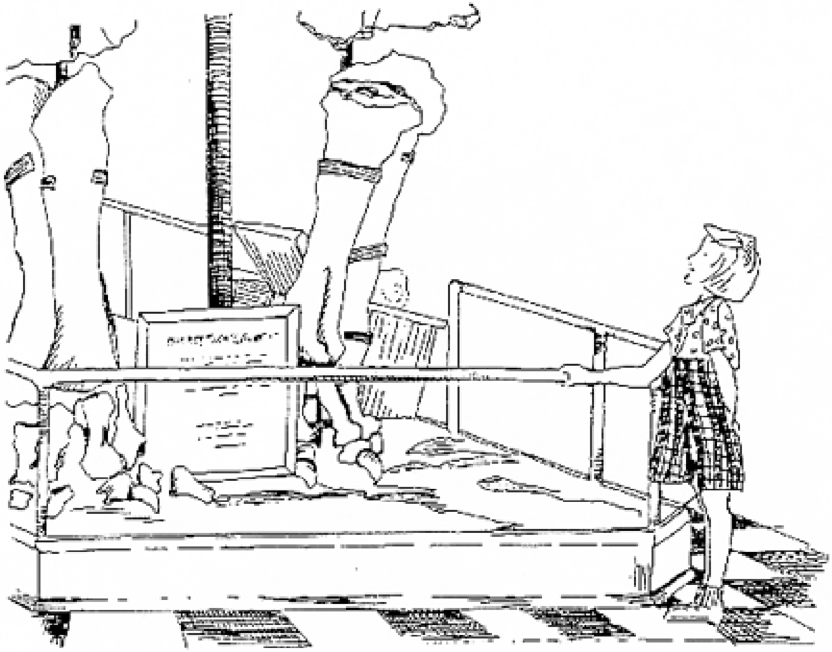
UNIT FOUR: HUMAN INFLUENCES



Introduction

The National Park System was created by the people of the United States, and its future depends on us as a nation. People who visit the national parks and monuments set examples when they take the time to understand the messages of the parks. Parks are not only places to renew ties with nature and past cultural or historic events, but also exceptional natural classrooms preserved for generations to come. We share the natural, historic, and cultural heritage they preserve. And we share in their care.

Other government agencies such as the Bureau of Land Management also manage, protect, and interpret fossils so that the American people can enjoy and learn from them.

In this unit, students will explore concepts of fossils as nonrenewable scientific resources, and learn how scientists find, manage, and study fossils. Central to this unit is an experience where the students design and staff their own natural history museum. By playing the roles of scientists and professional people they will gain a feeling for some of the routines and frustrations that real paleontologists experience. This experience, along with discussions with a working paleontologist on the staff of a museum, national park, or other government agency, will allow the students to better identify with scientists in general.

Objectives

After studying this unit, students should be able to:

1) explain the scientific importance of fossils in simple terms;

2) express in writing and drawing their understanding of the procedures used in finding, collecting, and preserving fossils; and

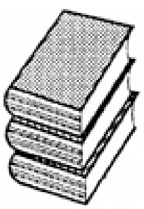
3) explain why paleontologists and students should use responsible procedures when studying and collecting fossils.

Materials included in the kit

selection of fossil casts modeling clay

Optional materials

modeling tools paper and crayons

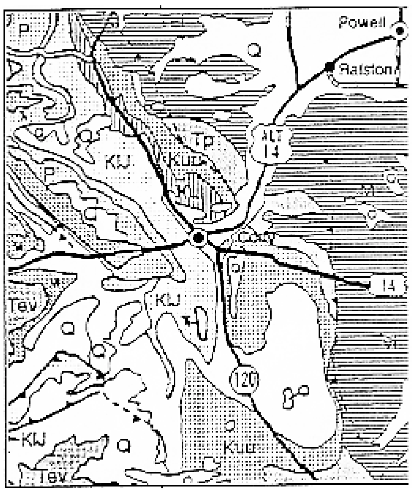


VOCABULARY

Classification	The organizing of living things based on characters that indicate relationship.
Comparative anatomy	The study of similarities and differences in anatomy of different organisms to discover evolutionary relationships.
Curator	An expert on a particular museum collection.
Invertebrate	An animal with no backbone. (See vertebrate.)
Natural resource	A naturally-occurring material that is useful to society.
Paleoenvironment	An ancient environment reconstructed by studying fossils and the rocks in which they were preserved.
Stratigraphy	Study of layered rocks, their distribution, origin, fossil content and relative age. Used to interpret Earth history.
Vertebrate	An animal with a backbone; in general, an animal with bones.

