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	<p style="text-align: center;">THE GREAT FOSSIL FIND</p> <p style="text-align: center;">Adptation by Steve Randak? and Michael Kimmel?</p>	<p style="text-align: center;">EVOLUTION Geological/Paleontological Patterns</p> <p style="text-align: center;">NATURE OF SCIENCE Basic Processes</p>
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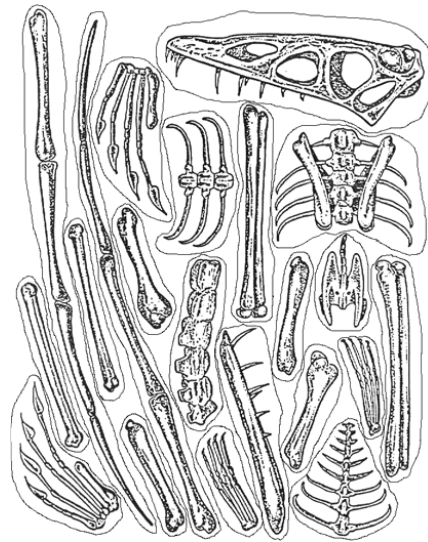
<p>SYNOPSIS</p>	<p>Students are taken on an imaginary fossil hunt. Following a script read by the teacher, students "find" (remove from envelope) paper "fossils" of some unknown creature, only a few at a time. Each time, they attempt to reconstruct the creature, and each time their interpretation tends to change as new pieces are "found".</p>
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<p>PRINCIPAL CONCEPT</p>	<p>Science is uncertain; as new evidence is revealed, ideas may change.</p>
<p>ASSOCIATED CONCEPTS</p>	<ol style="list-style-type: none"> 1. Scientists working together can be more effective. 2. Provides experience in the hypothesizing and testing of hypotheses. 3. Scientists use "fair test" criteria to determine the "best" solutions. 4. Provides some experience working with "fossils", as prep. for work with human fossils.
<p>ASSESSABLE OBJECTIVES Students will....</p>	<p>recognize the concepts listed for this lesson.</p>

<p>MATERIALS CLICK HERE for</p>	<ol style="list-style-type: none"> 1. Narrative for teacher to read. 2. Envelopes containing paper cut-out fossil pieces (1 per team) The original version of this page can be found in the <i>Laboratory Manual</i> for Scott, Foresman's text <i>Biology</i> (by Irwin L. Slesnick), 1985, page 75 (ISBN 0-673-22303-6). Thanks to Nancy Hein of Hawley, Texas for
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<p>PDF files of materials for easy downloading</p>	<p>bringing this to our attention.</p> <p>3. Alternative fossil sheet (Pakicetus) for cutting apart.</p> <p>4. Skeletal Resource Manual (1 per team) [Adapted from old skeletal anatomy sheets, probably from Carolina Biological Supply.]</p> <p>5. Optional: Worksheet, one per student, or one per team.</p>
<p>TIME</p>	<p>About 20-30 minutes.</p>
<p>STUDENT HANDOUTS</p>	<p>1. Fossils (paper cutouts in envelopes: 1 per team) 2. Skeletal Resource Manual (1 per team) 3. Work Sheet (1 per student or team)</p>
<p>TEACHING STRATEGY</p>	<p>Because this lesson provides an excellent opportunity to understand important elements of the Nature of Science, be sure to read our General Background Information, with our Rationale and our Approach, and tips for Presenting the lessons for maximum effect and Dispelling some of the popular myths about science.</p> <p>This lesson fits well just before getting into the Hominoid Cranial Comparison ("skulls lab") lesson. It also fits nicely as a more biological example of uncertainty in science, and could very well be included in the "nature of science" introduction to your course.</p> <p>First, you will need to get printouts of the pdf files at the end of this lesson. Make enough copies of the "fossils" sheets so you will have at least one sheet per team in a period, plus a few extras in case of loss. For a class of 32, you should have a minimum of 8 envelopes, each with a set of fossils for use by a team of 4. Some teachers may prefer teams of 2 or 3, requiring more fossil sets.</p> <p>Second, cut apart the bones on the fossil sheet. There is no need to cut along the outline of each bone, just cut enough to separate each bone (see the smooth "cutting lines" around each bone, shown below. Have lab assistants, spouse, other faculty, or anyone else you can cajole into helping you, as this is a labor-intensive task. Be sure to place the bones cut from one sheet all into one envelope. You should end up with enough envelopes so you'll have one per team (with 2 - 3 students per team). It's a good idea to number or letter each envelope to match any team designation system</p>

you have. One classroom set of envelopes should be sufficient for all your classes, for many years.



