Fossil Kit Laboratory Investigation 4: Fossil Leaves and Climate Change

Investigation Summary: Students observe the properties of leaf size, shape, and margin. Students categorize, or group leaves and use these categories to determine the temperature under which the leaves grew.

Enduring Understandings	**Essential Questions**
• Fossil leaves demonstrate how plants are influenced by their environment. • Fossil leaves provide information about how climate has changed over time.	• What properties of fossil leaves can be used to identify them? • How do those properties indicate what the climate was like when the leaves were alive?
Students will know…	**Students will be able to…**
• Different kinds of trees grow under different temperature conditions. • Fossil leaves have many different properties. • Leaf margins are an indicator of the temperature in which a tree lives or lived. • Paleobotanists use the margins of fossil leaves to infer past temperatures.	• Observe, describe and compare the properties of fossil leaves. • Examine how plants are influenced by climate. • Observe that climate has changed over geologic time. • Observe how different groups of plants occur in different fossil deposits. • Compare their work to the work of paleobotanists.

Assessment Evidence

Completion of Investigation Worksheet
Science Notebook Entries (as applicable)

Evidence Outcomes
Students can:

a. Use evidence to develop a scientific explanation for:
    1. What fossils tell us about a prehistoric environment
    2. What conclusions can be drawn from similarities between fossil evidence and living organisms
b. Analyze and interpret data to generate evidence about the prehistoric environment
c. Evaluate whether reasoning and conclusions about given fossils are supported by evidence

Vocabulary:

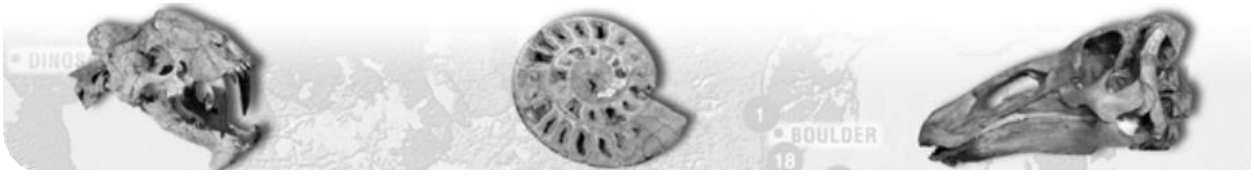
Adaptation	Characteristics	Classification
Climate	Diversity	Leaf margin
Paleobotany	Paleoclimatology	Prediction

Before You Teach

Climate has changed over Earth's history. Based on what we know from modern plants, we would expect that different types of plants would have grown in different climates in the past. One of the ways in which temperature can be estimated using fossils involves the study of the margins (or edges) of leaves preserved in fossil floras. A fossil flora is a group of leaves that are preserved together in a single rock unit or layer. In modern forests, it has been found that forests that grow in are cooler climates have a greater proportion of leaves with toothed margins than those that grow in warmer climates.

For this exercise, a sample of two floras will be used. These two floras are both from Colorado, and are both from the Eocene Epoch (which lasted from ~55 – 34 million years before present (b.p.). The Florissant Flora is 34 million years old (latest Eocene), and comes from the mountains near Pikes Peak. The Green River Formation, on the other hand, is a series of lakes that covered three states (Utah, Colorado and Wyoming) and is approximately 50 million years old (middle Eocene in age).

Both of these formations also preserved fossil insects and vertebrates in addition to plant fossils. Inferring the climate from the plants tells us more about the environment in which all these organisms lived.



Additional Teacher Resources

Vocabulary:

Adaptation – One of the basic phenomena of biology; the process whereby an organism becomes better suited to its habitat.

Characteristics – Features that can be used to identify or distinguish between different organisms or fossils.

Climate – The temperature, humidity, precipitation, winds, radiation, and other meteorological conditions characteristic of a locality or region.

Classification – A way of arranging things into groups using characteristics.

Diversity – Variety; diversity refers to the number of different kinds of organisms in an area (e.g., a high number of species would be high diversity).

Eocene Epoch – The second Epoch of the Cenozoic, ~55 - 34 million years ago (mya), characterized by warm climates and the rise of most modern mammalian groups.

Fossil flora – The entire fossil plant species that make up the vegetation of a given area at a given point in time.

