Lesson Six

Sorting Vertebrate Microfossils

*This is a modified version of the protocol used by members of Dr. Greg Wilson's lab at the University of Washington. It is modified to use in high school classrooms.

Summary

Fossils come in all sizes from huge dinosaurs down to microscopic specimens, each telling stories of life and death. In the Hell Creek Formation of Montana (68–66 million years ago), as in many other localities, big fossils grab the headlines and much of the attention of the public, and often paleontologists. But in recent years, very small fossils (microfossils) have also started to receive their due time, often under the microscope. Two advantages of smaller fossils relative to larger ones is that there are generally many more individual specimens of them and more species represented, which provide critical information to help paleontologists put together the paleoecological story of the Hell Creek. (For example, a recent study of the small teeth of a group of mammals known as multituberculates – a name that refers to their tooth shape – shows how these mammals diversified during the reign of dinosaurs.) Small fossils are also very useful for estimating the age of rock layers – a vital aspect of geological mapping and the search for oil, gas and other resources.

In this lesson plan, students will work with fossils and sediment from the Hell Creek Formation and try to identify what species and body part the fossils represent. Paleontologists refer to this process as sorting. It is an essential part of understanding the fossil record and using it to put together a picture of life in the past.

Sorting is the process of picking out, identifying, and labeling fossil specimens from concentrated *fossiliferous* sediment. In most cases it requires a microscope to sort fossils because many of them are as small as a millimeter or less.

Sorting requires patience, a keen eye, and a basic understanding of vertebrate anatomy. Sorting can be rewarding, especially when representatives of rare or new species are found among the numerous fossils that you discover.

Below are the basic steps you will need to understand and follow when sorting. Keep in mind that every step is important and that lost data is lost time and effort, not only on your part, but for those who have worked diligently to provide the sediment that you are about to sort! See the Educurious video to see the many labor-intensive steps leading up to sorting.

This is a two-part activity. Part 1 focuses on discovery and the thrill of finding fossils. Part 2 focuses on identification of the specimens. If you want to go further, you could then have students try to interpret what they have found, looking for patterns in diversity and/or abundance.

Objectives

Students will be able to:

1. Find microfossils in their sample
2. Compare and contrast various microfossils
3. Classify microfossils into their correct group

4. Work with a field guide to identify fossils
5. Understand the value of working with fossils of a wide size range

Estimated teaching time
At least one class period

Groups
This is a group project. Students will work both individually and in pairs within the group.

Materials:
For each student:
Teachers will need to provide from their own supplies:

- Sorting trays (Paper plates)
- Dixie cup or some other container in which students can put fossils that they identify

For each pair of students:
From the DIG Box:

- Paintbrushes
- Gel Caps
- Sorting Protocol page (which needs to be photocopied, one per student or pair)

For the groups to use:
From the DIG Box:

- Canvas bag with fossiliferous sediment
- Magnifying lenses
- Field Guide to fossils
- ¼ cup measuring cup
- Ziploc bag (one quart)

Teacher background
Microfossils are small, fossilized remains of organisms (animal, plant, or protozoa) that require magnification for study. They usually derive from the hard parts of organisms (skeletons, shells, jaws, teeth, seed coverings, etc.). Microfossils may be imbedded in rock or exist as loose particles within soft sediments.

The smallest microfossils may be only 0.001 mm (= 1 micron). The largest are typically less than 2.5 cm. Fossils larger than that are generally referred to as *macrofossils*. Vertebrate microfossils usually represent only a part of the once-living animal (for example, a tooth, a vertebra, a claw, a piece of turtle shell) and sometimes they are only fragments of that part.

Microfossils are relied on heavily for research advances in fields such as biostratigraphy, paleoenvironmental reconstruction, and paleo-oceanography. Research studies of microfossils provide insights into ecological and evolutionary relationships among plant and animal communities that existed on earth hundreds of millions of years ago. Microfossils also provide excellent hands-on material for science classroom education in general biology, evolution, and earth sciences.

In addition, researchers are using modern forms in environmental monitoring of aquatic environments subject to urban and industrial pollution. Even forensic investigations have relied on microfossils! (*Those diatoms in the mud tracked into the carpet in the suspect's home prove that he was at the scene of the crime!*)

Please also note that as in other activities, we highly recommend that students take detailed notes on their work. Remind students that this is how paleontologists would work in the lab and how important it is for researchers, as well as students, to have good record keeping that notes the date, data, results, hypotheses, etc.

