FEATURE ARTICLE

Owl Pellet Paleontology

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Abstract

In this activity for the beginning of a high school Biology 1 evolution unit, students are challenged to reconstruct organisms found in an owl pellet as a model for fossil reconstruction. They work in groups to develop hypotheses about what animal they have found, what environment it inhabited, and what niche it filled. At the end of the activity, the groups participate in a defense and peer review of their findings. This activity develops students' knowledge of the nature of science, evidence for evolution, and individual thinking and reasoning skills.

Key words: *Owl pellet; teaching evolution; nature of science; inquiry; evidence of evolution.*

Evolution is a topic that many teachers and students avoid or gloss over because of the real and/or perceived controversies around the teaching of evolutionary theory (Smith, 2010). Many states and school districts require that the strengths and weaknesses of the supports of evolutionary theory be taught as part of the curriculum. With this in mind, a novel approach to exploring paleontology's role in evolutionary theory provides students a chance to ease into learning about evolution so that there is less apprehension about dealing with evolution as the overarching principle of biology, as studied in a high school Biology 1 class. This activity takes something many teachers have used before, owl pellets, and changes the focus of the activity. Instead of using owl pellets as an ecology lesson, students will use them for a paleontological dig. Owl pellets now become an instrument of evolution to explore fossil evidence, study homologous and analogous structures, and provide a real connection to evolution for students. In reconstructing the bones and examining the other material found in the owl pellet, students can determine what the owl ate and where it might have been recently. In this reconstruction, students model the work of paleontologists; that is, reconstructing past organisms to get clues as to when, where, and how they lived. This action gives students the opportunity to experience the real work of field scientists; students can then appreciate the effect that past events have on the Earth and its organisms during different periods. Through guided discussion, we can then begin to discuss how these gradual changes in the world are what science refers to as "evolution" and that these changes over time result from the process of natural selection (Table 1).

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○ The Hook

At the beginning of the year, I tell my students that we are going to examine how we, as scientists, know about the world around us and how it works. Students are asked to generate a list of the types of information we use to know about biology and what other branches of science can help us learn about biology and the living world. This list is then used as a reference as we move through the different units of study. As we start this unit, I refer back to this activity so that we can piece some of the information from those branches of science back together to see what they can tell us about the organisms we know today. I also tell them that when talking about modern organisms, it is often useful to look back in time to see how things have changed, so we are going to talk about paleontology today. At this point I show a short video clip about paleontological digs. I have used the diggers segment of *Jurassic Park*, the discovery-of-the-iceman segment from *Forensics: Who Killed the Iceman*, or a clip of a group of students at a fossil dig in the area. I ask questions like: What kind of information can scientists derive from a paleontological dig? What kind of information can you get about living organisms? Are the fossils found at a paleontological dig related to any current organisms, and how do you know? How closely related are they? See Table 2 for more discussion questions with sample student answers.

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Table 1. National Science Content Standards (National Research Council, 1996; Pratt, 2012).

National Science Content Standards Used in Owl Pellet Paleontology
Standard A: All students should develop abilities to do scientific inquiry and develop understandings about scientific inquiry.
Standard C: All students should develop an understanding of biological evolution.
Standard G: All students should develop an understanding of science as a human endeavor and the nature of scientific knowledge.
Next Generation Science Standards (Common Core Ideas) Used in Owl Pellet Paleontology
LS4.A—Evidence of Common Ancestry and Diversity
Essential Science Practices
• Analyzing and Interpreting Data
• Constructing Explanations
• Engaging in Argument from Evidence
• Obtaining, Evaluating, and Communicating Information

Table 2. Discussion questions with sample student answers.

Discussion Question	Sample Student Answers
What kind of information can scientists get from what is found at a paleontological dig?	What kinds of animals lived there.
	If the animals lived in groups or not.
	What the environment might have been like.
What kind of information can you get about living organisms?	How they are similar to today's organisms.
	Nothing, they are different animals.
	What they came from.
Are the fossils found at a paleontological dig related to any current organisms and how do you know? How closely related are they?	They look kind of like what some animals look like now so they are probably related.
	They can't be related because they lived in different times and places. (To this I ask students if they are related to other people who live far away or people who lived in the past.)
	They might be kind of related like different kinds of birds (insects, reptiles, deer, etc.) are.

○ The Prompt: Welcome to the Dig

Students are told they are part of a group working at a paleontological dig in South Carolina (if you have southeastern owl pellets, or Washington State if you have northwestern owl pellets). Early sonar data have indicated a large number of fossils in the area. This leads the team to think this may be a fossil graveyard similar to the one outside Charleston, known as the Ashley Beds. The team has been assigned to work at the new excavation site and attempt to identify the remains found at the site. They have been assigned a specific area to explore and to document and remove all of the fossils for further study. They will also be responsible for some initial identification work; to do this they will have access to any number of the skeletal manuals, anatomy books, and the Internet to help them with their work.

