylon	Hardwood	Breadnut tree	21°C - 26°C
Platanoxylon	*Hardwood*	Sycamore Tree	10°C – 18°C
Pinus	Conifer Wood	Pine tree	4°C - 19°C
Palmoxylon	Palm Wood	Palm tree	17°C - 26°C

KEY



Students can use temperature tolerances of the nearest living relatives of fossil plants in southwestern Wyoming to infer a subtropical climate. Students can visually compare the rendition by the scientific artist to current Wyoming conditions and compare their estimation of past climate with the artists rendition of the paleoenvironment using multiple geological and fossil clues.

Class Discussion Questions

Note: The questions provided below are guide questions that students can discuss as a class in order to determine what they learned/took away from the kit.

1. Why is it important for scientists to study fossilized trees?
   If scientists study fossilized trees, then we can learn about the past environment of specific places.

For the teacher: Scientists who specialize in studying different fossil tree parts (leaves, reproductive structures, and pollen) benefit from each other's work. Fossil wood, leaves, fruit, flowers, and pollen each reveal unique information about past plant life and past environments. Some types of plant fossils, like flowers and fruit, are very useful for identifying what type of plants the fossils represent but are less useful for understanding past climate. Fossil leaves can be very useful for making inferences about past climate because the shape and size of leaves is heavily impacted by the climate that a plant lives in. Similarly, fossil wood can have growth rings and other features that tell scientists about the seasonality of the environment and how much water was available. Fossil wood can also be preserved in environments where other types of fossil plants are not preserved. For example, Canellaceae, a group of plants native to the Afrotropical and Neotropical regions, has a fossil record based on leaves from Brazil, pollen from Puerto Rico, and wood from Wyoming (Boonchai & Manchester, 2012). This is why all types of fossil evidence have to be considered in order to understand the past range of a plant. Unfortunately, some subfields of paleobotany—in particular, paleoxylology—have been less studied than others. Wyoming is an incredible state for paleobotanical resources and is rich with fossil wood deposits. However, between 1950 and 2025, fewer than 10 studies have been published on Eocene wood from Wyoming, whereas dozens studies have been published on Eocene fossil leaves. Ultimately, scientists benefit from using all available fossil evidence to understand past life.

2. What assumptions do paleobotanists make when using nearest living relatives (NLR) to infer past climate conditions? *Estimates using NLR's assume that the fossil has been correctly identified and that it had environmental tolerances similar to its nearest living relative today. Paleontologists are most sure of using NLR's for Cenozoic-aged vegetation and less sure for geologically older material.*

3. How has the environment of Wyoming changed since the Eocene era?
   Wyoming was tropical with palm trees! It is now dry and very cold and snowy during the winter. The fossil deposits are now sagebrush and bunch grass with no trees.

Reference

Boonchai, N. and Manchester, S. (2012). Systematic affinities of early Eocene petrified woods from Big Sandy Reservoir, southwestern Wyoming. *International Journal of Plant Sciences*, 173: 209–27.

Packing Instructions