Lesson 5
Where to Look for Fossils

Summary
How do people find fossils? They don't just go out in the field and hope to get lucky. Or at least they don't do that in modern times. In the past, luck may have played a role but now paleontologists must rely on the work of others. They investigate maps, read scientific reports, examine Google maps, and read old field notes.

This is a short activity designed for the teacher to work with all of the students showing them a variety of map images. The goal is to have students get a feel for how paleontologists determine where to go look for fossils. It builds on the work of the previous activities. They will need to know what types of rocks could contain fossils. They will need to know when dinosaurs roamed the Earth. They will also develop some new skills, such as map reading. (As an extension, one could use the maps provided to help students learn about latitude and longitude.)

It will help if the students have done the timeline activity, so they know when dinosaurs lived. If they haven't done this activity, you will need to show them a timeline that shows when dinosaurs lived. Also note that paleontologists now generally refer to non-avian dinosaurs and avian dinosaurs, or what most people call birds.

Objectives
Students will be able to:
1. Explain the difference between geologic and geographic (or topographic) maps.
2. Read a geologic map.
3. Describe how paleontologists figure out where to search for fossils.

Estimated teaching time
30-45 minutes

Groups
This can be done either as an individual activity, where the teacher presents the slides and the students answer questions on a worksheet or as a group activity where the students work together as a class.

Materials:
- Slides on CD to be projected on screen (There is a PowerPoint with all of the images in low resolution. All of the images are also in a high-resolution format, along with a few additional maps.)

Teacher background
One common question asked of paleontologists is how they decide where to look for fossils. Luck certainly played a part historically and to a small extent in modern times but for the most part paleontologists use three sources of information to decide where to search:

1. Geographic maps
2. Geologic maps
3. Scientific reports

Geographic maps show a variety of features such as the location of cities, roads, vegetation cover, rivers, and mountains. With this type of map you can also determine where and how (road, trail, 4wd road, etc.) you could access fossils if the right rock was there. A specific type of geographic map is a topographic map, which depicts land elevation.

Geologic maps show where rocks of different ages occur. Non-avian dinosaurs are found only in Mesozoic-aged rocks. Rocks from the Mesozoic formed during three time periods:

Mesozoic Era
Triassic Period: 251-200 million years ago
Jurassic Period: 200-145 million years ago
Cretaceous Period: 145-66 million years ago

A geologic map also indicates where the rocks were formed (on land, in the sea, or in a volcano). Dinosaurs are almost always found in continental rocks (formed on land). Dinosaurs or other land animals are never found in volcanic rocks and are rarely found in marine rocks. From a geologic map you can learn the ages and the types of rock in a region.

Scientific reports tell you where previous workers found fossils. They are written by professionals and are usually peer-reviewed, meaning that other paleontologists read them before publication to make sure that the science is correct. These reports may or may not point you to a specific spot. Sometimes researchers do not publicize the exact location because they don't want fossils that remain at the site to be damaged or stolen.

Student background
It helps if students have completed the "Age of the Earth" Lesson.

Introducing the activity
Tell the students that each of them is a paleontologist that will plan to go on a dig for dinosaurs somewhere in the United States. They have a series of maps that will show them possible areas to dig.

Facilitating the activity
1. Start by asking students how to find places they've never been to before? Get them to think about how they use maps, either on paper or electronically. How much do they rely on getting this information from previous visitors? Now, get them to think about how paleontologists find fossils. Get them to generate a list of three or four ideas. Have any of the students found fossils before? How did they do it?

   If you have not discussed dinosaurs, you may want to ask students if they know when dinosaurs lived? If they do know, see if you can get them to name specific times when specific dinosaurs lived. For example, *Tyrannosaurus rex* lived 67 to 66 million years ago (mya), *Triceratops* lived 70 to 66 mya, and *Stegosaurus* lived 150 to 145 mya.

   At the most basic level, first you have to determine when dinosaurs lived on Earth (answer: 230 to 66 million years ago). With this information you can turn to a geologic map to find rocks of correct age.

2. Show the geologic map of the United States and point out that there are not that many areas that have rocks of the correct age. Geologists code rocks by different colors, so each of the colors on this map represents a different period of time.

   ⇒ You might want to start by asking the students what they think the map shows and how is it shown?
   ⇒ Had any of them seen a geologic map before? Why? What were they looking for?
   ⇒ Ask them in what type of rocks could dinosaur fossils be found. (Most likely to find them in sedimentary rocks deposited on land). You might ask students to come up to the board and point out places where one might find dinosaurs.
   ⇒ In what type of rocks would you not find dinosaurs? (Igneous and metamorphic)

3. Show the map that illustrates different vegetation types.
   ⇒ You might want to start by asking the students what they think the map shows and how is it shown?
   ⇒ Ask them why it would be important to want to know this information.
   ⇒ Ask them what type of areas might be good or bad for finding fossils. (Places such as forests, swamps, or marshes would probably be bad it would take some effort to locate the fossils. Have them note that much of eastern Montana would be good spot, from a vegetation point of view to look for fossils. Now they have to determine whether you can even see those rocks at the surface. What would make it hard to find fossils? Show the map with different vegetation types and get them to look for places such as forests, swamps, or marshes. Not that you wouldn't find fossils here but it would take some effort.

