Engaging Students at All Academic Levels in an Inquiry-Based Paleoecologic Learning Activity—Even When You Don’t Have the Rocks

By René A. Shroat-Lewis and Melissa Hage

Inquiry-based learning is an educational strategy that emphasizes the student’s role in the learning process by having them propose and test hypotheses through experimentation and/or the collection of observational data. It emphasizes active participation, allowing students to take ownership of their learning. In doing so, inquiry-based learning results in the building of the critical thinking and communication skills necessary for participation in all fields of study. In this study, we provide an example of how to adapt an inquiry-based activity used in upper-level paleontology courses so that it can be used in all paleontology-related courses, as well as in lower-level historical geology courses. In paleoecology, large surfaces of substrate with encrusting organisms provide a wealth of paleoecologic information about the ancient communities and are an excellent tool for inquiry-based learning. However, a challenge in paleoecology is that large slabs of rock containing fossil communities are not easy to obtain. In this exercise, students create a simulated substrate using paper and stickers. Feedback showed that students were engaged in the process of doing science and used the skills that they had learned throughout the semester. They gained self-confidence and realized that they can, in fact, do science.

Inquiry-based learning is an educational strategy that emphasizes students’ roles in the learning process by having them propose and test hypotheses through experimentation and/or the collection of observational data. From a pedagogical perspective, student learning is most successful when the complex process of inquiry is scaffolded into smaller, logically connected topics that guide them through the steps of the scientific method (Pedaste et al., 2015). This method of learning is important because it provides students the opportunity to practice skills used by professional scientists to discover causal relationships between dependent and independent variables. Inquiry-based learning emphasizes active participation, allowing students to take ownership of their learning, which results in the building of the critical thinking and communication skills necessary for participation in all fields of study (Apedoe et al., 2006; Pyle, 2008). One of the fathers of American geology, T. C. Chamberlain (1897), stated that students should seek answers “by [their] own effort an independent assemblage of truth,” which is one of the main ideas cultivated in the inquiry-based learning process.

Unfortunately, inquiry-based learning activities are often only utilized in upper-level courses, with labs in lower-level courses dominated by activities that are merely recipes that students follow, with each arriving at the same answer. When they do not get the correct answer, students assume that they are “just not good at science,” when in fact they just have not had much practice with it. Kauffman and Shell (2012) explain that students believe that the ability to do science is the result of “natural” ability and intelligence rather than practice and that these views can be reinforced by teachers who praise students for doing well because they are smart. Therefore, it is imperative that introductory students be given the opportunity to practice science and think independently and critically about a scientific question as often as possible to overcome this belief.

Paleoecology is a subdiscipline of geology that investigates the relationships between ancient organisms and their physical and biological interactions and examines the organisms’ role in the community structure (Labandeira & Sepkoski, 1993; Poinar & Poinar, 1999). Large surfaces of substrate with encrusting organisms can provide a wealth of paleoecologic
information about the ancient communities and can be an excellent tool for inquiry-based learning. However, one of the challenges in paleoecology is that large slabs of rock containing fossil communities are not easy to come by. One option is to visit the location of rock outcrops containing fossil communities, which may not be possible because there are none found locally. For a second option, if slabs are collected in the field, they are not easily transported or stored in either academic or museum collections because of their weight and size. Instead, most fossil specimens found in academic and museum collections are often chipped-down remnants of the outcrop that highlight the organisms of interest rather than capture the ancient community’s structure. In this type of collection process, important paleoecologic data, such as spatial relationships, are lost forever. A third option, to purchase rock slabs from collectors, is often cost prohibitive.

What can you do when you do not have the rocks needed to give students the opportunity to participate in an inquiry-based, hands-on classroom exercise that explores a paleoecologic question? In the exercise that follows, students create a simulated substrate using easily purchased and affordable paper and stickers. The goal is for students to develop the skills necessary to improve proficiency in the scientific method and develop an understanding of the application of relevant paleoecologic methods used by scientists in their research. Additionally, this activity can be modified to be used in a variety of different-level courses. This activity was developed for use in an upper-level paleobiology course at the University of Arkansas at Little Rock and subsequently taught, with modification, in an introductory level historical geology course at Oxford College of Emory University. The paleobiology course had 14 students and included seven geology majors (50%), six biology majors (43%), and one geology graduate student (7%). The activity was done in the last 4 weeks of the semester as a group project that combined various topics students had learned throughout the semester into one capstone course project. The historical geology course consisted of 15 students: six first-year students (40%) and nine sophomores (60%). In the historical geology course, four (26%) of the students expressed interest in majoring in environmental sciences. The activity was done during a single 3-hour lab period 13 weeks into the semester and involved the incorporation of a pre-lab activity and time outside the lab to complete the assignment. The research done on student perceptions of this exercise did not require Institutional Review Board approval because it was not designed to produce generalizable information. All student information is anonymous and cannot be linked to any individual.

