SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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Student Materials

Learning Sequence Item:

907

Fossil Formation

March 1996
Adapted by: Brett Pyle

Contents

Lab Activities

Readings

This micro-unit was adapted by **Brett Pyle** (Grady Middle School, Houston)

Student Sheet

Science as Inquiry

What a Sap!

How can insects be fossilized?

Overview:

A fossil is any preserved part or trace of an organism that once lived. How many types of fossils can you think of? Are all fossils formed by the same process? As you consider the entire history of living things on Earth, you can imagine a wide range of organisms, from microscopic one-celled creatures to huge ferns and trees, many of which became extinct before modern humans (*Homo sapiens*) appeared on the scene. It is fascinating to study these ancient organisms based on the evidence available today. In this activity you will simulate one form of fossilization involving the natural hardening of tree sap.

Procedure:

Collect a dead insect for use in this activity. Place a layer of mucilage or hardening resin in a small cup. Carefully place the insect on top of the resin and set the cup aside to dry. Add a second layer of resin on top of the insect and again allow it to dry. You should now be able to remove the fossil.

Be sure to read "Brushing the Dust off Ancient DNA" before answering the questions below.

Questions:

1. Amber is hardened tree sap. Insects are attracted to the sweet sap. Explain how an organism becomes encased in amber.

2. What types of organisms would you expect to find fossilized in this manner? Why?

3. What types of things can you find out about an organism fossilized in this manner?

4. Why is amber such a good preservative?

Student Sheet

Science as Inquiry

You've Made Quite an Impression on Me

How are molds and casts formed?

Overview:

Ancient amber pieces that have been found are no more than six inches long. Obviously, this limits the types of organisms that can be fossilized by that process. Fossils may also be molds—hollows that are left in rock after the organic material decays. They may also be casts—mud that fills the mold in the rock and then hardens. Like amber fossils, molds and casts preserve certain features but not others. As you do this activity consider what types of organisms are likely to be fossilized by this process and what you can learn from these types of fossils.

Procedure:

Select a shell or fossil from which you will make a mold. Your teacher will provide plaster of paris for this activity. Prepare your shell or fossil with a light coat of a nonstick substance to make it easier to remove it from the plaster mold. Create your mold by pressing your specimen into the plaster, but do not press it more than halfway in or it will be extremely difficult to get it out without breaking the mold. It will be easiest to remove your specimen when the plaster is firm enough to retain the imprint but is still slightly wet.

Once the mold is completely dry, coat the inside with nonstick substance and then fill the mold with fresh wet plaster to form a cast. Remove the cast when dry.

Questions:

1. Compare the original organism to the cast and mold that you made. Describe what characteristics of the organism you can accurately determine just from looking at the mold and cast.

2. Describe what characteristics of the organism you cannot accurately determine just from looking at the mold and cast. Explain why these characteristics cannot be accurately determined.

3. What types of organisms are most likely to be preserved in this way? Explain why.

Student Sheet

Science as Inquiry

Track ‘Em Down

What can you determine about dinosaurs from fossil tracks?

Overview:

Scientists in various fields interpret the fossil record. Fossils represent the only direct evidence of evolutionary history. Inferences and conclusions about past life-forms are based upon the available evidence and reasonable analogies and comparisons with modern-day existing life-forms. For example, studies of upright tetrapods (humans are classified as bipedal tetrapods) have indicated that regardless of size, all types of tetrapods move in approximately the same manner. You can use such knowledge and a value called dimensionless speed to study fossilized dinosaur tracks. What other information can tracks provide? How do these fossils compare to the others you have studied?

Procedure:

Work in groups as directed by your teacher. To estimate dinosaur speeds based on their tracks you must first create a reference graph from measurements of all the students in your class. Find an area where you can lay out a 10-meter-long track to measure your speed and stride length. Each person in your group should be timed over the 10-meter course and actual speed (in m/sec) determined for each. You can choose to walk, run, or jog in order to cover the 10-meter course. In any case, two lab group members should mark the spot where the toe of the right foot hits on successive landings to determine stride length. Stride length and actual speed for each member of the group should be recorded in a data table.

Dimensionless speed is a calculated value that relates the actual speed of an animal to leg length and stride length. With this value, data collected on humans can be used to determine speeds of dinosaurs.

