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The Insect Connection

Using insects as a common teaching tool for many science lessons

I FIND INSECTS TO BE TERRIFIC CLASSROOM subjects. They are cheap, abundant, and easy to find. In the life science arena there is little that cannot be studied using insects. The possibilities are intriguing—insects lend themselves well to studies of diversity, genetics, taxonomy, locomotion, ecology, water quality, anatomy, and physiology.

Each year, students submit insect collections at the end of our diversity and taxonomy unit. The collections are only required to contain 10 insects representing 8 orders, but students become well acquainted with the most common orders of insects as the specimens are collected and classified. Students used to ask what they would do with the collections next, and it was anticlimactic when I said they could take them home. Now I respond that we will save them for the next unit—geology.

GEOLOGY WITH INSECTS

Jurassic Park (Crichton, 1993) was the spark that led me to begin a geology unit with the study of insects. Most students are familiar with the movie or the book, providing a basis for a discussion about the probability of extracting dinosaur DNA from ancient insects. Questions frequently asked are: How long does the blood in the mosquito saliva remain undigested? How would an animal as fragile as a mosquito be preserved as a fossil? What kinds of insects were alive during the Jurassic period? Could scientists really extract DNA from a fossilized insect?

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After doing some research I realized that the likelihood of extracting enough DNA from a fossil insect to produce a dinosaur is comparable to randomly pulling letters from alphabet soup and coming up with the Bible. However, I did find reports of scientists being able to extract ancient termite DNA (not dinosaur DNA) from amber (Grimaldi, 1993). This process is now being questioned, and some researchers think that past claims of success may have been the result of stray DNA from living organisms contaminating the laboratories. To date, no one has been able to replicate these results (Gibbons, 1998). I explain these studies to the class, relegating the re-creation of dinosaurs to the realm of fiction. We then progress to easier topics, such as the preservation of insects in amber and the evolution of insects.

When I return students' insect collections, I give each of them a chart of the geologic time periods and the common orders of insects that evolved during each period (Figure 1). I also give each student a Styrofoam strip that is the same length as the chart and is marked with spaces corresponding to the time periods on the chart. Students align the Styrofoam strips with the geologic chart, remove their insects from their collections, and position the insects on the Styrofoam strip in the

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spaces representing the time period during which each insect order evolved.

During the diversity and taxonomy unit students are expected to classify insects in the 14 most common orders. This is a good review of the insect orders and quickly introduces and familiarizes students with the geologic periods. Students are assessed on the number of insects they successfully place in the correct time periods. Rarely does a student miss more than one. The assessment can be done quickly if students leave insects pinned in the Styrofoam strip, lined up with the chart.

Some students do not want to take apart their collections, so I allow them to write the names of their insects and the corresponding geologic periods on pieces of paper and lay them on top of the collection display boxes. Such displays are a little more time consuming to assess but allow the collections to stay intact. The discussion, activity, and assessment can all be accomplished in a 55-minute period.

In the following class, we discuss each geologic time period and the insects that evolved during the period. Special note is made of the Carboniferous period with its oversized cockroaches and giant dragonflies, and I call attention to the fact that all modern orders of insects had arrived on the scene by the end of the Cretaceous period. Students find it quite interesting that, if they could slip back in time to the Jurassic scene, they would see representatives of all the modern insect orders except butterflies, moths, termites, and fleas. From this point, the discussion moves to which plants students would see during the Jurassic period. Would there be flowers? What about rodents? (I explain that the Jurassic world was one of gymnosperms, small mammals, and primitive birds—flowers did not appear until the Cretaceous period.)

GEOLOGIC RESEARCH

Next, pairs of students must choose a geologic time period to research. Students tend to choose the Jurassic period because they are most familiar with that term. So, I supply library books that include pictures as well as text for students to investigate before choosing the time period they will research. I encourage students to make choices that will result in all geologic time periods being covered by the class.

The assignment is to prepare a poster depicting a total ecosystem within a given geologic period. For example, students who choose the Mesozoic era should present a poster in which dinosaurs are surrounded by a representation of large animals, small animals, and plants appropriate to that time period. "Small animals" encompasses the insects, salamanders, lizards, mollusks, crustaceans, birds, rodents, and so forth. If a marine environment is represented, invertebrates as well as vertebrates should be included in the presentation. Students must label the ancient organisms on their poster, exhibit the

FIGURE 1.

Geologic time periods and insects that evolved during each.

CENOZOIC	Quaternary 2 million years ago					
CENOZOIC	Tertiary 65 million years ago	**bees** bent antennae body quite hairy narrow waist and stinger				
MESOZOIC	Cretaceous 144 million years ago	**termites** thick waist	**fleas** small; no wings	**butterflies & moths** antennae often knobbed or feathery and scales on wings	**ants** bent antennae narrow waist	
MESOZOIC	Jurassic 208 million years ago	**earwigs** wings do not cover abdomen				
MESOZOIC	Triassic 245 million years ago	**wasps** bent antennae narrow waist and stinger	**flies** only two wings			
PALEOZOIC	Permian 286 million years ago	**caddisflies** looks like brown moth but no scales on wings	**stoneflies** aquatic insects; two tails	**net-veined insects** lacy wings	**beetles** hard forewings soft hindwings	**hoppers** small triangle between wings; wings do not overlap
PALEOZOIC	Carboniferous 360 million years ago	**cockroaches** flattened body long antennae	**grasshoppers** long, tough forewings large hind legs	**dragonflies** clear wings slender abdomen	**mayflies** aquatic insects three tails	**true bugs** triangle between wings; overlapping wings
PALEOZOIC	Devonian 408 million years ago	**springtails** no wings small				

poster in class, and present at least a 3-minute lecture about the time period.

