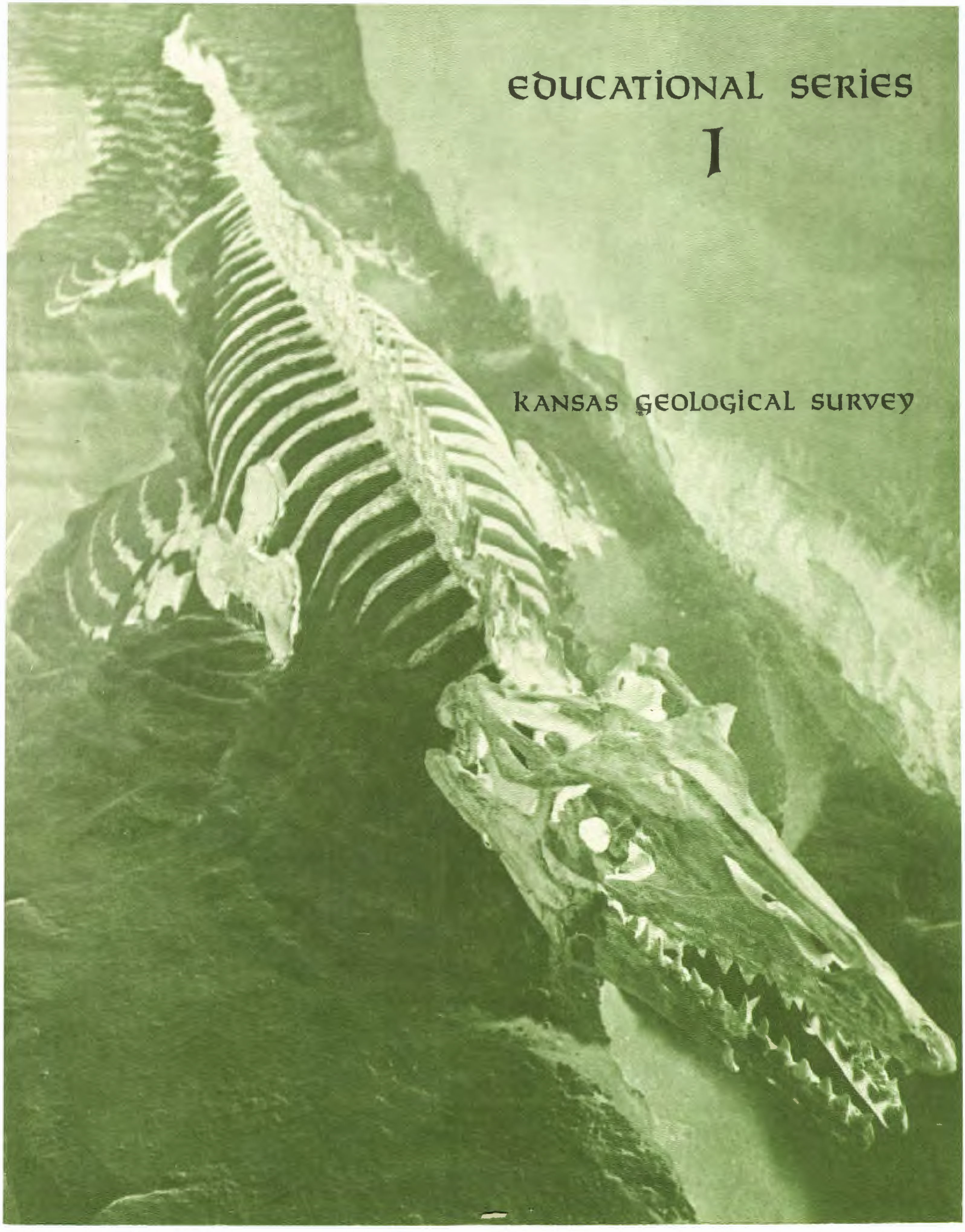
EDUCATIONAL SERIES 1

KANSAS GEOLOGICAL SURVEY



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For technical reading or study:

Andrews, H. N. Jr., **Ancient Plants and the World They Lived In,** Comstock Publ. Co., Ithaca (1947).

Arnold, C. M., **An Introduction to Paleobotany,** McGraw-Hill, New York (1947).

Beerbower, James R., **Search for the Past,** Prentice-Hall, Inc., Englewood Cliffs, N.J. (1960).

Dunbar, C. O., **Historical Geology,** (2 ed.), John Wiley & Sons, New York (1960).

Moore, R. C., (Editor), **Treatise on Invertebrate Paleontology,** Parts A-X; and Teichert, C., (Editor), Supplements and Revisions, Geological Society of America and The University of Kansas (Press) (1958 to present).

Moore, R. C., **Introduction to Historical Geology,** (2 ed.), McGraw-Hill, New York (1958).

Moore, R. C., Lalicker, C. G., and Fischer, A. G., **Invertebrate Fossils,** McGraw-Hill, New York (1952).

Romer, A. A., **Vertebrate Paleontology,** University of Chicago Press, Chicago (1945).

Shimer, H. W., and Shrock, R. R., **Index Fossils of North America,** John Wiley & Sons, Inc., New York (1944).

Shrock, R. R., and Twenhofel, W. H., **Invertebrate Paleontology,** McGraw-Hill, New York (1952).

Other publications about Kansas Geology:

Clarke, John G., **Towns and Minerals in Southeastern Kansas: A Study in Regional Industrialization,** Kansas Geological Survey Special Distribution Publication 52 (1970).

Merriam, Daniel F., **The Geologic History of Kansas,** Kansas Geological Survey Bulletin 162 (1963).

Tolsted, Laura Lu and Swineford, Ada, **Kansas Rocks and Minerals,** Kansas Geological Survey (1971).

Wilson, Frank W., **Kansas Landscapes: A Geologic Diary,** Kansas Geological Survey (planned).

Zeller, Doris E. (Editor), **The Stratigraphic Succession in Kansas,** Kansas Geological Survey Bulletin 189 (1968).

Suggested Reading

For younger readers:

Fenton, C. L., **Prehistoric World,** The John Day Company, New York (1954). Stories about a few fossil animals by a knowledgeable author. (6-7th grade).

Hassey, L. J., and Pessino, C., **Collecting Small Fossils,** Thomas Y. Crowell Company, New York (1970). Fairly simple, small book emphasizing invertebrates and telling how to start a collection. (6-7th grade).

Matthews, W. A. III, **Wonders of Fossils,** Dodd, Mead & Co., New York (1968). A brief but balanced treatment of fossils and their classification. (7-8th grade).

Scheele, W. E., **Prehistoric Animals,** World Publ. (1954). Adventurously illustrated, stresses vertebrates. (7-8th grade).

For more mature readers:

Fenton, C. L., and Fenton, M. A., **The Fossil Book,** Doubleday (1958). An excellent text written in everyday language; "must" reading for someone interested in learning about fossils of all kinds.

Fenton, C. L., **Tales Told by Fossils,** Doubleday (1966). A very good short book that stresses vertebrates.

Silverberg, R., **Mammoths, Mastodons and Man,** McGraw-Hill (1970). A readable story about these great ice age mammals.