Next, run off enough of the same number of copies of the "**Skeletal Resource Manual**" (so there will be one per team). They can be copied back-to-back to save paper, if you like. Put the title page on the front; sequence of others is not important. Staple them together, and number or letter them to match your team designations (as you did the envelopes).

Run off enough **worksheets** so there will be one per student (or one per team), for all classes doing this lesson.

BE SURE TO READ THE SUGGESTIONS AND MODIFICATIONS BY TWO WORKING TEACHERS IN THE EXTENSIONS AND VARIATIONS SECTION (BELOW)

PROCEDURES

1. Have the **envelopes** (with "**fossils**"), "**Resource Manuals**" and **worksheets** ready near each team.
2. Announce that you will be taking them on a fossil hunting expedition, and they will be working in teams of (2, 3, or 4). They should then get into their assigned groups, and get their assigned materials. Tell them **not** to open the envelopes until told to do so. Ask them to listen carefully and with "rapt anticipation" as you recount the adventure.

3. Begin the story (below, and also in pdf format at the end of this lesson).

The Great Fossil Find

[READ TO STUDENTS]

In this activity, you and the members of your team will play the roles of paleontologists working in the field in Montana, near the town of Randak. One clear crisp afternoon in October, you find four well-preserved and complete fossil bones.

(Withdraw four fossil bones from your envelope. Make sure you take them out without looking at the ones remaining in the envelope!)

It is too late in the day to continue with the dig, so you return to camp with your find.

A. That night, in camp, after dinner, around a Coleman lantern, you and your colleagues begin to assemble the 4 bones you found earlier. Since the bones were all found together and in an undisturbed layer, you assume that they are all from the same animal. You spend the rest of the evening trying different arrangements. (Take 3-5 minutes to try various combinations.)

As the night wears on, you get weary and decide to retire and begin anew in the morning. (Before you go to bed, jot down on your worksheet the type of animal you think it might be.)

B. Montana mornings are marvelous. They are clear, cool, and clean. Just the kind of day you need to get work done at the dig. The rock layers that hold your fossils are very hard and only grudgingly give up three more specimens. With the day at an end, you make your way back to camp for another try at assembling this mystery animal.

(Withdraw 3 more bones from the envelope. Use the next 3-5 minutes to incorporate your new finds in your fossil reconstruction.)

It's getting late, and you are getting weary. Maybe tomorrow you will find the answer to the puzzle. (Be sure to record on your worksheet your latest suspicion of the type of animal suspected.)

C. The next day is cold. It is the last day of the digging season. Winter lurks behind the mountains, and you must leave. Just as the day is about to end in disappointment and defeat, one member of the group cries out "I've got them! I'VE GOT THEM!"

(Withdraw 3 more bones from the envelope. Use the next 3-5 minutes to incorporate these latest finds. Record what you think it is now.)

D. Back in the lab at Randak, you go searching in the resource library, and you find some partial skeleton drawings from another group working at a different location but dealing with the same geological period. They have found a skeleton similar to yours, but with some additional bones that you don't have. You use this information to add to your own data.

(Take the next 3-5 minutes to compare your findings with those of a team near you, looking for clues that might help you in your reconstruction, and possibly even suggest an entirely different animal than your earlier ideas. Apply these latest clues to the assembly of your skeleton as best you can Record the type of animal suspected now Be as specific as you can.)

E. Once you are back in your own laboratory at Kimmel College Five and Dime, you find a **Skeletal Resource Manual** with drawings of the skeletons of some existing animals. You notice some interesting similarities between some of the drawings and your unknown fossil.

