ENSI Lesson

DEEP TIME

FINDING THE AGES OF ROCKS & FOSSILS

by Larry Flammer

SYNOPSIS:

This lesson should effectively and accurately inform students about the high level of confidence we have in the geological ages of an old Earth. At the same time, it should reveal an example of pseudoscience which should be part of any effort to improve science literacy and critical thinking.

Students are taken through a combination of some background information and interactive experiences, and checked frequently by questions to confirm understanding. The narrative includes concepts of isotopes, radioactive decay, half-life, mineral formation, age analyses, fair test questions, and isochrons. The lesson can be used as a one-day team activity, individually in class, or as a self-teaching homework assignment. It is intended to either stand by itself, or to serve as an introduction to the very effective online interactive Virtual Age Dating Tutorial. This lesson would be helpful in Biology, Earth Science, Physical Science, Physics, Chemistry, or Geology classes.

CONCEPTS:

1. Several independent lines of evidence confirm that the Earth is billions of years old.
2. A Fair Test analysis confirms that the Earth is billions of years old.
3. Half-life is a fundamental property of radioactive material, enabling accurate age-dating.
4. Methods exist for age-dating which are internally self-checking.
5. Efforts to overturn a massive body of work must be equally compelling.
6. Anything presented as scientific, yet clearly ignores the rules of science, is pseudoscience.

MATERIALS:

1. DEEP TIME Instructional Narrative, with information, activities, and questions: 6 pages
2. DEEP TIME Worksheet: 1 page
3. Key to Worksheet
4. Collection of Radionuclides: paper strips with half-life information for a sorting activity
5. Natural Radionuclides Sequenced, with half-lives of a million years or more.
6. Overhead Transparencies (black-line copies) for class discussion

ALL THE ABOVE ITEMS AVAILABLE AS PDF FILES: **CLICK HERE**

TIME:

One teaching period (40-50 minutes)

TEACHING PREPARATION & STRATEGY:

INTRODUCTION TO TEACHER:

An important requirement for natural selection to produce the great diversity of life we find on Earth is a substantial period of time. Unfortunately, there are many people who are convinced, based on an analysis of religious writings, that the Earth is only 6-10,000 years old. In spite of this, a large body of work, mostly over the past half-century by physicists, geologists and astronomers, presents an overwhelming collection of physical evidence for a much older Earth, on the order of some 4.5 billion years old.

However, some of those preferring the “young Earth” idea have attempted to seek “proof” of their position by presenting “scientific studies” which seem to undercut the established scientific conclusions. In addition, this position is widely publicized, suggesting there is (untrue) widespread uncertainty in the science community about the validity of those ancient ages. As a result, the general public, even those not particularly committed to the Young Earth position, are often not aware of the clear status of geological ages, and the diverse body of evidence pointing to such deep time.

It turns out, upon closer scrutiny, that the “scientific evidence” for a young Earth is nothing more than selective reporting of a handful of samples which were either poorly analyzed, or notable exceptions to the huge body of data pointing to a very old Earth. Such exceptions can be variously explained in ways that do not require a young Earth solution.

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STRATEGY AND PREPARATION:

1. This lesson would fit well at any point where geological time or fossils are introduced.
2. It can be started in class and completed as homework, with review and discussion the following day.
3. This lesson is probably best done in small teams (2-4), where the material can be discussed as they proceed. This is especially true for the item #15 Activity, where 34 radionuclide strips of paper must be sequenced and discussed. Multiple hands would be most useful here. In addition, the concept of isochrons may be a little tricky, and in-group discussion could be very helpful, focusing on key questions to raise in class-wide discussion.
4. Don't forget to emphasize the extensive multiple lines of evidence from many quality studies which a few have ignored and/or attempted to discredit with carefully selected "exceptions" as examples of pseudoscience. For further background, take a look at the TalkOrigins document: "The Age of the Earth" at <http://www.talkorigins.org/faqs/faq-age-of-earth.html#da101>.

5. Run off enough copies of the Deep Time 15 Activity sheet so that you (or lab assistant, or students in class) can cut apart the 34 strips on a sheet and place them in an envelope or small zip-lock bag, so there will be one set (bag) for each team of 4 (or team of 2, if preferred) in your largest class. As a time-saving alternative, copy the **third** page Nuclides sheet, with the nuclides already sequenced, and provide the left column as is, leaving only the remaining 17 nuclides to be cut apart and sequenced by each team.
6. Run off copies of the Deep Time narrative handout packet (6 pages; could be printed back-to-back and stapled), at least enough for all individuals in your largest class to use (times your total number of classes doing the lesson, if they will be taking it home). This packet can be re-used each year.
7. Run off copies of the Deep Time Worksheet, one per student.
8. Prepare overhead transparencies of the 2 pages of Deep Time enlarged figures, and the Sequenced Radionuclides sheet, to be used during class discussion.

PROCEDURE:

1. As part of your introduction to geological ages or fossils, mention that some people believe that the Earth is only several thousand years old, and have said that the million or billion year ages usually presented are not supported with good science. This has created some confusion, and since it is so important to a fully accurate understanding of the history of life, we're going to take a close look at just what the science of geological age dating works. We're going to take a peek at "DEEP TIME".
2. Tell them they will be reading some background information, doing some easy activities, and answering some questions on a Worksheet. You will ask them to work in teams of (4), so they can discuss items not clearly understood, and can help each other with the activities.
3. Point out that one of the activities requires the use of an envelope for each team, which you will distribute while they are getting started. When finished with that activity, please return all strips of paper to the envelope.
4. If every team finishes in time, there will be a class discussion to clear up ideas and share perceptions. If not, each student is to finish the lesson as a homework assignment. In fact, there is an online tutorial on Virtual Age Dating which you would encourage everyone with access to the internet to try. When you finish the tutorial, you will get a Certificate of Completion which you can show me tomorrow. We will then discuss your experience in class.
5. Hand out the Worksheets first, so everyone has one.
6. Hand out the DEEP TIME narrative packets.
7. While students are beginning their reading, distribute the envelopes, one per team.

