

The educational values of the University of California Museum of Paleontology

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Abstract

The University of California Museum of Paleontology (UCMP) maintains the largest university museum fossil collection in the world and promotes research and education at its home, University of California, Berkeley, and far beyond. The museum supplies crucial materials and intellectual resources to a wide variety of university courses, where graduate and undergraduate students gain first-hand experiences in studying fossil specimens in laboratory exercises and class projects. Our specimen-based approach generates greater interest in the subjects and uniquely enhances students' understanding of biological diversity and evolution. Discovery-oriented class projects often pave the way for scientific publications in professional journals, which contribute to the research mission of the museum. For grades K-12, the museum offers hands-on learning experiences to the public through museum tours and outreach programs at local schools. Further, the highly successful UCMP website relies on the fossil collection to make educational resources in paleontology and evolutionary biology accessible to students of all ages around the world. The museum's fossil collection is vital to educational programs that disseminate paleontological knowledge and cultivate scientific literacy.

Introduction

Established in 1921, the University of California Museum of Paleontology (UCMP) is today the world's leading university museum of paleontology, with nearly three million specimens and more than 60 museum staff, faculty researchers, and graduate students actively engaged in its research and educational missions. From museum tours to partnerships with local schools and undergraduate courses in biology, a wide array of educational activities, both within and beyond the boundaries of the university, is made possible by this unparalleled resource (LIPPS 2004). In this paper, we discuss three recent examples of how the UCMP collection is being used to disseminate the most current knowledge of paleontology. We focus on hands-on learning for students of all ages because it is fundamental to cultivating the public understanding and appreciation of the discipline, and because this is where the museum collection plays a pivotal role in science education.

The utility of fossils in evolution education

Evolution of the Vertebrates is a semester-long lecture and laboratory introduction to vertebrate paleontology and evolution offered by the Department of Integrative Biology at the University of California, Berkeley (UC Berkeley). The class is open to undergraduate and graduate students, and employs specimen-based techniques and resources to cover the 500+ million-year history of vertebrates. The course draws entirely upon collections from the UCMP in its laboratory section to provide students with hands-on education. Museum specimens convey to students a suite of important evolutionary transformations, including the origin and early evolution of the skeleton, the origin of vertebrate life on land, the origins of reptiles and mammals, the evolution of birds from other dinosaurs, and how processes of fossil preservation bias the nature of the fossil record. In a time when creationist ideas are accepted as a viable alternative to evolution by an alarmingly high number of students and teachers alike (MOORE & COTNER 2009), the ability for students to see and touch evolutionarily meaningful specimens is an irreplaceable educational opportunity.

To help students understand how paleontologists take fossils from discovery, through preparation, to description and reconstruction, we use two specimens of *Tiktaalik roseae*, a 375-million-year-old fossil

that, in combination with several other well-known animals, bridges the vertebrate water-to-land

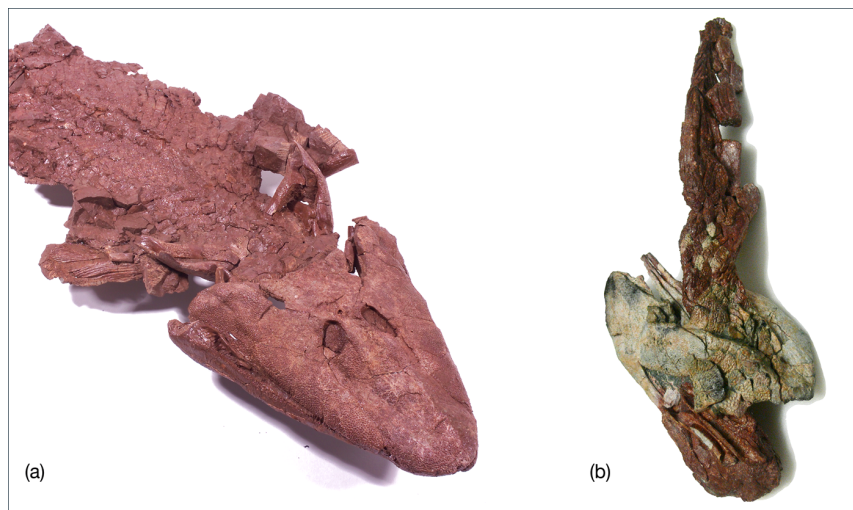


Fig. 1 - *Tiktaalik roseae*, a 375-million-year-old fossil 'precursor' of the first terrestrial vertebrates: (a) cast of the head and body; (b) cast of the right forelimb. See text for additional details.

