

## **MORE SUMMER READING!**

Articles in the latest (June 2009) issue of *Evolution Education Outreach Online*  
Information for teachers - current status of  
Transitional Fossils, Natural Selection Myths, and Evolutionary Trees  
Review by Larry Flammer

If you haven't checked out the awesome list of articles in the latest volume of *Evolution Education Outreach Online*, you need to go there! It's a special issue featuring **Transitional Fossils**. And best of all, the authors are all specialists in their fields, but writing primarily for biology teachers in relatively non-technical language, and pulling together broad collections of information, including recent data and interpretations.

Having developed and extended my whale evolution lessons, I was especially interested in reading "**From Land to Water - the Origin of Whales, Dolphins, and Porpoises**" by Thewissen, et al. Indeed, the article was very helpful. It brought in an extended discussion of the recently processed fossils of *Indohyus* as a member of the extinct artiodactyl group known as Raoellids, a much more likely pre-cetacean group than the mesonychids. Many other details about informative features in the groups of whale antecedents are well presented, including bone thickness, oxygen isotope ratios in teeth, comparisons of ear bones, semicircular canal size, nasal bone reduction, and sizes & positions of orbits and other skeletal features. Many clues about the likely environments for these creatures are also included. The many diagrams and photos help to make the article accessible for any students doing the **Becoming Whales** and **Whale Ankles and DNA** lessons who may want to explore the subject further and see what the current thinking is about cetacean evolution.

A natural extension from this was Donald Prothero's article on **Evolutionary Transitions in the Fossil Record of Terrestrial Hoofed Mammals** (since *Indohyus* and the earliest pre-whales with feet all had hooves). The number of examples of many transitional series of fossils was most impressive. In a time when creationists repeatedly assert that one of evolution's weaknesses is that there are no transitional fossils, it was refreshing to see how much progress has been made here. In reality, there have long been many such collections, but new material in recent years has filled in even more details, and added more series, for both perissodactyls and artiodactyls. The article makes a strong case for the reality of the "bushiness" of family trees, encouraging us all to point this out to our students, that the long-outdated linear idea of evolutionary chains, with their "missing links" is totally inconsistent with the fossil record. Examples include the abundance of material for the evolution of horses, rhinos, tapirs, camels, giraffes, and elephants. In all cases, the earliest members of each group are practically indistinguishable from each other, becoming gradually and increasingly different over time, just as we would expect from the process of evolution, and totally inconsistent with traditional ideas about the origin of diversity.

Another group that all biology teachers should explore is the Pre-Mammal group of tetrapods. Read the article by Kenneth Angielczyk, "**Dimetrodon is Not a Dinosaur: Using Tree Thinking to Understand the Ancient Relatives of Mammals and their Evolution.**" The author explains how an understanding of evolutionary trees and how they are currently built, provides a very useful tool to help students to see that the easily recognized fin-back synapsid known as *Dimetrodon* is clearly not a reptile, but rather a member of a large bushy series of tetrapods that began evolving away from their early tetrapods many millions of years before reptiles began to appear from a different group of tetrapods. Those pre-mammal synapsids document the gradual appearance of an increasing number of mammalian traits over 100 million years. For any student who raises the erroneous challenge of "where are the transitional animals between reptiles and mammals?" - you could offer this article to read, summarize, and reflect on the question. In fact, it wouldn't hurt to require any AP class to read this.

Of course, this all just whets the appetite for more! With the recent discovery of *Tiktaalik* - the fish with wrists - in contrast to the detractors' claim of "lack of 'convincing' evidence" for how land animals could have evolved from fish, I had to find out what was new in that arena. Jennifer Clack's article "**The Fish-Tetrapod Transition: New Fossils and Interpretation**" does this well. Again we see, as we would expect, that the more

fossils we find from the period where transition must have happened, the fuzzier it becomes. There are increasing numbers of fossils where lobe-finned fish begin to show some tetrapod features over time, and the earliest clear tetrapods still have some fish features. This makes it increasingly more difficult to say just when we have a tetrapod-like fish, and when we have a full-fledged tetrapod. As in all cases of transitional forms: they are always a shifting mosaic of the earlier features being gradually replaced by the newer features, precisely as predicted by evolution.

There are several other articles that might be of interest, but I turned next to another area of interest, beautifully presented in an article by T. Ryan Gregory: **Understanding Natural Selection: Essential Concepts and Common Misconceptions.** Since I have made a career of deeply incorporating evolution into my biology course, including pointed efforts to attack popular misconceptions, I was interested in seeing if my coverage had been accurate and appropriate, and had I overlooked any critical misconceptions. For the most part, it looks like I did ok. The paper discusses the extent and possible causes of misunderstandings of the process of natural selection, and presents a review of the most common misconceptions that “must be corrected before a functional understanding of natural selection and adaptive evolution can be achieved.” I did discover that I probably didn’t emphasize certain points as much as I should have. As a result, I will be doing two things: 1) review our “Evolution Knowledge Survey” pre-test instrument, to see if it contains checks on several critical points described in the article, and 2) review all of our natural selection lessons to be sure that teachers are urged to emphasize those critical factors in their discussions following the activities.