A fossil's journey

• **How do paleontologists find fossils?** The best way to find fossils is to look for them. Paleontologists often spend many days searching the ground for small fragments of fossilized shell or bone that might indicate that something worth digging up lies beneath. Fossils are not found everywhere, so scientists must use clues to help them narrow their search. The best way to start is by studying a geologic map. A geologic map shows the age and type of rocks at the surface (see figure at right). This method works because paleontologists generally know the age of fossils they want to find and whether they lived in a marine (saltwater) or nonmarine (freshwater or dry land) environment. Studying a geologic map will often allow a paleontologist to narrow the search down to a few square miles. Other factors that are important in deciding where to look are how well the rocks are exposed (looking for fossils is more productive where there is less vegetation covering the ground) and who owns the land. Often, permits are required to enter and dig on land owned by state or federal governments. These fossils are owned by the public as a whole. Only certain types of fossils on public land can be collected without a permit. If the land is privately owned, the fossils are the property of the landowner and he or she must give permission.



Geologic map of the area around Cody, Wyoming. \The different patterns show the age and type of rock exposed at the surface.

When a location has been chosen the next step is to begin prospecting. Prospecting is searching the ground for fossils and deciding whether or not anything important lies underneath. Searching for fossils in most areas is very timeconsuming and often frustrating when, after many days of searching, nothing of interest turns up. But there is no better feeling of satisfaction than making a new find.

When a paleontologist finds a fossil he or she must be careful to plot its position on a map so the place can be found again. The fossil or its wrapping is also labeled and notes made so that it can be associated later with its location.

• **Collecting a fossil** In some areas fossils are collected from surface finds only. Elsewhere a surface find may indicate that digging could uncover more fossils. If fossils are small and relatively durable, they may be collected simply by putting them into a box or vial with a little padding. Large fossils, on the other hand, such as those of dinosaurs, may require large-scale excavation and sophisticated wrapping and reinforcement to keep the fragile specimens from breaking up.

Paleontologists usually try to identify what they have found while still in the field. But dirt and rock covering a fossil may make identification difficult, and too much preparation (cleaning) under field conditions may damage the specimen. Thus, careful preparation and study are usually saved for the laboratory. Because of this, exciting discoveries are often made after specimens have been returned to the museum and prepared.

Collecting fossils usually involves collecting more than the fossils themselves. Fossils are useful only if details about where and how they were collected are also recorded. Field paleontologists take careful notes and record everything they find. They record the kind of rock and the position in the "stack" of sedimentary rocks where the fossils were found. The science of stratigraphy deals with the stories told by sequences of rocks-older rocks down low, progressively younger rocks stacked on top. So, knowing the stratigraphic position of a fossil is necessary to add the new fossil information to the stratigraphic story.

Knowing the kind of rock that fossils are preserved in helps put together the story of the environment in which the fossilized plant or animal lived and how it came to be a fossil. When the location of each fossil find and any other information the paleontologist thinks important have been recorded, then it is time to go to the museum.

The first step on returning to the museum is to clean the remaining dirt off the fossil, and glue it together if it is broken so it can be handled and stored. This is called preparation. A preparator is a person trained in the techniques of excavating, cleaning, and strengthening fossils. A preparator also needs to have training in the anatomy of the creatures he or she is preparing, so that important details will not be overlooked or destroyed.

After the fossil is clean and stabilized it can be studied, displayed, or stored for future use. Preparators quite often paint a permanent number on fossils (like a library catalog number on a book) so they can be found later. A collections manager is the person responsible for storing and keeping track of all the fossils in a museum collection.