Lesson plan and methods

Learning objectives for this activity in both courses are focused on general scientific thinking and include the following: (a) making evidence-based conclusions, (b) developing critical-thinking skills, (c) learning skills associated with paleontologic research, and (d) doing scientific research as a team to leverage the strengths and expertise of each team member and allow for the sharing of ideas between peers. Additionally, goals for the upper-level paleontology course include the following: (a) introducing students to scientific literature, and (b) providing students with a multifaceted course capstone experience that utilizes skills developed and content learned in the course (i.e., bringing

---

**FIGURE 1**

Main elements of edrioasteroid morphology.

*A*. A specimen of edrioasteroid *Carneyelli pilea* from Shroat-Lewis et al. (2011). *B*. A drawing of generalized edrioasteroid morphology. Five ambulacrum (A–E) are separated by interambulacral plates. The peripheral rim surrounds the specimen. The periproct (anus) is located between the C and D ambulacrum.

*Note.* Figure 1A shows a specimen of edrioasteroid *Carneyelli pilea* from Shroat-Lewis et al. (2011). Figure 1B shows a drawing of generalized edrioasteroid morphology. Five ambulacrum (A–E) are separated by interambulacral plates. The peripheral rim surrounds the specimen. The periproct (anus) is located between the C and D ambulacrum.
it all together) to address a specific question.

For the upper-level paleobiology course, students are expected to have a basic understanding of edrioasteroids, an extinct group of echinoderms common during the Ordovician. Topics taught in the course prior to this exercise should include basic paleoecological concepts such as population density, age structure, thecal orientation, spatial distribution, and degree of post-mortem disarticulation. Less detailed knowledge is required for the introductory historical geology course. For ease of use, we provide a brief synopsis of these important topics here. A deeper analysis can be found in Shroat-Lewis et al. (2011, 2014, 2019), all of which provide examples of several catastrophically buried edrioasteroid communities for reference.

**Edrioasteroids**

Edrioasteroids (Figure 1A) are an extinct clade of echinoderms that lived from the Cambrian through the Permian and reached their highest diversity during the Ordovician. Their skeletons (theca) are rarely preserved in the fossil record because they disarticulate rapidly after death (Bell, 1976; Brett et al., 1997; Sumrall et al., 2006). Rapid burial is essential to entomb the living benthic community and preserve specimens intact. Examination of edrioasteroid-encrusted slabs provides insight into the benthic community members and their relationships at the time of burial.

The theca consists of a five-part disc-shaped body that is composed of many calcite plates and a peripheral rim. Circling the theca are five arms, or ambulacra, within the body wall that radiate outward from the centrally located mouth (Figure 1A and 1B). These ambulacra grew either curved or straight and are made of plates that open and close for feeding (Sumrall, 2000). Edrioasteroids were sessile obligate encrusters, requiring a hard substrate (such as a carbonate hardground or shell) for attachment. The edrioasteroid theca easily disarticulates post mortem as the flesh that holds the calcite skeletal plates together decays. Thus, rapid burial was necessary to preserve the living community intact.

**Population density**

Density on the substrate is calculated by determining the length of the perimeter, calculating the substrate area, counting the number of organisms in the area, and then using the following equation:

\[
\text{Population density} = \frac{\text{number of organisms}}{\text{area}}
\]

**Thecal orientation**

Edrioasteroids undergo a planktonic larval stage before settling down into a permanent sessile lifestyle. Once attached to the seafloor, the thecal

---

**FIGURE 2**

Example histogram showing edrioasteroid diameter and frequency.