If you print and read any of the articles in this online volume, make it this one, on the many **misconceptions about Natural Selection.** From many studies cited, it is clear that natural selection is, in general, very poorly understood - even by those who have postsecondary instruction in biology! In fact, most disconcerting is the fact that “confusions about natural selection are common *even among those responsible for teaching it.*” “One cannot assume that **biology teachers**, with extensive backgrounds in biology, have an accurate working knowledge of evolution, natural selection, or the nature of science.” How about you? Is it time for a reality check? The article does a very nice job of summarizing just what natural selection is, as understood by evolutionary biologists today. This description is accompanied by an excellent graphic that shows Darwin’s 5 observations and 3 inferences that comprise his theory for natural selection as the main mechanism for evolution. The author explains in detail why natural selection (contrary to its detractors’ assertions) is a *non-random* process. He shows that natural selection is a two-part process, with a random component (mutations) and a non-random selection component (differential survival and reproduction). He also suggests that the random component of natural selection (mutation) might be less confusingly called “undirected” rather than random, and that most mutations are neutral (not detrimental, as widely assumed). A distinction is made between Darwinian “fitness” and the more familiar usage of “physical fitness,” and how confusion of those terms is probably one of the causes for misunderstanding. The author clearly explains why “Survival of the Fittest” is misleading, and why natural selection is not a tautology (case of circular logic) as some critics have suggested. The misuse of “adaptation” is discussed, as is the concept that it’s populations that evolve, not individuals. It’s also explained why mutations do not occur “in order to” improve fitness, and why evolution and natural selection are not the same thing. Lots of good stuff here to sharpen your evolution unit.

Gregory explains possible reasons why natural selection is notoriously so difficult to grasp accurately, while being deceptively perceived as being elegantly simple in principle. While pointing at the anthropomorphisms and suggestions of intent that are often included in descriptions of natural selection, along with the idea of Use and Disuse often ascribed to **Lamarck**, he also points out that those deep-seated ideas actually preceded Lamarck, while Lamarck contributed many useful and accurate ideas, along with the first (albeit ultimately incorrect) mechanistic theory for evolution.

Again - this should be a “Must Read” selection for all Biology teachers this Summer. And if you develop any kind of interactive lesson based on any of these articles, please share with ENSI so other teachers can benefit.

There are many more great articles.... I can't overlook Louise Mead's article on "**Transforming Our Thinking About Transitional Forms.**" She makes a strong case for why finding or searching for "The Missing Link" is so inappropriate for the branching tree nature of evolution. Long-outmoded ideas about the "evolutionary ladder" and the "chain of being" in which every creature has a position in a lineal ancestry must be explicitly discredited. Instead, focus must be put on the *characteristics* or *features* that have changed over time rather than the individuals represented by fossils. Suggesting that fossils represent individual species in the direct line of ancestry to modern species (or "forms") is just inconsistent with reality. Fossils represent *groups* of organisms that share various numbers of certain traits with other fossils and living groups, and it's the changes and shifting balance of those *features* in groups over time that provides the most compelling picture of evolutionary change. "Missing Links" have no place in this paradigm whatsoever. Mead cautions us to avoid using "link-thinking" terms like "primitive" vs "advanced", or "higher" vs "lower," and replace them with "ancestral" and "derived." Promote "tree-thinking" and focus on features, not forms or organisms. She also offers a number examples of the compelling power of multiple independent lines of evidence, and how important it is point this out clearly to your students. Most of the ENSI lessons make a point of doing just that.

Finally (for now), another must-read article in this online volume is "**A Name by Any Other Tree**" by Anastasia Thanukos. She provides an excellent introduction to the value of tree-thinking and the use of cladograms for understanding evolution, and to realize that cladograms show realistic relationships among diverse groups. "Students need to know that the guiding principle of modern classification has to do with common ancestry and the nested hierarchy formed by the tree of life." "Memorizing the ranks is *much* less important than understanding the concepts of clades and common ancestry." "When classifying hardware [as many students do], all classification schemes the students come up with will be equally valid - but the same is not true in biology." [The ENSI lesson "**Nuts & Bolts Classification...**" nicely addresses this issue.]

**To find the articles**, go to <http://www.springerlink.com/content/120878/> then click on Volume 2 Number 2 for June, 2009. This will take you to the list of contents of 21 articles from which to choose. For the selected article, click on its "PDF" link to download a printable copy. Direct link to this volume:  
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If you want to use some of the **figures** for a PPT presentation or overhead, use the HTML version - the figures are sharper and can be clicked and dragged to your desktop. If those aren't sharp enough, maybe you could email the author and nicely request a sharper JPG version of certain desired illustrations. The email address for each author is included in the article, and I suspect that they would be happy to comply if you explain what you are trying to do. Or email me at [flammer4@gmail.com](mailto:flammer4@gmail.com) A couple of the authors have sent me high res versions of some of their diagrams. Just be specific in your request.

Again, if you should develop any **clever interactive lessons** using this material, please share - send a copy to me to consider adding to the ENSI site for easy access by other teachers. You will, of course, be given all due credit for your lesson.