There are several ways that a fossil can be useful once it is in a museum.. Most fossils are part of research collections. Paleontologists use research collections to study the anatomy of the plants and animals they are interested in, and to discover paleoecological relationships among the different ancient organisms. A museum scientist, called a curator, specializes in the types of plants or animals in a collection. Curators often write books or shorter articles about their research interests. They often use the research collections of many museums to do their work.

Public exhibits constitute another part of a museum's mission. Displays of fossils allow the museum curator's scientific findings to be made available to a wider audience than if they were only described in print. Displays allow fossils and other natural objects to serve an educational purpose for schools and the general public. This is important because museums depend on the general public, either directly, through museum memberships and contributions, or indirectly, through government grants, for the funding that allows them to do their work. Also, paleontologists are justifiably proud of their finds and are eager to share them with as many people as possible.

Conservation of paleontological resources

• **What is a paleontological resource?** Fossils can be thought of as a kind of natural resource, something that occurs in nature that is useful for society. Fossils are non-renewable natural scientific and educational resources. The economic benefit of fossils may be less obvious than that of, say, coal or oil, but they are resources nonetheless. Closely associated with paleontological resources are other important pieces of information. The rocks that fossils are found in are valuable for paleontologists because they can tell about where the fossil organism lived and how it died. Stratigraphy (the story of layers in rock) is also important because it allows scientists to put fossils in perspective. So, the lands around places where fossils are found are needed by paleontologists to help them understand the resource.

• **How paleontologists conserve paleontological resources** Paleontologists have an unwritten code of ethics that guides them in their work and encourages the most efficient use of the resource. They are careful to get permission from the owner of the land on which they intend to work. If the land is owned by a state or federal government, they must apply for a permit to work there. Application for a permit requires describing what the paleontologist wants to look for and why, what kind of digging will be required, and how long the project will take.

Paleontologists try to disturb the land only as much as necessary to extract the fossils. They also remember to close gates and not disturb livestock that may be present.

Most paleontologists agree that vertebrate fossils, because of their rarity, should be collected and used primarily for scientific research and teaching. Generally, vertebrate fossils are not collected simply to be sold. Because of the quality of molding and casting today, high-quality plastic casts can take the place of actual fossils when it is necessary to share fossils with other museums, schools, or private individuals. Often the sale of casts can pay for part of the expense of excavating and preparing a large fossil.

• **How amateurs can conserve paleontological resources** Amateur paleontologists can and do make valuable scientific discoveries. But their discoveries are valuable to science only if they can be made available to people qualified to study them. For that reason amateurs can be most effective if they work through a museum or university. Scientific contributions can be made if someone recognizes rare and unstudied specimens and brings them to the attention of a specialist.

If done in a professional manner, amateur paleontology can be a successful and rewarding hobby. The greatest rewards **will** come to amateurs who know that their discoveries are going to help the science of paleontology. The true value of a fossil lies in the story it tells about our past. The specialist puts together the stories of many different fossils and adds to the big picture of life in the past. Sharing this knowledge with other scientists, students, and the public can enrich all of our lives.

Pre-questions

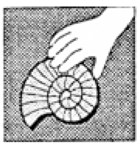
1. When is it good to collect a ***fossil?*** *Children should understand that not even professionals collect fossils unless they are prepared to do so. This includes knowing something about* the *fossils of the area you are collecting in, and knowing how to collect a fossil* without *damaging it. See the discussion in the Overview.*

2. Are there times when it would be best not to collect a ***fossil?*** When? *Fossils should not be collected without permission of the person or government agency that is responsible for the land. If is also best not to collect fossils if you don't yet have experience.*

3. What does a paleontologist do? A *paleontologist studies fossils and puts together stories of life in the past.*

4. Is paleontology important to you? Why or why not?

6. Would you like to be a paleontologist? Why or why not?



Pre-site activities

ACTIVITY 18 A classroom natural history museum

A museum run by the students will provide many opportunities for them to show what they have teamed in paleontology. The large number of different jobs to fill in a museum will also provide a forum for the diverse talents of the students. A classroom museum is a project that could take several weeks or a month to complete, and could be the theme behind the entire unit in paleontology. The classroom museum has some advantages over a public museum in that "hands-on" time is available for students.