Lanham, U., **The Bone Hunters,** Columbia University Press (1973). The story of the pioneers in American vertebrate paleontology and their competition to make spectacular discoveries.

MacFall, R. P., and Wollin, J. C., **Fossils for Amateurs,** Van Nostrand (1972). A complete book on how and where to collect fossils; not for fossil identification.

Matthews, W. H. III, **Fossils, An Introduction to Prehistoric Life,** Barnes & Noble, Inc., New York (1962). One of Everyday Handbook Series, a good paperback dealing with the nature of fossils.

Rhodes, F. H. T., Zim, H. S., and Shaffer, P. R., **Fossils, A Guide to Prehistoric Life,** Golden Press, New York (1962). One of the Golden Nature Guide Series, this paperback is a very good, pocket-sized, well illustrated and comprehensive handbook on most common fossils.

Pedicle beak. The pointed end of the pedicle valve. A small opening through which the pedicle passed may be located near this end *(16)*.

Pedicle valve. The brachiopod valve that contains the pedicle, and is regarded as ventral *(5b)*.

Pinnule. The individual leaflets of a fern frond *(1)*.

Planispiral. The coiling of some snails and cephalopods in which the center of each coil lies in the same plane *(6, 15, 17)*.

Pleural. Refers to side, thus, one of the lengthwise side lobes of a trilobite.

Plicate. Having folds in the shell that appear on the inside as well as the outside *(13)*.

Polygonal. Many sided.

Porous. Having small holes or pores.

Posterior. Toward the rear, opposite from Anterior *(5a, 5b)*.

Predaceous. Living by killing and eating other animals.

Productid. Articulate brachiopods with concavo-convex shells, commonly having spines and inconspicuous interareas *(7, 12)*.

Pseudopunctae. False punctae—small, rod-shaped structures within the shell of some brachiopods, that commonly appear on the inner surface of the shell as small bumps.

Pygidium. The posterior or tail segment of trilobites, called by some the tail *(11, 11b)*.

Radial. Arranged so that the features extend in all directions from a single point.

Ray. A radial feature, such as the arms of a starfish; also the sting-ray, a kind of shark having greatly flattened, wing-like bodies.

Rhynchonellid. Articulate brachiopods of small to medium size with biconvex plicate shells, short hinge line and pointed pedicle beak *(17)*.

Secrete. To produce by separating a substance from body fluids. Saliva in our mouths has been secreted by salivary glands.

Sediment. Material such as mud, sand, gravel, calcium carbonate, and salt that are deposited by, or settle out of, water.

Septa. Dividing walls or partitions *(3, 6)*; a vertical ridge near the middle of a brachiopod valve *(19b)*.

Shale. A fine-grained sedimentary rock formed from mud and silt, commonly gray to black; tends to split into thin layers.

Siliceous. Contains silica, or silicon dioxide. A common silica mineral is quartz; a common product made principally of silica is glass.

Species. The basic unit of biologic classification. In the *Canis familiaris*, the common dog, *familiaris* is the species name. Fossils of the same species have all distinctive features in common with one another.

Spicules. Small needle-like skeletal parts of sponges. They may be of various shapes from simple rods to stars, and connect to form lattice-like frames.

Spines. Stiff, sharp, outward-projecting features, as on a porcupine, or on echinoids or brachiopods *(7, 12, 16, 19a)*.

Spiral. Coiled; like the thread of a screw.

Spongin. The flexible material which forms the skeleton of the common bath sponge and which readily decays upon death of the animal.

Stalk. An elongate supporting organ.

Stem. A structure resembling the stem of a plant, such as the column of a crinoid *(14a)*.

Strophomenid. Articulate brachiopods that commonly have a hinge equal to greatest width, wider than long, well-defined interareas on each valve, pseudopunctate but no spines *(7, 10)*.

Substrate. The mud, sand, rock, or the like that forms the bottom of the sea or estuary.

Sulcus. The rounded depression down the center of many brachiopod shells opposite the fold, commonly on the pedicle valve *(5b, 12)*.

Tabulae. Floor-like partitions or cross structures found within the skeleton of some kinds of corals *(11)*.

Tabulate. A coral that has tabulae.

Tegmen. The part of a crinoid above the dorsal cup and within the arms that forms a cover for the vital organs. It may be leathery or consist of plates, and may be formed into an anal sac *(14a)*.

Terebratulid. Articulate brachiopods with a loop brachidium, endopunctae, commonly subcircular to teardrop shape *(16)*.

Test. The shell of a foraminifer.

Thoracic. Refers to features found on the thorax, or middle region on a trilobite; the area between the cephalon and the pygidium, comprised of numerous flexible segments *(11b)*.

Thread. Fine thread-like ridges that coil down the outside a snail shell *(9a)*.

Unchambered. Lacking chambers.

Valve. Either one of the two shells of a brachiopod or a clam.

Ventral. Opposite direction from dorsal, the underside; pedicle valve of brachiopods *(5a, 5b)*.

Vertebrae. The bones that form the backbone of higher animals such as fish and mammals.

Whorl. One coil of a coiled shell *(9a)*.

Echinoderm. Marine animals having spiny skeletons, including starfishes, echinoids, and crinoids.

Electron microscope. A microscope capable of extremely high magnification, commonly used to view objects too small to be adequately seen through the usual (optical) microscope.

Environment. The surroundings in which an organism lives.

Equilateral. Each side equal to the other—refers to brachiopod symmetry *(5b).*

Estuary. An arm of the sea at the mouth of a river.

Facial sutures. The lines along which the cephalon of a trilobite split open when shedding its skeleton, permitting growth *(11b).*

Flagella. Hair-like parts of sponge cells that move to create water currents.

Flute. The wrinkling of a septum *(6).*

Fold. The rounded swelling down the center line of many brachiopods, usually on the brachial valve *(5b).*

Foraminifers. Mostly marine, one-celled animals that secrete a chambered or unchambered shell or test, commonly with numerous pores through which pseudopodia extend *(2).*

Furrow. Shallow groove *(2a, 11b).*

Gastropod. Snails and slugs.

Genus. A rank of scientific name used in classifying organisms. The dog has the scientific name *Canis familiaris. Canis* is the genus.

Geologic. Referring to geology, the study of the earth, its history and life as recorded in the rocks.

Glabella. Central rounded lobe portion of a trilobite cephalon *(11b).*

Globose. Globe shaped; rounded or shaped like a ball.

Hinge axis. A line passing through the points of articulation between valves of a clam or brachiopod, along which the valves pivot in opening or closing.

Hinge line. Portion of valve along dorsal margin of clams or posterior margin of brachiopods that is permanently in contact with opposite valve, and where valves articulate.

Hinge teeth. Projections from a valve that articulate with the dental sockets in the opposite valve.

Horny. Of a hornlike (chitinous) substance.

Imperforate. Not having perforations, pores or holes.

Inarticulate. Not having a hinged shell.

