COMMENTARY

SWOTing at Paleontology

By Roy E. Plotnick

It's hard not to preen a little when someone asks you what you do and you reply "I'm a paleontologist." Almost invariably (and this is not restricted to seven- to twelve-year-olds), the response is some variant on "cool!" This is often followed by "I always wanted to be a paleontologist," a reference to Ross on *Friends*, and questions on how many dinosaurs you have discovered. On a broader scale, paleontology is clearly one of the most popular topics in science within the media and the public. A quick check of the *New York Times* Science website reveals more than 830 articles under the topic "paleontology"; a similar search on LiveScience.com yields more than 5,000 hits on the word "fossils." New paleontological discoveries are prominently featured on the homepage of the National Science Foundation. We paleontologists clearly have numerous opportunities to interest and excite the public about our research. It might seem contradictory, therefore, that the perception shared by many in the paleontological community is that funding for paleontological research has become effectively nonexistent, posing a threat to the long-term vitality of the field, in particular to the careers of young scientists.

Alert readers, in particular those with experience in preparing strategic plans for businesses and organizations, might have noticed my deliberate use of the terms "opportunities" and "threat." These are usually coupled with "strengths" and "weaknesses" to form the acronym SWOT (**S**trengths, **W**eaknesses, **O**pportunities, **T**hreats), which describes an approach to identifying those factors that have the most impact on an entity. In particular, strengths and weaknesses generally refer to internal factors, whereas opportunities and threats comprise external influences.

This essay is an attempt to perform an admittedly incomplete SWOT analysis on paleontology as a discipline. I will focus on the structural aspects of the field, rather than on new research directions. These have been the subjects of a variety of efforts in the past decade, such as the recent workshop on *Future Research Directions in Paleontology* (Bottjer, 2007). I will also focus on paleontology in the United States, although many of the same issues concern our colleagues in other countries (for a slightly dated but still relevant overview with an international perspective, see the report of the 1997 workshop *Paleontology in the 21st Century http://www.nhm.ac.uk/hosted_sites/paleonet/paleo21/rr*).

Strengths

The most obvious strength of paleontology is its continued intellectual productivity. At the 2007 GSA meeting in Denver, 22 sessions were sponsored or cosponsored by the Paleontological Society; most days had three or even four sessions going on simultaneously. Hundreds of other presentations were given at the Society of Vertebrate Paleontology meeting in Austin two weeks previously.

Paleontological journals are similarly flooded with submissions with hundreds of papers being published each year. Paleontological papers also frequently appear in high profile journals such as *Science*, *Nature*, *Geology*, and *Proceedings of the National Academy of Sciences*. This is a testament both to the continued pace of new and significant discoveries, such as the early vertebrate *Tiktaalik*, and to major advances in analyzing the known fossil record, such as major extinction events. Student interest also remains high, with many talented young people entering the field every year. The professional societies have made major efforts to support and reward their research.

Paleontologists have also been active in the development of new databases and online resources. The Paleobiology Database (PBDB) makes the "raw stuff" of the fossil record and tools for analyzing it accessible to a wide audience. The Paleontology Portal gives simple access to numerous paleontological resources, including the ability to easily search museum collections.

Outreach to educators is also an important strength. Access to educational materials about the field is readily obtained through the The Paleontology Portal, as well as linked sites run by the University of California Museum of Paleontology. PRI and its Museum of the Earth have an active and ongoing educational component.

Weaknesses

A looming, critical problem for the field is the erosion of expertise in the general area of descriptive and systematic paleontology. Although some groups have multiple specialists working on them, others, for example stromatoporoids, are effectively down to their last expert with no prospects of replacements being trained. A side effect of this decline is a growing tension between the remaining "classically" trained paleontologists and those whose interests are more analytical or theoretical. This is unfortunate, because the two approaches can and should be mutually illuminating. Without taxonomic expertise, there will be no way of assessing the quality of data entered into any current or future database or used in synoptic analyses of evolution in the fossil record. At the same time, analytical approaches can highlight those areas of the fossil record that are in need of detailed and informed taxonomic work.

