

## *Fossils as evidence of past environments*

### **Age Range – Grade 9-12**

**Aim:** These modules are based on the paleontological resources found in Garden Park and the local geology of the Cañon City Basin. The modules provide students with an understanding of the local geological history and prehistoric life.

**Pre-Requisite:** Students will know what a fossil is and how organisms become fossilized

### **Meets Standards:**

#### **Colorado Science standards and expanded benchmarks (2004/2005) 1:2, 1:5, 3:3, 4:2**

- Ask questions for information based on observations
- Pose a question around a testable vs. non-testable problem
- Communicate results of investigations
- Understand how living things interact with each other and the environment
- Recognize Earth's features

#### **Content Standard C Life Science: Diversity and Adaptations of Organisms**

- Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient to allow its survival.
- Fossils indicate that many organisms that lived long ago are extinct.
- Extinction of species is common; most of the species that have lived on the earth no longer exist

#### **National Science Content Standard D Earth and Space Science: Earth's History**

- Fossils provide important evidence of how life and environmental conditions have changed

**Goals:** Students will have an understanding of prehistoric life and ancient environments on during the time of the Jurassic-aged dinosaurs by interpreting the fossils left behind.

### **Learning Objectives:**

Students will learn that:

- fossils help us understand how biodiversity has changed through time.
- fossils help us understand how organisms are related.
- most organisms that lived in the past are now extinct.
- fossils provide evidence of mass extinctions.

- the extinction of one species can affect other organisms.
- recognizing changes in past biodiversity can give us clues about how biodiversity is changing today.
- fossils provide clues about both abiotic and biotic factors of past ecosystems.
- fossils provide evidence about the changes in climate and temperature of past ecosystems.
- fossils can give us clues about how organisms interacted with one another.

### **Resources:**

Computers with internet access

Library

<http://www.handsontheland.org/garden-park/index.php>

The website -use the education section links to various pages on the website, the geology section and the rock column found on that page, and the interactive map.

Models or pictures of dinosaurs and non-dinosaur reptiles – crocodile, turtle.

*The Dinosaurs of Marsh and Cope: The Jurassic Dinosaurs of Garden Park*, by Kenneth Carpenter. Book available as a free pdf from the link below.

<http://www.dinosaurdepot.com/kids.htm>

*Geologic Guidebook to the Gold Belt Byway, Colorado*, edited by Thomas W. Henry et al., (Gold Belt Tour Scenic and Historic Byway Association: Gunnison, Colorado. 2004). This book can be purchased from the Dinosaur Depot in Cañon City.

Pencils and Paper

**Teacher Directions:** Familiarize yourself with the web pages – take note of the different types of the dinosaurs; the paleo-environment of Temple Canyon and the specimens found here; and the other types of fossils found in Garden Park. Teacher Preparation time 60-90 minutes.

### **Introduction:**

Fossils can provide us with a great deal of information about the past. They can also help us to understand the present. These modules are designed to introduce students to four different aspects of fossil interpretation. Students explore how fossils provide evidence of:

- Dinosaur adaptations
- Biodiversity and Ancient Environments
- Extinction of species
- The age of rocks

## Module 1. DINOSAUR ADAPTATIONS

### Activity 1. What do Fossils tell us about dinosaurs?

In this activity students will learn the differences between dinosaurs and non-dinosaur reptiles – all of which have been found in Garden Park. The presence of these animals as represented by the fossils help us interpret the environment in which they lived.

**Time Needed:** 30 minutes per activity

#### Resources:

models or pictures of dinosaurs and non-dinosaur reptiles that show different features/adaptations – a good illustrated dinosaur book

the link to the Cope-Lucas dinosaurs on the education page of the website. The illustrations show different adaptations, such as teeth for carnivores and herbivores

Pencils and Paper for note taking

**Guided questions:** What is a dinosaur? what are the characteristics of a dinosaur?

Ask the students (to gauge an idea of what they know) about dinosaurs before they explore the Cope-Lucas dinosaurs and non-dinosaurs page and the other links to fossils on the education page.

Allow 5 minutes for students to respond and then direct them to the computers to find out if they are correct.

**Directions:** Working in pairs, let the students explore the links to find out about the different features of the dinosaurs and differences between dinosaurs and non-dinosaur reptiles. Allow 15-20 minutes for students to explore the different pages and links. Remind them to write down the characteristics of each dinosaur that helps them understand the differences between the dinosaurs.