transition. *Tiktaalik* shares many limb characteristics with both aquatic and terrestrial (i.e., land-living) vertebrates (fig. 1). By comparing two *Tiktaalik* specimens, and discerning the identity, articulations, and profile of their limb elements, students learn how to apply paleontological techniques to reconstruct the limbs of *Tiktaalik roseae*. Often in science courses, information flows from 'what is known' to 'how it came to

be that way'. However, by encouraging students to start without 'the answer' and work from smaller factual data sets to larger inferences, this exercise facilitates understanding of how unknown organisms are described, and how paleontological knowledge begins before elementary and descriptive data are integrated into the larger dynamic of macroevolutionary scenarios of history and change. This course integrates museum specimens at its core, and focuses on the utility of evidence in evolution and student inspiration at both graduate and undergraduate levels.

Course research project using museum specimens

Examination of specimens lies at the heart of traditional laboratory courses in zoology and geology with the main objectives of illustrating key concepts with concrete examples and fostering practical observational and identification skills. In *Morphology of the Vertebrate Skeleton*, another biology course at UC Berkeley, this approach is taken a step further by integrating museum specimens into a core research project.

In the fall semester of 2008, students undertook a project investigating the locomotor habits of the extinct saber-toothed cat (*Smilodon fatalis*) and the dire wolf (*Canis dirus*) by quantifying the shapes of limb bones of UCMP specimens. The pedagogic goals of this project were to (1) acquaint students with the history of the UCMP and the regional paleontology of California and (2) provide them with first-hand experience of specimen-based research in paleontology and vertebrate morphology. The choice of the study organisms was based on the fact that both are well known from the state of California¹ and are represented by more than 3,000 cataloged specimens in the UCMP collection. Furthermore, these specimens carry a significant piece of the museum's history, having been collected in the 1920s under the direction of John C. Merriam, a professor of paleontology whose leadership was instrumental to the early development of the paleontology program at UC Berkeley (LIPPS 2004). We think that the use of museum specimens with regional and historical connections to the university made the project more engaging for students, and promoted awareness of the museum as a public institution of science with relevance to its surrounding communities.

¹ *S. fatalis* is the official state fossil.



Fig. 2 - A student measures a specimen of the saber-toothed cat, *Smilodon fatalis*, to estimate its body mass.

For students, the most important aspect of this course project was the opportunity to conduct original research consisting of data collection, analysis, and the presentation of findings in written and oral reports (fig. 2). Specifically, students learned (1) the state of knowledge on the subject by reading and discussing the most recent journal articles, (2) how to take proper measurements of specimens, (3) how to analyze quantitative data with statistical software, and (4) how to make inferences about the functions of limb bones based on analysis of their shapes. The research culminated in two papers (one on the saber-toothed cat and the other on the dire wolf) that are potentially publishable in professional journals. In other words, the students not only learned how to conduct specimen-based research, but also actively generated new knowledge, contributing to the research mission of the UCMP. We suspect that similar, research-oriented course projects using museum specimens

are possible in many other academic fields in both the sciences and humanities.

Outreach efforts in San Francisco Bay Area K-12 public schools

The collection of the UCMP has been used for a variety of outreach efforts. First, in conjunction with a local non-profit educational organization called Community Resources for Science, a classroom lesson on fossils is periodically presented to second graders in different public schools throughout the cities of Berkeley and Oakland. The second-grade science curriculum in California covers fossils and the history of the earth, so this lesson complements the work that teachers and students are already doing in their classrooms. During the lesson, students learn what fossils are, how they form, and why paleontologists study them. By allowing students to touch and examine UCMP specimens, students remain focused, engaged, and enthusiastic about the material. This experience is particularly beneficial to students at schools where field trip funding has been reduced or eliminated, as it allows children to experience the excitement of studying fossils without ever leaving their classrooms.