![Histogram](image_url)

**Note.** Modified from Shroat-Lewis et al. (2014).
orientation is irreversible, and no further movement occurs. The edrioasteroid anus is located just posterior of the mouth between the C & D ambulacra (Figure 1B). A preferred thecal orientation would place the anus down current from the oral opening in an effort to prevent fouling during waste elimination. Thecal orientation is determined using the position of the A ambulacrum of each edrioasteroid relative to a “North” direction (Figure 1B). Rose diagrams are constructed using the directional data binned into 30-degree increments (Figure 3). Students in the paleobiology course used PAST: Paleobiological Statistics software package for education and data analysis (Hammer et al., 2001) to plot and analyze their data. This software program is available online for Windows and Macintosh for no charge.

Nearest neighbor analysis

This technique uses one measurement, the distance from one individual to the individual closest to it. Spatial distribution examines the edrioasteroid distribution pattern on the substrate and compares the observed mean distance between nearest individuals to the expected mean distance. To calculate the observed mean distance, total the observed mean distances between each specimen and divide by the number of specimens.

To determine the nearest neighbor statistic, students use the following calculation:

\[ R = \frac{r_{\text{obs}}}{0.5 \sqrt{\frac{a}{n}}} \]

where \( r_{\text{obs}} \) is the observed mean value of the nearest neighbor distances, \( a \) is the area sampled, and \( n \) is the number of points (in this case, the number of edrioasteroids). An excellent exercise and tutorial on the techniques of Nearest Neighbor Analysis (Rodrigue, 1998) can be found online at http://web.csulb.edu/~rodrigue/geog442/labs/nearestneighbor.html.

A clustered distribution is often seen in plants that drop seeds to the ground directly below the parent plant and in animals that live in groups; it also can be an indication of patchy resource availability. A uniform distribution is often associated with animals that stake out and defend territories and can indicate competition for a limited resource. A random distribution is associated with favorable conditions for survival and consistent resource availability.

Taphonomy

The science of the “laws of burial” helps establish processes affecting organism preservation from death, through decay and disintegration, until discovery. A taphonomic scale to assess the degree of disarticulation was proposed by Shroat-Lewis et al. (2011; see Table 1).

Instructor pre-lab preparation

Before beginning the exercise, instructors will need to create “edrioasteroids”—circles cut from sticker paper. Circle punches were purchased from a local or online arts and crafts store and ranged in size from 1/4 inch (6.35 mm) to 2 inches (51 mm). A minimum of four punch sizes should be used to provide a variety of theca diameter options. A simple edrioasteroid theca was drawn on each of the punched circles with the five ambulacra and an anus (Figure 4). Student edrioasteroid sets that were created contained at least 30 specimens and included a random variety of sizes. The exact number of specimens per group could vary, and no two student sets were identical (Figure 4).

Paleoenvironment construction

At the beginning of class, the instructor assigns the students into working groups. The size of the group depends on the class size, but there should be no more than four students per group. Smaller groups provide each member the opportunity to contribute to the project equally through the processes of environment creation, data collection, and preparation of the final product. Smaller groups also mimic the group...
approach to working in a geologic community.

To prepare the edrioasteroid environments, it is important that students complete the following steps in order, one step at a time:
1. Select a sheet of kraft or butcher paper (45–60 cm wide) up to 1 meter in length.
2. Remove the sticker back from the edrioasteroids and randomly attach them to the paper environment.
3. Draw a north arrow on the paper environment (see Figure 4).

For the data collection portion of the lab assignment, students should complete the following steps, which can be done in any order:
1. Measure the outside of the paper environment in centimeters to determine area ($L \times W$).
2. Count the number of edrioasteroids on the environment and perform a density calculation.
3. Measure the width of each edrioasteroid in millimeters.
4. Using a protractor or compass, determine the orientation of the edrioasteroids in a 360-degree space and in relation to the north arrow drawn by students on the environment, with north designated as 0 degrees.
5. Calculate the distance between each edrioasteroid and its nearest neighbor in centimeters.
6. Use a random number generator, found online at no cost, to select a number from 1 through 5 until each edrioasteroid has been assigned a number corresponding to taphonomic grade.

**Student deliverables**

Exposure to relevant papers in the field helps with student comprehension by giving them the opportunity to analyze and critique the work done by others, which improves their own scientific literacy and critical thinking skills. After collecting their data, students in the paleobiology course were required to share their findings with the instructor by writing a mock research article for the journal *PALAIOS*. All appropriate sections—such as abstract, introduction, geologic setting, methods, results, and conclusions—were included in the article. However, because the student-generated slabs were made of paper, there was no collection information about the geologic setting. Instead, students used their notes, textbook, and other edrioasteroid research articles to determine an environmental setting logically consistent with known parameters for successful edrioasteroid survival. Finally, *PALAIOS* author instructions were distributed to help with correct formatting in addition to research by Shroat-Lewis et al. (2011, 2014, 2019), which served as both a reference and model for this part of the exercise.