Interarea. The flat or curved surface between the pointed part of a brachiopod valve and hinge line along the posterior margin (*3; 7* triangular area of shell, lower right; *19a).*

Ligament. Elastic tissue along the dorsal margin of clams that automatically opens the valves when the adductor muscles are relaxed *(4).*

Lignite. Also called brown coal, it is burnable, softer than coal, and has the texture of the original plant fragments preserved.

Limestone. A rock that consists principally of calcium carbonate, commonly derived from an accumulation of the shelly remains of organisms.

Lip. The outer edge of the opening of a snail shell *(9a, 17a).*

Lirae. Fine lines running down the sides of snail shells *(9a).*

Lobe. A rounded division or portion *(11b, 19).*

Locomotion. The ability to move or travel from place to place.

Loess. An accumulation of wind-blown dust.

Loop. A simply bent, non-spiral brachidium *(16b).*

Lophophore. A feeding organ in brachiopods bearing tentacle-like structures that carry food to the mouth; commonly supported by a brachidium.

Lumen. The central hole in a crinoid columnal *(14).*

Margin. Edge; may indicate the outer limits of certain rocks on a geologic map; also, the edges of a valve.

Marine. Living in the sea and not in fresh water.

Matrix. The substance of the rock in which a fossil or other object may be enclosed.

Median plane. The imaginary flat surface that divides a feature down the middle and into two equal parts.

Molar. A broad tooth used for grinding rather than for cutting.

Muscle scar. A circular or crescent-shaped area on the inside of brachiopod or clam shells marking where a muscle attached.

Node. A raised area, commonly one that serves as a place of attachment for another structure.

Nodal. A columnal plate bearing nodes for the attachment of cirri *(14).*

Non-marine. Living in fresh water and not in the sea.

Oblique. Slanting; not perpendicular.

Organic. That which pertains to living organisms.

Organism. Any living thing.

Orthid. A group of articulate brachiopods having unequally biconvex shells with hinge line parallel to hinge axis and well-developed interareas on both valves; rounded outline, and costate surface.

Oxygenated. Combined with oxygen, or containing dissolved oxygen.

Pallial sinus. Toward posterior inner surface of some clams, an S-shaped line or groove near the margin of valve, marking the space into which tubes (siphons) that draw in food and water and expell waste are withdrawn.

Pedicle. A leathery or muscular stalk that serves to attach a brachiopod to the substrate.

Biconvex. When each valve of a brachiopod or clam is rounded outward like the outside of a ball.

Bilateral symmetry. Divided into two halves that appear to be mirror-images of each other by an imaginary plane passing between them *(5a)*.

Bivalve. Having two shells or valves, as in brachiopods and clams.

Brachial plate. One of the kinds of crinoid arm plates *(14a)*.

Brachial valve. The brachiopod valve that bears the lophophore; the dorsal valve *(5b)*.

Brachidium. The skeletal part of some brachial valves that supports the lophophore.

Brachiopod. A marine invertebrate that utilizes a lophophore for food gathering, and has two differently shaped valves and equilateral symmetry *(5b)*.

Brackish. Water that is more salty than fresh water, but less salty than normal ocean water, common in estuaries and marshes where fresh water mixes with sea water.

Byssal threads. Thread-like fibers secreted by a clam which extend outward from within the shell through a notch and fasten to some object on the sea bottom.

Calcareous. Contains calcium carbonate.

Calcium carbonate. ($CaCO_3$) A principal component of limestone which, when burned, yields lime.

Cartilage. An elastic tissue in animals and fishes that commonly becomes bone in the adult vertebrates, although in some (sharks) it does not.

Cell. The smallest, usually microscopic, unit of living matter that is capable of living as an independent unit and performing all of the fundamental life functions. Some animals and plants are of only one cell; others are composed of many, many cells.

Cementation. The manner in which some animals attach or stick themselves to the sea bottom or to other objects.

Cephalon. The head segment of a trilobite *(11b)*.

Chamber. A portion of a shell, separated from another similar portion by a wall or septum, as in the foraminifers *(2a)* or cephalopods *(6)*.

Chitinophosphatic. Composed of chitin, a substance similar to fingernails, and calcium phosphate.

Chonetid. Articulate brachiopods, usually concavo-convex, with spines along hinge of pedicle valve, small to medium size; one or more septa in brachial valve *(19)*.

Cilia. Hairlike structures found on many cells, that can move back and forth.

Circulatory organ. A part of the circulatory system such as the heart and blood vessels.

Cirri. Slender series of plates that outbranch from some crinoid stems.

Coal. A rock composed of carbonaceous material capable of being burned, usually black, derived from plants that have partially decomposed in the absence of air, under pressure and temperature.

Column. The skeletal portion of a crinoid that extends from the base of the dorsal cup to the substrate, also called stem *(14a)*.

Columnal. One of the plates which, together with other plates, comprises the column of a crinoid *(14)*.

Commissure. The location where the two valves of a brachiopod or clam come together *(5a, 5b)*.

Concavo-convex. One valve of a brachiopod is rounded outward as the surface of a ball, and the other valve is depressed inward as a bowl.

Concentric. Having the same center. A bullseye is an example of concentric circles.

Concretion. A nodular concentration of mineral matter that, during weathering of the enclosing sedimentary rock, commonly is more resistant and freed as more-or-less rounded rocks (*1*, 3a, b; *17*, top).

Conispiral. In mollusks such as snails, having a shell that is coiled in the shape of a cone.

Cord. A thick thread; a pronounced spiral ridge on a snail shell *(12)*.

Correlate. To tell from evidence found in two or more separated rock units that they are of the same age.

Costae. Ornamental ridges that run from the pointed portion of the shell outward, toward the margins of the valves, but are not reflected on the interior of the shell *(3, 12a)*.

Costate. Surface of valves bearing costae.

Costella. Thin costae.

Crenella. Fine radiating ridges on the flat surface of a crinoid columnal *(14)*.

Crest. Ridge at the center of the whorl of some snails *(17a)*.

Crown. The portion of the crinoid skeleton above the column *(14b)*.

Deciduous. Falling off after the growing season, as the leaves of some trees.

Dental sockets. Depressions along the hinge line of a valve shaped to receive the protruding parts (hinge teeth) of the opposite valve.

Discoid. Shaped like a disk.

Dorsal. A direction toward the back or upward side of an organism, dorsal valve of brachiopods is the brachial valve; dorsal in clams is toward the hinge line *(5a, 5b)*.

Dorsal cup. The cup-shaped skeleton of a crinoid that comprises the body in the lower part of the crown and encloses the vital organs *(14a)*.

Vocabulary*

Accessory cusps. Small raised portions of a tooth in addition to the central raised principal cusp *(21)*.

Adductor muscle. A muscle that serves to close the valves of a brachiopod or clam and which commonly leaves a scar. See muscle scar.

Ambulacral groove. One of the five grooves arranged as a star, found in starfish, echinoids, crinoids and related animals and which leads to the mouth, serving as a passage down for food.

Amoeboid. Like the simple animal *Amoeba,* consisting of one cell.

Anal sac. An upward protrusion of the tegmen, on which is located the anal opening through which body wastes are passed *(14a)*.

Anterior. The front.

Apex. The highest point of a cone-shaped snail shell *(9a)*.