A second outreach effort also compliments the second-grade state science curriculum. Local classrooms send Flat Stanleys – paper dolls named after the character in a popular children's book by Jeff Brown (1964) – to the UCMP, and graduate students in the museum photograph each Stanley with museum specimens of their choice, write a short narrative, and return the Stanleys to their home schools (fig. 3). Back in the classrooms, teachers recount the story of Stanley's adventure as a part of a lesson on paleontology, thus providing the students with a virtual fieldtrip to the museum. Teachers report that Flat Stanley is a valuable pedagogic tool, heightening students' interest in the subject and significantly enhancing their retention of the material.

Finally, specimens from the UCMP play an integral role in a summer program for socioeconomically disadvantaged high school students called Summer Math and Science Honors Academy, run by the

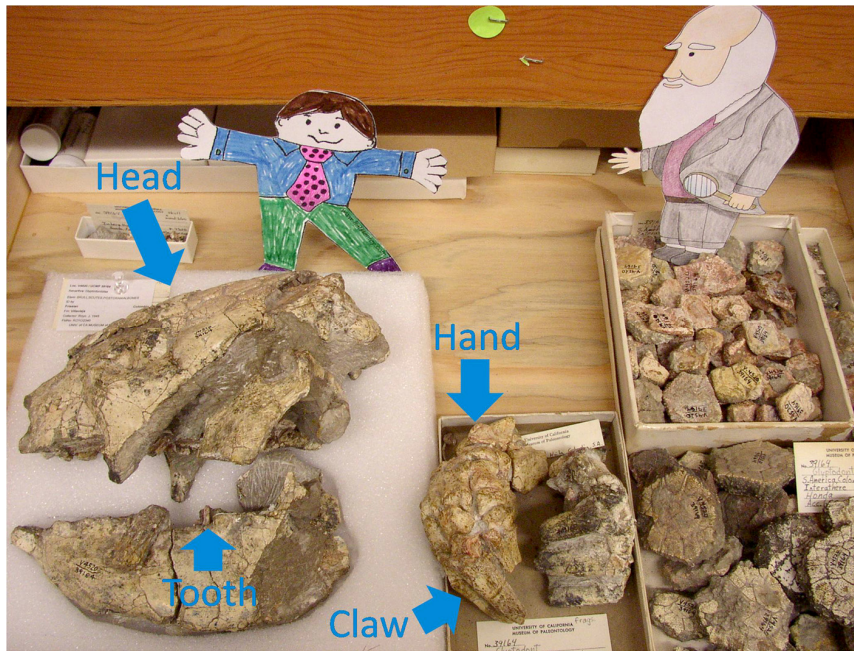


Fig. 3 - A 'Flat Stanley' from a local elementary school interacts with 'Flat Darwin' and several specimens from the UCMP. Pictured here are fossils of a glyptodont – a large, extinct relative of the modern-day armadillo. Stanley was returned to the students with several photos and a narrative about his visit to the UCMP, which were incorporated into the teacher's lesson on fossils and earth history. Photo: S. Tomiya

Level Playing Field Institute. Each summer, a small group of rising 10th graders work on a project to reconstruct the evolutionary relationships among several species of mammals. They observe and measure specimens from the UCMP's comparative skeletal collection, and use their data to determine how the mammals are related to each other. The use of specimens is essential for this activity, because photographs cannot capture the three-dimensional complexity of skeletal form. Moreover, access to specimens allows students to learn how to

ask and answer questions like scientists, how to collect and analyze data, and how to think critically about evolutionary problems.

Because the UCMP, like many other university museums, has limited exhibit space to display museum specimens, these outreach efforts are particularly important means of sharing the collection with the local community and building awareness of the museum and its missions.

Conclusion

We wish to note that the above examples illustrate only a small portion of the multi-faceted educational enterprise pursued by the UCMP – other successful programs sponsored by the museum include award-winning internet-based teaching and learning resources on the process of science² and evolutionary biology³. We hope to have illustrated the unique contribution of the university museum to the research and educational goals of the university, both as a powerhouse of new knowledge and as an institution of learning. With the realization that the understanding and appreciation of paleontology are crucially enhanced by personal contact with museum specimens and active involvement in the process of science, it is our conviction that the UCMP's collection will continue to play integral roles in science education.

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² *Understanding Science*: undsci.berkeley.edu (accessed September 7, 2009).

³ *Understanding Evolution*: evolution.berkeley.edu (accessed September 7, 2009).

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