Leaf margin – The edge or border of a leaf; whether it is smooth, toothed, wavy, etc. is a helpful feature in plant identification.

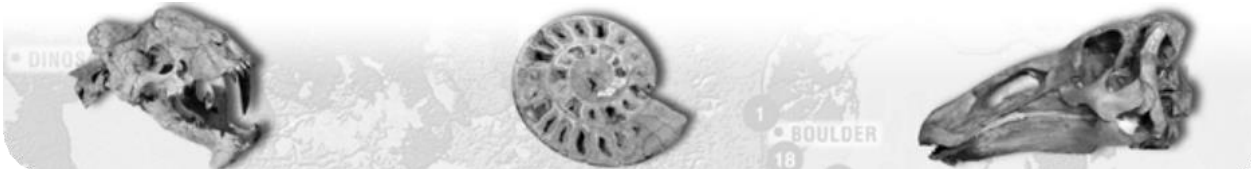
Modern – Recent times; things that are living on Earth today.

Paleobotany – Study of ancient plants from fossil leaves, wood, and other evidence.

Paleoclimatology – Reconstruction of ancient climates by using evidence such as tree rings and air trapped in ice cores.

Related – Sharing a common ancestor.

Sediment – Material that makes up sedimentary rocks (which are the kind of rocks in which fossils are preserved). Examples of sediment include sand grains, pebbles, and mud.

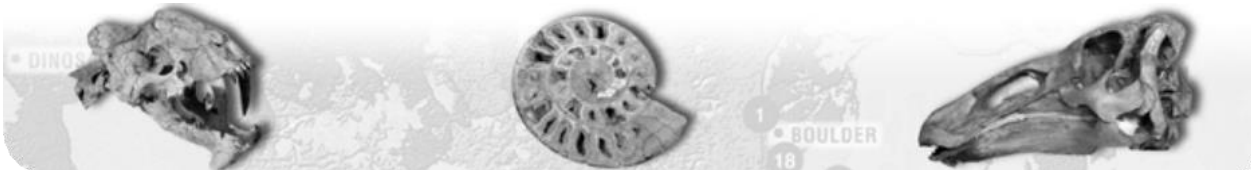


Online Resources

http://www.stratigraphy.org/column.php?id=Chart/Time%20Scale is a website where you can download a global Geologic Time Scale as ratified by the International Commission on Stratigraphy.

http://www.newyorkscienceteacher.com/sci/esl/es/spanish-es.pdf is a website that lists Spanish translations of Earth Science Terms.

http://puzzlemaker.discoveryeducation.com/ is a website where you can easily create your own crossword puzzles or word searches using the listed vocabulary words.



Laboratory Investigation 4:
Using Fossil Leaves to Identify Climate Changes over Time

Materials:

24 Fossil Leaf Cards (12 each from Florissant Flora and Green River Flora)

2 Fossil Leaves – one smooth edged and one jagged edged

Paleotemperature Chart

Diagram of Leaf Margin Classification

Investigation Worksheet

Conducting the Investigation:

1. Introduce Paleobotany.

Explain to students that they are going to be paleobotanists and that the study of fossil plants is called Paleobotany. The word "Paleobotany" comes from "paleo," meaning "ancient," and "botany," which is the study of plants. Tell them that paleobotanists use many features of fossil plants to tell them about what plant life looked like in the past.

Fossil plants are different from fossil animals in many ways. One important way in which they differ is that plants have parts that they make and lose constantly, like leaves, branches, roots, pollen, and seeds. A single tree makes tons of leaves which can be preserved, while most animals are either preserved whole, or as parts that are limited in number (bones and teeth, for example).

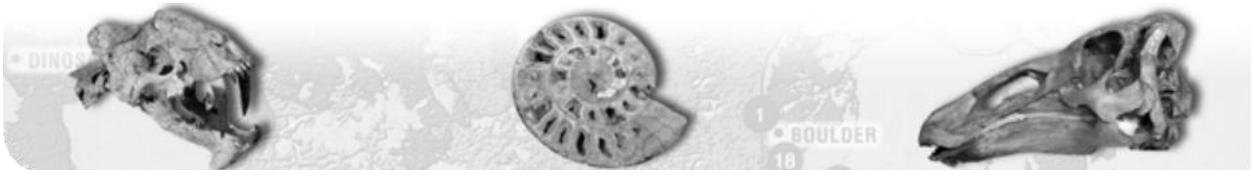
Also, some plant parts can travel very far away from the plant that makes them. Leaves that fall from trees into lakes or streams tend to get combined with the leaves of other trees in the area into a single deposit. These deposits are called floras and they represent a sample of the trees that lived together in an area at one time.

