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The Kansas School Naturalist is sent upon request, free of charge, to Kansas teachers, school board members and administrators, librarians, conservationist, youth leaders, and other adults interested in nature education. Back numbers are sent free as long as supply lasts, except Vol. 5, No. 3, Poisonous Snakes of Kansas. Copies of this issue may be obtained for 25 cents each postpaid. Send orders to The Kansas School Naturalist, Department of Biology, Emporia Kansas State College, Emporia, Kansas, 66801.
FOSSILS OF KANSAS

In the State of Kansas fossils are exceptionally abundant, highly varied, and easily found. The rocks exposed in the eastern portion of the State were deposited during the Paleozoic Era (Age of Invertebrates) see Fig. 1; the rocks exposed in the central region were deposited during the Mesozoic Era (Age of Reptiles), and those in the west edge of the State, as well as those forming the river terraces and valley flood plain deposits in other parts of the State, were formed during the Cenozoic Era (Age of Mammals). This wide range of ages of the rocks exposed at the surface in Kansas results in the vast variation of fossils that we find—from ancient, ocean-floor-dwelling sponges and corals to modern-looking rhinos and horses.

The ancient geographic conditions varied from dry land to far-from-shore oceanic environments allowing for both marine and non-marine types of life to alternately exist during the formation of the rock layers now exposed in Kansas.

Evidently, environmental conditions extremely favorable to intense organic activity prevailed in the state for long intervals of geologic time. This has resulted in the fantastic wealth of fossils that some layers of rock in Kansas contain. During much of the Paleozoic Era, for example, the state was covered by a shallow, warm, inland sea that appears to have been teeming with life. A similar environment existed for an extended period of the Mesozoic Era. The Cenozoic Era brought no inland sea to Kansas, but the environment has been ideal for various types of mammal life throughout most of this Era.

There have been intervals of time, however, which were not so hospitable to life. Today these times are recorded in barren, non-fossiliferous layers such as those seen in the uppermost Paleozoic rocks of south-central Kansas.

The fact that the rocks exposed at the surface of the State of Kansas are nearly all sedimentary is another reason for our wealth of fossils. Igneous rocks almost never contain fossils since organisms cannot live in

The Cover: The fossil shown on the cover has been given the rather impressive name of Stroparolis gladfelteri. It was named in honor of Clarence F. Gladfelter, Professor Emeritus of Biology at EKSC, who for many years taught classes in Historical Geology at the college.

This issue of The Kansas School Naturalist was written by Paul Johnston, Associate Professor of Geology at EKSC. He is the author of an earlier issue on Kansas geology, but the demand exceeded the supply, and the issue is no longer available for distribution. Pictures by Robert Boles.

This is the first of a two part series on the Fossils of Kansas. This part treats such topics as how fossils were formed; where to go to collect them; and how we have made use of fossils. The second part, which will be published later, deals primarily with the description of the more common fossils found in Kansas accompanied by sketches and photographs to assist in their identification.
the temperature that exists in the hot, molten magma and lava from which these rocks form. In metamorphic rocks, fossils are usually obliterated during the time the original rocks are changing into metamorphic rocks by the extreme pressure and heat. Sedimentary rocks, on the other hand, form under conditions that are ideally suited for fossil formation. The slowly accumulating sea-floor sands and clays which will eventually form sandstone and shale bury the remains of dead organisms that are also accumulating on the sea floor. The muds and sands in which the organism is buried form a protective cover keeping away scavengers and the consuming, decaying action of oxygen.

The more accessible rocks are to examination, the better the chances are of finding fossils. Kansas has a multitude of bedrock exposures and these are all readily accessible due to the grid system of roads that prevails from one edge of the state to the other. Soils and other debris at the surface of the state are generally fairly thin. This allows for easy removal by natural erosion and the exposure of the underlying and generally fossiliferous bedrocks.

WHAT ARE FOSSILS?

Any evidence of prehistoric life preserved in rocks is a fossil. Although most consist of an actual portion of the preserved remains of the plant or animal, a fossil can be merely a trace of the organism, such as a footprint, burrow, trail, or impression. Fossils such as the preserved shells of one-celled organisms are microscopic in size, while others, like the well-known dinosaur skeletons, are very large. Some fossils are of animals; others are of plants, but all are prehistoric in age.

HOW DO FOSSILS FORM?