Prepare data tables like the ones below. Use appropriate measurements and calculations to complete the tables, using the following formulas when necessary:

$$\text{dimensionless speed} = \frac{\text{actual speed (meters/second)}}{\sqrt{\text{leg length (meters)} \div \text{gravitational acceleration (meters/s}^2\text{)}}}$$

$$\text{actual speed} = \text{dimensionless speed} \times \sqrt{\text{leg length (meters)} \div \text{gravitational acceleration (meters/sec)}}$$

$$\text{leg length of dinosaur} = \text{footprint length} \times 5$$

Table 1

student	stride length (m)	time to go 10 m (sec)	actual speed (m/sec)	dimensionless speed (m/sec)

Table 2

track set	footprint length (m)	leg length (m)	stride length (m)	dimensionless speed	actual speed (m/sec)

Construct a graph of stride length vs. dimensionless speed of all the students in your class. Stride length should be on the Y-axis. Use stride length of the dinosaur and your graph to determine dimensionless speed of the dinosaur. Record this information and use it to calculate actual speed of the dinosaur using the appropriate formula. Using the following diagrams of dinosaurs and their tracks, identify what type of dinosaur made the tracks that you measured.

Questions:

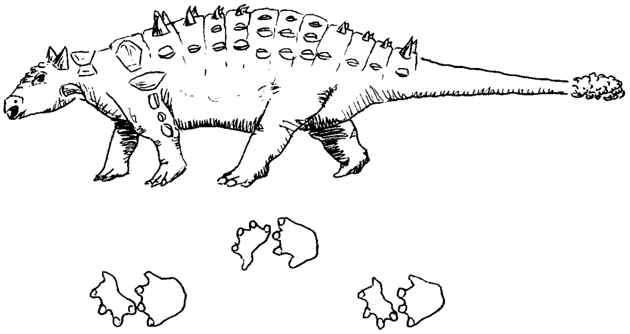
1. How do fossil tracks compare to other types of fossils (like amber, molds, and casts) in terms of the information they provide about the organism that made them?

2. Tell whether the dinosaurs were running or walking when they made the tracks you studied. Explain how you determined your answer.

3. Could you outrun the carnivorous dinosaur whose tracks you measured? Explain why or why not based on your data.

4. Young animals, such as puppies, have large feet relative to body size. If you had tracks made by a young dinosaur with large feet, would the speed calculated from tracks be overestimated or underestimated? Explain why.

A.



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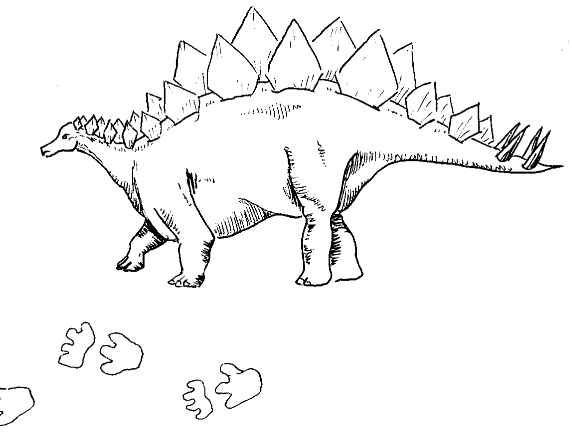

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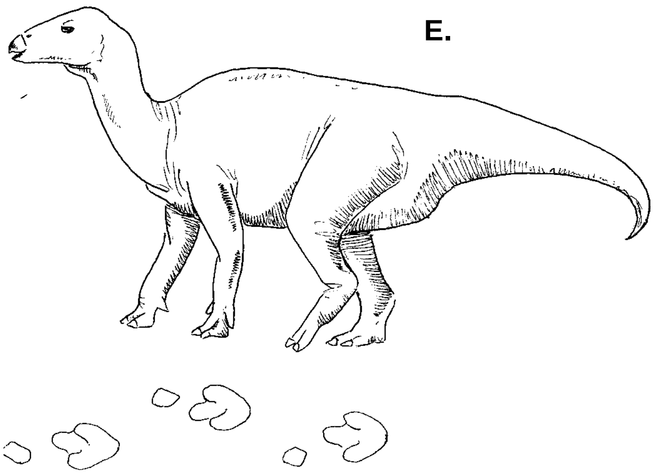