2. Introduce paleoclimatology.

Fossil leaves can be useful to paleobotanists in understanding what past climates were like. Students have probably heard the term "climate change" and may be familiar with the idea that climates on Earth have gone back and forth between warmer and cooler times.

Show students the Paleotemperature chart, and explain the axes (time and temperature) and that the chart shows how temperatures on Earth have changed through time with warmer temperatures and cooler temperatures.

Explain that one of the warmest times on Earth was about 55 million years ago at the beginning of the Eocene Epoch. Fossil plants from Colorado at this time look more like what we find today in tropical areas than those that grow in Colorado today.



When climate changes, the plants living in an area change too. Some plants are adapted to warm areas and some are adapted to cooler areas. Plants that prefer cooler areas tend to have leaves that have jagged (or toothed) edges or margins, while ones that prefer warmer areas tend to have leaves with smooth (or rounded) edges.

Paleobotanists can use the number of plants with jagged edges in a flora to estimate how warm or cool it was when the plants were alive.

3. Introduce leaf margin classification chart.

Explain that paleobotanists use many characteristics of a leaf to identify it. Leaves have different patterns of veins, outer edges, sizes, and shapes. Many leaves can look very similar at first, but upon closer inspection are really quite different.

One important characteristic used to identify leaves is the way the outer margin (or the edge of the leaf) looks. A margin can be either entire (smooth) or toothed (jagged). Show students the leaf margin classification chart with examples of entire and toothed margins. Some leaves are tricky; the margin may be hard to see, or they may have features like lobes (on an oak, for example) that look like they might be teeth but are really whole.

4. Introduce the fossil leaf cards and start the investigation.

Show students the fossil cards and explain that they are pictures of actual fossils from two Colorado floras. Explain that most of these leaves belong to plant groups that are still alive today, although they may not still live in Colorado. Both floras represent a time when Colorado was warmer than it is today.

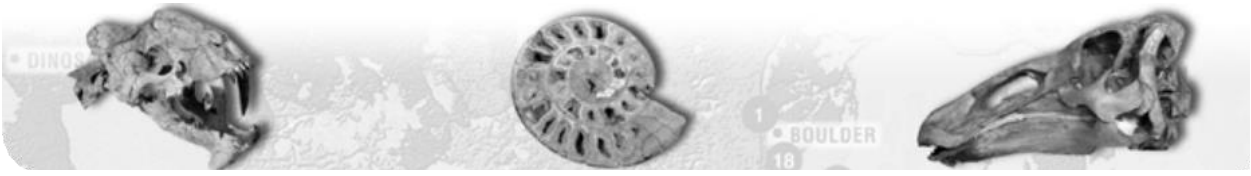
Instruct students that their challenge is to determine what the temperature was like at the time these leaves were growing.

5. Introduce fossil leaf Investigation Worksheet to record data.

Distribute copies of the worksheets and go over what will be recorded. Walk students through which numbers to use for the math section.

6. Use data to estimate what the temperature was like at the time these leaves were growing. Show students how to use their temperature estimate to tell where their floras fit on the climate curve. Have the students compare the past temperature estimate to the temperature in Colorado today.

“What might Colorado look like today if the climate was still the same as when these floras existed?” Students can write about or draw their impression of what they think Colorado might have looked like when these floras lived here.



