Using Photographs as Case Studies to Promote Active Learning in Biology

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If a picture is worth a thousand words, think about how long it takes your students to read a thousand words. Case studies are effective and stimulating ways to teach a variety of subjects, including the biological sciences. In learning the details of a particular case, students develop skills in both deductive and inductive reasoning, hypothesis forming, and developing tests for hypotheses, among others. Reading and developing case studies takes up a great deal of time, however, and this is not always practical in a class like introductory biology in which time is critical and large amounts of information must be covered. We present here the use of photographs as case studies for biology teaching—not as a substitute for regular lecture time, but as a supplement to it.

The basic principle of using case studies in teaching sciences is to give students a single specific circumstance or example that allows them to deduce general principles. Such cases are often used prior to more traditional classroom techniques in order to make students understand the nature of the information and thought processes that they need to develop to fully understand the case at hand. Alternately, case studies may be presented after material has been discussed in class to help students understand why the material and thought processes they just learned are important to them personally. Whenever they are applied in the classroom setting, case studies usually involve the incorporation of video or text materials in the class, then engaging in lengthy class discussions to elicit responses indicative of insight and/or understanding from students.

Case studies often take up a large amount of time, both in class for the instructor and out of class for the students. Reading long cases can be difficult and, in classes where there are already hundreds of pages of reading, may simply be too daunting to students. It might therefore seem odd to advocate for the use of case studies to supplement lectures rather than substitute them, but especially in the case of introductory level classes, we have found that it is well worth the time when a photograph can be used as a case study. In upper-level classes, case studies are well worth the time they take, but in introductory classes students typically need to be given a large amount of information before they can begin to think about cases effectively or simply to satisfy state requirements or pass a standardized exam. Spending a few extra minutes under these conditions to use a photographic case study reinforces points, helps students internalize information, and gives students an image to associate with a concept aiding them in recall on exams.

The photograph as a case study

An individual photograph preserves an instant frozen in time. At first thought, the instantaneous nature of a photograph may seem like its chief drawback as a case study, but in fact it is one of its greatest assets. Because the photograph does preserve only a particular 1/125th of a second or so, it invites the twinned questions: What happened just before this moment? and What is going to happen next? In order to answer the
first question, students must invoke deductive reasoning: If I see this, then X, Y, and Z must have occurred to get the subjects of this photograph to this point. To answer the second question, inductive reasoning must be used: Because I am seeing this and I have reasoned that it occurred because X, Y, and Z happened, then it is logical that A, B, and perhaps C or maybe D should follow, depending on how the variables develop.

Inductive and deductive reasoning are the hallmarks of scientific thought, and interpreting a photograph creates an easy and instinctive way for students to develop these abilities. Perhaps the most important part of using a photograph as a case study is that students will readily come to these conclusions and develop a comfort level discussing their often conflicting interpretations with each other. As a classroom discussion commences, they will typically become convinced of their interpretations. At this point the instructor has the ideal opportunity to hit them with the question they are not prepared for: Why?

Students typically will have a high degree of certainty about their interpretation, but they usually will not have thought about why they think what they think. How could one student have applied one principle to the photograph and a second student applied another? Although it may seem obvious to an instructor, it will not be as obvious to a naïve student. Asking students “why” forces them to evaluate what they thought and to recognize their own ability to think about situations and apply scientific principles. Further discussion about the “whys” of the photograph will enable a class to recognize that one interpretation is most likely to be correct, or that both interpretations may be correct and independent of one another, or that in fact the two interpretations are actually synergistic with one another. Simply looking at a photograph in the context of a classroom lecture can elicit classroom discussions, build students’ confidence with their knowledge of and ability to apply material, and help them develop the critical skills of both deductive and inductive reasoning—all in much less time than a traditional case study.