There is much discussion in class as the posters are being prepared. Students who choose the Permian period, for instance, might want to know if they should include all animals in the time periods prior to that since those animals would have already evolved. Such questions lead to discussions of extinction and the length of time certain species populated the Earth. The topic of extinction is confusing to students because the insect charts were prepared with only modern insect orders. Students can include any insects on the chart that are below the time period they are surveying because all the insects on the chart are still living today.

Another question that always comes up is: How do we know what color to make the animals? This opens the door for a discussion of uniformitarianism. We explore the concept that the present is the key to the past by considering dinosaurs. Species of modern birds and reptiles (dinosaurs' nearest relatives) include both camouflaged and brightly colored animals. Students need to think about dinosaurs' habitats and behaviors to decide what their coloration would be. This process gives them an idea of what paleontologists must consider as they try to re-create a species from bone fragments.

Preparing the lectures and posters takes about a week of 55-minute class periods. Assessment is based on accuracy of information in both the poster and lecture. Clarity, organization, and familiarity with the subject are also criteria on which the presentations are assessed. This activity is aligned well with the *National Science Education Standards* because it emphasizes the evolution of life at a level that is appropriate for high school students who are capable of understanding such a long-term process.

The main purpose of the exercise is to familiarize students with the terminology used when discussing the geologic past and to provide a basis for the study of stratigraphy in which we discuss local rock strata and the time periods in which they developed. When I turn to a discussion of the Devonian fossils found in the mountains surrounding their homes, students understand. This activity also makes it easier to discuss more advanced geological concepts such as plate tectonics and it puts processes such as mountain building into a more realistic perspective.

The most satisfying aspect of this activity is that it successfully integrates the life sciences with the Earth sciences. Recently, a student interrupted me as I was pointing out the different organisms that had evolved from Devonian to Carboniferous to Jurassic to Quaternary and said, "Hey, it all fits together! It's almost like the classification system!" I could only smile. They were finally getting it. ✧

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NOTE

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FIGURE 2.

Presentation assessment criteria.

Poster	Oral presentation
Includes large animals	When did period occur?
Includes small animals	Important geologic events
Includes plants	Interesting specific details
Organisms labeled	Clarity
Includes name of period	Familiarity with subject

Each item is worth 2 points with the maximum number of points being 20.

Note: The reason that the organisms are listed as large and small animals rather than vertebrates and invertebrates is that the earliest periods had no vertebrates. Also this ensures that students will include both large and small vertebrates during the Mesozoic.

AMBER AND EVOLUTION

Amber is a hard, yellowish-brown substance that comes from resin exuded by conifers. Often, insects were trapped in the sticky sap before it hardened into amber, and the resinous compounds in the sap prevented the trapped insects from decomposing. The transparent qualities of amber allow these fossilized insects to be studied in three dimensions.

The amber with which most people are familiar is Baltic amber, which is from a huge forest of extinct pine trees that stretched from Germany to the Ural River in Russia. More than 150 000 fossil insects have been collected in this region, mainly from the alluvial soils near rivers and beaches. Baltic amber was formed during the Tertiary period after the extinction of dinosaurs. The Dominican Republic amber used in the movie *Jurassic Park* was also of Tertiary origin and therefore is incapable of harboring dinosaur blood.

However, there was some amber formed during the reign of the dinosaurs. Cretaceous amber has been found in western Canada and in New Jersey. Midges have been found in this amber. True modern midges resemble mosquitoes but do not bite, so it is likely that ancient midges were not blood-sucking creatures either. And although insect fossils are also found in shale and in tar pit remnants, these fossils do not contain the actual insect as amber does. They are simply molds, casts, or carbon prints of the insects.

The majority of modern insect orders evolved long before the dinosaurs, and the Paleozoic era is known as the age of insects. The earliest fossil insects are springtails, which evolved in the Paleozoic era more than 400 million years ago. Springtails can be found today living in soil, decaying material, and on pond surfaces.

One of Earth's most successful creatures, cockroaches, evolved in huge coal-producing swamps approximately 360 million years ago. Cockroaches have changed very little since then. It is interesting to consider how these lowly creatures have survived eons of upheaval and change when such magnificent beasts as *Tyrannosaurus* and *Triceratops* succumbed to extinction.

Dragonflies appeared on the scene about the same time as cockroaches. The ancient dragonflies included an extra-large species with a 75-centimeter wingspan and a 38-centimeter-long body. These giant dragonflies, the largest insects ever known to exist, became extinct toward the end of the Paleozoic era, but smaller species have survived to modern times.

By the end of the Permian period, about 245 million years ago, 14 modern orders of insects had evolved. These included beetles, grasshoppers, lacewings, caddisflies, stoneflies, mayflies, and true bugs. The presence of these orders means that the adaptations of complete metamorphosis and incomplete metamorphosis had appeared in the scheme of evolution by that time.

Several other insect groups emerged simultaneously with the evolution of dinosaurs during the Mesozoic era. Wasps and flies appeared at the same time as the early dinosaurs. By the Jurassic period, all but six of the common modern orders of insects had evolved. Butterflies, fleas, ants, and termites evolved in the company of *Tyrannosaurus* during the Cretaceous period, as did flowering plants, which evolved with bees in the Tertiary period.

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