The teacher may decide whether the best way to divide the labor of the museum staff is to let the students volunteer for jobs, or to assign them. They will probably work more productively in teams. Whatever the arrangement, it may be a good idea to let them change jobs at least once during the exercise to give each student a feel for more than one job.

Here is a list of possible museum jobs with brief job descriptions. You and the students may think of more.

Jobs in the paleontology museum

Field paleontologist	Collects fossils and records location and stratigraphic information for fossils found.
Preparator	Removes fossils from their field packages, keeping field notes with the fossils. Cleans fossils and prepares them for storage or display.

Photographer	Photographs fossils in the field and in the laboratory for publication and museum records.
Curator	Identifies and studies fossils. Writes scientific articles on fossils, including paleoecology and geology.
Collections manager	Puts fossils in permanent storage and prepares permanent records of all information about each fossil. In charge of maintaining museum records.
Editor	In charge of museum publications.
Writers	Write articles for museum publications and public displays.
Artist (scientific illustrator)	Makes drawings of important fossils for publication and display.
Display designer	Designs and supervises building of displays for public part of the museum.
Guide	Conducts tours through the museum for the public and school groups.
Librarian	Organizes the museum's library. Keeps records of museum publications and other books and journals used for research.

You may decide to limit the scope of the museum and decrease the size of the job list accordingly. For example, if the museum is concerned only with field exploration and research, your museum would employ only field paleontologists, a preparator, curator, photographer, and artist. Much of what the classroom museum decides its mission is depends on the ambitions and talents of the teacher and students.

Build and expand the museum by using casts in this kit and fossils collected by students on field trips. Specimens donated by the students may become a permanent part of the classroom to be used again and augmented in future years. A collection like this will be especially useful if there is no museum or national park unit nearby.

ACTIVITY 19 Paleontology research teams

During the course of studying about fossils, visiting a national park unit or public lands, and putting together their own museum, the students probably have some favorite fossils they would like to know more about. Learning more about these favorite fossils will be the job of the paleontology research teams. Each team consists of three or four students who together find out as much as they can about a particular fossil animal or plant they have encountered. They research its way of life, the environment it lived in, including the other animals and plants, where it lived, and how long ago. The students will probably find that all of the information they would like on their fossil is not available. At this point it will be their job to use what they have teamed about how paleontologists study fossils to make some observations and form their own hypotheses. The team will put together a notebook containing all the information they have gathered.

Some observations the students might make in forming their own paleontological hypotheses:

1. Compare the fossil organism to living plants or animals. Does it look like anything living today?

2. Study the anatomy of the fossil organism. If the fossil is a vertebrate, its teeth will often be the best clue to diet. Are they the teeth of a carnivore or a herbivore?

3. Reconstruct the ancient environment. Use reference books to find out what kinds of plants and animals lived with the fossil organism being studied. How did they live together? Have the students put together the ancient food web.

4. Ask the students to compare their paleoenvironmental reconstruction with the present environment where the fossil was found. Is it similar or different? How much has it changed?

After the data-gathering phase, the teams will be responsible for organizing the information into some form to present their story to the rest of the class. The presentation could be in the form of posters, sculptures, or dioramas. Each team will then present its findings to the rest of the class. Along with visual displays, the students might want to use another medium such as a puppet skit using cardboard cutouts of ancient animals and plants.

A talk with a paleontologist

The best way for students to get a picture of human influences on paleontology is first-hand, from a practicing paleontologist. You might have the opportunity to talk with a paleontologist about his or her job in the course of a visit to a fossil site, or by asking a paleontologist to visit your classroom. The latter case might give you more opportunity to talk about paleontology in general terms.

Many national parks and monuments, and some other land management agencies such as the Bureau of Land Management, will be glad to send a representative trained in paleontology to a school. Museums may also be willing to loan the advice of a person on their staff. Another source might be university geology departments if they have a graduate program in paleontology. There are many people in the community with interest and expertise in paleontology who would be eager to talk to children. Start by calling your local museum, park, BLM office, or state geological survey (see Appendix C, page 74).

Before the visit, tell your paleontologist what the class has been studying and that they are specifically interested in hearing about the science of paleontology itself. Mention that you would like to discuss ethical questions and other problems associated with human influence.