A related weakness is the marked decline of paleontology at major oil companies. At one time, most companies had large in-house paleontological programs for paleoecology and biostratigraphy, including associated databases and collections. Today, many of these programs are either gone or much smaller, with much of the work being contracted out. Farley & Armentrout (2000) noted that the number of paleontologists employed at major oil companies declined 90% from 1985 to 2000! They also pointed to the accompanying decline of oil company support for paleontological research at universities and museums.

Another major concern, and an important emphasis in the *Future Directions in Paleontology* report (FRDP), is the state of paleontology's professional societies. The societies are approaching a critical turning point in their missions. Traditionally, a major role of the societies was to promote the field by organizing meetings and publishing journals. For many of us, the major incentive to join a society was to receive a personal copy of its journals. Over the last decade, however, nearly all of the journals have become available electronically through college and university libraries. Probably as a result, many scientific societies, not just those in paleontology, have seen major decreases in membership. A critical task for the societies, therefore, will be to create new incentives for being a member.

Even more critical, in my view, is the lack of internal unity in the field and a concomitant lack of a common voice. A paleontologist might belong to the Paleontological Society, the Society for Vertebrate Paleontology, the Paleobotanical Section of the Botanical Society, or to SEPM, but rarely to more than one of them. These societies rarely if ever meet together and have relatively little formal contact. Paleontologists with interests in paleoclimatology or paleoceanography might attend the American Geophysical Union meeting rather than GSA. With the exception of the infrequent North American Paleontology Conventions, paleontologists rarely if ever meet as a unified group. This disunity within the field has made it very difficult for there to be long-term planning and follow-through on research initiatives or for cases for their support to be made to NSF, the wider scientific community, the public, or members of Congress.

Opportunities

As pointed out earlier, paleontology is one of the most popular fields of science among the general public; after all, who doesn't love dinosaurs? The construction of the Museum of the Earth, and of the new paleontology exhibits at places such as The Field Museum and Museum of the Rockies, is a testimony to this abiding interest. This interest also extends beyond dinosaurs. The continued popularity of the writings of the late Stephen Jay Gould shows the market for our science, if interestingly explained, among the educated public. We also have an active and enthusiastic amateur community. Paleontology remains, along with astronomy and malacology, one of the few fields where the trained amateur can make a fundamental discovery and be recognized for it by the professional community.

In addition, the importance of paleontology continues to be recognized by many in the broader scientific community. Paleontologists have moved into new areas of expertise, as our "parent" fields of geology and biology have changed over time. Paleontological expertise is an essential part of studies of the dynamics and history of the entire Earth system, where fruitful collaborations have been established with geoscientists in areas such as paleoclimatology and biogeochemistry. Similarly, the paleontological record of early life is an integral part of areas such as evolutionary developmental biology ("evo-devo") and studies of the phylogeny of major groups. In the latter case, paleontological data have played a critical role in constraining the timing of the origin of new taxa based on molecular data.

Threats

Paleontology as a discipline finds itself threatened on many fronts. First, our central tenet, that life has a long and complicated history, is taught in a country where approximately half of the adult population does not accept the validity of evolution. The new Creation Museum is on the way to having some half-million visitors during its first year!

But a more immediate concern is the erosion of funding for paleontology. The number of potential financial supporters for paleontological research is quite limited. Private and foundation funding is virtually nonexistent. The National Geographic Society supports some fieldwork, and the Petroleum Research Fund supports projects if they are potentially related to the petroleum or alternative energy fields. This leaves government funding, in particular the National Science Foundation. The most visible unit within NSF for funding paleontology is the Sedimentary Geology and Paleontology (SGP) Program, part of the Division of Earth Sciences (EAR) within the Directorate of Geosciences. Based on the forthcoming FRDP, funding for paleontology comprises 2.5% of the EAR budget and only 0.5% of NSF's overall Geosciences budget. Note that SGP funds paleontology, plus sedimentology and stratigraphy.

There are two opportunities (rounds) of funding within SGP within any given year. In one of the most recent rounds, 126 proposals were submitted, with a total budget request of $26 million. Of these, 18 proposals were funded, for a total of only $1.6 million. Although the probability of a successful proposal was about 15% (not terrible by NSF standards, but half of what it was 2001!), the average grant amount was <$90,000.