We spend a few minutes talking about the environment in the area and brainstorming what kinds of animals and plants they might find. We also talk about the tools, both physical and cognitive, they will need to complete their assignment (Table 3).

Teacher Notes

The size of the individual groups, the time frame, and the space available will be the determining factors in the amount of preparation for this activity. Students can work individually or in groups of two or three. I don't recommend more than three in a group because the owl pellets are difficult to divide so that there is something for everyone to do throughout the period. Use newspaper to cover the work area to catch the dirt, feathers, and fur from the pellet as it is broken apart. This also facilitates a quicker clean-up. If you have students with allergies to dust, make disposable ear-loop masks available for them. I have students wear gloves to protect their hands from scratches they may get from the bones in the owl pellet and also to alleviate some of the ick-factor for some students. I have found that my students are more comfortable working at a grouping of desks rather than at the lab benches in the room for this activity because they are able to sit and balance their arms on the desk rather than standing at a lab bench where the potential for jostling is greater. After the dig portion of the activity, be sure to wipe down the desks or lab benches to minimize any remaining debris that fell through the newspaper or got out of the dissecting trays.

A list of potential digs that can be referenced to customize the activity to your area can be found on Wikipedia at http://en.wikipedia.org/wiki/List_of_fossil_sites#North_America. The list is alphabetical by site name and lists the state/region along with the age of the fossils found at the site. The list also has links to further information on the Wikipedia site regarding most of the digs listed.

○ The Activity: The Dig

Each student or group is given their excavation tools and an owl pellet (Figure 1). The owl pellet represents the plot at the dig site they will be working. As students work, the teacher should circulate through

Table 3. Materials needed (per group of 2 or 3).

• Gloves
• Lab aprons/coats
• 1 owl pellet
• 2 dissecting probes
• 2 teasing needles
• 3 stiff bristle paintbrushes
• Dissecting tray or newspaper to cover excavation area
• Construction paper or cardstock for display
• Glue
• Transparent packing tape
• Markers

Figure 2. Students using skeletal references to identify bones found in their owl pellet. (Photo by author.)

Figure 1. Students exploring owl pellets and extracting bones and bone fragments found for later identification and reconstruction. (Photo by author.)

the room to help their efforts and ask questions regarding what they found and what organism they think they might have found. As the groups work, some students will be ready to start identification of the bones; here is where the use of the pellet starts to deviate from what we would normally expect. Around the room I will have laid out bone-identification charts (skeletal outlines of various organisms, not just what you would find in an owl pellet; in fact, I don't put all the possibilities out, and I include a few "red herrings," like an alligator or cat), some anatomy books, and field guides to birds and small mammals (Figure 2). Students then begin to identify the types of bones they have and try to piece them together to identify the organisms they have discovered. As I circulate to monitor the activity, I question the students regarding

- what they are finding
- how they identified the bones/organisms
- what this might tell them about the time/environment this organism lived in
- what kind of population/community is represented

As the students begin to reassemble the organisms, they will find that most, if not all, of their skeletons are incomplete (Figure 3). I have the students glue the bones down on sheets of construction paper or large notecards in what they think is the most likely structure for the organism (Figures 4 and 5). I also have them catalog their extra or unidentifiable bones by laying them in organized groups (long bones together, thin bones, curved vs. straight, etc.) on a strip of wide transparent packing tape; they then fold the tape over to create a small packet of bones that can still be seen from all sides. Inevitably there are some reconstructions that are grossly incorrect, given that this is an owl-pellet excavation. Some students fail to remember they cannot find large animals, but this is acceptable at this point, and I use these misconstructions in part of the next day's lesson. This part of the activity usually takes the majority of the day (40–50 minutes), and groups will be finishing at different times, so I also have them write a short journal entry about what they found and how they identified their bones/organism.

Figure 3. Student beginning the reconstruction of an organism based on the hypothesized type of animal bones found. (Photo by author.)

Figure 4. Reconstruction of bones found in owl pellet. (Photo by author.)

Figure 5. Reconstruction of bones found in owl pellet glued to a piece of construction paper prior to being displayed as part of the peer review process. (Photo by author.)

