Lesson 10 - C

Plants of the Hell Creek Formation

Summary
In addition to its wealth of animal fossils, the Hell Creek Formation contains abundant plant fossils, although few were collected until the late 20th century. The total now runs into the tens of thousands, the majority of which come from Hell Creek rocks in North Dakota. Of these fossils, the majority is of angiosperms, the flowering plants. They make up 90 percent of the flora both in number of taxa and specimens collected. Ferns, cycads, gingkos, and conifers make up the remaining 10 percent. Paleobotanist Kirk Johnson has written that the "abundance of large dinosaurian herbivores argues that they should have had some role in the shape and density of the vegetation."

Objectives
Students will be able to:
1. Distinguish between broad-leaved trees, conifers, and other
2. Describe the plants of the Hell Creek ecosystem
3. Describe the relationship between plants and animals in this ecosystem

Estimated teaching time
NA

Groups
NA

Materials
- Worksheets and laminated plant photographs

Teachers Background
Three conditions are required for the preservation of plant fossils:
1. Removing the material from oxygen-rich environment of aerobic decay;
2. "Fixing" the organic material to retard anaerobic decay;
3. Introducing the fossil to the sedimentary rock record (a.k.a., burial).

Consequently, plant fossils are generally preserved in environments very low in oxygen (e.g., anaerobic sediment) because most decomposers (e.g., fungi, most decomposing bacteria and invertebrates) require oxygen for metabolism. Such sediments are commonly gray, green or black rather than red, a sedimentary signal of oxygen-rich conditions. The "fixing" requirements means that plant material must fall into an environment rich in humic acids or clay minerals, which can retard decay by blocking the chemical sites onto which decomposers fasten their degrading enzymes. Plant material can also be "fixed" by removing degradable organic compounds during the process of charring by wildfire. This is a common and spectacular mode of preservation for flowers. Plant material can then be incorporated into the rock record in areas where sediment is being deposited, which usually, but not always, requires the presence of water. Consequently, streams, flood plains, lakes, swamps, and the ocean are good candidates for fossilforming systems. Plant fossils are commonly preserved in fine-grained sediment such as sand, silt, or clay, or in association with organic deposits such as peat (coal).

Plants are divided into two broad categories. Angiosperms are the flowering plants and include such common plants as elms, daffodils, roses, and corn. Angiosperm trees are often called broad-leaved. Within the angiosperms there are two groups, the dicotyledons (dicots) and monocotyledons (monocots). Dicots have two seed leaves and usually have leaves with branching veins. Monocots have one seed leaf and leaves with parallel veins. Angiosperms are deciduous, meaning the plants drop their leaves. Gymnosperms, which refers to a naked seed, are what most people think of as conifers. Most conifers have modified leaves known as needles, which remain on the tree year round. One exception to this is the gingko, which has broad leaves and is deciduous

Facilitating the activity
Pass out the worksheet and photographs to students. As noted in the introduction to this lesson, teachers should give a broad overview of activity to the students and tell them that each group is contributing to solving the overall issue of the paleoenvironment of the Hell Creek.

See Introduction to Lesson Ten for information on Assessment, Going Further, References, Teaching Standards, and Glossary.

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In this activity, you will work with photographs of plant fossils from the Hell Creek Formation. You will try to distinguish what types of plants were growing, why they grew where they grew, and the relationship between plants and animals.

1. Look at the nine photos, which illustrate seven different plants (Images 4, 7, and 9 are from the same plant, though two different specimens). Which do you think are broad-leaved trees, such as oak, elm, or maple? Which do you think are conifers, such as pine, fir, or spruce? Which ones are something else? Explain your choices.

2. Judging by the size of the leaves do you think that most of the fossils came from large or small plants? Why?

3. What do you think would account for the variety of plants?

4. The types of plants illustrated in this lesson give a relatively close approximation of the ratio of types of plants (angiosperm to gymnosperm) found in the Hell Creek. How would you describe this ecosystem (meaning what types of plants dominated)?

5. How did the animals use this ecosystem? (circle all that apply)
   a. Plants provided a good food source for the many large, herbivorous dinosaurs.
   b. Animals might have taken advantage of the dense foliage to escape predators.
   c. Mammals and birds lived in the trees.
   d. Dinosaurs ate the wood for fiber as part of a healthful diet.
   e. Animals moved away during colder times when the plants dropped their leaves.

6. On the other side of this piece of paper draw your favorite fossil plant specimen. Include measurements and a scale bar, and list five characteristics that help distinguish this specimen from the fossil plant material of other species.

Lesson 10C – Plant Descriptions

"Artocarpus" lessigiana (Lesson 10C – Plant 1) – There is some confusion about what modern family this plant is related to. The use of the genus name *Artocarpus* in quotes implies by some a relationship to modern day *Artocarpus*, a genus in the mulberry family, also known as the breadfruit or jackfruit family. Other paleontologists place it in the Laurel family.

Ginkgo adiantoides (Lesson 10C – Plant 2) - The genus *Ginkgo*, represented today by the widely-cultivated Chinese species *Ginkgo biloba*, has an evolutionary lineage that dates back to the Lower Jurassic, about 190 million years ago. Although this genus has undergone much change over this length of time, fossilized leaf material from the Tertiary species *Ginkgo adiantoides* is considered similar or even identical to that produced by modern *Ginkgo biloba* trees.