A class exercise before the field trip or visit should be to come up with questions to ask the paleontologist. Students will probably be full of questions now and will have even more to ask when the question session begins. It is a good idea to get some of them on paper beforehand to stimulate discussion and thought. Some possible questions include: Why did you decide to become a paleontologist? What fossils do you like to study most? What is the most exciting fossil you ever found? How do you feel about kids collecting fossils? How do you feel about people collecting fossils to sell? Be sure to allow time for the children's spontaneous questions.

Post-questions

1. Pretend you are a paleontologist. What would you do to make paleontology interesting for people who come to visit your museum? *Answers to this and most of the questions in this set depend on opinions of the students. Some possible answers: make interesting displays; go out and look for new, exciting fossils to study and display.*

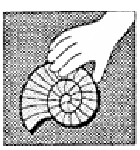
2 **What is something bad that you might do as a paleontologist that would make it hard for other paleontologists to learn about the fossils you find?** *Examples: do a bad job of digging up a fossil; sell a fossil without studying it; put fossils in drawers without good labels so no one can find them.*

3. What kind of fossils did you like learning about most?

4. Is there something about the science of paleontology that would make you want to become a paleontologist? What is it?

5. Do you think that paleontology is a useful thing to do, or would we be better off if paleontologists did something else like fix cars?

7. **What would be the best thing to do if you found a rare fossil while hiking in the hills?** *The best thing to do would be to leave the fossil alone, mark the position on a map or write it down in your notebook, and get the help of someone who is an expert in fossils.*



Post-site activities

ACTIVITY 20 Which bone goes where?

Message **Vertebrate** paleontologists learn how to put fossils together by looking at how bones are arranged in living animals.

Materials Diagrams of skeletons of fossil and living animals (see Appendix E, handout pages 93-94); drawing paper and crayons. Optional: modeling clay and sculpting tools.

Fossils are the raw materials of paleontologists, the source of most information on how extinct plants and animals lived. Vertebrate paleontologists, people who study fossils of animals with skeletons of bones, often have to deal with just a few bones from a skeleton, or haphazard mixtures from different individuals or even different species. It then becomes his or her job to make sense of a confusing situation. How does a vertebrate paleontologist figure out how to put fossil bones together into a skeleton? The answer lies in comparative anatomy.

Comparative anatomy is the science that uses the anatomy of living and fossil organisms to learn about their evolutionary relationships. While comparative

[redacted]

anatomists are often concerned with unique specializations of an animal, that is, features that may indicate some special adaptation, the similarities may also be useful. From the point of view of a vertebrate paleontologist, similarities between extinct and modern animals might be the key to piecing together the skeleton of an extinct beast.

In this exercise the students will compare the skeleton of an extinct vertebrate with that of a living vertebrate. They will then try to stump their classmates by asking them to identify their "mystery bone." Examples will be the drawings of horse and Stegosaurus skeletons found in Appendix E. Other suitable diagrams of animal and human skeletons can be found in veterinary or human anatomy textbooks.

Procedure

1. **Show the drawing of the Stegosaurus skeleton to the class.** Explain to them that fossil skeletons do not always come assembled or complete and that vertebrate paleontologists must put them together from unattached and broken bones. Ask them to come up with some ideas on how a skeleton like this one could be put together.

2. Show the drawing of the horse skeleton. Tell the students that since the horse is a living animal, we know how its bones fit together. Not only that, but we know how the various parts, including the bones, function together.

3. **Compare the two drawings.** Point out a few of the larger and more distinct bones and ask the students to notice the similarities between the two skeletons. The names of some of the major bones are given on the drawings; use this opportunity to introduce a few of these into their vocabularies.

4. **Compare with the human body.** Have the students find each bone on the drawings in their own bodies. Begin at the head (skull and jaws) and work down the neck (neck vertebrae), shoulder (scapula), upper arm bone (humerus), lower arm bones (ulna and radius), ribs, back bones (vertebrae), leg bones (femur, tibia and fibula), and foot bones (metatarsals and phalanges). Tell them that many of the bones in the human body are similar to those in the horse and Stegosaurus.