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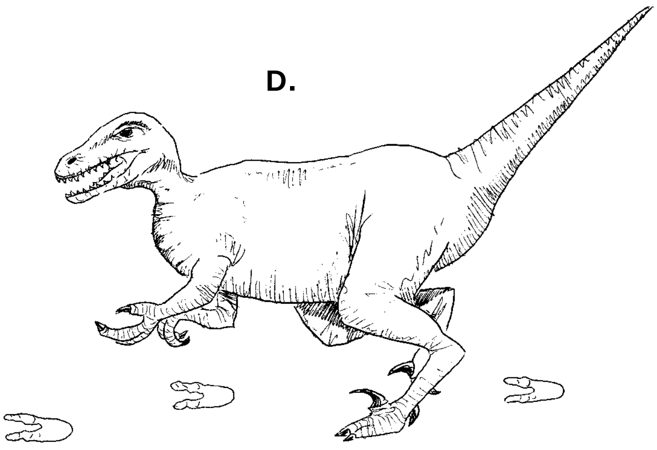

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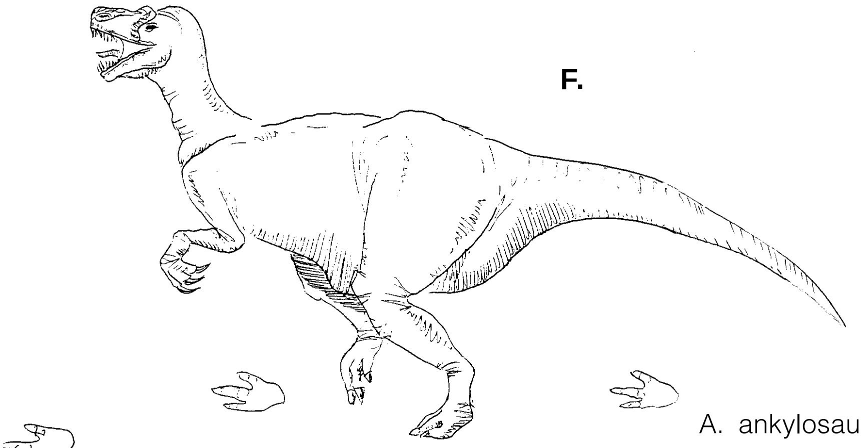


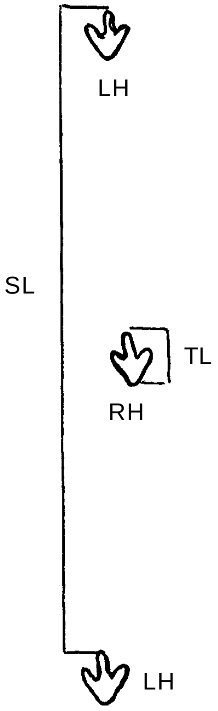
A. ankylosaur *Euoplocephalus*
B. stegosauran *Stegosaurus*
C. sauropod *Brontopodus*
D. raptor *Velociraptor*
E. iguanodont *Iguanodon*
F. carnosaur *Carnosaurus*

A. carnivorous dinosaur trackway
B. quadrupedal herbivorous trackway

SL = stride length
TL = track length

The tracks are labeled right (R), left (L), front (F), and hind (H).

A.



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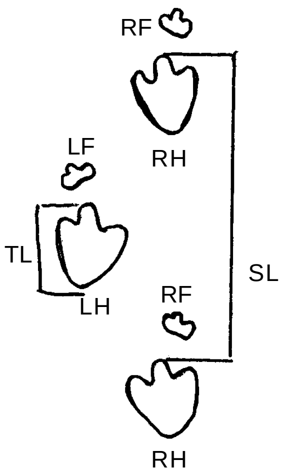


Science as Inquiry

Makin' Tracks

How do you study animals you can't see from evidence they leave behind?

Overview:

Ancient animal tracks are just one form of fossil to be considered in this micro-unit. Any indication of an organism's former presence is considered a fossil. Fossils may be footprints, burrows of worms, nests of insects, pieces of amber, molds, casts, or even hardened dung. Each fossil type may reveal limited information about ancient life forms, but taken together they provide valuable clues to what the environment and ecology was like. Many scientists specialize in the study of fossils. Paleontologists look for and study fossils. Geologists use fossils to explain the history of the earth. Physical anthropologists study human fossils. In this activity you will learn about the work of these scientists and consider for yourself what information you can gain from animal tracks.