Although having a hard part (bone, tooth, or shell) is not an absolute prerequisite for fossilization, the usual way that an ancient organism became a fossil was through a hard part becoming buried and preserved in the sediments before it had a chance to decay. Soft tissue was, under the right conditions, capable of being preserved too, but more rarely and usually less intact.

As time passes, unburied dead organisms tend to rot away, but burial hinders the decay and allows for other processes to occur. A hard skeleton or shell may, under the proper conditions, be preserved essentially unaltered for centuries. More often, however, water carrying dissolved minerals will leech away the bone or shell and replace it with other minerals, particularly quartz and calcite. The specimen literally turns slowly to stone. This process is called petrification.

Sometimes instead of becoming petrified or remaining unaltered, the specimen will become carbonized. If exposed to oxygen, the carbon in a dead organism will oxidize during the
<table>
<thead>
<tr>
<th>ERAS</th>
<th>PERIODS</th>
<th>DEVELOPMENT OF LIFE</th>
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<tbody>
<tr>
<td>CENOZOIC</td>
<td>QUATERNARY</td>
<td>Appearance of man</td>
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<td></td>
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<td>Widespread continental glaciation</td>
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<td></td>
<td>TERTIARY</td>
<td>Rise of modern mammals and birds</td>
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<td>(Began 70 million years ago. )</td>
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<tr>
<td>MESOZOIC</td>
<td>CRETACEOUS</td>
<td>Extinction of dinosaurs and many other reptile groups</td>
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<td>JURASSIC</td>
<td>Domination by giant reptiles</td>
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<td></td>
<td></td>
<td>Beginning of birds and mammals</td>
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<td></td>
<td>TRIASSIC</td>
<td>Beginning of dominance of reptiles</td>
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<td>(Began 200 million years ago. )</td>
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<tr>
<td>PALEOZOIC</td>
<td>PERMIAN</td>
<td>Extinction of many invertebrate groups and primitive type plants</td>
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<td>PENNSYLVANIAN</td>
<td>Many coal forests of spore bearing plants</td>
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<td>First reptiles</td>
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<td></td>
<td>MISSISSIPPIAN</td>
<td>Abundant spore bearing plants</td>
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<td>Many insects</td>
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<td></td>
<td>DEVONIAN</td>
<td>First amphibians</td>
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<td></td>
<td></td>
<td>Numerous marine fishes</td>
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<td>SILURIAN</td>
<td>First land plants</td>
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<td>First land animals (scorpions)</td>
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<td>ORDOVICIAN</td>
<td>First indication of vertebrates (fishes)</td>
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<td></td>
<td>CAMBRIAN</td>
<td>Invertebrates numerous and varied, trilobites dominant</td>
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<td>(Began 500 million years ago. )</td>
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<td>PRECAMBRIAN</td>
<td>Bacteria, algae, and a few primitive invertebrates</td>
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<td>(Began 4.5 billion years ago. )</td>
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Fig. 1. The Geologic Time Scale.
decay process and change to carbon dioxide leaving little trace. However, if no oxygen is available, such as occurs in impervious muds, the carbon portion of the organic tissue will be left as a black film in the rocks, resembling a charcoal sketch of the original specimen (see Fig. 2).

As noted previously, the remains of the animal might not even be present; however, a footprint, trail, burrow, or impression of the ancient organism preserved in the muds as they harden into shale constitutes a fossil (see Fig. 3).

**OF WHAT USE IS A FOSSIL?**

Without fossils, man's knowledge of the past would be limited. The rocks themselves yield certain clues as to the conditions that were in existence when and where they formed, but a rock containing a fossil provides a much clearer picture so the geologist is able to reconstruct with much greater detail the environment in which the rock was deposited. Sedimentary rocks that formed from sediment on the sea floor will contain fossils of marine organisms. Certain marine organisms we know live in more shallow water than others; and many modern organisms survive only at low latitudes in warm seas and are not seen at higher latitudes. The same appears to be true of many of the ancient plants and animals. Some
animals lived in freshwater, some on dry land, and still others lived in brackish water. Geologists can speculate on the environmental conditions that prevailed in a region at various times of the past by identifying the fossils found in the various ages of rocks.

Therefore, one of the primary uses of fossils has been to help man understand the complex, ancient climatological events and geographic patterns that existed on earth throughout geologic time (see Fig. 4).

The sequence of fossils preserved in the rock layers from very ancient to the more modern forms comprise a chronological record of life on earth. It is through the study of this sequence that man has gained an understanding of the history of life on earth and its evolutionary development.