In terms of their application in the classroom, photographic case studies can fit in easily anywhere. Typical uses fall into two categories: just before the introduction of a new topic and just after completion of a topic. We have used them in both contexts and found that the efficacy of the position of the case study in the class program is dependent on the audience. When dealing with introductory college science classes (e.g., general biology, general geology, and anatomy and physiology), we have discovered that it is most effective to use photographic case studies just after completion of a topic. This placement gives students a break before moving on to new subjects and a chance to immediately apply what they have learned. This process certainly helps students internalize the information and develop confidence with new material. The students also appreciate the photograph as a hook to help them remember different principles. We have frequently been approached by students with tales of being confused on an exam but then remembering a photograph from class and getting the answer right.

At the introductory level, students often don’t have the base of knowledge needed to ask the appropriate questions about a photograph to develop new ideas, and so using photographic case studies to introduce a new subject is usually less profitable. In upper-level electives and graduate courses, however, starting off with a photographic case study can be an excellent method. Under these conditions, students should be trained to ask questions and induce predictions on the basis of data. A photograph provides an excellent source of data for these inductions and can lead to very useful classroom discussions. We have found that the most effective way to begin a topic using photographic case studies is to present the photograph to the students and then ask them to make observations of what is happening. Once these observations are tallied on the board or screen in a “what” column, an instructor can begin a “why” column. A “what next” column comes next in the series, followed by a “what do we need to know” column. This is usually the key column because it creates the opening for students to figure out what the next topic of discussion in the class should be. With a good group of students, the class will figure out exactly what it needs to learn in agreement with the syllabus a surprising proportion of the time with only a little prodding from the instructor. Such a method gives students not only a sense of accomplishment and confidence, but also a sense of ownership over the material. A course is no longer just an assemblage of information that someone else has decided they need to know, but it is a collection of inquiries that they developed and information that they decided was necessary to understand a selected portion of their world.

Examples
Photographic case studies can easily be used to teach a wide range of science subjects. We have used them most extensively in the field of biology, but they can certainly be used
in other disciplines as well. Geology is particularly well suited to photographic case studies, and there are even many applications in chemistry and physics. Photographs of rock outcrops or hand specimens provide mechanisms for students in an entire class to apply their knowledge simultaneously and without ambiguity. Photographs of ice on a pond or erosion on a statue are excellent entry points for discussing the importance of certain types of atomic bonds and chemical reactions. Photographs of building sites or dinosaurs provide excellent examples of the principles of mechanics, leverage, and torque in a physics class. Because we are primarily biologists, the examples we present here are biological in nature and intended to elucidate a variety of ecological principles.

Figure 1 is a photograph of a breeding male Common Yellowthroat. This is a common species of wood warbler found throughout the lower 48 states. Although it is a common bird, it is unlikely that students will be familiar with it. At first glance this looks like a cute, healthy little bird, but when asked to look more closely, students will notice some telltale signs of poor health. There is a fairly obvious growth or tumor of some sort on the bird’s bill and some of the toes are malformed. When asked if they think that these conditions are having an adverse effect on the bird’s ability to function, students will look at the full feathers and plump physique and usually decide that the bird is doing just fine. When they see the photograph on the opening page, a healthy male Common Yellowthroat, they will notice some significant differences. In the first bird (Figure 1), the plumage is much paler and the black mask across the face is dull and flecked with white feathers. Now students realize that although the first bird seems to be functioning and feeding well in its environment, it is not able to commit the metabolic resources necessary to developing ideal breeding plumage. When asked “Which bird would you rather mate with if you were a female Common Yellowthroat?” students universally pick the second male (opening photograph) and, in so doing, recognize the importance of sexual selection in evolution and ecology. In a very few minutes, the important distinction between reproductive fitness and environmental fitness has been internalized, as well as the connection between health and metabolic resources and how these factors are advertised to potential mates. A wide range of important biological principles have just been independently discovered by each student in the class with an example out of their own backyard to remember them by.