5. Divide the class into teams. Each team will study one of the drawings and choose a bone as their "mystery bone." They will then collaborate to create a drawing of that bone. Have each team present their mystery bone to the other teams as a contest. The object is to create the most easily-recognized bone in the assigned skeleton. If the other team correctly guesses the mystery bone in one guess, the team gets ten points. If it takes two guesses, they get five points. If it takes three guesses, they get one point. After three turns, the team with the highest score wins.

Variation 1: Paleontological sculptures If sufficient three-dimensional fossils or casts, or very good drawings, are available, the teams could sculpt, rather than draw, their mystery bones.

Variation 2: Specializations Both the horse and Stegosaurus have some bones that are not shared by the other. That is because each is specialized in some way. The horse is adapted for fast running, and therefore its feet have become specialized for running: they are simpler than those of Stegosaurus, with only one toe bone on each foot.

Horses also have very specialized grinding teeth, while the teeth of Stegosaurus are simple pegs.

Stegosaurus, on the other hand, has some very spectacular specializations in its huge armor plates and tail spikes. Some of Stegosaurus's specializations are for defense because it was not a fast runner.

What other differences between the horse and Stegosaurus can you find? Can you think of a possible adaptation for these bones?

Variation 3: Imaginary creatures
Draw a picture of a made-up creature with adaptations for a special way of life. Examples: a fast flier that eats leaves from the tops of trees; a burrowing animal that digs holes so fast no other animal can catch it. Describe how this animal is special and how it accomplishes what it does. Could paleontologists find out about these particular specializations from fossils?

ACTIVITY 21 Ethical questions in paleontology

Message **Paleontologists** have to consider possible harmful effects of their actions. Good ethics pertain to professionals, amateurs, and students.

Materials Sheets of paper or cardboard, drawing instruments.

Paleontologists, like all members of society, have certain responsibilities to the rest of society and the natural environment. These responsibilities are a part of everyday activities. Now that the class has found out first hand how paleontologists do their work, they are ready to think about some ethical consequences of paleontological activities.

Procedure

1. Pick paleontological activities. Begin by dividing the class into groups of three or four. Each group will decide on an activity that a paleontologist might do. Then they will discuss it. Some ideas for activities include, but are not limited to:

    a. hunting for fossils

    b. collecting a fossil for a museum

    c. digging a large excavation

    d. collecting a fossil to sell

    e. taking a picture of a fossil in the field

f. describing the geology of a fossil find in a notebook

g. putting a number on a fossil and putting it in a museum drawer

h. putting together a skeleton in a museum exhibit

The chosen activity might be something the students have seen in their visits to national parks, public lands, or museums.

2. Illustrate each activity. Ask each group to draw a picture of the activity on a card. Make sure they also label the activity. This step is more to make them think about the activity than to be an accurate depiction of it. .

3. **List some positive features of the activity.** Each group will make a short list of positive things about their chosen activity. For example, why is the activity good or necessary? How will it help the person doing the activity? How will it help other people? For example, collecting a fossil to sell might bring in a lot of money that would allow the person selling the fossil to build a big museum.

4. List some negative features. How is the activity detrimental? Will it have negative effects on the person doing the activity or other people? For example, selling a fossil to a private collector would keep it from being studied by scientists. Then no one would ever know that this creature existed. Selling fossils also makes fossils more desirable to collectors who are not scientists. This can make fossils so expensive that museums cannot afford to buy them.

5. Make individual decisions. Would it be possible to make sure that this activity is done only for good, or should responsible people (ethical scientists) refrain from doing it altogether? Allow for disagreement among the students on these points. Some might feel that selling fossils should be outlawed in every case; others might think that some fossils could be sold, but some not at all or only after a scientist has had a chance to study them.

6.Discuss the decisions as a class. After each group has had time for discussion, gather the class back into a single group and discuss the activities together. Lay out the drawings for the class to see. Ask the students to explain their drawings and comment on their own behavior in each circumstance.

National Parks and Monuments
And Public Lands

Parks and public lands preserving fossils

In all of the national parks and monuments with significant fossil resources, you will find examples of scientists and teachers using fossils in different ways. In many of these parks you will see how fossils are being studied and interpreted by scientists to team about the past In each national park or monument you will team how the resources of that park are preserved for educational use by scientists, teachers, students, and the public.