**Modifications for an introductory lab**

Although an understanding of the detailed paleoecology of edrioasteroids is not necessary for an introductory historical geology course predominantly taken by nonmajors, the inquiry-based learning and critical-thinking skills developed during this activity are useful for all students. Students completed the work during a single 3-hour lab period, in addition to completing a pre-lab assignment designed to give them experience working with the Nearest Neighbor Analysis and a short post-lab write-up of the questions investigated during the lab.

A brief introduction to edrioasteroids and paleoecological concepts was given to the class. Students prepared the edrioasteroid environment as described above and conducted all the calculations except for the assignment of a taphonomic grade to the edrioasteroids. The discussion of the collected data was more surficial and focused primarily on determining what questions could be asked from the data and brainstorming possible explanations of the data collected rather than focusing on correct answers or making a comparison with the published literature.

**Findings and discussion**

Whether incorporated over several class periods in an upper-level paleobiology course or in a single 3-hour

### TABLE 1

<table>
<thead>
<tr>
<th>Taphonomic grade</th>
<th>Appearance of edrioasteroid theca</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Thecal collapse. All plates and ambulacra intact.</td>
</tr>
<tr>
<td>2</td>
<td>Cover plates begin to disarticulate. Shifted disruptions to theca.</td>
</tr>
<tr>
<td>3</td>
<td>Interambulacral plates begin to shift.</td>
</tr>
<tr>
<td>4</td>
<td>Only peripheral rim remains intact.</td>
</tr>
<tr>
<td>5</td>
<td>Peripheral rim is incomplete.</td>
</tr>
</tbody>
</table>
lab in an introductory historical geology course, this inquiry-based paleoecology slab lab offers several benefits. It allows all students to emulate an authentic investigation conducted by professional scientists using hypothesis testing and the scientific method, build critical-thinking and question-asking skills, and gain a deeper understanding of the topic. The activity was constructed in such a way that students used the geological knowledge and scientific-inquiry skills they had acquired over the semester to critically assess their student-created environment. As is most often the case with professional scientists, students collaborated within and between their groups on ways to approach problems; they asked questions, formulated and tested hypotheses, collected and analyzed data, and wrote about their findings in a manner consistent with scientific inquiry.

Although it might not seem intuitive at first, one important aspect of the success of this activity is that students create their own slabs. In doing so, any limitations and pressures are removed for students to find what they believe must be the right answer, one that the professor knows and is not sharing with them. Instead, this activity helps students recognize that when science is done, old hypotheses are modified and new hypotheses are created as data are collected. The lack of a singular right answer allows students to focus instead on making evidence-based conclusions and professors to focus on assessing the students’ critical-thinking skills and ability to provide evidence for claims, which tells the instructor more about what students have learned rather than what they have memorized.

In this activity, we are not just pretending that there is not a right answer for learning purposes. For example, a review of published literature about edrioasteroid thecal orientation shows that some researchers have found that there is a preferred thecal orientation (Smith, 1983), while others have found that there is none (Sumrall, 2001, 2010; Shroat-Lewis et al. 2011, 2014, 2019). Each of these scientists examined different edrioasteroid-encrusted slabs and published different results based on their specific edrioasteroid population, just as students will find different answers based on their created environment.

Instructors should be patient and not step in to answer questions about where the students should start with the laboratory. This is especially true when students are frustrated with where to begin to answer the paleoecological problem. Several groups of students in both the paleobiology and historical geology courses tried to get answers from the instructors without success. Instead, students were instructed to talk among themselves and their groups. Although it happened gradually at first, the student groups were able to formulate a plan, and with time they became more comfortable with the exercise, the data collection process, and the formation of their evidence-based conclusions. Teamwork played an important role in their success.