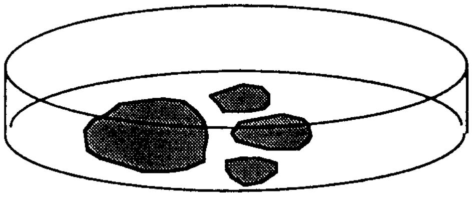
Procedure:

Your teacher will direct you to an area where you can locate and study animal tracks. Ideally you could visit a local nature preserve or park, but the activity could be done on your school grounds.

Use a field guide about animal tracks for your area if one is available. Working in groups as directed by your teacher, locate as many different sets of tracks as possible. Use your field guide to identify what animal made the tracks. For each set of prints that you find, try to note as much as possible about the animal that made the tracks, such as stride length, dimensions of the prints, approximate size and weight of the animal, etc. You should discuss with your lab group what other information can be reasonably inferred from the tracks and include these observations in your notes. You may wish to categorize your observations as either fact or inference; discuss the difference with your lab partners.

Make an outline drawing of all of the different tracks you have seen. Give the name of the animal under each if you were able to identify it.

When you locate a good print, make a plaster cast of the print for further study and reference when you get back to the classroom. A good print is well defined and complete and has some depth (at least 2–4 mm). To make a cast, first clean any leaves, sticks, or other debris from the track. Then place a cardboard ring around the print (cut cardboard to the approximate size needed), tape it in place, and pour plaster over the print, partially filling up the ring (see figure below).



Placement of cardboard ring around print to hold plaster.

After allowing the plaster to dry, remove the cast, brush away any excess dirt, and label it. If enough plaster is available, make casts of three to four consecutive footprints in order to study stride length and movement.

Questions:

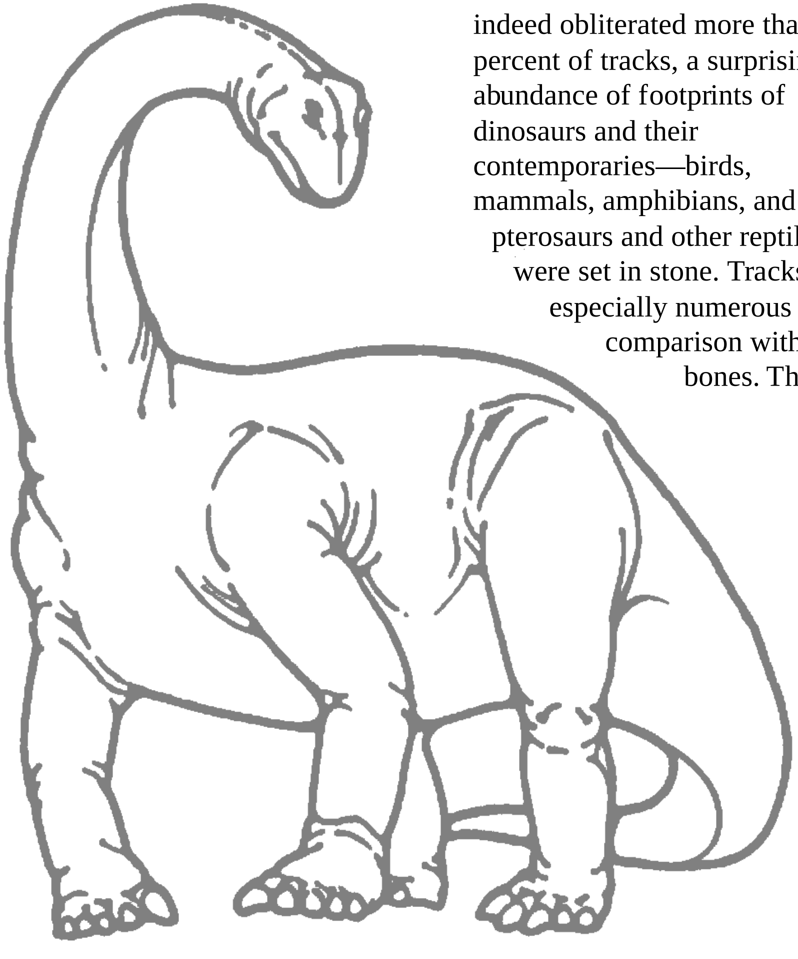
1. Explain how you can tell if an animal was running or walking by examining its tracks.