Student background
It helps if students have done the Lesson Plan Four on fossilization.

Set up
Acquire paper plates and Dixie cups. Make copies of Sorting Protocol page.

Introducing the activity
Tell students that they are going to be working with real fossils collected from the Hell Creek Formation. Fossils similar to the ones they will be working with have become important evidence for paleontologists to understand complex questions about evolution, extinction, adaptation, and past environments.

Facilitating the activity (Part 1– Discovery)

> Please note that the sediments that the students are using has not been"salted"; these are sediment samples from real fossil localities that Dr. Greg Wilson at the University of Washington and his students collected, bagged, carried to camp, screen washed, and then put into ziplocs. The fossils that the students find have never been seen before by anyone, so each fossil is recording a brand new piece of information that can be used in real scientific research.

1. Start by asking students to describe what type of fossils they think they will be working with. Also ask them what types of fossils they have seen before. (Most likely they will describe large fossils.) Ask them what they think microfossils are, why paleontologists would want to study them, and what they can learn from them?
2. Tell the students that they will be working in groups searching for microfossils.
3. Pass out equipment to students, including sorting trays (paper plates), protocol page, magnifying lenses, brushes, and Dixie Cups (or equivalent).
4. Tell students to make a grid on their paper plate. This will help them when sorting the fossils. (see photo)

5. Give each group one Ziploc of sediment and have the students put about a tablespoon on their plates.
6. Tell students to follow the protocol below to work with sediments and sort fossils. The goal in this part of the activity is simply to find fossils within the sediment. When they do find a fossil, they can pull it out of the sediments and put it into a Dixie Cup. Students can either try to separate out fossils and put like with like (either individually or as a group) or each student can put all the fossils he or she finds into one cup. Either way, they will eventually separate out the fossils, identify them, and if they want, group like with like.
7. After students have sorted their sediments to find fossils, have them return their sediments to the group Ziploc bag.

Sorting Protocol:

a) After receiving your tablespoon of sediments, carefully spread the material onto your empty sorting tray so it covers only the surface of the tray (see Fig. 2A). Having too much sediment will make sorting difficult, be more time consuming, and you will likely miss fossils (see Fig. 2B).

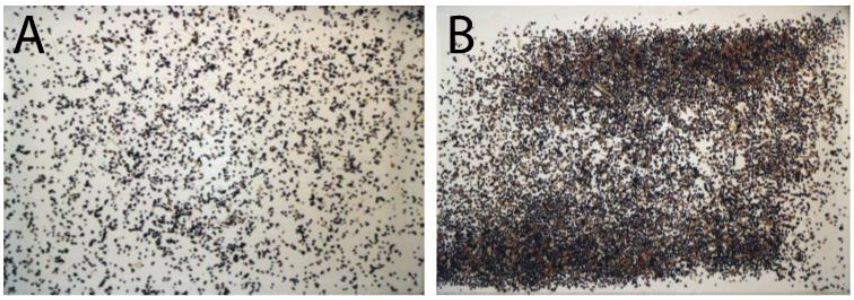
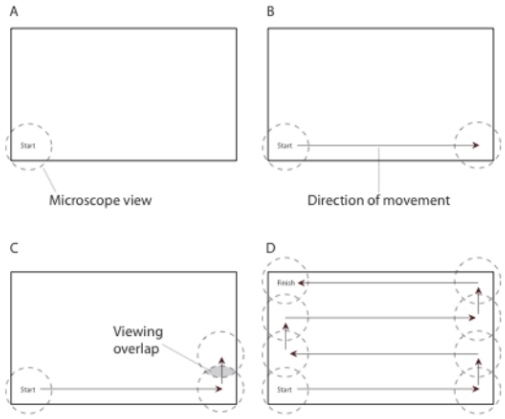


Figure 2. A) Ideal density of sediment for sorting. **B**) Too much sediment on this tray.

b) Using your magnifying lens, start sorting at the bottom left corner of the sediment-filled tray and proceed in a zig-zag fashion from left to right and up the tray (see Fig. 3).