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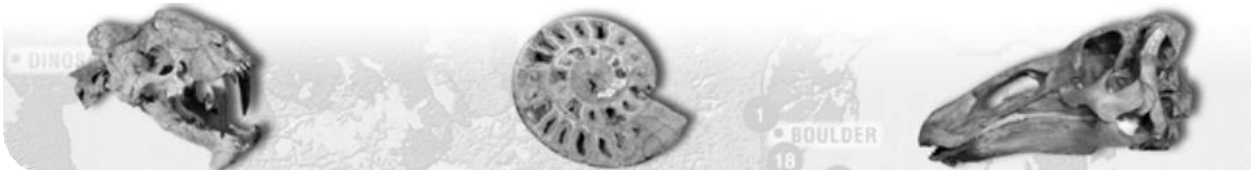
Laboratory Investigation 4: Fossil Leaves and Climate Change

1. Examine the fossil leaf photos, looking at leaf shape and details such as veins and edges.
2. Draw an example of a leaf with smooth edges and a leaf with jagged edges.
3. Sort the leaves into two piles based on whether the edges are smooth or jagged.
4. After you have sorted the fossil leaf photos, record the number of smooth-edged leaves and the number of jagged-edged leaves in the table below:

	Drawing of Leaves
Smooth-edged leaf	
Jagged-edged leaf	

	Number of smooth leaves	Number of jagged leaves
Florissant (34 million years ago)		
Green River (50 million years ago)		



Step #1: divide the number of smooth-edged by the total number of leaves, 12 in this case:

Step #2: Multiply your Leaves answer by 31:

Florissant: smooth ÷ 12 = _____ × 31 = _____

Green River: smooth ÷ 12 = _____ × 31 = _____

Step #3: Add 1.14 to your answer from Step #2:

Florissant: _____+ 1.14 = _____(temperature in degrees Celsius)

Green River: _____+ 1.14 = _____(temperature in degrees Celsius)

Now convert Celsius to Fahrenheit:

1. Take the temperature in degrees Celsius and multiply 1.8

_____× 1.8 = _____
(Temperature in degrees Celsius) (Celsius x 1.8)

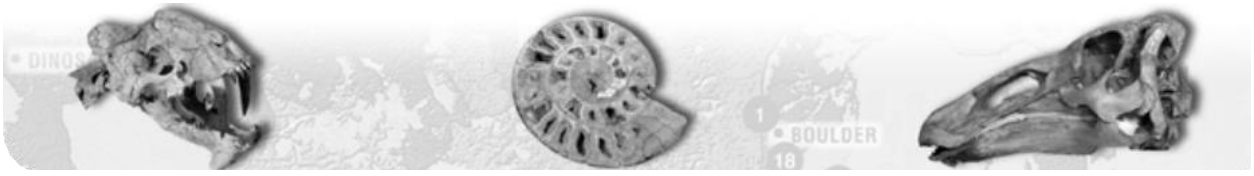
2. Add 32 degrees

_____+ 32 = _____
(Celsius x 1.8) (Temperature in degrees Fahrenheit)

3. The result is degrees Fahrenheit:

Florissant: _____

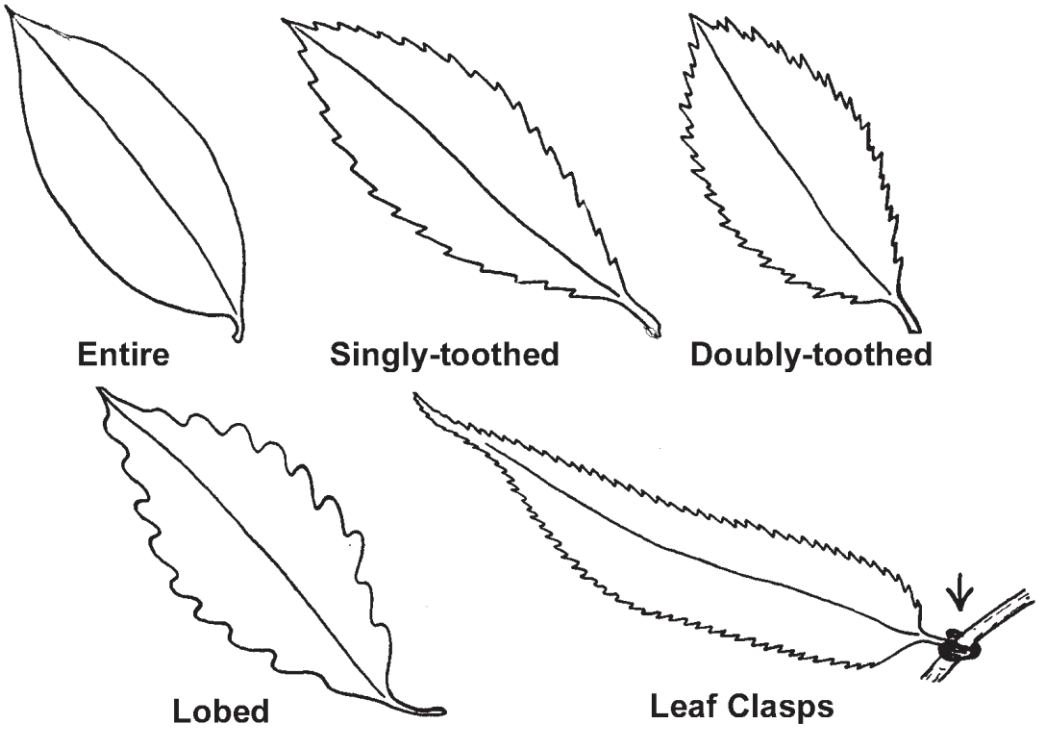
Green River: _____

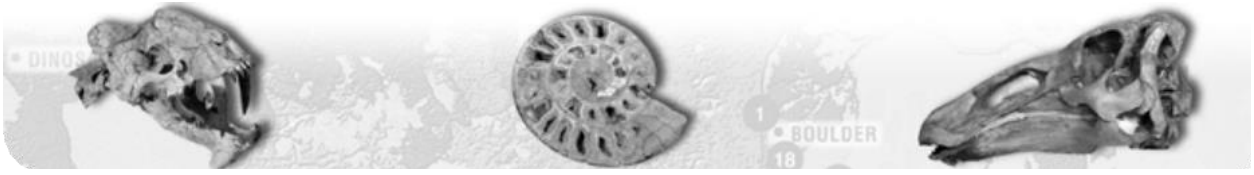


Laboratory Investigation 4: Fossil Leaves and Climate Change

Below are examples of leaf margins that you might see in the fossil leaf images.

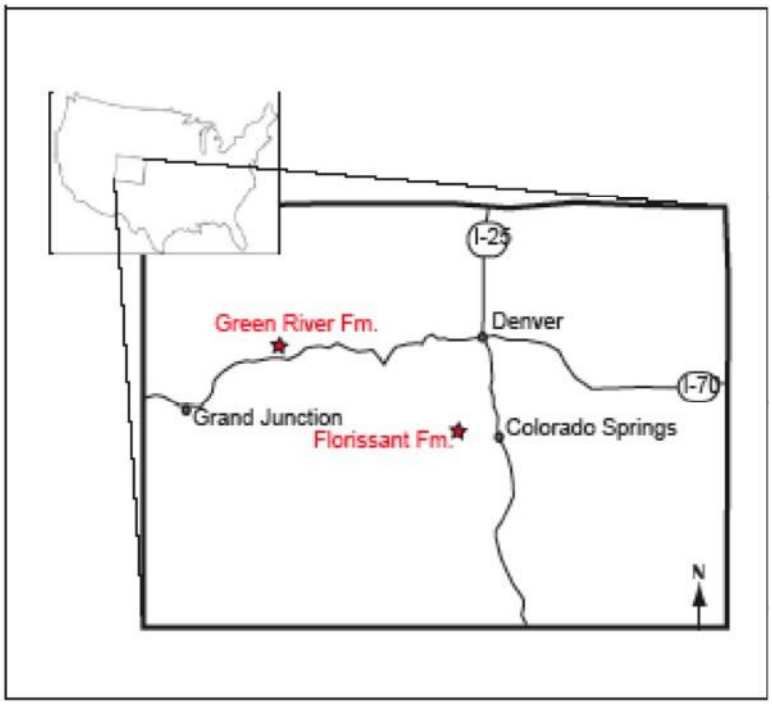
The leaves labeled “entire” and “lobed” would be counted as SMOOTH. The leaves labeled “singly-toothed” and “doubly toothed” would be counted as JAGGED.