2. What can you tell about the size of an animal from its tracks?

3. How can making plaster casts help in the study of animal tracks?

Science as Inquiry

Track Records



The past decade has seen a resurgence in the search for, and study of, fossil footprints, those seemingly ephemeral traces in the sands and muds of time. While time and erosion have indeed obliterated more than 99 percent of tracks, a surprising abundance of footprints of dinosaurs and their contemporaries—birds, mammals, amphibians, and pterosaurs and other reptiles—were set in stone. Tracks are especially numerous in comparison with bones. This is not only because each animal could make millions of tracks in a lifetime; it is also a function of where and how tracks are made and preserved. Unlike bones, which usually end up on the surface after an animal dies and have to be washed into a site with particular conditions if they are to be preserved, tracks are the result of an animal constantly sticking its feet into the mud, sand, and other impressionable surfaces that form the very foundation of sedimentary rocks today. Dinosaurs and other ancient creatures were extremely obliging in making direct impressions into what is now the fossil track record.

What, then, can be learned from such a vast storehouse of footprint data? Tracks (or footprints) and trackways (trails of consecutive tracks) are dynamic evidence of creatures on the move. As paleontologist Greg Paul put it, they are the nearest thing we have to movies of living dinosaurs. Trackways thus provide insight into a wide range of individual and social

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By Martin Lockley. Reprinted with permission from *Natural History* (June 1995). Copyright the American Museum of Natural History, 1995.

Measurement and color coding of the tracks at Davenport Ranch in Texas reveal that 23 sauropods crossed the area together. Track sequences and their extensive overlapping suggest that most of the animals were moving in line, with the largest individuals leading the herd.

Illustration by M. Lockley

behaviors. For example, they can be used to estimate speed; trackways suggest that a few medium-sized theropods—bipedal carnivorous dinosaurs—occasionally ran as fast as Olympic sprint champions. Large quadrupedal dinosaurs such as the huge sauropods, plated stegosaurs, and armored ankylosaurs may have been able to run, but according to the track record, they ambled most of the time.

Although most trackways record dinosaurs that were simply walking, not all exhibit monotonously regular patterns. Every so often we find a trackway in which alternating long and short steps testify to animals that had a distinct limp. The reasons for such abnormalities are generally not known, although we do know that the afflicted individuals range from sauropods to theropods to ornithopods (duck-billed hadrosaurs and their kin). In one case, a limping theropod left tracks showing a distinct foot deformity.

Analyses of sauropod trackways show that they fall into “wide gauge” and “narrow gauge” categories, as noted by paleontologist James Farlow. This observation may be the first step toward using tracks to distinguish between sauropod families. Brachiosaurs, for example, were probably wide gauge and are indeed wide bodied in comparison with members of other families of sauropods that must have produced narrower trackways. My research group and I conducted a follow-up analysis of more than 400 sauropod trackways from around the world, which usually indicated only one category on any given surface. In addition, narrow-gauge forms are more common in the Jurassic, from about 208 to 145 million years ago, whereas wide-gauge forms predominate in the Cretaceous, from 145 to 65 million years ago. This suggests that as sauropods evolved over time, their locomotor style changed.

Single surfaces with abundant trackways of the same type are common, and a significant number of these sites, especially those with footprints of sauropods and ornithopods, display multiple, parallel trackways. Not every example of two or more parallel trackways is convincing evidence that the animals preferred to live in groups, since such patterns may result from individuals following a preferred path, such as a shoreline or riverbank, over long periods of time. But when we find dozens of parallel trackways that are of the same type and are also regularly spaced and of the same depth, the evidence for the passage of a herd is compelling.

In the late 1930s, Roland T. Bird, the longtime field assistant to fossil-hunter Barnum Brown of the American Museum, was the first to report convincing dinosaur trackway evidence for social behavior, long before other lines of evidence, such as the existence of nesting colonies, emerged. Following leads that took him to outcrops of 100-million-year-old limestone in Texas, Bird discovered two small but significant sites. The first, now the site of Dinosaur Valley State Park near Glen Rose, Texas, was the scene of a major excavation to remove a segment of sauropod trackway and a parallel segment of theropod trackway, which are on display in the American Museum's new Hall of Saurischian Dinosaurs. Although these have been cited as evidence for a predator (the theropod) attacking its prey, I have serious doubts about this interpretation. Based on Bird's map and original field observations, the site contained twelve regularly spaced, parallel trackways of large sauropods and trackways of not one but three large theropods following the same path. Rather than a one-on-one attack, I believe that these trackways represent a group of theropods stalking or following a herd of sauropods.