8. When each team has completed that activity, and answered questions 16-19, collect that team's envelope.
9. It's probably best to start the lesson so that there will be little or no time for most to finish in the period. This will allow the slower readers to complete the work at home, and anyone with access to the internet to try the online Tutorial. If you have access to a computer lab, plan to get the entire class into the Tutorial, doing at least the Isochron segment, and perhaps the Carbon 14 segment if they have time (or can do it at home) as an optional ("extra credit"?) item.
10. When the class has finished at least the DEEP TIME Worksheet, go over the questions and let them check their answers, expanding on any items which seem to raise questions.

11. Provide the Tables (taken from Dalrymple's *The Age of the Earth*), either on the **overhead**, or as **handouts** (they are included in the materials on the PDF-access page). Below are the summaries for each Table of data (you might want different teams to figure these out, if you like, and share with each other). Even a cursory overview of these data point to a high level of agreement over an approximate age of around 4.5 billion years, based on different radiometric methods by many different people.

Table 5.6: Oldest Lunar Rocks	**Table 6.3: Oldest Meteorites**	**Table 7.6: Earth Age Estimates**
Average Age: **4.26 BY**	Average Age: **4.49 BY**	Average Age: 4**.55 BY**
Range: 4.51-3.9 BY	Range: 4.6-4.29 BY	Range: 4.75-4.43 BY
Mode: 4.36 BY	Mode: 4.48	Mode: 4.53 BY

12. Try to get class consensus that the studies of Deep Time are very reliable and well-established, based on an overwhelming amount of quality science and very compelling work. The few discrepancies found can easily be attributed to factors which do not destroy the general picture, and in any case are generally very minor. Also point out that any position to the contrary would have to explain away this huge body of evidence. You might also point out (especially if you can reference some of the "science" which attempts to "disprove" the ancient Earth consensus), how either poor science was used (e.g. selecting favored data, and ignoring all the other data), or they are examples of pseudoscience.

EPILOG AND COMMENTS:

1. It is important that no religious group (or even "creationists", and certainly no students) be ridiculed for their beliefs which include the young Earth idea. Simply make the general true statement that there are many who misunderstand and may misrepresent geological dating, and the point of this exercise is to clearly demonstrate the basis and some of the techniques for measuring deep time, primarily to clear up the widely held misconceptions. If asked where the misconceptions came from, explain that lots of new ideas can be misunderstood, and if someone writes articles presenting a misconception, many people accept it without questioning, and innocently repeat the ideas to others. This is especially true if the misconception seems to strengthen one's deeply held beliefs.

2. Encourage students (especially those who find it difficult to let go of the young Earth idea) to explore the issue further. Suggest they carefully read the material suggested in the references (some of it online), and perhaps prepare a report of their careful comparison of the ideas. Be sure they include a fair balance of "Young Earth" "evidence" and the ancient Earth evidence, what each side criticizes about the other, and what the counter-arguments are. Encourage the use of Fair Test questions wherever possible, along the answers to those questions, and how they affect the conclusions.

BETA TESTING: Since this lesson has not been extensively classroom tested, if you like the idea, try it as a "Beta Tester", and please get back to us. Let us know how it goes, any problems, questions, suggestions for improving it, etc. We will share your experiences with other teachers. Contact us through the webmaster: flammer2@pacbell.net

ASSESSMENT:

1. Of course, you can collect the Worksheets from every student, or at random, one from each team, and assign grades to all team members based on their one sample from that team. Be sure they realize this strategy beforehand, so that everyone has a chance to compare notes and understanding, and makes his/her paper an accurate example of the team's efforts. This reduces your grading load, and encourages collaboration and peer teaching.
2. Prepare a quiz, or include some questions in your next exam which reflect accurate understanding of the concepts presented in the lesson. Avoid questions about specific numbers (memory work), but rather ask questions which would only be answered correctly if a concept is properly understood.

EXTENSIONS & VARIATIONS:

1. If time allows, consider doing one or more of the other lessons on this site in the Geological/Paleontological category. A particularly compelling lesson is "Varve Dating." Students actually count sedimentary layers in a sample from an ancient lake bed, and extrapolate to the amount of time for the entire deposit to have formed. This turns out to be at least a few million years! You would need to order a set of samples, but it's worth the effort.

2. In addition, be sure to install a geological timeline in your classroom, something students can view throughout the year, and to which you can often point when talking about or showing something in prehistoric time. Some excellent ideas for this can be found in the "Time Machine" lesson.

REFERENCES:

The Age of the Earth: <http://www.talkorigins.org/faqs/faq-age-of-earth.html#dal01>
Geological Time Scale: <http://www.talkorigins.org/faqs/timescale.html>
Miller, Kenneth R. 1999. *Finding Darwin's God*. Cliff Street Books. Chapter 3
Dalrymple, G. Brent. 1991. *The Age of the Earth*. Stanford University Press.

ATTRIBUTIONS:

Lesson created by: Larry Flammer, September 2002. Based mainly on material presented in Miller's *Finding Darwin's God*, chapter 3. This lesson was intended primarily to serve as an introduction to the interactive online Virtual Age Dating Tutorials, but can also be used as a stand-alone lesson.