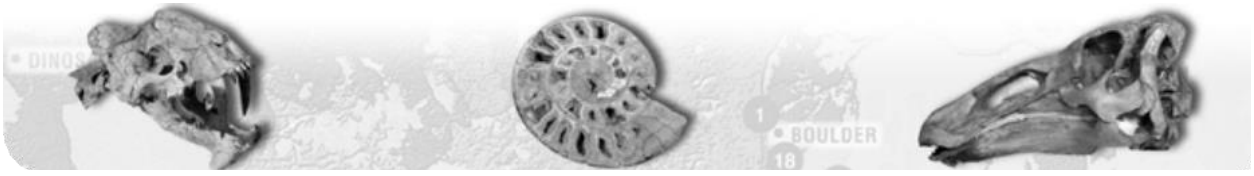


Map showing the location of the fossil flora of Green River and Florissant

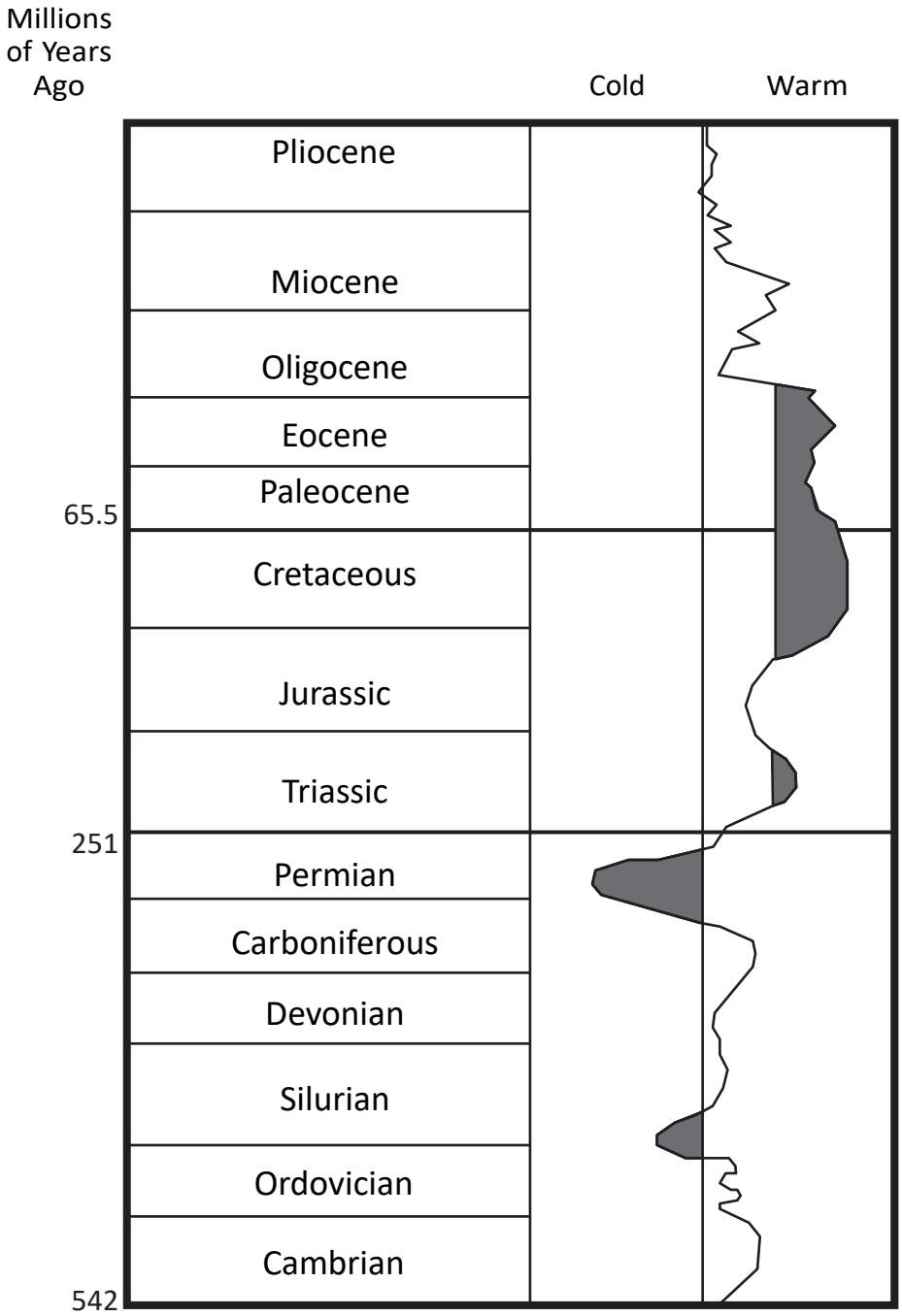
Paleontologists dug in the sandstone in the Green River and Florissant areas to find the fossil leaves. The rocks were sedimentary and had very obvious layers. By prying apart the rock layers, the fossil leaves were exposed. Sometimes there is a print of the leaf on both the top and bottom layer. The two images are "mirror images" of each other. They are exactly the same size and shape, but facing opposite directions. Look closely at the real fossil leaves included with the leaf pictures.