(Use the drawings to assist you in your final assembly of the fossil skeleton. Record your final interpretation)

[To teacher: note any resourcefulness as you circulate amongst your students, e.g., using their texts, supply catalogs, etc.]

F. Answer the questions on your worksheet. When done, be sure to return all of the "fossil bones" to the envelope.

AFTER THE STORY

Be sure that all envelopes (with their bones) and Skeletal Resource Manuals get returned to the team tray (or other holding site).

Now have every team share with the whole class what they figured the creature to be, and see how many were the same, and how many different interpretations were made. This lesson is, in this way, very similar to the ["Palpating Pachyderms"](#) lesson which they may have done earlier, and if so, it might be interesting to see if anyone remembers what past activity this lesson brings to mind (a little re-cycling never hurts!).

You may want to discuss their answers to the questions at this time. Is there general consensus on what the creature was? If so, discuss what the most telling clues were, and what influenced them most. (Did the conclusions of others have any influence???) Is this the way that scientists work?

If there is NOT consensus, discuss what solution seems "best", and why it seems best; what criteria are being used? What factors are influencing this decision? This would be a good place to consider what would make a "fair test", and discuss the elements of what is involved in how scientists select the "best" hypothesis out of competing ones (see the General Information" page on this site).

In any case, if you happen to know, or even suspect, what the creature was, do NOT tell your students! They will clamor to know, but you have to tell them that science is NOT in the business of KNOWING; just coming as close as we can to the MOST LIKELY solution is the best we can do. (We have purposely not told you what the creature is for this very reason.) Tell them this is what really happens in science...we often don't have all the pieces, and may never ever find them, so we simply rely on our "best" interpretation based on the clues we do have. Leave them with whatever they figured out (just as in the ["Mystery Boxes"](#) lesson, [The Checks Lab](#) lesson, and the ["Great Volume Exchanger"](#) lesson). An incidental product of this mystery is that word does not reach other classes as to what the unknown creature is, and spoil the experience for them.

Below are some reasonable answers to the last few questions on the worksheet:

6. If this "Fossil Find" scenario is typical of the work of scientists, what features of the nature of science does it demonstrate?

	<p>ANS. its uncertainty, and that teamwork is more efficient.</p> <p>7. From looking at the fossil and the resource manual, what could you say about how and where this animal lived?</p> <p>ANS. probably on land, perhaps able to fly.</p> <p>8. Is it possible for scientists to do studies about things that happened millions of years ago? Explain.</p> <p>ANS. Yes. All sorts of clues, from fossil bones, pollen, leaves, ripple marks in sandstone, volcanic rocks, etc., scientists can do an amazingly accurate reconstruction of life and activity in the distant past.</p> <p>9. On the back of this sheet, list what you see as the 3 goals of this experience.</p> <p>ANS. a. Show the uncertainty of science. b. Show how it helps to work together to solve problems. c. To see how scientists develop hypotheses from observation, then test those hypotheses. d. Gave us some "experience" working with "fossil bones".</p>
<p>ASSESSMENT</p>	<p>Walk around, observe, and see that everyone is engaged and participating in the effort to figure out what the creature is.</p> <p>Include a test question or two in their next quiz or exam in which they have an opportunity to relate their experience in this lesson with the "uncertainty of science", how interpretations can change, how scientists select the "best" hypotheses, and the benefits of team work.</p>
<p>EXTENSIONS & VARIATIONS</p>	<p>VARIATIONS AND SUGGESTIONS BY TWO TEACHERS:</p> <p>1. Teacher Amelia DeLaPaz adds her experience, and a few clever modifications she has been kind enough to share: "I just wanted to let you know that the lesson went GREAT! I had 100% of my students engaged with the</p>

material, which is rare, and many of my students who caused me a lot of trouble previously have calmed down a lot since the fossil find. I think it really changed the way my students look at me, and my class.