The students in the historical geology course were not given scientific papers about edrioasteroid paleoecology to use to help interpret their data; rather, the students focused on developing multiple hypotheses to explain the data. For example, when asked to interpret the size distribution of their organisms, many groups made the connection between size and age, even though this was not something...
discussed in the pre-lab lecture. However, one group had the following hypothesis:

The size frequency was not just a display of the edrioasteroids stage in life, either juvenile or mature. Their size could be a result of a lack of food supply—the bigger the edrioasteroid, the more food they had access to.

Another group developed this hypothesis:

The size distribution could be explained by each size being a different species of edrioasteroids, which could explain the random pattern of sizes observed in the graph. If these different-sized edrioasteroids were all of the same species and the different sizes showed growth over time (i.e., the oldest ones would be the biggest), we would have expected to see that most of the population is smaller, with only a few larger ones because less organisms survive into adulthood. The different numbers of each of the different species could be explained by how well they are suited to the environment.

When developing hypotheses to explain the observed cluster analysis, one interesting suggestion was that the cluster of organisms that formed a circular shape with what appeared to be a tail in one group’s environment could be explained as follows:

Edrioasteroids encrusting themselves onto a benthic organism that had a head and a tail in that shape. The benthic organism must have provided a very good habitat to allow so many edrioasteroids to grow on it. The rest of the edrioasteroids could have encrusted themselves throughout a coral reef, explaining the randomness of their placement and the space between them (i.e., the space between them is because of the space between the coral).

<table>
<thead>
<tr>
<th>TABLE 2</th>
</tr>
</thead>
</table>

**Likert Questionnaire Data*.**

<table>
<thead>
<tr>
<th>Statement number</th>
<th>Statement</th>
<th>Mean (paleobiology)</th>
<th>Mean (historical geology)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The instructor seemed genuinely interested in the project.</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>2</td>
<td>I was free to ask questions and express my opinions and ideas.</td>
<td>5.00</td>
<td>4.60</td>
</tr>
<tr>
<td>3</td>
<td>I discussed ideas about this project with others outside the classroom.</td>
<td>4.50</td>
<td>3.80</td>
</tr>
<tr>
<td>4</td>
<td>This project has been (or will be) of value to me.</td>
<td>4.36</td>
<td>3.20</td>
</tr>
<tr>
<td>5</td>
<td>This project inspired me to learn more about paleoecology.</td>
<td>4.21</td>
<td>3.20</td>
</tr>
<tr>
<td>6</td>
<td>This project helped me to evaluate new information and reassess my knowledge.</td>
<td>4.57</td>
<td>4.20</td>
</tr>
<tr>
<td>7</td>
<td>I gained confidence in my understanding of how to properly conduct scientific inquiry.</td>
<td>4.50</td>
<td>4.0</td>
</tr>
<tr>
<td>8</td>
<td>If given the opportunity, I would like to participate in another project-based project.</td>
<td>4.57</td>
<td>4.0</td>
</tr>
<tr>
<td>9</td>
<td>I gained an understanding of basic principles and concepts of edrioasteroid paleoecology.</td>
<td>4.57</td>
<td>4.20</td>
</tr>
<tr>
<td>10</td>
<td>I can apply the general principles that I learned in this project to other topics.</td>
<td>4.71</td>
<td>3.8</td>
</tr>
<tr>
<td>11</td>
<td>Students of every major should experience scientific inquiry in at least one course.</td>
<td>4.93</td>
<td>4.6</td>
</tr>
</tbody>
</table>

*Point values: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree
Note. Paleobiology course n = 14. Historical geology course n = 5
Although the students were not aware of it before the lab began, an example of this phenomenon is often informally referred to as the trilobite bus, wherein a trilobite carried around edrioasteroids on its exoskeleton while it was alive. (A picture can be found at http://www.myfossil.org/files/file/bus-slide/ and has become quite famous to those working in the discipline.)

Some students attempted to make connections between the different data sets (i.e., size and orientation) to develop their hypotheses:

*Individuals in the small, medium, and large size groups faced mostly south. Individuals in the very small size group predominantly faced west. This dichotomy of orientation is difficult to interpret; however, it could indicate some change in the surrounding environment between the conception of the individuals in the small group and those in the very small group. This is because, as obligate encrusters, after the organisms have started to encrust in an area, they cannot change their orientation. As filter feeders, it would have been most advantageous to the organisms to face in a direction opposite that of the current, allowing the most passage of water through them and subsequently more food. Had the current changed, it could have proved more advantageous to be positioned west than south as the older individuals were. The orientation could also explain the grades in size of the organisms that face the south. If the small and medium sized individuals were part of the same generation, and the currents switched to flowing east, then we would expect the west most line of organisms to be the largest as they would have been exposed to the most nutrient dense water; not yet filtered by other edrioasteroids. This fits with the observed distribution of individuals, with the largest individuals appearing in the west.*