The oldest fossils come from a single location in what is now the Asiatic part of the former USSR. During the Middle Jurassic there was a great increase in ginkgo fossil sites throughout the northern parts of the Laurasian supercontinent. At least two species existed at this time. Maximum diversity was reached during the Cretaceous with five or six species identified in the Northern Hemisphere. These species are mainly distinguishable on the basis of leaf anatomy and geographical distribution.

By the Paleocene, diversity in the genus *Ginkgo* was reduced to a single polymorphic species, often referred to as *Ginkgo adiantoides*, which produced leaves virtually indistinguishable from modern-day *Ginkgo biloba*. This species was mainly distributed in the northern regions due to the tropical environment at that time. As the Earth's climate cooled during the Oligocene, the species took on a more southerly distribution than it had occupied previously. In addition, the number of fossil sites decreases sharply. Approximately seven million years ago it disappeared from the fossil record of North America.

Although *Ginkgo adiantoides* was particularly abundant in Europe at the start of the Pliocene, it was gone from that region by about 2.5 million years ago. There are very limited numbers of fossils found from the Pliocene, and for the Pleistocene, no fossils of *Ginkgo* are known. Scientists thought that the genus had become extinct, however, through mysterious events, *Ginkgo biloba* managed to survive in China until modern times. These ginkgoes were mainly found in monasteries in the mountains, where they were cultivated by Buddhist monks. The ginkgo was brought out of these mountains by approximately 1100 AD and spread quickly throughout temperate Asia. It was first planted in Europe in the early 1700's and in America later that century. (Description comes from Univeristy of California Museum of Paleontology web site - www.ucmp.berkeley.edu/seedplants/ginkgoales/ginkgofr.html)

Araliaephyllum polevoi **-** (Lesson 10C – Plant 3) – This plant is related to the modern family Lauraceae, or laurels.

Sabalites - (Lesson 10C – Plant 4, 7, 9) - Sabalites is a member of the family Arecaceae or Palm family. The earliest unequivocal palm fossils are from the lower Upper Cretaceous (around 85 mya). They are geographically wide spread with a range of parts, including leaves, roots, fruits, seeds, and stems. Modern palms are found in tropical and some warm temperate landscapes.

Metasequoia – (Lesson 10C – Plant 5) - *Metasequoia* are known as a living fossil. Botanists long thought the trees had been extinct for millions of years, but in the 1940s a Chinese forester discovered them growing in a small grove in China. Around the same time, a Japanese scientist found fossils of the trees, which turned out to be the same species. The similarities weren't discovered until after World War II. Botanists from Harvard's Arnold Arboretum traveled to China, collected seeds, and distributed them to arboreta and gardens around the world. The trees now grow in many places and are known as the dawn redwood. Dawn redwoods are most unusual in that they are cone-bearing trees that are deciduous—they lose their leaves in winter. Pine and fir trees keep their leaves all winter. In autumn the living dawn redwood leaves turn to orange and gold colors that recall the colors of the sky at dawn. Leaves of the dawn redwood, or *Metasequoia*, are one of the most commonly found fossils in the Republic flora and it is the state fossil of Oregon.

Paleobotanists have found Metasequoia fossils from Alaska to Utah to Siberia to China. Those in Washington state are around 50 – 55 million years old. They have been found near Bellingham from the Chuckanut Formation and near Republic. During the deposition of the Chuckanut, streams flowed across a broad plain and deposited thousands of feet of sand, silt, and conglomerate (a mixture of sizes). Judging from the plant remains the climate was sub-tropical with many swamps rich in conifers. In contrast, Republic was more of an upland site, with a shallow lake, surrounded by a mixed/conifer upland forest. Trees include conifer and deciduous, such as sassafras, maple, and alder. Botanical research shows that Republic had a mean annual temperature of 50 degrees versus 63 degrees on the coast.

Laurels (Lesson 10C – Plant 6) – There is an extensive fossil record of plants in the Laurel (Lauraceae) family, including leave, fruits, seeds, wood, flowers, and pollen. The majority of the evidence is from the Cenozoic, or the past 65 million years. One of the oldest fossils is from 105 million year old rocks. At present, the family consists of 3000 tropical and subtropical species. Most are trees or shrubs and many have aromatic oils.

Leepierceia preartocarpoides (Lesson 10C – Plant 8) - Long thought to be a member of the Ficus genus, the modern genus of which includes figs. Reclassified recently when better specimens were examined. *Leepierceia preartocarpoides is* extremely common in the lower Hell Creek Formation near Marmarth, North Dakota, and Ekalaka, Montana, but disappears approximately 40 meters below the K -T boundary in both areas. Brown (1939) reports that Barnum Brown collected numerous specimens from the Hell Creek Formation in the Fort Peck region of central Montana.

The genus name is in memory of Lee Steven Pierce (1960—1987) of Canton, New York, a Yale University graduate student whose untimely death truncated a promising research career in angiosperm leaf evolution.