Bird's second site, known as Davenport Ranch, contains twenty-three trackways of sauropods of different sizes. All but two of the trackways of larger animals overlap, indicating that the sauropods were crossing the area in a line, not spread out on a broad front. The suggestion has been made that the large animals were protecting their young in the center of the herd. I have carefully analyzed Bird's meticulous map and have color coded and measured each trackway, paying special attention to what overlap could reveal about the sequencing of prints. Although the image of protective parents is an appealing one, the evidence is lacking. However, we can conclude that the herd veered from right to left and took a minimum of several minutes to cross the area, and that some of the larger sauropods were leading the way.

Since Bird's day, further examples of parallel sauropod trackways have been discovered, including other 100-million-year-old Cretaceous sites in Texas and 150-million-year-old Jurassic sites in Utah, Colorado, and Portugal. The trackway evidence for social behavior in sauropods is thus widespread, and we can begin to look for patterns. Both wide- and narrow-gauge sauropods appear to have traveled in groups. Some were composed only of large animals, others only of small animals, and occasionally we find a mixture of sizes. I suspect that sauropods were social throughout their long history, from their first appearance in the Jurassic to their disappearance at the end of the Cretaceous, not just for the two epochs for which a good track record exists.

In contrast to the wealth of clues to sauropod sociality, only three tracksites, in Connecticut, Bolivia and Australia, have been reported as examples of gregarious behavior in the carnivorous theropods, even though theropod trackways are abundant. Perhaps these predators were less social than their plant-eating contemporaries. For some of the other large herbivores also, trackways are still scarce. We have no tracksites showing social behavior among either stegosaurs or ankylosaurs, and only one site suggests that the horned dinosaurs were social, but this is probably because tracks of all three groups are, so far, rare. In contrast, ornnithopods, especially the large Cretaceous iguanodonts and duckbills, left an extensive track record of social activity.

Dozens of ornithopod trackways in Colorado, New Mexico, Utah, Canada, England, and Korea suggest that these animals lived in herds. At the New Mexico site, our research team and other trackers have mapped fifty-five parallel trackways of small individuals all heading north and trackways of twenty-five larger individuals heading south. (One of the smaller animals was limping but apparently kept up with the herd.) The pattern of large individuals going one way and

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Lasting Impressions

Tracks are often regarded as shortlived phenomena, easily destroyed by the next tide or flood to wash over them. Indeed, our studies of modern tracks at Lake Manyara in Tanzania confirm that they remain in recognizable form at the surface for only a week or so before being obliterated by rain, waves, or trampling by other animals. This has led to the notion that tracks can only be preserved if they are made in suitable settings where the exposed clay or sand is rapidly dried by sun or wind so that it becomes rock hard by the time the next tide or flood washes in an overlying layer of sediment. But this explains only one way in which tracks are preserved.

Another explanation has been overlooked until recently: large animals make large footprints that can penetrate deeply into sedimentary layers and register on surfaces that are already buried. Such buried tracks may record where the actual foot came to rest, or they may represent “undertracks” on a surface just below the deepest level at which the foot came to rest. In either case, the footprints are safely buried beneath the surface and thus are protected from the destructive forces of erosion and weathering. At Dinosaur State Park, in Connecticut, visitors can see a fine example of the trackway of a prosauropod (one of a group of large quadrupedal dinosaurs that resembled, but preceded, the sauropods). Each footprint in the trackway is so detailed that beautiful skin impressions are visible. In between each of these tracks, the sediment surface was scoured by the erosive force of sand-laden flood waters that covered the surface after the tracks were made. But the indented tracks were nestled in the substrate as localized and protected pockets, and thus escaped damage from the erosion.

In more than a decade of tracking, I have found a track of a baby carnivorous dinosaur in Utah that was less than two inches from heel to toe tip and the footprint of a sauropod in Colorado that was close to a yard in diameter and two feet deep. Track depth, however, is a measure not of the weight of the track maker but of the water content and consistency of the sediment. (A 130-pound person makes deeper tracks in mud than in firm sand.) The weight of the track maker can be estimated, however, from the size of the tracks. Various formulas show that most dinosaurs have a hip height four or five times their foot length. We can then extrapolate from foot size to leg length, then to overall body size, and finally to estimated weight.—*ML* small ones another is repeated at sites in Colorado and is reminiscent of the segregation of animals by size at most sauropod tracksites. These dinosaurs seem to have enjoyed the company of individuals of their own species that were of the same size and, presumably, the same age. Size groupings could also represent male and female congregations, but this is mere guesswork.