Appendage. A limb such as an arm.

Aquatic. Living in water.

Arms. The appendages of a crinoid that extend upward and outward from the body *(14a)*.

Articulated. Held together by joints, as a human arm, or hinged as a door so that the parts may move.

Auricle. The ear-like extension of the hinge found on some clams *(12a)*.

Axillary. A plate on a crinoid arm above which the arm branches into two series of plates *(14a)*.

* Terms are defined in the sense they are used in this book; figure references in parentheses

Phylum Brachiopoda (Marine bivalves, equilaterally symmetrical on either side of a plane that halves both valves)
Class Inarticulata (Chitinophosphatic or calcareous valves commonly held together by muscles and having no hinge-teeth or dental sockets) *Lingula (8), Crania (8),* and *Orbiculoidea (17)*
Class Articulata (Calcareous valves, hinge-teeth and dental sockets)
Informal Group Orthids (unequally biconvex shells with hinge line parallel to hinge axis, well developed interareas on both valves) *Rhipidomella (15), Enteletes (5),* and *Schizophoria (9)*
Order Strophomenida (Pseudopunctate; commonly hinge line equals greatest width, shell wider than long, and one valve concave, the other convex)
Informal Group Strophomenids (Well-defined interareas on each valve; no spines) *Derbyia (3, 10), Meekella (7)*
Informal Group Chonetids (Concavo-convex, spines along hinge on pedicle valve; small to medium size; one or more septa in brachial (valve) *Chonetinella (19)* and *Neochonetes (19)*
Informal Group Productids (Concavo-convex shells with spines distributed over shell surface and inconspicuous interareas) *Linoproductus (12), Echinaria (12)* and *Juresania (7)*
Informal Group Rhynchonellids (Small to medium, biconvex, with short hinge line and pointed pedicle beak, plicate) *Wellerella (17)*
Informal Group Spiriferids (Spiral brachidium, most with biconvex shells and ornamented by radial costae) *Hustedia (13), Punctospirifer (13), Neospirifer (13)* and *Composita (8, 16)*
Informal Group Terebratulids (Loop brachidium, endopunctae, commonly subcircular to tear-drop-shape) *Beecheria (16)*
Phylum Mollusca (Unsegmented body with highly developed nervous and digestive systems; commonly secretes a shell)
Class Gastropoda (Snails, unchambered, typically coiled shells)
Informal Group Amphigastropods (Shell symmetrical, non-coiled or planispirally coiled)
Informal Group Bellerophontids (Incompletely coiled to so tightly coiled that only the last whorl is seen; slit in middle of outer lip leaves a raised crest of groove along mid-line) *Bellerophon (17)* and *Pharkidonontus (15)*
Subclass Prosobranchia (Spiral shells) *Hypselentoma (9), Shansiella (12), Turritella (18)* and *Amphiscapha (11)*
Class Cephalopoda (Marine, bilaterally symmetrical with highly developed head with image-forming eye and powerful jaws with beaks; ring of tentacles; shell divided into chambers and may be coiled (Nautilus), curved or straight; some have only internal shell (octopi, squids)
Order Ammonoidea (External shell; chambers separated by complexly fluted septa) *Baculites (6)* and *Scaphites (6)*

Class Bivalvia (Clams; aquatic, paired valves)
Subclass Paleotaxodonta (Equal valves; single adductor muscle; simple hinge with numerous short comb-like teeth, some or all of which are perpendicular to hinge margin)
Order Nuculoida—Nuculacea (Blunted posterior outline, no pallial sinus) *Nuculopsis (5)*
Subclass Pteriomorpha (Generally attach to substrate by byssal threads or by cementation; two unequal adductor muscles, with anterior muscle smaller or absent)
Order Pterioida (Pearl clams, oysters, scallops; generally one valve larger, thus lack bilateral symmetry; either with two muscles, anterior smaller, or with only one adductor muscle; line on interior of shell near margin lacks S-shaped deflection; members habitually lie on their sides)
Suborder Pteriina (Adults fixed by byssal threads through notch in right valve or cemented by right valve) *Myalina (4), Inoceramus (18)* and *Aviculopecten (12)*
Suborder Osterina (Oysters; one adductor muscle at posterior; generally cemented by left valve) *Gryphaea (18)* and *Pseudoperna (18)*
Subclass Anomalodesmata (Relatively short to elongate; poorly developed hinge teeth without lateral teeth; mother-of-pearl common; burrowing clams)
Superfamily Pholadomyacea (Equivalve, generally elongate with simple external ligament) *Wilkingia (10)*
Phylum Arthropoda (Jointed-legs; segmented body, hard exterior skeleton; includes insects, spiders, lobsters, barnacles and many other common examples)
Class Trilobita (Trilobites, three lengthwise lobes)
Subclass Ptychopariida (More than three thoracic segments mostly with facial sutures intersecting posterior edge of cephalon; glabella usually simple, tapering forward; commonly with simple parallel furrows) *Ameura (11)*
Phylum Echinodermata (Marine, bilaterally symmetrical modified by a secondary five-fold symmetry; calcareous skeleton of plates)
Subphylum Echinozoa (Radial symmetry, lack outspread feeding appendages; commonly free-moving; body oval, globose, discoid) *echinoid spines (16)*
Subphylum Crinozoa (Some degree of five-fold symmetry; globose or cup-shaped body enclosing vital organs; have food-gathering appendages; commonly attached to substrate)
Class Crinoidea (Mostly attached by stalk, cup covered by tegmen; having radially outspread branching arms for food-gathering) *crinoid fragments (14)*
Phylum Chordata (Having spinal cord)
Subphylum Vertebrata (Skull and backbone of vertebrae consisting of bone or cartilage, or with notochord)
Class Chondrichthyes (Fish, including sharks) *Corax (21), Lamna (21)* and *Ptychodus (21)*
Class Reptilia (Cold-blooded, air-breathing, egg-laying, including snakes, turtles, lizards) *Platecarpus* (Cover) and *Testudo (20)*
Class Mammalia (Hair and milk-glands, warm-blooded)
Order Proboscidea (Elephants and mastodons) *Mastodon (22)* and *Mammoth (22)*
Order Perissodactyla (Odd number of toes or hoofed, including horses and rhinoceroses) *Pliohippus (21)*

Classification of Illustrated Fossils

PLANT KINGDOM

Subkingdom Thallophyta (Simplest plants, no roots, stems or leaves; includes fungi and algae) *"Algal biscuit" (10)*

Subkingdom Pteridophyta (Ferns and fernlike plants)

Subdivision Lycopsida (Leaves small, simple, spirally arranged) *Lepidodendron* (stem) *(1)*

Subdivision Sphenopsida (Scouring rushes; stems jointed, with whorls of leaves at nodes) *Calamites* (stem) *(1)* and *Annularia* (leaves) *(1)*

Subdivision Pteropsida (Ferns and seed-ferns) *Pecopteris* (pinnule) *(1), Neuropteris* (pinnule) *(1), Alethopteris* (pinnule) *(1)*

ANIMAL KINGDOM

Phylum Protozoa (One-celled organisms)