A less dramatic but equally important function of fossils is found in the correlation of rock units and geologic events. We know that individual species of organisms existed on earth for a particular interval of geologic time, died out, and, in most cases, gave rise to a new species. In other words, during a given period of geologic time, the animals and plants that existed were unique—differing from the fauna and flora that went before and from those that existed after. Naturally, some species lived for longer intervals of time than others, and there were, of course, overlapping of species from
one time period to the next. After years of studying the fossil record found in the rocks throughout the world, man has acquired the ability to recognize from which interval of geologic time a rock belongs by analyzing the fossil content of the rock. He then uses this knowledge in establishing the contemporaneousness of events in separate areas. He is thus able to tell whether such things as a change in the climate indicated in certain rocks from an early age in Kansas was a local condition or part of a worldwide climatic variation.

WHERE DO YOU LOOK FOR FOSSILS?

In deciding where to look for fossils, it helps to be somewhat familiar with the geology of the State of Kansas (see Fig. 5). Since the flora and fauna of the various periods of geologic time are unique, certain fossils will be found in one province of the State and not in others. Generally, the younger, more recently deposited rock layers are exposed at the surface in the western part of the state while older rocks occur in the East. There are, of course, younger sands and gravels deposited in more

Fig. 4a. This limestone, collected West of Grenola, Elk County, Kansas, was deposited in a marine environment, as indicated by the ocean-floor dwelling brachiopod fossils it contains.
recent times along the stream valleys in all regions of the state, but the exposed bedrock in the East is older than in the West. Paleozoic rocks occur at the surface in the Osage Cuesta and Flint Hills provinces of Eastern Kansas. During the time these rocks were forming, ancient invertebrate animals thrived in the sea that fluctuated in and out across the state. One would, therefore, expect to find invertebrate marine fossils in the bed rock layers in these regions (see Fig. 6). Mesozoic fossils—more modern-looking deciduous tree leaves, sharks' teeth, swimming reptiles, and fish (see Fig. 7)—occur in the Smoky Hills and Blue Hills province. The most modern-looking fossils, Cenozoic mammals, (see Fig. 8) are found farther west in the High Plains province. Mammal fossils also occur in the sands and gravels deposited during the Cenozoic along the modern streams of Eastern Kansas.

One rarely looks for fossils by digging. Once located at the surface, it may be necessary to dig a fossil out, but the initial discovery normally is made where the exposure resulted from natural erosion. One should check road-cuts, stream banks, gullies, and quarries. Newly exposed layers in quarries are usually not as productive as older weathered
Fig. 5. Geologic Map of Kansas.
exposures. Considerable time is required for the natural processes of weathering and erosion to expose and loosen the fossils in rock layers. Banks of larger streams too often are formed in sand and gravels or other alluvium deposited by the stream and contain few fossils. Smaller dry stream gullies and washes are much more productive, but only if the gullies are deep enough to have penetrated the soil cover and exposed bedrock below.

Any type of sedimentary rock can contain fossils, but some rock types tend to be more productive than others. Sandstone generally does not contain a great abundance of fossils except perhaps locally. When fossils do occur in sandstone, they are usually imprints and impressions. Porous sand allows water to trickle through readily, dissolving shells within the deposit, and leaving little to be fossilized. Also, sandstone deposits form in regions of strong currents and turbulent water which are not as conducive to life as other regions.

Shale, on the other hand, is impervious to water and capable of protecting anything buried within it from decay. The best fossil collecting localities are in exposed shale layers.
Fig. 7. Typical fossils of Mesozoic (Cretaceous) rocks of Kansas. (a) Deciduous tree leaves in sandstone from the Smoky Hills region in Ellsworth County, and (b) fish vertebrae in chalk deposits from the Blue Hills region of Trego County.
As the clay-forming shale comes into contact with water it turns to mud and is washed away, leaving the larger, heavier fossils behind to litter the surface of the shale exposure. After the fossils have all been collected from the shale surface, one merely waits for another rainstorm to wash away more shale and expose new fossils. Digging into shale to collect fossils is usually not productive. Clay cakes onto the shells rendering them invisible and much damage is done to the shells by the digging process.

Limestone is quite fossiliferous, but collecting from it is difficult. The durable rock tends to hold shells fast, and they have to be dislodged with a pick or chisel. Removing the shells by dissolving the rock in acid is unsatisfactory, except in rare instances, because the calcium carbonate composition of the limestone rock is usually the same as that of the shell.