The visible track-bearing surface of rocks is usually controlled by the erosion of sedimentary layers in cliffs, quarries, streambeds, and wherever the rocks are exposed. When a trackway abruptly disappears, every tracker knows that there must be more tracks in there, where the layer is still buried. But how can one tell how far the layer goes before one runs out of tracks on the original surface? The only way is to follow the layers as best we can wherever they surface. Although this is impossible in some cases, in others it can lead to spectacular results.

By piecing together information from every available outcrop, we have now traced several surfaces over huge areas. We call these megatracksites. The oldest and smallest (a few hundred square miles) are in 150-million-year-old rocks in Utah and Switzerland; the largest—on the order of tens of thousands of square miles—are three sites about 100 million years old in the western United States. Such extensive trampled layers conjure up images of huge numbers of dinosaurs stomping around, and certainly such an image is consistent with the evidence of widespread herding. Megatracksites also reflect ancient geology; they represent once extensive coastal plain deposits, similar to the present-day coast of the Gulf of Mexico, in which large stretches of land lie close to sea level. In such settings, mud flats, marshes, swamps, delta plains, and other wetlands provided ideal surfaces for track making.

Two of the western U.S. megatracksites are in Texas and incorporate Bird's famous sites and about fifty others into vast limestone complexes that represent the Gulf Coast plain of 100 million years ago. About two million years later, the sea penetrated North America to form the great Western Interior Seaway, whose shores ran north-south through parts of Colorado, New Mexico, and Oklahoma. Dinosaurs moving along these shores left trackways that today run roughly parallel to an interstate freeway. Taken together, these trackways form another megatracksite, dubbed the "dinosaur freeway."

Each of these megatracksites reveals individual sites where we have recorded one to ten tracks per square yard (one to twenty-five million per square mile), leading to an estimate of literally billions of prints for each megatracksite. Given these astronomical numbers, the track record is remarkably consistent. Almost all the Texas sites are those of sauropods and large theropods in limestone, whereas the interior dinosaur freeway records only large ornithopod and small theropod tracks, along with crocodile and bird tracks, in sandstones and mudstones. Thus, each megatracksite has its own distinctive faunal record relating to particular ancient environments. Such consistency throughout each complex is a fine advertisement for the fidelity of the track record in revealing the representative composition of dinosaur communities and even the population structure at any given time. The abundance of tracks also highlights the sparse nature of the skeletal record, for not a single bone is known from the dinosaur freeway area, and precious few are known from Texas.

The consistent track censuses obtained from the dinosaur freeway have led to suggestions that it was a dinosaur migration route, and indeed it may have been. Iguanodont and hadrosaur track makers appear to have ranged over an area of about 30,000 square miles. As large herbivores that were both abundant and gregarious, they probably migrated to avoid depleting resources in a particular area. The megatracksite does not prove unequivocally that individuals or herds migrated along particular routes, but it does show the scope of their movements and is about as near to direct evidence of migrations as we are ever likely to extract from the fossil record.

A decade ago, we knew only of Bird's discovery of two sets of parallel trackways from Texas. Today we have abundant trackway evidence for social behavior among a variety of sauropods and ornithopods from around the world. In addition, we have at least some indication of social behavior among theropods and horned dinosaurs, a theory that is further supported by discoveries of nest sites and bone beds. Thus, the growing trackway database indicates that most of the major dinosaur groups engaged in social behavior at least part of the time. Trackways can also tell us where, when, and how many animals were active in a particular area, to what groups they belonged, in which direction and how fast they traveled, the size range of individuals in a given sample, whether any social tendencies were common or persistent in a particular group, and when in geological time they first appeared.

Just as important is the great promise dinosaur tracking holds for giving us a greater understanding of the distribution of dinosaurs, and other extinct creatures, in both time and space. In particular, sites with multiple trackways can provide censuses of ancient animal populations and communities. The renaissance in fossil footprint research during the past ten years has made these moving pictures" of dinosaurs a mainstay of paleontology.