○ Closing (Day 2): Peer Review of Findings

On the second day of the activity, each group is asked to display their findings so that they can be viewed and evaluated by the class. Students are given about 15–20 minutes to view the findings of other groups and formulate questions about the findings of other groups. We then come together as a class to discuss what was found. Each group makes a 2-minute presentation to explain what they found and how they decided what kind of organism(s) they have from their dig. Then the floor is open for questions from the rest of the class. Usually the first couple of groups get only a few questions from the rest of the class, but I ask some pointed questions, such as

- How do you know these bones fit together or are even from the same animal?
- Is/are the fossil(s) you found similar to known organisms?
- Does the position in which you found the bones indicate what niche the animal might have filled? (This is a hard question for them because of the nature of the owl pellet and how they excavate the bones.)

We also examine those reconstructions that, on further evaluation, we know are mistakes; for example, the alligator reconstruction put together because the bones retrieved from the owl pellet look very similar in size and shape to the diagram of the alligator skeleton. As we talk through the process, groups realize that the bones are the wrong size and that owls really don't eat alligators. This then leads to a discussion about how paleobiologists don't always know what they are looking at right away, how scientists draw conclusions about the evidence they have, and the limitations of those conclusions.

As we go through this process, students see how the background knowledge and/or information brought to an experience can affect the way new information and objects are pieced together. This is exceptionally important to the study of evolution because the views and prior learning students bring to class color their assumptions about the topic. As part of the follow-up discussion, we also talk about how scientists are also biased by prior knowledge and views when they form hypotheses, interpret data, and draw conclusions. Students can also begin to see the value of fossils as evidence of evolution and of the environmental conditions these animals lived in. If the remains really are alligator bones, does that change what you might surmise about the environment in the area long ago?

For an assessment, students are asked to journal about the activity, making sure they answer the following questions:

1. What kind of animal did your group decide you have? Explain what evidence you used to make this decision.
2. Did information you might have discussed with other groups influence your assumptions? How would you change any of your findings after the class review of the findings? Discuss how the class review might change your findings and explain what your new conclusions are regarding what organisms you found.
3. Why do scientists look at fossils? What can fossils tell us about the organisms in the past and how they interacted with one another?

Table 4. Commentary on possible student journal responses.

Students will have a variety of responses, some based on how well bones fit into the outlines of various organisms on the bone guides. More thoughtful responses will take into account prior knowledge about where owls live and the kinds of food they ingest.
While many students, especially at lower cognitive levels, maintain that their initial assumptions are the only correct way to view the organisms, many are also able to take into account how others may have equally valid but different views on what they found and how this can lead to conflicting ideas of what, where, or how the organisms lived.
Students often mention that by knowing about how organisms lived in the past, we may get a better understanding of why they react to different situations now.
Most responses center on the need for being careful not to break bones and keeping things "in order." They often remark that working with living organisms is much "easier."
There are usually a wide variety of answers here, ranging from there being no differences because they are all old, to the realization that age and environmental conditions may have caused deterioration of material.

4. What kinds of skills are needed to be an archeologist or a paleobiologist? Compare these skills to those needed by scientists who work with extant species.
5. Explain how you would expect fossils from 200,000 years ago to look compared with fossils from 2000 years ago.

This activity can be followed up with the reconstruction of the *Scaphognathus crassirostris* fossil in the Great Fossil Find activity (Randak & Kimmel, 1999) (see http://www.indiana.edu/~ensiweb/lessons/gr.fs.fd.html) or a *Xenosmilus hodsonae* activity (Janulaw, 2004) (see http://www.ucmp.berkeley.edu/education/lessons/xenosmilus/xenosmilus.html). Students reconstruct the fossil on their own, once again using the identification charts. Most will come up with a reasonable version of the animal as it is known, but there will be some deviation from the accepted version, which once again leads to a discussion about what we know and how we know it (Table 4).

As we move on to activities and discussions about homologous and analogous structures, what they can tell us about organisms, and how related they are to each other, I refer back to this activity and have students think and write about what the structures of their organism are used for and how they might be related to other organisms. This gives the students the opportunity to make their own connections to what they know about the structure of organisms they are familiar with and how those structures work within the environment.

○ Conclusion

Many students believe that science can be done only if there are variables to manipulate and data (Cooper, 2004). This activity gives students a chance to see that studying patterns in nature is a valid way of doing scientific research as well. Discovering patterns that do not involve the collection of measurable data and using these patterns as support for a hypothesis gives students an opportunity to work with data that are not numerical but observational, in a way not often included in many science classes. In doing this lesson, I have also found that my students are, in general, much more open to learning about evolution because they now have first-hand experiences similar to those scientists use to piece together information to support the evolution of organisms over long periods. Starting off a unit of study on evolution with an activity such as this one allows students to explore the complex nature of science and understand that knowledge is fluid. We must reexamine what we know about the world on the basis of new evidence as it is found. Along with activities later in the unit on changes in a gene pool and speciation, students see how these pieces of evidence fit together to make a coherent theory about the evolution of organisms and the world around us.

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