#### Teaching points:

Models or pictures of dinosaurs and non-dinosaur reptiles are useful visual aids

Four limbs that are under the body – unlike other reptiles that have a sprawling gait like crocodiles

They can't fly and swim, they are strictly land dwellers

They can be herbivores or carnivores - we know this from the different types of fossilized teeth found.

Bi-pedal, or walk on all four limbs

Not everything big and dead is a dinosaur – other reptiles lived at the same time as dinosaurs

## **Activity 2. Fossils reveal a wealth of information about how dinosaurs looked and behaved.**

In this next activity students will hypothesize on how dinosaurs looked and behaved by making comparisons with clues left behind by modern animals.

**Time Needed:** 30 minutes

### **Resources:**

Computers within internet access

Library for research

Education page – links for Cope-Lucas quarry, Dinosaur Depot Exhibits – select Dinosaur Track Way exhibit and the interactive map that can be found here

<http://www.handsontheland.org/garden-park/data/flash/fullscreen.htm>

Pencils and Paper

**Guided questions:** Ask the students to think about the modern environment. Ask the students to concentrate on a modern land environment – what might they see? What clues let us know what types of animals live in the area?

As in a modern environment, a paleo-environment reveals similar clues, but this time as fossils.

**Directions:** Students remain in their groups. Allow 5 -10 minutes for student discussion and writing down ideas and then come back together as a class so they can share their ideas.

**Teacher Directions:** write down on the board the clues the students come up with

### **Teaching points:**

Size of bones can help us determine the size of the animal

Tracks left behind help us identify the animal and its size (from the size of the track and its stride)

Scat may be used to identify the species of animal, size of animal, and what the animal ate

Fur caught on trees may help us identify the animal

Feathers

Students may come up with others, but there are only a few that we can use in the fossil record

**Guided questions:** How can we use some of these clues to determine the type of animal in the paleo-environment? Compare to the modern environment and/or nearest living relative

What are those clues?

What are some of the facts we know about dinosaurs today based on what they left behind?

**Directions:** Students break up again to discuss what might be found in the fossil record and what it tells us about the dinosaur. Remind them to take notes. Allow 15 minutes for discussion and exploration of the website, before coming back in a group to discuss what they found. Allow 5 – 10 minutes for discussion.

### Teaching Points

Coprolites – fossilized dung – tells us what the animal ate; plants, woody vegetation, animal Eggs – fossilized eggs found in Garden Park tell us that dinosaurs laid eggs

Tracks – like those at Skyline Drive in Cañon City – reveals the types and sizes of dinosaurs and other animals that roamed the earth

Bones – the size of the bones reveal the size of the animal

Teeth – the size and shape indicates the diet of the dinosaur. For example, *Allosaurus* teeth are sharp with serrated edges that were used for biting and tearing at flesh – therefore he was a carnivore. Teeth can also tell us what type of animal it was; therefore giving us an idea of what the environment was.

**Emphasize here that although we can learn a lot from the fossil record there are some things we don't know.** Example: we don't know the colors of dinosaurs.

At the end of this module students should understand that different types of dinosaurs lived in the Garden Park area during the Late Jurassic period. The fossil remains help us determine what they ate and how big they were and also the relationships between the dinosaurs, other animals, and the environment.

## **Module 2.**

### **BIODIVERSITY AND ANCIENT ENVIRONMENTS**

This module focuses on the past biodiversity and the environment of Garden Park and Temple Canyon during the Late Jurassic period. Students will investigate dinosaurs in more detail to gain an understanding of the adaptations and features of four dinosaurs that ensured their survival during the Jurassic period. In the second section, students will investigate other types of fossils to learn how paleontologists recreate the ancient environment.

#### **Resources:**

Computers with internet access

Library

The links on the education page for the descriptions and illustrations of the fossils in the Cope-Lucas quarry and the Kessler quarry,

Illustrated Dinosaur Book with clear illustrations of Dinosaurs

Pencil and Paper

**Time Needed:** 45 minutes per activity

#### **Activity 1. The dinosaurs of Garden Park**

Directions: In pairs students explore the website to get an understanding of the major dinosaurs found in Garden Park. Focus on the dinosaurs listed below. Students will write down the major adaptations of dinosaurs that ensure their survival and will note what they need to survive.