Subphylum Sarcodina (Single-celled, amoeba-like body capable of developing pseudopodia)

Order Foraminiferida (Have shell or test protecting body)

Informal Group Fusulinids (Marine, commonly spindle-shaped, coiled about long axis with numerous long chambers) *Triticites (2)*

Phylum Porifera (Single individuals or in colonies; no internal organs, nervous tissue, or circulatory or digestive organs, but with cells organized in two-layer tissue that forms a porous body with chambers and canals)

Class Calcispongea (With skeleton of calcareous spicules and no spongin nor siliceous spicules) *Amblysiphonella (15)* and *Girtyocoelia (4)*

Class Demospongea (With skeleton of siliceous or horny spicules and spongin, no calcareous spicules) *Heliospongia (4)*

Phylum Coelenterata (Body interior carries on vital functions, have stinging cells)

Class Anthozoa (Corals, interior divided by various partitions)

Order Tabluata (Colonial corals with tabulae but only weak or absent radial partitions) *Chaetetes (11)* and the *auloporid (3)*

Subclass Zoantharia (Corals with radial partitions as well as tabulae)

Order Rugosa (Tetracorals, in which radial partitions appear in ordered sequence in quadrants producing bilateral symmetry) *horn coral (3)*

Phylum Bryozoa (Aquatic colonial organisms with well-defined digestive tract and organs occurring in fan and branching shapes or as incrustations) *fenestellid (2)*

FIGURE 22

Figure 22. Two kinds of fossil elephants are commonly found in Kansas, the mastodon and the woolly mammoth. Remains of these extinct animals are commonly found in gravels and bottom lands and other unconsolidated earth. They are easily distinguished from each other by the appearance of their teeth. Mastodon molars at the left have large conical cusps, are low crowned and rooted, whereas the mammoths and other true elephants have molars, right, with 12 to 30 high, thin, transverse enamel ridges or crests, high-crowned and rootless. Mammoth teeth acted like mill-stones, with varying hardnesses across the grinding surfaces.

Mastodons were smaller than mammoths, not exceeding a height of 9.5 feet at the shoulder. They ranged over the entire United States and Canada, and became extinct in post-glacial time, possibly even within the span of written history. They were hairy with a heavy undercoat of wool. Since pottery and charcoal, evidence of campsites of early man, have been discovered in levels of earth below, and hence older than, those at which mastodon remains have been found, it is probable that mastodons were hunted by men.

Mammoths were the largest North American land mammals to have ever lived, growing to a height exceeding 13.5 feet at the shoulder, and were the only true elephants to have been native to North America. The best known of them ranged along the front of the glaciers and southward as far as Texas and Florida. Some have been found frozen (the flesh still edible) in frozen gravels in Siberia, and it has been determined from studying the stomach content of the specimens that they ate grasses in summer and needles and twigs from coniferous trees in winter. Pictures of them have been found on walls in the cave dwellings of Cro-Magnon man in Europe. They are called "woolly" because of their dark brown to black hair that was up to 20 inches long, over a dense layer of wool up to 12 inches thick. (Pleistocene, eastern Kansas)

FIGURE 21

Figure 21 (Slightly enlarged). At the upper left are two teeth from the ray **Ptychodus.** The uppermost is a view of the surface of the tooth, the other a side view. Note that they are low and rounded with shallow ridges much like a grinding wheel, and have no sharp cutting edges. **Pychodus** had up to 600 teeth in each jaw, arranged in parallel rows forming a continuous pavement. These teeth reveal that the fish lived on or near the bottom, and were adapted to gathering and crushing crabs and oysters. In contrast, **Corax,** upper right, and **Lamna,** lower left, were active predaceous sharks as revealed by these sharp cutting and tearing teeth. **Lamna** had 300 or more large, pointed teeth, some of which had accessory cusps, as pictured here. Shark's teeth commonly weather out of the enclosing rock, such as the chalk in western Kansas, and lie about on the surface as though suddenly deposited by some great flood. No recent flood accounted for these fossils, for the rocks from which these teeth have weathered are about 75 million years old! (Greenhorn Limestone, Upper Cretaceous)

Pliohippus represented a stage in the development of the modern horse from an animal no larger than an average-sized modern dog. **Pliohippus** was about the size of a pony, and differed from earlier "horses" in having only a single toe. Here, at lower right, is a molar from this extinct horse. (Ogallala Formation, Pliocene)

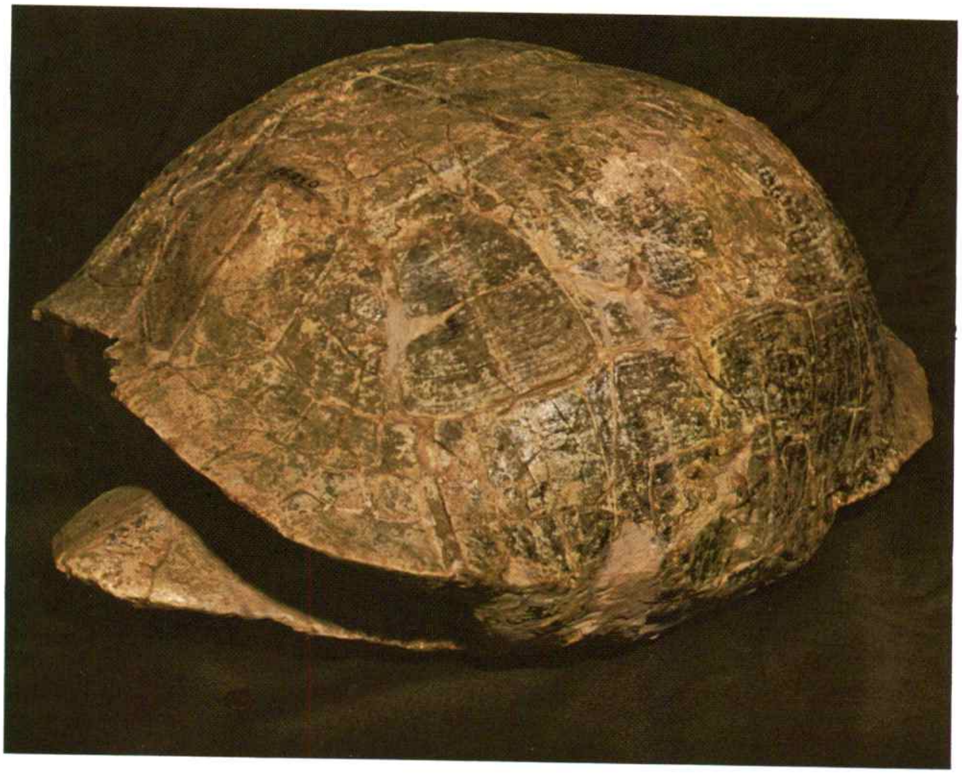
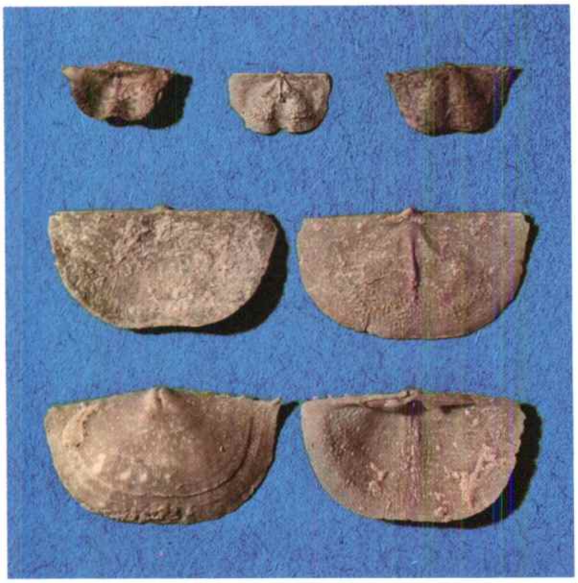