The **student worksheets** section contains a **table** that I had the students fill out to guide them as they worked through the activity (I wanted them to make the link that scientists make guesses, but they have evidence to support them) and the questions. Most of the questions were from the ENSI lesson - I added a few of my own and had them explain any yes or no questions.

The kids' **posters** (they worked in pairs) worked really well. The poster instructions are fairly self-explanatory. I cut the sheet in half to save paper- that's why its doubled.

Finally, I modified the instructions and included a map. I changed the name of the town they were working in to a town in MT that I have actually been to and worked in (the students liked that tidbit!) I put these instructions on a transparency on the **overhead** projector and uncovered them little by little so my students could follow along as a read and refer back later as they worked."

Amelia's Worksheet, Table, Overhead instructions and Poster instructions are available in PDF format on the Materials page.

2. Dr. Christine Lotter, a professor of secondary science education, kindly offers this modified version of the lesson:

"I've used the fossil hunt for a few years in my courses and modified it so that it is a little more student-centered. I cut the reading part into segments and place them in separate envelopes so that each student in a group of four has to read one or two of the scenarios and then the group follows the directions. This allows the college students to work at their own pace more and delve into some areas further without constant interruption from the teacher. This may be less effective for younger kids. My pre-service teachers like the lesson and a few have used it in their own classrooms."

3. For an interesting variation, cut apart the fossil bones from the early four-legged **fossil whale skeleton: [Pakicetus](#)**. What a surprise when your students learn that it's a **whale** fossil! [Click Here](#) for the articulated skeleton from which those bones were taken and some

	<p>additional information for why this four-legged creature is considered the earliest whale: (teeth and ear bones). It was found in 50 million year old sediments in Pakistan (and your narrative version for this "Fossil Find" expedition should reflect that). This could be a great springboard into whale evolution, using our "Becoming Whales" lesson, or the Whale Evolution Kiosk, or both.</p> <p>4. If you have access to good pictures or drawings of all or most of the bones of some creature (living or extinct), it would be nice to have other alternative creatures to work with. Students may indeed share their experience and ideas with students in other classes, so this might discourage that kind of sharing. If you do assemble a set for a new creature, be sure to share it with us. E-mail me with the info, and we'll add it to the lesson, with full credit to you.</p> <p>5. An alternative (or reinforcement) to this lesson could be The Checks Lab. Take a look at it. It uses the same kind of thinking and analysis that is used in the Great Fossil Find.</p>
<p>OTHER RESOURCES</p>	<p>You might find some good skeleton pictures in some vertebrate anatomy books. The creature need not be something bizarre or unusual, but don't use one of the animals in the "Skeletal Resource Manual". Photo copy and cut them apart, re-pasting them as separate bones on one sheet of paper. Or scan the photocopy, and do the cutting and pasting electronically with Adobe's PhotoShop Elements or similar application.</p> <p>An excellent resource for skeletal material to cut out is <i>Investigating Science with Dinosaurs</i>, by Craig A. Munsart, 1993, Teacher Ideas Press (available from Amazon.com for \$24.50 + 3.95 p&h). See especially pp.65-74. There are lots of other goodies there, too.</p> <p>By the way, the collection of bones doesn't have to be complete, or even from the same creature! It would be especially interesting to use bones from a bird-like dinosaur (e.g. <i>Deinonychus</i>, <i>Velociraptor</i>, or some smaller dinosaurs of that group, or even an "exploded" view of an <i>Archaeopteryx</i> skeleton). Or, try the bones from a more or less familiar animal, e.g. a dog, cat, bear, chicken, cow, horse, etc.</p>
<p>ATTRIBUTION</p>	<p>1. Original Source: Adaptation by Steve Randak and Michael Kimmel</p>

Some of the ideas in this lesson may have been adapted from earlier, unacknowledged sources without our knowledge. If the reader believes this to be the case, please let us know, and appropriate corrections will be made. Thanks.

The original version of the fossil pieces page can be found in the *Laboratory Manual* for Scott, Foresman's text *Biology* (by Irwin L. Slesnick), 1985, page 75 (ISBN 0-673-22303-6). Thanks to Nancy Hein of Hawley, Texas for bringing this to our attention.

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