Allow 15 minutes for students to explore the site and come up with brief descriptions and needs of each one –diet, environment

*Allosaurus, Stegosaurus, Diplodocus, Camptosaurus*

#### **Teaching Points:**

***Allosaurus*** - The largest carnivore in the Jurassic period. Sheds teeth like modern reptiles and are continually replaced. The skeleton is 25-30 ft long and about 6-8 ft tall at the hip. The tail makes up half of the body length. Weighed 1 ½ -2 tons. The skull is about 2 ft long. Teeth are long and slender with serrated edges and suited for biting and cutting flesh. The arms are short – 3 ft long, with 3 fingers with raptor-like claws for grasping prey. The feet also have claws.

*Allosaurus* was a mean fighting and eating machine.

*Stegosaurus* is a type of armored herbivorous dinosaur. They are large dinosaurs with flat plates standing on end along the backs and sharp spikes on their tails. The skull is elongated and appears too small for the body and is close to the ground. The teeth are very small and rounded indicating a diet of plants. For many years what we knew about *stegosaurus* was based upon the single discovery at the Marsh quarry at Garden Park, now on display at the Smithsonian. It was up to 24 ft long and 7 ft tall at the hips and weighed 5 tons. The discovery of another *Stegosaurus* in 1992 in Garden Park – the Dinosaur Depot has a virtual exhibit about it (listed in resources above) -changed the way paleontologists thought about the dinosaur.

*Diplodocus*- is a sauropod and is herbivorous. It grew to be 84 feet in length and 14 feet tall, but it only weighed 11 tons. It is slender and a considerable portion of the body is neck and tail. The long head has pencil-like teeth that were used to strip leaves from tree branches. Recent carbon remains discoveries show that *Diplodocus* had a frill or fringe or small triangles, similar to lizards, extending along its neck and back, while other pieces show that the skin was pebbly.

*Camptosaurus* is an Ornithopod – a bi-pedal group of herbivorous beaked dinosaurs. The location of the teeth in the skull of *Camptosaurus* suggests that it had fleshy cheeks. These would have helped keep food from spilling out as *Camptosaurus* chewed rough vegetation. Along with other ornithopods, *Camptosaurus* spent some of the time on its hind two legs, and some of the time on all four legs. Some scientists have proposed that *Camptosaurus* could run on its hind legs at speeds of up to 15 mph, or 25 km/h. A living *Camptosaurus* would have been about 18 feet long and weighed around 1500 lbs. Most ornithopods are thought to have traveled in herds, which would have protected them from predators like *Allosaurus*.

Come back together as a group and allow students to share what they learned. Allow 5 -10 minutes for the group discussion.

**Teacher directions:** Using a wipe board or overhead projector, teacher writes down the features and adaptations of each dinosaur. Allow 10-15 minutes for this activity

For Example:

*Allosaurus* - Carnivore, sharp teeth, sharp claws, bi-pedal, fast, strong

Note that the herbivores feed on different types of vegetation – close to ground, high in trees, bushes -they adapted to their environment.

**Guided questions:** Compare dinosaur adaptations to modern day animals – What would be the equivalent animal today? where are these animals found?

**Extension activity:**

Using the internet or library, students can explore modern environments and animals in the same way they did with the dinosaur activity

Teacher directions: write down the modern day equivalents next to the dinosaurs

**Emphasis here is that dinosaurs, like modern animals, adapted to their environment and developed features that ensured their survival, herbivores eat different vegetation ensuring they have enough to eat > They filled different niches. Carnivores need meat to survive – some are scavengers, while others hunt**

### **Activity 2. Other Clues to the Paleo-environment**

The goals of this section is to show students that fossils can tell us much more about environments and that dinosaur bones are not the only fossils that paleontologists collect and study.

#### **Resources:**

Computers with internet access

Students will explore the Education links to the Jurassic plant, fish, and Dinosaur Depot Exhibit “Tony’s Tree.”

Teachers may want to read the article on Temple Canyon as background reading. The link to the article is on the Education page – “Description of a Late Jurassic Environment, Temple Canyon” The area has been interpreted as a lake, or as a wetland with periods of water fluctuation.

Pencil and Paper

#### **Time Needed: 45 Minutes**

**Directions:** In Pairs, the students will explore the links on the website to the plant, fish, and tree on the education page, and also the link on the Welcome page to *Late Jurassic Flora*. Students will write down names of the species that have been found in Garden Park and in Temple Canyon including the environment in which they lived. Students may also use the internet to find out more information on certain species if needed. Students will then share their research with the rest of the class.

#### **Teaching Points:**

**Gingko** - still exists today, is known as a living fossil because it first appeared during the Early Jurassic period some 150 million years ago. It lived near stream environments and grew as a low, open shrubbery canopy. Gingko was a non-flowering plant (Gymnosperm) – Flowering plants (angiosperms) didn’t appear until the Cretaceous period, at which time the genus Gingko became restricted in its range and declined in diversity. Found at Temple Canyon.

