

First Contact: Teaching Evolution to Middle Level Students

by Vince Sperrazza
August 2008

The middle school science classroom is often students' first contact with a scientific presentation on evolution. This is an expanded version of the author's article "*Evolution and Middle-Level Education: Observations and Recommendations*" that was published in the Jan/Feb 2005 issue of NCSE Reports. Note that this article is based primarily on the author's experience rather than academic research. A list of selected resources follows.

The 12 year old hand goes up at the first mention of the word evolution, "Is it true we came from monkeys?" It's the first day of school, and I mention evolution in a list of topics for the year ahead in my 7th grade life science classes.

That's the nature of middle school students. Impulsive, inquisitive, focused on their peers, yet they can still be excited about learning. As their brains try to catch up with their fast growing bodies, they are "hormones with feet," as one adolescent psychologist characterized them many years ago.

I taught 7th grade science in a small rural public school district in upstate New York, about an hour's drive from Syracuse, for 33 years before retiring in June 2006. (I did my undergrad work at SUNY Geneseo, biology major, class of '73.) Right from the start, I taught evolution both as a separate unit and integrated as part of the total life science class. I have never succumbed to pressure to reduce or eliminate my emphasis on evolution. Richard Dawkins summed up the excitement best:

"I should love to have everybody taught about evolution from a fairly early age, because it is so important, so exciting. It answers so many questions and mysteries; it solves so many problems. Until you know about it, you're wandering around on this Earth looking at trees and birds and flowers, not knowing why any of them is there. Evolution is the answer to that riddle, so you're not really a whole person if you don't know where you come from and why you exist. And it's not difficult. It's not like relativity, it's not like quantum theory – it's something teachable to fairly young children."

Richard Dawkins: July 18, 2008

The students

Teaching middle school students any subject can be a challenge. During my teaching years, I mentored over a dozen student teachers, and have been interested in teacher preparation. Always, I stressed to student teachers that evolution is a vital part of the curriculum, to resist efforts to reduce or eliminate the teaching of evolution, and to consider religious beliefs totally outside both the realm of science and the science classroom.

Of course, a student teacher needs to first learn about 7th graders. And to some, it's a surprise. Recently my friend John married, and his wife has 2 children, a girl in 5th grade and a boy in 7th grade. So he asked me,

"How did you deal with those kids? Jimmy drives me crazy...he has the attention span of a gnats ass!"

"...normal" I said.

"He's always trying to get out of work."

"...normal."

"He says lots of dumb things without thinking."

"...normal."

"He's always teasing and bothering his sister."

"...normal."

Beginning teachers react just like my friend. How do you deal with this? How do you deal with the short attention span, the interest in the opposite sex, the rebellious behavior? Veteran middle school teachers say the average attention span of a 12 or 13 year old is about 10 minutes. Many teachers agree that it's a good strategy to "change the activity" at least 3 times in a 40 minute class period. Effective middle school teachers learn to be honest with the students and earn their trust, yet provide a firm, consistent discipline, and to use humor to defuse problems and make the classroom a relaxing, comfortable place.

It doesn't even matter if the jokes are good or not. "Is that a real (human) skeleton? Yes...it's real plastic." Or on the symbiotic organisms of fungi and algae..."Livin' on rock and lichen it." Once, a gentleman came up behind me at a local home improvement store and identified himself as a former student simply by reciting one of the more notable, and dumber, jokes: "What do you call a lizard crossing the desert?... Sandy Claws." (Yes, it's useful to help students remember some differences between amphibians and reptiles.)

Effective teachers, in teaching any subject at any grade level, often rely on these fundamental ideas.

- Communicate your passion for the subject. If the students sense you are excited about science, and teaching and learning about science, it's catching. They will be excited about learning too.
- Tell good stories. Our brain seems to be programmed to learn through stories. The stories can be formal or informal, read out of a book or told off the top of your head. I've had many former students remark about remembering stories.
- Engage the students in their own learning. From 10 minute activities and games to thought provoking discussions and multi-period labs, get the students working. When I was a beginning teacher, a veteran teacher told me, "The one doing the work is the one who's learning. If you're standing up there talking, doing all the work, who's learning? Get the kids involved, get them working. Then they are the ones learning."