A more involved example is presented in Figure 2. This is a particularly fun picture (shot in Central Park in New York City) that takes more time to go through, but involves many different learning points. It has been our experience that most classes will have at least one student interested enough in baseball to recognize the bird as a Northern “Baltimore” Oriole. It doesn’t look quite right, though. Why not? It’s missing the black head associated with the typical adult male Oriole depicted on the baseball team’s
caps and numerous other symbols associated with the state of Maryland. Why? This bird is either a subadult or in winter plumage. Breeding plumage doesn’t just attract females of the species, it also triggers aggression in males. This aggression helps males establish nesting territories but would be a waste of resources at other times of year. Alternately, it is a disadvantage for juveniles to engender aggressive responses from adult males early in their lives when they cannot mate and are ill prepared to defend themselves. The simple plumage pattern reveals some profound points about animal behavior and adaptation to social systems.

The oriole’s appearance elucidates interesting biological principles, but looking at what it is doing brings up many more. At first glance the bird appears to be pecking at a leaf, but why? Does it eat leaves? Looking at the shape of the bill it certainly doesn’t look like it would eat a leaf. What part of the leaf is it pecking at? If you look you can see a pale patch in the leaf. This pale spot is an area where a leaf miner insect is eating its way through the mesophyll of the leaf. Leaf miner larvae burrow through a leaf’s epidermis into its mesophyll and then chew their way through the leaf without being exposed on its surface, reducing their exposure to predators. The oriole, however, has keyed into this strategy and has a bill with a sharp enough point to enable it to peck through the weakened section of the leaf to extract the insect within. Look around the bird and in the background and you will notice that many leaves have many holes in them that are the result of the actions of leaf miners. In spite of the holes, the leaves are bright green, turgid, and apparently in good health. There is clearly a complex ecological interaction among the plants as producers, the parasitic leaf miners as primary consumers, and the oriole whose role as a secondary consumer keeps the plants in relatively healthy condition. Is this interpretation correct? Maybe, but whether or not it is, students are suddenly discussing complex ecological principles and gaining an understanding of their environment that will stay in their heads when exam time rolls around.

Photographs need not be as complex as these, either; simple points can be just as important. A photograph of a shark compared with a reef fish will illustrate important points about anatomy. Simple photographs of different animals eating make excellent entry points for discussions about the digestive system or trophic dynamics. Walk into a forest and stand at the foot of a tree, then point the camera up and you will have an excellent photograph to discuss the principles of transpiration or the structure of a water molecule that make it possible. Finding opportunities to create photographic case studies is simple; one just needs to pay attention to one’s environment and carry a camera.

Conclusions
Case studies add to any style of teaching and clearly help students develop a better understanding of difficult material. They also take a lot of time. A photograph contains a huge amount of information in a form
that is easily accessible to all students. Learning by looking is innate to all people and forms the basis of our earliest forays into assimilating information into our consciousness. Using a photographic case study creates all the benefits of any other form of case study in class, but with much less time being consumed. Depending on the course one is teaching, this saving of time may be a very important consideration. In upper-level electives, one can devote a lot of time to single subjects, but when teaching a general biology or any other introductory science class, one is obligated to cover a vast amount of material. It doesn’t matter if the course is aimed at educating students for the Medical College Admission Test or an Advanced Placement exam; there is a great deal of pressure on an instructor to finish the syllabus. Using photographic case studies allows an instructor to significantly enhance his or her lectures without a significant loss of class time.

Finally, it has been our experience that the most important aspect of using photographic case studies is that the instructors make a personal effort to create them. The senior author (Krauss) has been taking wildlife photographs such as those figured here for years and often shares them with his class. When an instructor presents the case, leads a discussion about what may have happened, and then finally relates that this was a photo he or she took over spring break or last week in the park, students are more likely to personalize the case and, through it, the information being taught. Photographs don’t have to be perfect National Geographic-quality shots, but the use of personal photographs lets students know that their instructor cares and is making an extra effort. If one is not comfortable taking pictures, then making an effort to find pictures on the internet is also worthwhile. The point is to make an effort to find extra material and let the students know that there is more to a subject than what is in their textbook.

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