This is no trivial matter. Universities have become increasingly reliant on external funding, especially federal dollars. This is even true of public universities, which have seen major cuts in state support. This has generated a steady rise in "proposal pressure," driving upward the number of proposals submitted to NSF. For example in 1999-2003, SGP received an average of 63 proposals in paleontology. In 2005-2007, that number increased to 90.

One-third to one-half of a typical NSF grant does not go directly to the principal investigator, but is taken by the institution as "overhead," ostensibly to pay for light, heat, secretarial services, etc. A large grant will generate correspondingly more overhead. As Steve Vogel wrote in 1998, there is a "growing institutional preference for expensive science," with deans and department heads favoring faculty that will generate more overhead. In an academic environment, especially at research universities, where worth is often judged not only by receiving a grant but by its size, current funding levels threaten both future hiring and tenure decisions.

As also pointed out in the FRDP, there is also a lack of funding for long-term infrastructure, in particular for database projects such as the Paleobiology Database (*http:// paleodb.org*) and CHRONOS (*http://chronos.org*), despite the great current utility and potential of these projects.

It should be mentioned that research dollars are available outside of SGP. Some paleontological research is funded as part of Arctic and Antarctic research, the Assembling the Tree of Life (AToL) Program, and other initiatives in systematic biology, and programs investigating aspects of global change.

There is good evidence that the funding situation has already had a major negative impact. Flessa & Smith (1997) compared changes in academic employment between 1980 and 1995 among paleontologists, geochemists, and geophysicists, based on data in the American Geological Institute's *Directory of Geoscience Departments*. They found that although the total number of paleontologists was stable, the relative number of geochemists and geophysicists had increased. They also noted that the typical paleontologist was becoming older, as the number of untenured (assistant professor) faculty decreased.

With the help of Cindy Martinez of AGI, I have compiled the distribution of ranks among the three disciplines in the current version of the Directory (Table 1). It is clear that the trends noted by Flessa & Smith have continued. Particularly notable are the far lower number of assistant professors and the very large number of emeritus faculty who are paleontologists. The graying of the field is definitely continuing!

Table 1. Distribution of faculty by ranks in the 2007 *Directory of Geoscience Departments*. Full professors include those listed as Heads or Chairs.

	Asstistant Professor	Associate Professor	Full Professor	Emeritus
Paleontologists	81	127	333	184
Geophysicists	126	133	406	126
Geochemists	129	142	313	100

Toward a Strategic Plan

A SWOT analysis is only a start; it does not address the key question is what is to be done. To me, the issue is not whether we can identify important and interesting areas of research; this has been done repeatedly in the last decade and can be found in such documents as *Geobiology of Critical Intervals* (Stanley et al., 1997), *The Geological Record of Ecological Dynamics* (Flessa et al., 2005), and the FRDP. Instead, what is needed are structural changes in our institutions to make them more effective advocates for our science. Some of these changes are contained in a section of the FRDP that was drafted by a group including past and present leadership of the PS and SVP. This section includes specific actions that should be taken, including activities within and among the societies to enhance research and funding prospects, and promoting paleontology to other scientists and to the public at large, including elected representatives. This section calls for much closer cooperation among our disparate societies.

Also needed are individuals who can effectively represent the science of paleontology to those outside our community to act as conduits in coordinating the efforts of disparate societies. Some of these might have to be paid professionals; societies such as the PS are fundamentally volunteer-operated and members of PS council already carry out tasks without compensation and at a significant cost to their own research and teaching.

Finally, the paleontological community should take the steps necessary to develop a full strategic plan – one that can guide the field over the next decade and beyond. The astronomy community already does this on a routine basis. Although the FRDP is a good start, it only addresses a fraction of what is necessary. Key elements of the plan should include an expanded SWOT analysis to establish the current context of the field, a statement of overarching goals or the major scientific problems on which the field should focus in the next ten years, and an assessment of the infrastructure and expertise needed to attain these goals. I have prepared a framework for such a plan as an online "wiki" document (*http://paleontologyplan.pbwiki.com*).

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