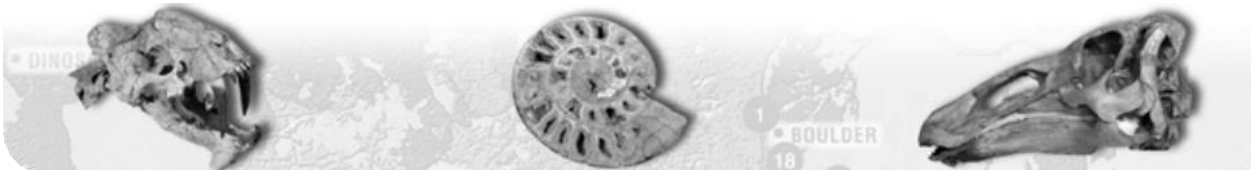


Draw a mirror image of one of the leaves



Mean Global Temperature





Laboratory Investigation 4: Vocabulary for Fossil Leaves and Climate Change

Adaptation – One of the basic phenomena of biology, the process whereby an organism becomes better suited to its habitat.

Characteristics – Features that can be used to identify or distinguish between different fossils.

Climate – The temperature, humidity, precipitation, winds, radiation from the sun, and other meteorological conditions characteristic of a locality or region.

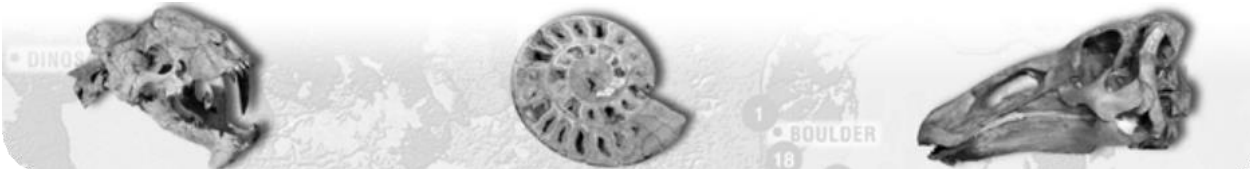
Classification – A way of arranging things into groups using characteristics.

Diversity – The number of different kinds of animals and plants in an area. For example, if lots of different species of plants and animals live in an area, that is high diversity.

Leaf margin – The edge or border of a leaf; whether it is smooth, toothed, or wavy is a helpful feature in plant identification.

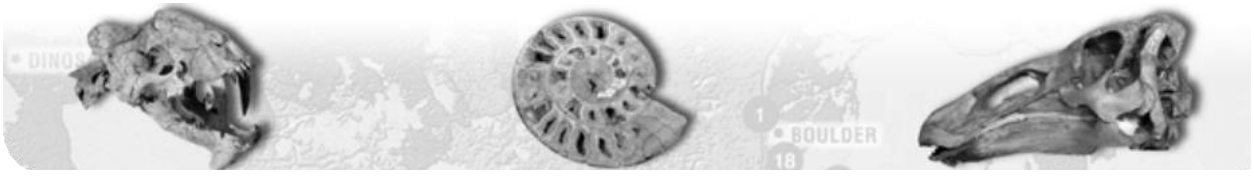
Paleobotany – The study of ancient plants from fossil leaves, wood, and other evidence**.**

Paleoclimatology – The reconstruction of ancient climates.