In science, as in all subjects, an engaging classroom environment is essential. I had a skull and skeleton collection, a shell collection, a fossil collection, a dried fungi collection, and many preserved animals. Many specimens, excluding those purchased in the typical “animal kingdom survey set” were brought in by students. Seventh graders love to share. Early one morning, a student came in and said he ran over a snake with his bike on the way to school. I asked him where it happened, and he said right on the sidewalk in front of the school.

“Did you leave it there?” I asked.

“Oh no.” he replied. “It’s right here.”

And he pulled the dead milk snake, all 88 cm of it, out of his backpack. We preserved it that morning.

The subject: Evolution

Back to the question, “Is it true...?” I usually respond by first asking “Do you want the long answer or the short answer?” Seventh graders generally want the short answer. So I answer that we’re most closely related to chimpanzees, and that the best evidence (stressing evidence) leads to a common ancestor of both humans and modern African apes roughly 6 million years ago. And that we aren’t descended from modern apes because they are the result of 6 million years of their own evolution. Informing the students that we’ll study evolution in more depth later in the year ends the discussion as we need to continue with routine opening day tasks.

The start of the school year is the time for the teacher to set the tone (classroom management) for the entire year, and it’s also the time for the science teacher to engage the students in activities that stress the nature of science. Effective activities at the middle level often include work that ranges from “give an example of...” to “describe or explain...” as well as “compare and contrast...” and understanding the difference between observations and inference. (See student texts and ancillary materials.) A poster in my classroom, inspired by the National Academy of Science, sums up the nature of science. “Science requires careful description. Science is cumulative knowledge. Science explains the natural world.” The students saw the poster all year. It was posted on the door to the microscope cabinet, and referred to when necessary.

Dobzhansky’s well known quote, “Nothing in biology makes sense except in the light of evolution.” may be a little deep for middle level students, but their teachers need to know how to apply this concept. In class, evolution surfaces throughout the life science curriculum,. For example, when studying the Plant Kingdom, we looked at our local spore-forming vascular plants, the ferns and horsetails. I typically had a tray of live horsetails on the desk, and would talk about their place in the evolution of plants. (A good poster on earth history is essential.) Then, in story mode, I would invite students to join me on an imaginary time travel to the Carboniferous forests, complete with giant horsetails, huge dragonflies and more. With animals, we discuss and study amphibians as the first terrestrial vertebrates, as well as common ancestors to reptiles, birds, and mammals.

In the context of the whole school year, many middle level teachers (and texts) prefer to study evolution after the genetics unit. This leaves the students with at least a sense of understanding when describing mutations and the inheritance of the best suited traits.

Before starting the actual unit on evolution, I have found it best to keep the administration informed. As I have worked with many principals over the years, I made it a practice to remind each one as to the New York State curriculum requirements on evolution. When one of the later principals started, I alerted her that she may get a call from a parent objecting to my refusal to “balance” evolution with creationism. A few days later, the principal told me she indeed did get that call. Her response? She told the parent that the New York State curriculum was explicit, that evolution only would be taught. The principal added that if the parent still objected, she could take her objections “to a higher power.” So the principal gave the parent a phone number for the State Education Department. As far as I know, New York State does not have an opt-out policy for its required curriculum.

I found it helpful to present evolution by starting out with a good story. I used to tell the classic story that puts all of earth’s history into a 24 hour clock, while some teachers prefer to start with the story of young Charles Darwin and the voyage of *The HMS Beagle*.

It is important to present a complex topic like evolution in a manner that is easy to understand for 12 year olds, but not over simplified. Beginning teachers might do well to simplify the unit into a few key points.

- Define evolution as “descent with modification.” Help students understand it is much more than change over time. People grow, trees lose their leaves. Evolution shows descent with modification through genetic inheritance, as well as common ancestry.
- Earth History – After using the 24 hour clock analogy, I found it helpful to have the students read and interpret a chart on earth history. Students may be asked to calculate the length of time of the Mesozoic Era, or to determine from the chart the period often called “The Age of Fishes.” This is also a good time to review the fossilization process.
- Charles Darwin – Some textbooks do a good job presenting the story of Darwin’s voyage on the *Beagle*, told in an interesting manner for middle school students, leading to the publication of The Origin of Species. (*The book on your desk?...Yes*) Working with social studies teachers, students can understand Darwin’s work in context of the time just before our Civil War. Students also need to see Darwin’s work as the first published explanation of the mechanism of evolution. It is also important to tell the story of Darwin and Wallace. In class, student activities on Origins are usually centered on textbook readings, including questions and discussion.