FIGURE 20

Figure 20. Testudo, a land tortoise, is familiar to all because it has living representatives today. This specimen (shown at slightly less than one-sixth actual size) comes from the Pliocene of western Kansas. **Testudo** is known to be restricted to areas where temperatures remain above freezing all year; therefore, it is believed that this fossil indicates that Kansas was warm all year during the time the animal lived here. (Ogallala Formation, Pliocene)

FIGURE 19



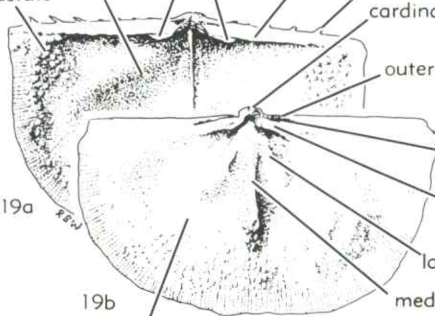


Figure 19 (Slightly enlarged). **Chonetinella,** the top three specimens, and **Neochonetes,** the lower four, are chonetid brachiopods. Extremely common in Pennsylvanian rocks, they are readily distinguished from other brachiopods described in this book by their small size, shape, and flattened form. Note the hinge spines on both genera. These spines served to balance or attach the adult shells to the sea bottom in a concave-upward position. With shells as flat as these, the volume of the soft body within must have been very small. **Chonetinella** may be identified by its small size, its pedicle valve which is divided by a pronounced sulcus into two lobes (top right), and a well-defined central ridge (termed a median septum) in the interior of the brachial valve (top center). **Neochonetes** is also distinguished by its size, elevated median septum (right center) inner and outer socket ridges, and fine radiating ridges on the exterior of the shell (Fig. 19a, b). (**Chonetinella,** Kansas City Group, Upper Pennsylvanian; **Neochonetes,** Florena Shale, Lower Permian)

FIGURE 18

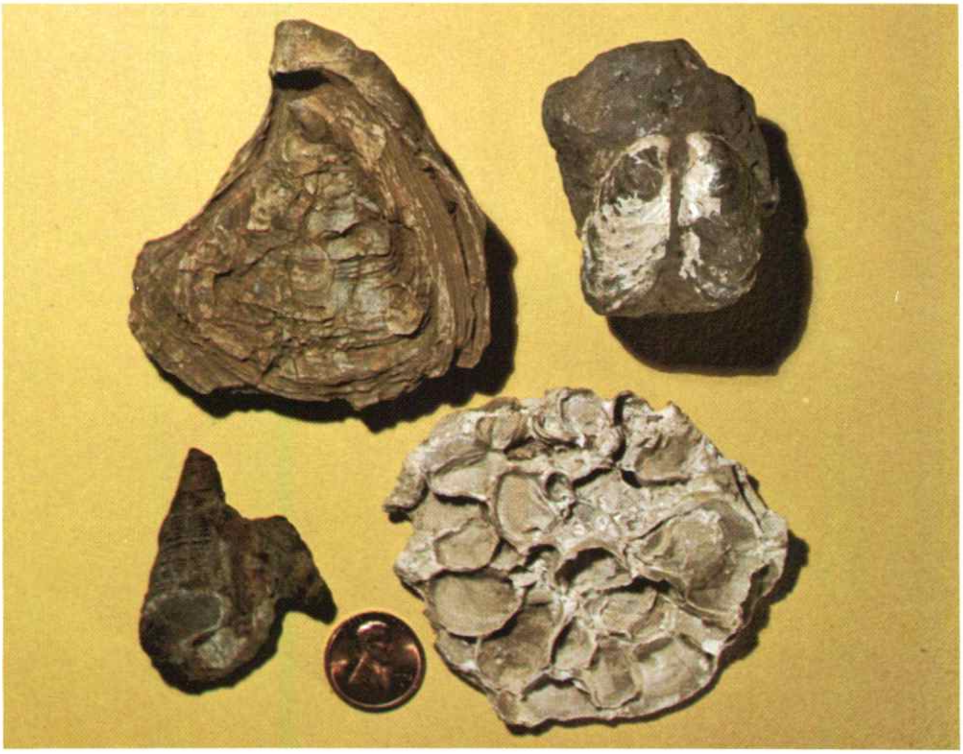


Figure 18. Of the four mollusks represented in this figure, one, **Turritella,** is a snail (lower left) and the remainder are clams.

Gryphaea in the upper left is a rather large oyster ranging in size to over four inches long. The right valve is seen nestling within the left valve rather like a lid. The shells of oysters do not interlock with hinge teeth but remain together through the action of muscles, and lack the bilateral symmetry of other clams. Oysters attach themselves by the left (largest) valve to some object; another shell, a rock, the roots of trees such as mangroves, and to pilings and piers. They live in shallow marine or brackish water. **Gryphaea** is found in Creataceous rocks in western Kansas but not in Paleozoic rocks.

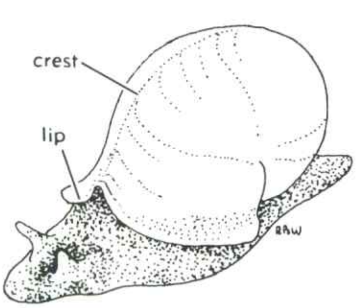
Pseudoperna in the lower right is another oyster. Very small, it lived in congested groups. In western Kansas Cretaceous rocks, they commonly appear as slab-like incrustations on the shell of a very large species of the clam **Inoceramus.** The specimens here are on such a fragment. (Niobrara Formation, Upper Cretaceous) All species of **Inoceramus** are not so large, as the specimen in the upper right reveals. This clam, concentrically wrinkled, also comes from western Kansas and is a characteristic Cretaceous fossil. Each valve, although lacking hinge teeth, is nearly a mirror-image of the other and is thus distinguishable from the oyster. (Pierre Shale, Upper Cretaceous)

Turritella (lower left) is a very high-spired snail with many whorls, and ranges from the Cretaceous to the Recent. (Kiowa Formation, Lower Cretaceous)

FIGURE 17

Figure 17 (Slightly enlarged). Along the top, a specimen of **Orbiculoidea** is shown encased within a concretion. Seen here is the conical brachial valve on the left, and its impression on the right. The pedicle valve is nearly flat with the pedicle opening, a narrow slit, not reaching the margin. **Orbiculoidea** is an inarticulate brachiopod, its valves held together by muscles only, and has a chitino-phophatic shell. See Fig. 8 for two other inarticulate brachiopods. (Iatan Limestone, Upper Pennsylvanian)