**Equisetum** – still exists today; is known as a living fossil because it dates back to the Paleozoic era some 200 million years ago; Lives near streams and other damp or wet environments.

**Conifer** – still exists today, and appeared on the earth some 300 million years ago. The conifer was the most diverse and dominant tree during the Jurassic period.

**Fish** – Presence of this type of fish – pholidophoriform- indicate a supply of fresh water with high oxygen content – they can live in streams, ponds, lakes, or rivers, but the water supply is continuous in order for fish to survive. Found at Temple Canyon.

**Tree** – a large tree found in Garden Park – possibly conifer or sequoia – but presence of permineralized trees suggest that forests or stands were found in the ancient environments.

**Fossils**- Emphasize that fossils are not just bones. Tree trunks, plants, shells, and even micro-organisms can be fossils. Paleontologists study all types of fossils to learn more about past life.

**Guided questions:** what might have happened to cause the Gingko plant to become more restricted to a particular environment and less diverse? Possible answers, the flowering plants of the Cretaceous period took over; climate change caused the environment to become more arid. Encourage students to start thinking about hypotheses.

### **Extension activity**

Creative writing activity – imagine you were transported to the Jurassic period, what would you see, hear? Be specific – name actual species – what would the environment be like? How are different species inter-related?

### **Module 3. EXTINCTION OF SPECIES – WHAT HAPPENED TO THE DINOSAURS IN GARDEN PARK?**

In this module students will learn that many animal species that lived during the Jurassic period are now extinct and were replaced by other dinosaurs such as T-Rex and Triceratops – although the Cretaceous period is represented in Garden Park by rocks, we have found no fossilized skeletal remains of Cretaceous –age dinosaurs. We have found tracks that prove that dinosaurs lived in the area during the Cretaceous and they can be seen along Skyline Drive west of Cañon City.

Students will learn that extinction happens all the time and some explanations can be attributed to changes in climate and the environment in which they live – note the actual causes of ancient mass extinctions cannot be known, only hypothesized. By looking at the fossil record and rock formations, paleontologists can observe species extinction, the rate at which species evolve, and changes in the environment and ecological communities. This information can be used to hypothesize how modern extinctions might happen.

**Pre-Requisites:** students will have an understanding of basic earth and life sciences concepts.

#### **Resources:**

Computer with internet access to explore websites that discuss extinctions and explanations

<http://www.handsontheland.org/garden-park/index.php>

Explore the garden park website, - education links - including the rock column on the geology page, and the *Late Jurassic Flora* link on the Welcome Page

<http://www.worldwildlife.org/climate/index.html> The World Wildlife Fund page on climate change

<http://www.greenfacts.org/en/global-biodiversity-outlook/index.htm>

library

Pencils and paper

**Time Needed: 90 Minutes per Activity – 180 minutes in total**

#### **Activity 1. Understanding the Rock Column**

In this section students will examine the rock column on the Geology page of the website. You may want to print off copies in advance if this helps. Using the information on the rock column, research on the internet, and information off the Garden Park website, Students will recreate a visual aid to show species distribution through time. Using their visual aids, students will develop some hypotheses on extinction, and also gain an understanding on how paleontologists

use the rock record and fossil record to recreate ancient environments and ecological communities and the geologic time scale.

**Directions:** Students, in pairs, study the rock column on the geology page (these can also be printed out if easier). Ask the students to construct their own column – or graph - of the different geologic times that are represented in the Cañon City Basin and include what fauna and flora has been found in each. This can be their own design and doesn't need to be so detailed, but they will need to leave room to add more information on the flora and fauna. Then using the links on the education pages to the Jurassic age flora and faunas they can “add” to what is known from the different time periods.

Some research – internet or library - will be required to find out when some of the animals died out, such as the trilobite or the bacculite; and a search to see what other animals of the Paleozoic and Mesozoic eras also went extinct.

Students should develop a visual aid to show species distribution through time and share their aids with the rest of the class. As a class, discuss what the visual aids show: what can we learn from the displayed information?

### **Teaching Points:**

For example, *Equisetum, Ginkgo, and Conifer* first appeared in the Paleozoic and are still present in the modern environment; therefore they must have been present in all the other geologic times in between – once a species goes extinct it stays extinct, it does not resurrect itself – paleontologists often discover gaps in the fossil record.