- Variation / mutation, inheritance, and selection – Many teachers center the discussion and activities around Darwin’s finches, leading to speciation. The textbook may have activities investigating natural variation. The mechanisms of mutation, as well as inheritance of the best adapted traits, need to be understood through a previous unit on genetics. This is also a good time to discuss the evolution of antibiotic resistant bacteria.
- Speciation – It is important for students to know that speciation is best shown as a branching model “tree of life” instead as a ladder model. This contrast is often illustrated with the fossil sequence of horses.
- Evidence for evolution – It is imperative that teachers help the students understand the presentation of radioactive dating, often confusing and oversimplified, in textbooks. Then on to convergent evidence including the fossil record, homologous structures, embryological evidence, and DNA evidences. Activities may include comparing fossils to modern species and listing various evidences for students to classify as to type of evidence. Coloring anatomical diagrams is an easy way to help students see homologous structures.
- Human evolution – I’ve found that students enjoy the story of finding the “Lucy” fossil and naming it. This is an excellent way to start a discussion of human evolution. Diagrams and posters are necessary to help students understand the branching model and the co-existence of multiple species of hominids. Video clips are important to give depth to the discussion. Photos of fossil skulls can help the students to understand the evidence for human evolution.

In addition, it’s helpful to have a good fossil collection, as well as a good collection of instructional graphics on evolution. As for texts, middle level science texts vary widely in their approach to evolution. In evaluating recently published texts, I looked at the contents and index first, then the chapters and ancillary materials. Some texts use the word “evolution” directly in their chapter titles, while some seem to fear the controversial “e-word.” This will show up in the index too. I found that some texts purposely omit any reference to human evolution, while others do a good job presenting human evolution in a way that the students can understand. There should be many age appropriate activities. As far as budgeting class time, my experience is that at least 2 weeks are needed to do the job.

Inevitably, the creation question arises in class. Some recommendations for a beginning teacher include discussing:

- “Theory” as used in science is much more than a “just a guess.”
- Creationism, in any guise, is religion, not science.
- Students are entitled to their religious beliefs, but religion is not science.
- The New York State Intermediate Level Science Curriculum Guide does not include creationism.
- Teaching religion does not belong in any science classroom.

Of course, 12 year olds most often repeat their parent's opinions. However, to the 7th grade brain, peers count most, teachers are down the list, and parents inhabit the very bottom. Often, I find students understanding evolution, while their parents simply refuse. Yet, a teacher needs to be aware there may be vocal student opposition to evolution. A few years ago, one student rather vehemently wanted me to give creationism "equal time" with evolution. Her classmates were quick to respond. "Didn't you listen?" they said, "Religion doesn't belong in science class."

But yet, some students insist on pushing their religious views, and want to avoid the evolution unit. However, in New York State there is no "opt out" for academic curriculum, so their options are limited. Sometimes, I've had students refuse to answer questions on tests or labs, saying something along the lines of "God did it." My response was simply to deny credit, "Religion is not science." Welcome to the real world.

Student questions

These are actual questions from 7th graders. I invite the reader to design answers suitable for 12 year olds.

1. Is it true we came from monkeys?
2. My father says evolution is as likely as wind blowing through a junkyard making a car.
3. Evolution is only a theory...
4. How can Earth really be 4 and a half billion years old?
5. How do you know dinosaurs and people never lived at the same time?

Answers? Assuming the above questions are asked by students at the end of the unit, during review, here are some samples answers.

1. Is it true we came from monkeys? A. The evidence shows that we are descended from a common ancestor (an apelike creature) with the African apes about 6 million years ago. Remember that the African apes evolved over that same length of time, so we did not evolve from modern apes.

2. My father says evolution is as likely as wind blowing through a junkyard making a car. A. Understand that evolution is a gradual process requiring vast amounts of time. (Reference an earth history poster, point out the time involved.) First cells here, soft bodied animals here, shelled animals here, dinosaurs here, first mammals here, etc.