A handful of national parks and monuments have been designated "fossil parks" by the National Park Service because of their excellent fossil resources. These are Badlands and Petrified Forest National Parks, and Fossil Butte, Dinosaur, Agate Fossil Beds, Hagerman Fossil Beds, John Day Fossil Beds, and Florissant Fossil Beds National Monuments. These parks have staffs especially eager and able to interpret the paleontoh ogy of the region for visitors.

• Dinosaur National Monument The oldest of these parks, and the only one established primarily to preserve dinosaur fossils, is Dinosaur National Monument, in northeastern Utah and northwestern Colorado. It was designated in 1915 to protect an extraordinary concentration of fossils, dominated by large dinosaurs, discovered by paleontologist Eart Douglass six years earlier. The fossils are preserved in the Momson Formation, deposited in the late Jurassic Period by rivers and lakes. The main fossil-rich bed is a thin sandstone layer, originally a sandbar in one of the ancient rivers, on the south side of Split Mountain in the Utah portion of the monument. The sandstone was tilted to about a 45°-angle by mountain-building forces coinciding with uplift of the Uinta Mountains.

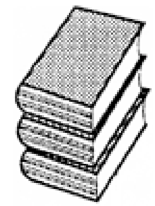
Over the course of fifteen years, tons of fossils were carefully excavated from the dense jumble of bones in the deposit. Many of the dinosaur skeletons went to the Carnegie Museum of Pittsburgh, Pennsylvania, as well as to other museums around the United States. In 1958 the Dinosaur Quarry building was erected over the fossil-rich sandstone to protect the remaining bones and to provide a place where visitors could see them just as they were found. The park staff began to "relief"the bones, removing the sandstone from around them but leaving them in place in the tilted bed. Today, the staff has finished the task of reliefing the bones, and works at various Morrison sites outside the quarry itself. Particularly significant finds (such as an embryo of a small plant-eating dinosaur, and a possible new species of meat-eater) are excavated and brought to the quarry laboratory for preparation, which visitors can watch when it is in progress.

More than 300 partial skeletons of dinosaurs have been found at the Dinosaur Quarry. Many of these are familiar: Allosaurus, Diplodocus, Apafosaurus, Stegosaurus, and Camarasaurus. Fossils of less spectacular but still important crocodiles, turtles, and frogs, as well as freshwater mollusks, are also found in the monument.

Various other National Paris Service areas, though established to preserve other resources, have some dinosaur fossils. The Morrison Formation, with occasional dinosaur bones, is exposed in several other parks and monuments in Utah and Colorado. One of the earliest known dinosaurs was discovered in the Triassic beds of Petrified Forest National Park, Arizona, and some Cretaceous dinosaur fossils occur in Big Bend National Park, Texas.

Many areas of public land have also produced important fossils that are now displayed in museums all over the world. One such site is the Cleveland-Lloyd Dinosaur Quarry in Emery County, Utah. Dozens of dinosaur skeletons were collected from this quarry in the Morrison Formation. Paleontologists are still working at the quarry, and it can be visited by school groups.

In Colorado, the Bureau of Land Management manages the Garden Park Fossil Area near Canon City. A visitor center is planned to showcase the paleontology and history of this area, where dinosaurs have been collected from the Morrison Formation for well over a century. Tours can be arranged by calling the BLM Canon City District Office.



References for further reading

A Field Manual for the Amateur Geologist, Alan Cvancara, Prentice-Hall, 1985. (ISBN 0-13-316530-2) A well-written and invaluable reference for the beginning geologist or paleontologist. Among many useful chapters, one (Ch. 13), titled "Parks for geologic observation and contemplation," contains a summary of noteworthy attractions in 84 national parks, monuments, and seashores. Other highlights are guides for identification of minerals, rocks, and fossils. Appendix A has a list of geological and paleontological museums in the USA and Canada.