Wellerella, center, is a small rhynchonellid brachiopod. It is typically small, globular, with a pointed pedicle beak, and a moderately well developed fold and sulcus. It is primarily classified upon internal features. (Drum Limestone. Upper Pennsylvanian)

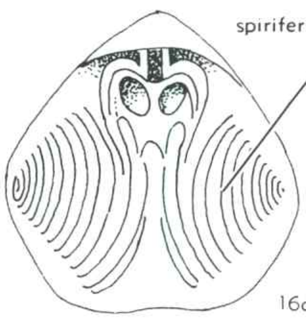


17a

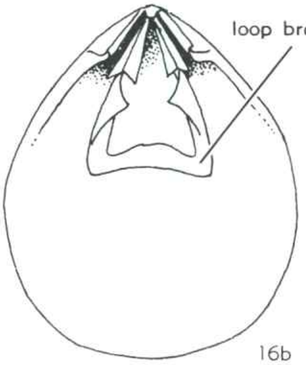
Bellerophon at the bottom is a snail somewhat similar to **Pharkidonotus** (Fig. 15). It is characterized by its globular shell, low crest and ornamentation of simple growth lines. A reconstruction of how the snail carried its shell is shown in Fig. 17a. (Drum Limestone, Upper Pennsylvanian)

FIGURE 16

Figure 16 (Slightly enlarged). The elongate objects in the center of the figure are echinoid spines. Sea urchins are living echinoids with similar spines. Echinoids, whose name is derived from the Latin word for prickle, are generally globular, discoidal, or heart-shaped animals having a box-like skeleton composed of many plates enclosing the vital organs. They are covered with movable spines which give protection and provide locomotion. At the lowest extremity a narrow base may be seen that is concave and fits onto a ball-like structure on the skeletal plate. Thus, there is a socket-and-ball relationship between the spine and plate. The ring or flange just above the base of the spine provides an area to which muscles attach; it is the flexing of these muscles that move the spines that in turn propel the echinoid across the sea bottom. These spines are common fossil fragments. (Topeka Limestone, Upper Pennsylvanian)



16a



16b

Beecheria and **Composita** are common brachiopod genera and are shown here to invite comparison and distinction. Illustrative of some of the difficulties encountered in paleontology is the outward similarity of these two very different genera, because these fossils are assigned to different groups on the basis of internal features. **Composita,** upper and lower right (and Fig. 8), is a spiriferid, with a lophophore-supporting structure (brachidium attached to the brachial valve which resembles two springs coiling outward to the right and left (Fig. 16a). The lophophore is a feeding organ that sets up water currents which carry food particles toward the mouth of the animal. (Beil Limestone, Upper Pennsylvanian)

Beecheria,[1] upper and lower left, has a brachidium that is a simple loop (Fig. 16b), and is assigned to the terebratulids. The upper view is of the pedicle valve, the lower view the brachial valve and showing how the pedicle valve overhangs the brachial valve at the beak. The small circular area in the lower view is the pedicle opening. The pedicle, a leathery stalk, protrudes through this opening and adheres to the substrate. Sometimes, weathered specimens may be found that display the aforementioned internal features. (Beil Limestone, Upper Pennsylvanian)

[1] Of even greater difficulty than distinguishing **Beecheria** from externally similar forms is that of distinguishing it from **Dielasma** which is nearly identical externally. Both **Beecheria** and **Dielasma** are terebratulids, and can be told apart only by detailed examination of small internal features.

to the anal series forming an anal sac or tube (see Fig. 14a, arms not shown at left to reveal anal sac) that rises above the tegmen, the area of the crown above the cup and within the arms covered by a leathery membrane or by plates. Down the inner surface of the arms and across the tegmen to the mouth are depressions termed ambulacral grooves. Along these grooves are located cilia that generate water currents to carry food along the grooves to the mouth. (Lecompton Limestone, Upper Pennsylvanian)

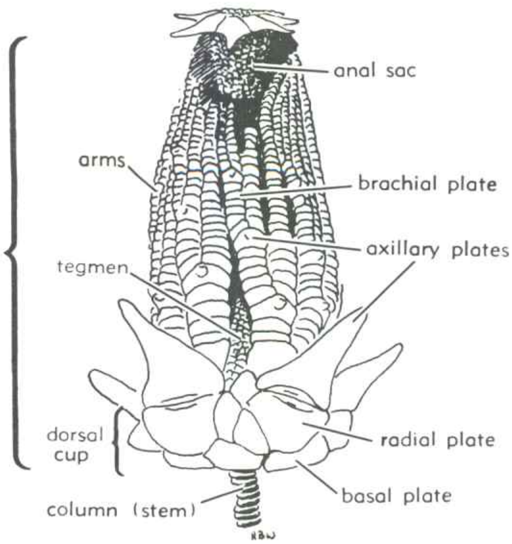
FIGURE 15

Figure 15 (Slightly enlarged). **Rhipidomella** along the top row is a common orthid brachiopod genus. It is recognized by its subcircular outline with numerous fine radiating ridges, called costae. Weathered forms may reveal a large scalloped muscle scar in the pedicle valve, and no brachidium (see Fig. 16a, b) in the brachial valve. (Hughes Creek Shale, Lower Permian)

To the lower left is the sponge **Amblysiphonella.** It is similar in structure to **Girtyocoelia** (Fig. 5), but differs in that the chambers are less bead-like or globular, and it has an axial tube, seen as a circular aperture in the specimen. This specimen is rust-colored because the original skeletal material has been replaced by an iron-rich mineral. **Amblysiphonella** is restricted to Upper Pennsylvanian rocks. (Topeka Limestone, Upper Pennsylvanian)

Pharkidonotus belongs to the bellerophontid snails, which are unusual in that they are coiled planispirally, and not conispirally as are most other snails. Thus, as the snail grew, it added material at the opening (aperture) in such a fashion that the earlier whorls were totally enclosed. This kind of coiling is common among the cephalopods (Fig. 17). **Pharkidonotus** is identified by the raised ridge or crest down the center line and the corrugations across the whorls. (Eudora Shale, Upper Pennsylvanian)