3. Evolution is only a theory... A. We talked all year about how some words may have one meaning in English class, and another meaning in a scientific context. Theory is such

a word. It is no more “just a theory” than the gravitational theory, (drop a book) or the heliocentric theory or others such as the cell theory or germ theory.

4. How can Earth really be 4 and a half billion years old? A. Radioactive decay gives scientists an accurate measure of the age of igneous rocks. There are rocks on earth dated at 3.5 billion years old. Scientists estimate that the earth formed about a billion years before that.

5. How do you know dinosaurs and people never lived at the same time? A. We studied how humans and dinosaurs are separated by 65 million years of evolution. There are no credible fossils showing human and dinosaur fossils in the same rock layers.

Beginning teachers sometimes overlook the importance of summarizing a unit. I would end the evolution unit by pointing out to the students that we are all descendents of ancestors who survived, at least long enough to reproduce, the earth calamities. Pointing to the appropriate location on the ever-present earth history poster, I would say, “Think about what all of your ancestors survived. They survived...”

“large scale predation in the Devonian period.”

“the mass extinction at the end of the Permian period.”

“getting stomped by dinosaurs.”

“the great impact event that wiped out the dinosaurs.”

“the ice ages.”

“the Black Death and other plagues of the middle ages.”

“various world wars and more.”

I finished with “Just you? No...every living thing you see is the result of 4 and a half billion years of evolution.” If you time it right, you finish seconds before the bell rings. (Note to beginning teachers: Anything said after the bell is lost. It may as well be sent out to intergalactic space.)

Before students get to middle school, elementary teachers can help lay a foundation for student understanding of evolution whenever dinosaurs show up in their reading and lessons. Using a good earth history poster, they can dispel ideas of dinosaurs and humans living together, (i.e. Flintstone cartoons, cave man movies, creationist “museums” etc.) by showing that humans and dinosaurs never lived at the same time; that humans and dinosaurs are separated by more than 60 million years of earth history.

Engaging 7th graders in a unit on evolution can be challenging. However, in over 30 years of teaching, I’ve found students to be quite interested in both understanding the evolution of life on earth and the scientific evidence that explains it.

Author contact: Vince Sperrazza - vksperr@adelphia.net

Selected resources

Books

... essentials

Darwin, Charles. The Origin of Species. New York: Signet Classic. 1859.

National Academy of Sciences, Institute of Medicine. Science, Evolution, and Creationism. Washington D.C.: National Academies Press. 2008.

Scott, Eugenie C. and Branch, Glenn. Not in Our Classrooms: Why Intelligent Design Is Wrong for Our Schools. Boston: Beacon Press. 2006.

Teaching about evolution and the nature of science. Washington, D.C.: National Academy Press. 1998.

... notable

Allen, Katy et. al. Holt Life Science. New York: Holt, Rinehart & Winston. 2005.

Alters, Brian. Defending Evolution: A Guide to the Evolution/Creation Controversy. New York: Jones and Bartlett. 2001.

Biggs, Alton et. al. Life Science. Columbus, OH: Glenco/McGraw-Hill. 2005.

Dawkins, Richard. The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe Without Design. New York: Norton. 1996.

Dixon, Dougal. et.al. Atlas of Life on Earth. New York: Barnes & Noble Books. 2001.

Eldredge, Niles. The Triumph of Evolution: and the Failure of Creationism. New York: Neveraumont. 2001.

Flannery, Tim. The Eternal Frontier: An Ecological History of North America and Its Peoples. New York: Atlantic. 2001.

Gamlin, Linda. Eyewitness Books, Evolution. New York: DK Pub. 2000.

Gould, Stephen Jay. The Living Stones of Marrakech: Penultimate Reflections in Natural History. New York. Harmony. 2000.

Gould, Stephen Jay. Wonderful Life: The Burgess Shale and the Nature of History. New York: Norton. 1989.

Gridley, C. Robert. Openers for Biology Classes. Portland, ME: J. Weston Walch. 1990.

Haines, Tim D. Walking with Dinosaurs: A Natural History. New York: DK Pub, 2000.

Haines, Tim D. and Horley, Daren. Walking with Prehistoric Beasts: A Prehistoric Safari. New York: DK Pub. 2001.