Sleuthing Fossils: The Art of Investigating Past Life, Alan Cvancara, Wiley, 1990. (ISBN 0-471-51046-7) A book about fossils for amateurs. It answers some of the pressing questions beginners have about paleontology, such as: How can I collect and properly care for fossils?, and What makes a good paleontologist? Presents fossils as natural resources. Discusses some hot topics in paleontology. Serious amateur paleontologists, some of them even as young as the third grade, will get a lot out of this book.

Handbook of Paleontological Techniques, Bernhard Kummel, W.H. Freeman, 1965. (No ISBN) An old, but still useful, reference for paleontologists in the field and the laboratory. Details techniques of excavation, preparation, and preservation of fossils.

A Field Guide to Dinosaurs, David Lambert, Avon Books, 1983. (ISBN 0-380-83519-3) A beginner's guide to scores of different dinosaurs from around the world with some thought-provoking ideas about the lives and histories of dinosaurs. Contains a list of museum displays featuring dinosaurs.

The Field Guide to Prehistoric Life, David Lambert, Facts on File, 1985. (ISBN 0-8160-1389-6) This book concisely explains concepts of paleontology in layman's terms. Includes plants, invertebrates, and vertebrates. Probably contains more information than a teacher would need for background but might serve as a useful introduction and reference for those deeply interested in the subject.

Geology of Our Western National Parks and Monuments, Royle C. Rowe, Binford and Mort, 1977. (ISBN 0-8323-0237-6) Introduces 52 western national parks through brief summary statements and photographs. Designed to increase geologic knowledge, and therefore, appreciation of national parks and monuments by laypersons. The mostly non-technical discussions will be appreciated by teachers and students.

Pages of *Stone: Geology* of *Western National Parks and Monuments,* Halka Chronic, The Mountaineers, 1984. (ISBNs: Vol. 1, Rocky Mountains and Western Great Plains, 0-89886-095-4; Vol. 2, Sierra Nevada, Cascades, and Pacific Coast, 0-8988x-095-4; Vol. 3, The Desert Southwest, 0-89886-124-1; Vol. 4, Grand Canyon and the Plateau Country, 0-89886-155-1) This well-written four-volume set offers geologic tours through the western national parks and monuments, pointing out highlights and describing in detail the most important features. Each volume begins with an introduction to geologic processes that can be observed in the region discussed. Volume 1 has a fairly extensive non-technical introduction to geology and paleontology that will help even beginners get the most out of a visit. This set would be a useful reference for the classroom.

The Geologic Story of *the National Parks and Monuments,* David V. Harris and Eugene P.1Cnrer, Wiley, 1985. .(ISBN 0-471-87224-5) This book begins with coverage of geologic principles and processes that will be useful for teachers. Discussions of the national parks are organized by "geomorphic provinces," areas with internally similar history and landforms. Treatment is slightly more technical and detailed than the other national park guides, but a layperson should still get a lot out of this guide.

Old Bones and Serpent Stones: A Guide to Interpreted Fossil Localities in Canada and the United States, Volume 2: Western Sites, Theresa Skwara, McDonald and Woodward, 1992. (ISBN: 0-939923-08-4) Handy guidebook describing all areas in the West where one can see fossils interpreted, especially outdoors.

Books for children

Understanding and Collecting Rocks and Fossils, Martin Bramwell, Usbome Publishing Ltd., 1983. (ISBN 0-86020-765-X) This book is best for children in the 4th through 6th grades. It describes what the Earth is made of and explains the forces that are constantly changing it. Looks at rock families, the most common rocks, minerals, and fossils, and explains how to identify and understand them. Also has activities.

Digging up Dinosaurs, Aliki, Crowell, 1981. (ISBN 0-690-04098-9) An interesting introduction to how paleontologists do their work. Describes the roles of people who dig up and prepare fossils (especially dinosaurs) for the museum. Discussions of fossilization, history of paleontology, field work, and mounting skeletons.

Find Out About Dinosaurs, Dougal Dixon, W.H. Smith Publishers, Inc., 1986. (ISBN 0-8317-3326-8) Poses, then answers hundreds of questions not only about dinosaurs, but also about other kinds of fossils and the science of paleontology. Presents some modem concepts and controversies in paleontology in a way understandable to third-graders and older.

Appendices