4. Ask them what would be the next step after determining that there are rocks of the correct age and that the rocks are exposed? (Can they reach the rocks?) Show them the map of the USA. What would prevent you from reaching a particular area that had the right age fossils? Lack of roads. Private land. Certain public land. One could get around the fact that it is private land by asking for permission. On public land, you may be able to access the fossils but you cannot keep any fossils of vertebrate animals. How could you be able to collect and keep those fossils? (Paleontologists get special permits to collect and study specimens.)

5. Ask them what is wrong with all of the maps that have been shown. They all have too broad of a scale and need to be narrowed down to show small areas of land.

6. Tell them that you are now going to focus specifically on Montana. Again start with broad scale then get tighter, or at least go to maps with more specific information. Consider same questions as before on vegetation, private/public land, access, geology, and topography. Where could you find the right age and type of fossils? What information do you need to help read the maps? On the map the letter K, as in Km – Montana Group, means Cretaceous.

Assessment

- What are some ways to locate fossils?
- What information do you need?
- Can you collect anything you find?
- Additional questions not necessarily covered in lesson.
- What tools would you need?

- Who should you contact if you have questions about fossils? (Federal officials, such as Bureau of Land Management (BLM), United States Forest Service (USFS), or National Parks Service (NPS); local museum or university)

Going further

- Project the 1:24:000 topographic maps to have students work with understanding latitude and longitude.
- If the students go out and collect specimens for any of the previous activities, ask them to make detailed notes, which could allow other students to find that same location. If they have compasses or GPS units, have them use those to add spefic geographic directions to their field notes. You could also have the students draw maps showing the location(s) where they found their specimens.

References

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Teaching standards

Science Content Standard 1 - Students, through the inquiry process, demonstrate the ability to design, conduct, evaluate, and communicate results and reasonable conclusions of scientific investigations. Benchmark End of Grade 4, Number 1 - Develop the abilities necessary to safely conduct scientific inquiry, including (a step-by- step sequence is not implied): (a) asking questions about objects, events, and organisms in the environment, (b) planning and conducting simple investigations

Glossary

NA

Background on How Barnum Brown located the first *Tyrannosaurus rex*

You may want to read this to the students to give them an idea of how Barnum Brown located the first Tyrannosaurus rex specimen.

In May 1902, William T. Hornaday, founding director of the New York Zoological Park (now the Bronx Zoo) showed photographs from eastern Montana to paleontologist Barnum Brown of the American Museum of Natural History. They were taken somewhere near the badlands of Hell Creek, south of the Missouri River. The photographs showed the remains of an animal. Brown identified it as a *Triceratops*.

Hoping to help him out, Hornaday sent Brown a letter "I am just in receipt from…Mr. L.A. Huffman…giving the location of the dinosaur found by Mr. Harrison. I send you Mr. Harrison's map of the location, from which I am sure you will have no difficulty locating it on one of the land-office maps of Montana. It will not, however, be quite so easy to find it on the ground! But you will manage that."

[Could show the map of Montana, which is from 1880, to give an idea of how unpopulated Montana was then. Note that the railroad, which Brown used, had yet to be built in this map, though you can see the planned route.]

Brown traveled to Miles City in middle June, the closest place with a train stop to where Hornaday described. He learned from the locals that they knew of large fossils between there and the town of Jordan, more than 80 miles as the crow flies, but over 100 miles by foot, to the north. He quickly began to locate specimens and by July 7, he had progressed north to Jordan. It had taken him five days to reach Jordan by wagon, passing "numerous flocks of sheep and fewer herds of cattle." They camped near a high sandstone hill called Mount Sheba, which they later "attacked with plow and scraper." The temperatures ranged to 110 degrees without any shade. Some of the blocks were huge, including one that weighed 4,150 pounds. It took four horses to transport it.

On July 12 he wrote to Henry Fairfield Osborn, his boss at the American Museum of Natural History. "We are now camped seventeen miles from the Missouri River on the head of Hell Creek…there may be plenty of fossils here for we have prospected only the one day…The great drawback to this region is the distance to freight fossils. It is over a hundred and thirty miles to Miles, the only available point [to ship fossils east.]"

Brown and his team continued to search and unearth fossils, including a skull and lower jaw of *Triceratops*, over the next month. On August 12, 1902 he sent another note to Osborn: "Quarry No. 1 contains the femur, pubes, humerus, three vertebrae and two undetermined bones of a large carnivorous dinosaur not described by Marsh…I have never seen anything like it from the Cretaceous. These bones are imbedded in flint-like blue sandstone concretions and require a great deal of labor to extract."

He still had to dig them up, which required the use of dynamite, pack them, and ship them to New York. For the packing, he had to spend $275 (more than $6,000 in modern dollars) on three horses, a new wagon, and other equipment. The fossils, which totaled 19 boxes weighing more than 10,000 pounds, including the *Tyrannosaurus rex*, a *Triceratops*, a duckbill dinosaur, and a crocodile-like reptile reached New York by the end of 1902. Total costs for the expedition, excluding shipping, but including labor, travel, equipment, and supplies was $1,345 (roughly $30,000 in modern currency).

The first formal description of *Tyrannosaurus rex* was in 1906 by Henry Fairfield Osborn.