Holtz, Thomas R. Jr Dr. Dinosaurs: The Most Complete, Up-to-Date Encyclopedia for Dinosaur Lovers of All Ages. New York: Random House. 2007.

Humes, Edward. Monkey Girl: Evolution, Education, Religion, and the Battle for America's Soul. New York: Harper Collins. 2007.

Johnson, Kirk R. and Troll, Ray. Cruisin' the Fossil Freeway: An Epoch Tale of a Scientist and an Artist on the Ultimate 5,000-Mile Paleo Road Trip. Boulder CO: Fulcrum Publishing. 2007.

Judson, Olivia. Dr. Tatiana's Sex Advice to All Creation: The Definitive Guide to the Evolutionary Biology of Sex. New York: Holt. 2002.

Miller, Kenneth R. Only a Theory: Evolution and the Battle for America's Soul. New York: Viking. 2008.

Scott, Eugenie C. Evolution vs. Creationism: An Introduction. New York: Greenwood Press. 2004.

Shermer, Michael. Why Darwin Matters: The Case Against Intelligent Design. New York: Times Books. 2006.

Shubin, Neil. Your Inner Fish: A Journey into the 3.5-Billion-Year History of the Human Body. New York: Pantheon. 2008.

Stein, Sara. The Evolution Book. New York: Workman Publishing. 1986.

Thompson, Ida. The Audubon Society Field Guide to North American Fossils. New York: Knopf. 1982.

Wallace, David Rains. Beasts of Eden: Walking Whales, Dawn Horses, and Other Enigmas of Mammal Evolution. Berkeley, CA: University of California Press. 2004.

Zimmer, Carl. Evolution: The Triumph of an Idea. New York: HarperCollins. 2001.

Internet resources

... essentials

Understanding Evolution - the best "one stop shopping for evolution education" - from The National Center for Science Education and the University of California, Museum of Paleontology at Berkeley

<http://evolution.berkeley.edu/>

National Center for Science Education - supports the teaching of evolution
<http://www.natcensci.ed.org/>

New York State Intermediate Level Science Curriculum Guide – from the New York State Education Department
<http://www.emsc.nysed.gov/ciai/mst/scirg.html>

... notable

15 Answers to Creationist Nonsense – from *Scientific American*, 2002
<http://www.sciam.com/article.cfm?id=15-answers-to-creationist>

24 Evolution Myths and Misconceptions - from *New Scientist*, April 2008
<http://www.newscientist.com/channel/life/dn13620-evolution-24-myths-and-misconceptions.html>

Americans United for the Separation of Church and State – works to keep religion out of science classes
<http://www.au.org/site/PageServer>

Becoming Human – from the Institute of Human Origins, "journey through the story of human evolution," a Webby "Best Science Site," includes a learning center
<http://www.becominghuman.org/>

Devonian Blues – a paleontological blues story set to music; “Your momma was a lobe finned fish”
<http://www.trollart.com/sound/devonianblues/index.html>

Evolution for Teachers – companion to PBS Evolution series – very valuable with lesson plans <http://www.pbs.org/wgbh/evolution/educators/>

Evolution List-o-Links – from the blog “The Sensuous Curmudgeon.” An excellent, and very thorough list on evolution, “posted as a public service, so that each new evolution debate doesn’t have to start at ground zero.”
<http://sensuouscurmudgeon.wordpress.com/list-o-links/>

Museum of Paleontology, Berkeley - all about fossils, geologic time periods, and more
<http://www.ucmp.berkeley.edu/index.html>

NatureServe Explorer - This online encyclopedia provides authoritative "information on more than 70,000 plants, animals, and ecosystems of the United States and Canada. Explorer includes particularly in-depth coverage for rare and endangered species."
<http://www.natureserve.org/explorer>

Science Odyssey: You try it: human evolution – activities for students
<http://www.pbs.org/wgbh/aso/tryit/evolution/>

Talk Origins Archive - dedicated to the scientific study of human origins
<http://www.talkorigins.org/>

Teachers Under Fire – suggestions and more resources for science teachers from biologist / anthropologist Greg Laden
http://www.scienceblogs.com/gregladen/2008/03/teachers_under_fire.php

The Panda's Thumb – a place to discuss evolutionary theory, critique the claims of the antievolution movement and defend the integrity of both science and science education
<http://www.pandasthumb.org/>