* * *

Science as Inquiry

Lessons *from* Leavings

Many people are surprised when they learn that I study fossilized feces. “Whatever for?” is their unspoken question. I learned the informative value of scat during my tenure as a naturalist for the National Park Service. Wild animals are usually very shy, so finding dung is often the next best thing to observing the animal itself. Park visitors on my guided nature hikes were bemused at my delight in finding animal feces, until I explained that such calling cards can provide important information about an animal’s feeding habits and distribution.

Extinct animals are certainly more elusive than living ones, and when I began to study paleontology, I hoped fossil dung would be similarly informative. Unfortunately, fossil feces, known as coprolites, are more enigmatic than fresh fecal material. Biological and geological processes have altered the original contents—sometimes beyond recognition. This complicates dietary interpretations and can make it difficult to identify coprolites in the first place.

Furthermore, the detached nature of feces makes it nearly impossible to match a coprolite with its maker. Despite these drawbacks, I was quite excited when paleontologist Jack Homer, of the Museum of the Rockies, told me that he had found some probable dinosaur coprolites in the badlands of Montana. I was working for Jack at the time, making histological sections of fossil bone. This technique prepares ultrathin slices of fossils so they can be examined microscopically. I asked if I could slice the purported coprolites as well, and my work on fossil dung began.

Coprolites more than a couple of million years old have usually been preserved through mineralization; that is, they have turned into rock. This means that such distinguishing characteristics as color and general appearance are not always reliable clues for confirming a fecal origin. Nevertheless, the first fossil feces were identified on the basis of shape and composition by British geologist William Buckland in the 1820s. Since that time, many other coprolites have been recognized, usually by their distinctive fecal shapes. Form, however, can be a misleading criterion when applied to variable soft material that has been altered over millions of years.

The specimens Jack discovered are full of plant fragments but have blocky shapes unlike other described coprolites. Some of the blocks are also large, measuring more than 13 by 13 by 9 inches. Jack suspected that the blocky aggregations of plant material were the fossilized feces of some of the Cretaceous dinosaurs whose bones he was finding in the same sediments. I began to analyze the specimens for evidence that could test the hypothesis that these blocks were indeed dinosaur droppings.

Microscopic examination of the thin sections I made revealed that the blocks are composed predominantly of small pieces of conifer stem tissue. The chopped-up nature of the plant material resembles the chewed residues found in the feces of living plant-eating animals such

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as horses and elephants. Other evidence supporting a fecal origin includes the sporadic distribution of the aggregations and their proximity to other dinosaur fossils. Bones and eggshells indicate that plant-eating duck-billed dinosaurs were common visitors to the area.

But the evidence that clinched the case for coprolites came from burrow traces left by some previously unheralded participants in Cretaceous ecosystems. Conspicuous burrows ranging from one-sixteenth of an inch to more than one inch in diameter pockmark many of the blocks. Some of these burrows are open tunnels; others show that plant tissue had been backfilled into burrows in the original adjacent soil, which was sometimes preserved along with the plant material. I suspected that the burrowers had been dung-eating beetles, but I couldn't verify that they were the perpetrators until I consulted Canadian entomologist Bruce Gill, who has studied many living dung beetle species. We found that the burrows in the blocks have many of the same characteristics of modem dung beetle burrows. The most diagnostic feature is the presence of large, backfilled burrows; dung beetles are the only living organisms known to cache plant matter in such sizable burrows. Thus, these burrow traces of ancient dung beetles helped confirm that the blocks are indeed coprolites.

We know that these coprolites were produced by plant-eating dinosaurs: other possible Cretaceous herbivores, mammals, for example, were simply too small to have produced dung in such quantities. The value of these specimens lies in the information they provide on the diets and ecology of dinosaurs. Although digestion, decomposition, and geological changes significantly altered the composition of the feces, recognizable plant tissues in the specimens indicate that these dinosaurs browsed on conifer stems. The coprolites also reveal an ecological link between dinosaurs and dung beetles. The beetles capitalized on the success of herbivorous dinosaurs by utilizing their copious wastes, and this recycling activity in turn benefited other organisms. A similar dung-based ecological web exists today in Africa, where dung beetles exploit elephant feces.

While the roles of dinosaurs in Mesozoic ecosystems have long been a subject of speculation, fossil evidence of dinosaur interactions with other organisms is rare. Thus, these humble pieces of fossil dung are particularly significant because they provide us with a brief glimpse of Cretaceous ecosystem dynamics.

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