**MATERIALS NEEDED IN COLLECTING**

The materials and utensils one should have when fossil collecting depend on the type of rock in which one is prospecting and what type of fossil the rock contains. One should always take along a geologist's
hammer or prospector’s pick and a chisel; a paint brush or whisk broom is handy to brush away dirt; newspaper or tissue is good for wrapping specimens so they do not get damaged; masking tape is ideal for sticking on labels for later identification; and a collecting bag of some sort is a necessity. Ideally, the collecting bag should fit over the shoulder or back to free the arms for climbing and digging. For fragile specimens, such as carbonized leaf imprints, a can of clear spray lacquer or a jar of fast-drying shellac is useful. This is applied to the specimen in the field to hold it together. Collecting larger fossils, such as a skeleton of prehistoric swimming reptiles in the Blue Hills region of Kansas, requires much more equipment and know-how. A minimum of equipment would include a pick, shovel, brushes, plaster, and burlap—the latter two items to form a protective cast around the specimen before lifting it from the dig.

A notebook and pencil are a must. One should always record where a specimen was found and, if possible, the name of the layer from which the fossil was collected. A convenient technique is to place a number with tape on the specimen and record pertinent information regarding the specimen with a corresponding number in a notebook. Some people prefer to write this information on a scrap of paper and wrap this with the fossil in newspaper or place it in a cloth collecting bag or a baggie with the specimen. Whatever the technique, documentation of the find
while on location is far superior to relying on memory when one finally gets around to sorting through the collection back home.

IDENTIFYING YOUR FINDS

Once the fossil has been collected, labeled, and brought home, the task of identifying begins. It is sometimes necessary to first clean the specimen in order to see it more clearly. This can be done by soaking in water or vinegar, briskly brushing with a tooth brush (unless the fossil is too fragile), gouging and prying with a mounted pin or, if available, an electric vibrating or roto tool. Oftentimes, merely washing well with water is sufficient.

The scientific nomenclature of fossil organisms is the same as that of living plants and animals. The specific name consists of two parts, each derived from Latin or Greek. The first part, the generic name, is capitalized and indicates to which genus the organism belongs; it may be used alone. The second part, the trivial name, is not capitalized and is always preceded by the generic name. As in living animals, similar genera are grouped together into the same family. Families are grouped into orders and so on up through classes and phyla.

Working with living organisms differs from working with fossils in that the paleontologist does not have living tissue to examine while classifying unknown specimens. He has only that portion of the animal or plant that has survived centuries of time buried in the rocks. Normally this consists of only a bone or shell. This makes classification work of fossils more difficult than that of living organisms. The extent of the difficulty depends partly on whether or not a close relative of the fossil form is still living or not.

Because fossils are commonly imbedded in rock and impossible to extract one sometimes has but one side or a small portion of the specimen to view. This can lead to much confusion and misidentification. Another reason for confusion is that many people find it difficult to imagine that the State of Kansas was covered by seas throughout most of geologic time. Marine fossils are, therefore, sometimes not recognized for what they are. Upon finding a fossilized marine organism such as a sponge, people try to identify it in terms of things it resembles living in Kansas today (see Fig. 9). Also, objects that occur in the rock layers that are not of organic origin are commonly mistaken for fossils. Spherical-shaped, inorganic nodules for example are often mistaken for fossil eggs.

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The Division of Biological Sciences will offer a four-week course in Mountain Ecology during the first summer session of 1975. The course will be taught in the Pecos Wilderness of Northern New Mexico from June 9 through July 3, and may be taken for either graduate or undergraduate credit. A brochure describing the course in greater detail is being prepared. A copy may be obtained by writing to either of the instructors, Dr. Dwight Spencer or Dr. Robert Parenti, Division of Biology, EKSC.

EB 530. Workshop in Conservation. Plan now to attend the 1975 Workshop in Conservation, which will be a part of the 1975 Summer Session at EKSC, June 3 to 20. The Workshop will provide lectures, discussions, and field trips emphasizing teaching of environmental science. Especially designed for elementary teachers. For further information write Dr. Thomas Eddy, Division of Biology, EKSC, Emporia, Kansas 66801.

The dates of the 1975-76 Audubon Screen Tours at EKSC will be Sept. 23 and Nov. 20, 1975, and April 20, 1976.

The Division of Biology extends an invitation to all graduating seniors and Junior College transfers to visit, meet the staff, and be shown about the Science Building.