Flora appears to be more resilient to environmental changes than animals. For example, dinosaurs appeared at the beginning of the Mesozoic but disappeared at the end of the Mesozoic; yet species of plants and trees that evolved during the Paleozoic are still around today.

Fish first appeared in the Paleozoic era

Crocodiles and turtles first appeared in the Mesozoic era

### **Extra Activity**

Directions: Using the rock column and other resources, students will tell the environmental story of the Cañon City Basin, beginning in the Paleozoic era and ending in the Cenozoic era. Students will focus on past environments and organisms.

This activity tests the students' ability to read, understand, and interpret the data. Students will learn that: geologists and paleontologists interpret rock formations to understand past environments or ecological communities over time; fossils can help geologists and paleontologists date the age of the rocks; fossils can demonstrate change over time within

species; rock formations and fossils provide us with clues on causes of extinction and changes in the environment or ecological communities

### **Activity 2. Where did *Allosaurus* and *Stegosaurus* go?**

**Resources:** Computer with Internet access, library

<http://www.fws.gov/endangered/>

<http://www.handsontheland.org/garden-park/index.php>

Pencil and paper

#### **Time Needed: 90 Minutes**

Introduction/Geological background

The end of the Jurassic saw dinosaurs such as *Allosaurus* and *Stegosaurus* go extinct. No one knows for sure what caused their extinction or how fast the extinction occurred, but using what is known from the rock record paleontologists have developed some scenarios.

During early Jurassic time, climate change resulted in the deposition of dune sands in a warm, desert climate. The climate change was a result of the separation of the North American plate from Africa. North America gradually moved northwards and away from the equator. The separation also changed land and sea configurations. During the Jurassic period there were times when marine waters advanced from the northwest, but after the final retreat of this Jurassic sea the entire region became a huge continental lowland of lakes, swamps, dunes, and braided and meandering streams – which is visible in the Morrison Formation in Garden Park. The climate was becoming warmer with periods of aridity and drought.

By the beginning of the Cretaceous, sea levels rose, and Colorado became flooded with the Western Interior Seaway – the Gulf of Mexico moved northwards and Arctic seas moved southwards. This was also a period of mountain uplift and volcanic activity. The Cretaceous period saw the introduction of angiosperms (flowering plants) and pollinators such as wasps and butterflies. The climate was subtropical.

**Directions:** Having presented the above information to the students, students will investigate modern biodiversity. Working in pairs, have the students choose an endangered species they are not familiar with

<http://www.fws.gov/endangered/> type in Colorado in the “find endangered species” search box on the right and students can choose a species from this list. Students will discuss and write down why the species might be important to biodiversity. Then have the students hypothesize what impact climate change might have on the species – for example the population of polar bears is decreasing because of sea warming and loss of ice rafts. Seals, a source of food, hang out

on the ice rafts and without the ice rafts seals have nowhere to rest, which means less food for the polar bear.

Take a quick break to ask each group what their species is, why the species is important to biodiversity, and what impact climate change might have on their species.

Students then go back to do more in depth research on their chosen species

Students' next research their selected species to determine its value – economic, ecological, or other – determine the impact that climate change can have on the species and habitat. After their research, should write up what they have found out about their species, include: what environment the species is typically found in; why the species is valuable; how the species will be impacted by climate change. Write a paragraph on how their research showed different results from their hypotheses. Have students present to the class their research.

### **Extra Activity**

The next activity will involve students taking what they learned from the previous activity and applying that knowledge to the fossil record.

**Directions:** Students will choose one of the dinosaurs discussed on the website <http://www.handsontheland.org/garden-park/index.php>, and using the same format as above, students will investigate the dinosaur, its habitat, what it ate, why the species was valuable to the ecosystem, and why it might have gone extinct. Students will form hypotheses or scenarios to suggest why the dinosaur went extinct. Have students present their research to the class. Be sure to justify your hypothesis.

### **A plausible scenario**

The dramatic changes to the land and climate affected the environment and ecological communities. Competition for food, loss of habitat, and loss of food source, are likely scenarios to explain the extinction of Jurassic-aged dinosaurs.

### **Teaching points:**

Extinctions happen

On the land, while animals often go extinct, plants tend to be highly resistant to mass extinctions. Sea animals such as reptiles and fish appear to be more resilient than land animals to changes in the environment

Preferential disappearance of exotic forms of life during mass extinctions – the large sauropods of the Jurassic went extinct

By interpreting the past, we can gather clues to what might happen under similar circumstances in the future