Figure 3



c) Use your fine paintbrush to turn over possible fossils.

d) Fossils come in many shapes, sizes, colors, and textures. Recognizing fossils comes with practice.
Tips for finding fossils:
   1. Bone is porous; you may see many holes, especially along broken edges.
   2. Bones, teeth, and scales are usually darker than sediment grains.
   3. Scales and teeth are usually black or brown and shiny.
   4. Fossils have clearly defined shapes, e.g., rounded, curved, diamond-shaped.
   5. Fossils lack recognizable grains like sediment.

e) Pick up individual fossils by gently pushing the paintbrush bristles around the specimen. Try not to use tweezers to pick up specimens as they may damage them if squeezed too hard. Place the fossil in your Dixie Cup.

f) If a delicate or rare specimen is encountered, *ask your teacher for a gel capsule* and place the fossil in it before putting the capsule into a Dixie Cup. Examples of these types of specimens are isolated mammal teeth or jaws with teeth of mammals, lizards, or salamanders.

g) When you have sorted through the entire tray, keep your tray of sediments. You will eventually return your fossils to your plate and then return all material back to your teacher.

Facilitating the activity (Part 2- Identification)

1. Students will now be working in pairs. Each pair will work together using a *Field Guide* to try and identify their specimens. Each pair should have six labeled Dixie Cups or paper plates. Write a different one of the following categories on each cup or plate.
    a. *Chondrichthyes* - cartilaginous fish, commonly found members include rays and sharks
    b. *Osteichthyes* - bony fish, commonly found members include gar (Lepisosteidae), and bowfin (Amiidae)
    c. *Amphibia* – includes salamanders and frogs
    d. *Reptilia* – includes turtles (Testudines), lizards and snakes (Squamata), Champsosauridae, Crocodilia, and dinosaurs (Pachycephalosauridae, Ceratopsidae, Hadrosauridae, and Theropoda)
    e. *Mammalia* – includes rodent-like mammals (Multituberculata), marsupials (Metatheria), and placental mammals (Eutheria)
    f. *Gar scales* – these fish scales are very commonly found! They are members of Osteichthyes, but are so common we will give them their own box
2. Use "*An Illustrated Guide to latest Cretaceous Vertebrate Microfossils of the Hell Creek Formation of northeastern Montana"* to help you identify the fossils. First, use the plates on pages 10–23 to help you with the initial identification. Then use the more detailed descriptions that start on page 25 to further help with identification.
3. Once all groups have identified their fossils, have the groups compare what they have found and see if there is a consensus about the identification of each specimen. If they can, have them reconcile their differences. It is okay if there are some discrepancies as it is not always easy to identify the fossils, especially broken pieces.
4. Have someone in each group prepare a table listing what they have found in each of the six categories.
5. Have students choose their favorite microfossil and draw it.
6. Put all sediments/fossils back in Ziplocs and return all tools and Ziplocs.

Facilitating the activity (Part 2- Identification)

1. Help students to identify fossils by encouraging them to use their observation skills; What is the shape and texture of the fossil? Students will often simply guess instead of carefully zeroing in on the identification by narrowing/excluding options; Is it long and cylindrical like a limb bone? Is it flat like a scale? Does it have a shiny coating of enamel like scales and teeth? Is it pointed like many teeth? And so on.
2. Now that the students have figured out what they have identified, have the groups come back together as a class.
3. Write up the name of each of the six categories on a blackboard. Have each group report what they found and record that information on a blackboard and in the accompanying sheets, so that other classes doing this project can compare what they found with what others found. Students should also record this information in their field notebooks.
4. Ask the students to consider the commonness or abundance of each category. What do they think that it means? Questions they might consider include: Does it reflect the number of individuals of that animal? Does it reflect the environment? Does it reflect the number of bones? How did their study of these fossils compare to what other classes found while working on this lesson?

Assessment

- Why would paleontologists study microfossils?
- What are the advantages to studying microfossils?
- What are the challenges to studying microfossils?
- What are some ways studying microfossils is easier than studying larger fossils?
- What do these fossils tell us about the environment of the Hell Creek Formation?

Going further

N/A [UNLESS ONE OF YOU HAS A SUGGESTION. NONE LEAP TO MIND.]

References

NA

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

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