Investigation 4: Fossil Leaves and Climate Change – Answer Key

1.	Florissant Formation	*Cotinus fraternal*	Smooth
2.	Florissant Formation	*Fagopsos longifolia*	Jagged
3.	Florissant Formation	*Athyana haydenii*	Jagged
4.	Florissant Formation	*Bursera serrulata*	Smooth
5.	Florissant Formation	*Carya libbeyi*	Jagged
6.	Florissant Formation	*Cedrelospermum lineatum*	Jagged
7.	Florissant Formation	*Populus crassa*	Jagged
8.	Florissant Formation	*Quercus* sp.	Jagged
9.	Florissant Formation	*Quercus* sp.	Smooth
10.	Florissant Formation	*Rhus obscura*	Jagged
11.	Florissant Formation	*Rosa hilliae*	Jagged
12.	Florissant Formation	*Rubus coloradense*	Smooth
13.	Green River Formation	*Aleurites* sp.	Smooth
14.	Green River Formation	*Allophylus* sp.	Jagged
15.	Green River Formation	*Athyana* sp.	Jagged
16.	Green River Formation	*Cardiospermum coloradensis*	Smooth
17.	Green River Formation	*Cardiospermum* sp.	Smooth
18.	Green River Formation	*Cedrelospermum* sp.	Jagged
19.	Green River Formation	*Macginitiea wyomingensis*	Jagged
20.	Green River Formation	*Parvileguminophyllum* sp.	Smooth
21.	Green River Formation	*Populus cinnamomoides*	Jagged
22.	Green River Formation	*Rhus* sp.	Jagged
23.	Green River Formation	*Salix* sp.	Jagged
24.	Green River Formation	*Syzigiodes Americana*	Smooth



	Number of smooth leaves	Number of jagged leaves
Florissant (34 million years ago)	4	8
Green River (50 million years ago)	5	7

Step #1: divide the number of smooth-edged by the total number of leaves, 12 in this case:

Step #2: Multiply your Leaves answer by 31:

Florissant: smooth ÷ 12 = _____.333__ × 31 = _____10.323___

Green River: smooth ÷ 12 = _____.417___ × 31 = _____12.917___

Step #3: Add 1.14 to your answer from Step #2:

Florissant: ___10.323___ + 1.14 = ___11.463__ (temperature in degrees Celsius)

Green River: _12.917__ + 1.14 = ___14.057___ (temperature in degrees Celsius)

Now convert Celsius to Fahrenheit:

1. Take the temperature in degrees Celsius and multiply 1.8

Florissant: _____11.463_____ × 1.8 = _____20.633_____
Temperature in degrees Celsius — Celsius x 1.8

Green River: _____14.057_____ × 1.8 = _____25.302_____
Temperature in degrees Celsius — Celsius x 1.8

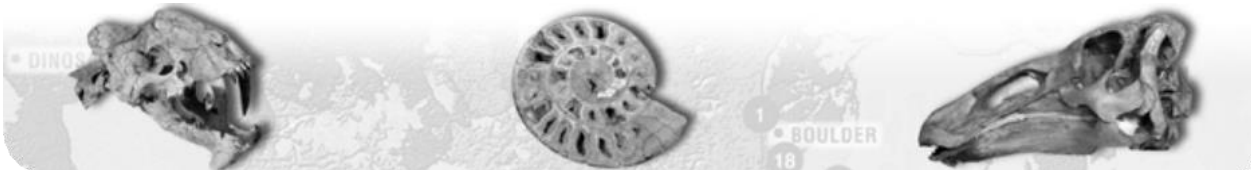
2. Add 32 degrees

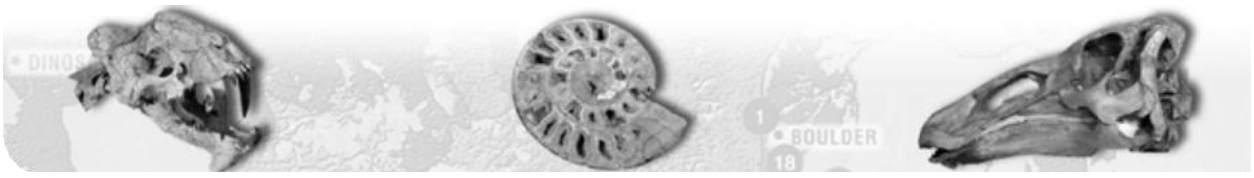
Florissant: _____20.633_____ + 32 = _____52.633_____
Celsius x 1.8 — Temperature in degrees Fahrenheit

The result for Florissant is 52.633 degrees Fahrenheit.

Green River: _____25.302_____ + 32 = _____57.302_____
Celsius x 1.8 — Temperature in degrees Fahrenheit

The result for Green River is 57.302 degrees Fahrenheit




BOULDER