**Student feedback**

To assess students’ perceptions of the effectiveness of this exercise, we used a two-part questionnaire consisting of Likert-type statements and free-response questions. All students involved in the courses were asked to participate; however, participation was voluntary. The questionnaire was given to the students at the end of the project. Likert statements were generated from a review of literature on inquiry-based teaching and student evaluations. No demographic data were collected. Overall, students responded favorably to the laboratory despite some initial hesitation about the inquiry-based learning approach (Table 2).

The mean was calculated for the responses to each statement in the Likert questionnaire (Table 2). Students in the paleobiology course rated all statements above a 4.0, and students in the historical geology course rated most of the statements above a 4.0. Scores were slightly lower overall for the historical geology class, which can happen when only five students take the survey. A higher response rate might have captured the opinions of a wider range of students (e.g., first-year vs. second-year students and nonmajors vs. majors). Overall, these high scores indicate that this exercise contributed to student understanding of the scientific process and helped students with their understanding of paleoecology.

Two statements that received high scores in both courses were the following:

1. I gained confidence in my understanding of how to properly conduct scientific inquiry.
2. I can apply the general principles that I learned in this project to other topics.

This suggests that students are confident in their ability to use the accepted research practices effectively, which in turn ensures integrity in future research processes. Self-confidence, the belief one has in being able to successfully execute a task to gain a desired outcome, plays a vital role in both the learning and performance processes. In teaching geology, instructors have often heard “I’m just not good at science,” when, in fact, students have just not had enough practice to gain the confidence needed.

Another important statement that received high scores in both classes is “Students of every major should experience scientific inquiry in at least one course.” This suggests that students enjoy the research challenge when given the opportunity, which makes the work more meaningful and the skills more transferable. It also shows the importance of true scientific inquiry being used in introductory labs where there are students with a variety of majors.

All of the responses—but the responses to these three statements in particular—suggest the activity learning objectives are being met. These data indicate that students not only recognize the importance of working outside of their comfort zones but also enjoy doing so. This activity pushes students’ boundaries by allowing them to engage in critical thinking.
and develop evidence-based conclusions rather than following a recipe provided to them, which is often the case in traditional undergraduate labs.

For the free-response data, summarized in Table 3, students responded that the most important things they learned from this project were (a) that science is doable by everyone, and (b) that there are different methods for analyzing data. Responses such as these and others found in Table 3 suggest that the project provided students with a sense of empowerment, in that they gained confidence knowing they were able to address a research question currently being pursued by research scientists.

**Conclusions**

The results of this exercise are encouraging for faculty who would like to do more inquiry-based learning to promote critical-thinking skills in their courses but lack the resources to do so. We have shown that student-generated environments can be just as beneficial when the rocks are not available without compromising the integrity of the discipline. Furthermore, this lab does not have to be restricted to edrioasteroids, as any organism that is sessile in nature, such as trees or coral reefs, could be substituted in their place. As we search for better ways to engage students at all levels of academia in the scientific process, faculty should consider being creative with the materials available to them, keeping in mind that we want to not only help students learn how to think but also make their work meaningful. This exercise helps students build self-confidence and shows them that they, in fact, can do science. Finally, these results demonstrate how inquiry-based learning does not have to be reserved for upper-level students and that more advanced inquiry-based activities can be easily adapted to whatever level of student is being taught.

**Acknowledgments**

We would like to thank the students who participated in this exercise. We thank Colin Sumrall at the University of Tennessee, Knoxville, who inspired this exercise by having students in his paleobiology course do the Slab Lab using real rocks. Finally, we thank two anonymous reviewers whose thoughtful comments and suggestions contributed greatly to this manuscript.

**References**


René A. Shroat-Lewis (rashroatlew@ualr.edu) is an associate professor in the Department of Earth Sciences at the University of Arkansas at Little Rock in Little Rock, Arkansas. Melissa Hage is an assistant professor of environmental science in the Division of Natural Sciences and Mathematics at the Oxford College of Emory University in Oxford, Georgia.