FIGURE 14



14a

Figure 14 (Slightly enlarged). Crinoids, various fragments of which are pictured here, are known from rock formations from the Lower Ordovician to the Recent. They have living representatives with world-wide distribution. Exclusively marine, these highly complex and varied echinoderms are commonly found as dissociated, broken apart and scattered, that is, fragments. Often referred to as "sea lilies," most crinoids resembled flowers and sometimes grew in garden-like clusters. Most commonly found are fragments of the stem, represented as long slender fragments (1a and 1g), or isolated columnal plates, the round, button-like fragment (1c). The stem or column is composed of many columnals stacked one above the other. Columnals commonly have radiating ridges called crenella, and a central hole, the lumen (1c). The lumens together comprise an axial canal down the center of the stem that contains some of the animal's organs. The columnals may interlock or may have ligamentous tissue inserted between the facets allowing varying degrees of flexibility (somewhat like man's backbone). Columnals may be circular to pentagonal, star-shaped or elliptical, and may be wider than long to longer than wide. Many stems thicken and branch at the base (resembling a root) and hold the animal fast to the soft substrate; however, the animal does not receive nutrition through the root as do plants, but rather has a complex food-gathering system in the crown. The crown is situated at the top of the stem and is composed of the dorsal cup, arms and tegmen (Fig. 14a). 1b in the photograph is a dorsal cup with a portion of its stem still affixed. Note that it is composed of plates that fit closely together and form a cup. It is within this cup that the vital organs are enclosed. 1e, 1f, and 1h are plates from such a cup. Reaching above the cup are arms composed also of minute plates variously arranged in elongate series. The plates in the cup to which the arms attach are termed ray plates or radials. The plates in the arm series are termed brachial plates. The arm continues upwards with a series of brachials until it divides at a specialized brachial plate, an axillary (Fig. 14a). The spinose brachial plate (1d in the photograph) is an axillary plate, as shown in Fig. 14a. Above the axillaries continue a series of brachials, then dividing at axillaries and so on. Different crinoids may have all or only a few of these features. Commonly set between two radials is a special plate that leads

Compare these specimens with the clam **Aviculopecten** at the upper left, and see Figures 5a and 5b to compare brachiopod with clam symmetry. **Echinaria** is recognized by its large size, concentric rows of short spines, and shallow sulcus or depression running down the center of the pedicle valve. **Linoproductus,** *on the other hand, has long, fine radiating costae and* concentric rows of more widely spaced spines. (**Echinaria,** Stanton Limestone, Upper Pennsylvanian; **Linoproductus,** Farley Limestone, Upper Pennsylvanian)

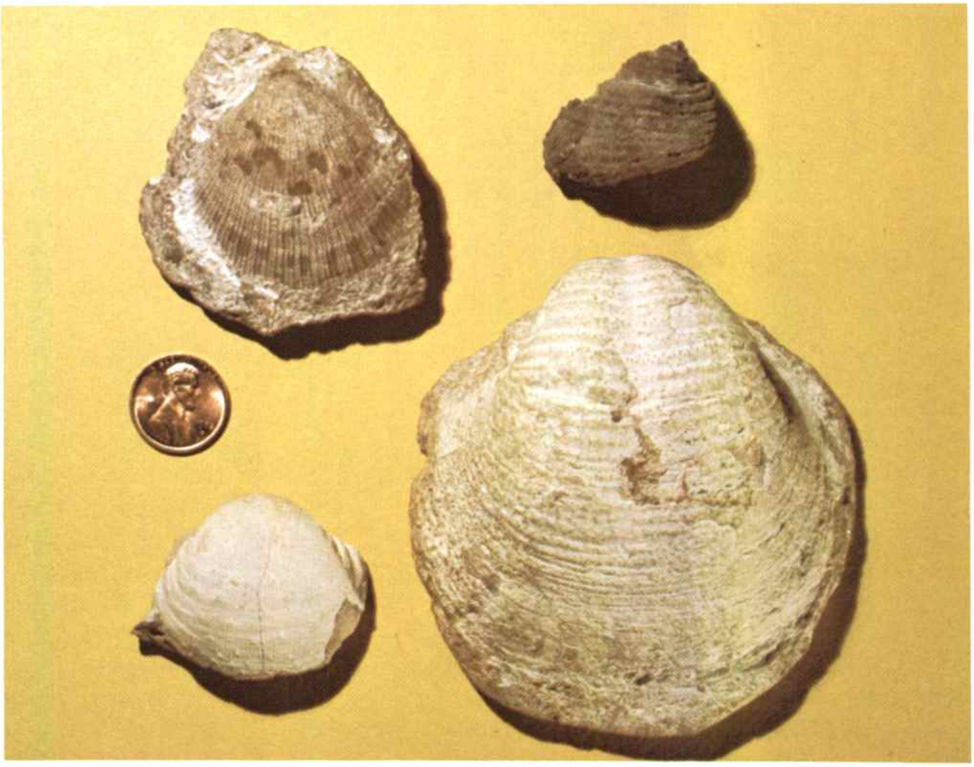
FIGURE 13

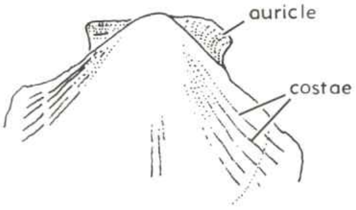
Figure 13 (Approximately natural size). **Hustedia,** the three small articulate brachiopods at the top left to center, is classed with the spiriferids on internal features. Note the prominent, even, radiating ridges (plications), the pronounced beak containing the pedicle opening on the pedicle valve (side view), and the absence of a fold and sulcus. (Beil Limestone, Upper Pennsylvanian)

Punctospirifer (upper right) and **Neospirifer** (bottom left and right) are also spiriferids. **Punctospirifer** is rather small with a distinct fold and sulcus, and the line along which the two valves meet, or commissure, is deeply folded (plicate) especially along the sides. (Beil Limestone, Upper Pennsylvanian)

Neospirifer, on the other hand, is rather large. Note that there is a fold and sulcus, but that the radiating plications, rather than being strong and individually pronounced, vary in size and appear to be bundles containing a principle plication and numerous minor ones. There are also growth lamellae present as concentric bands parallel to the outer margins. (Beil Limestone, Upper Pennsylvanian)

FIGURE 12





12a

Figure 12. Aviculopecten, the marine clam at the upper left, is one of the clams that is very nearly equilateral and is thus difficult to distinguish from the brachiopods. Only a trace of an auricle, or ear-like lobe (Fig. 12a) can be seen at the upper right margin of the specimen in the photograph. The radiating ribs, or costae, are a typical feature of the group to which it belongs. The well-known Shell Oil emblem is derived from the living scallop, which is a close relative of this clam. Some of these clams attached themselves to the bottom by means of byssal threads, but others were free-moving and swam about by means of clapping the valves together, rapidly expelling water and moving in a jet-propelled darting fashion. (Kansas City Group, Upper Pennsylvanian)

The snail **Shansiella** at the upper right is recognized by its rounded whorls bearing low, spiral cords separated by wide spaces. Snails move by means of a muscular foot that extends from the aperture, with the pointed part of the shell directed rearward and the aperture downward. Most snails feed upon vegetation, but some are scavengers and others are provided with a filelike rasping mechanism which is used to bore through the shells of living prey. (Lane Shale, Upper Pennsylvanian)

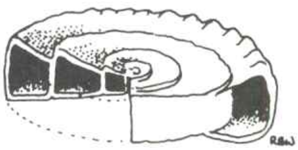
Linoproductus at the lower left and **Echinaria** at the lower right both are productid brachiopods. The productids characteristically have a straight hinge line and a brachial valve (hidden from view here) that is flat or even concave. Another common feature is the presence of spines. These specimens also possess another feature that gives them a scallop-like appearance, that of the outward-flaring shell in the area of the hinge.

FIGURE 11

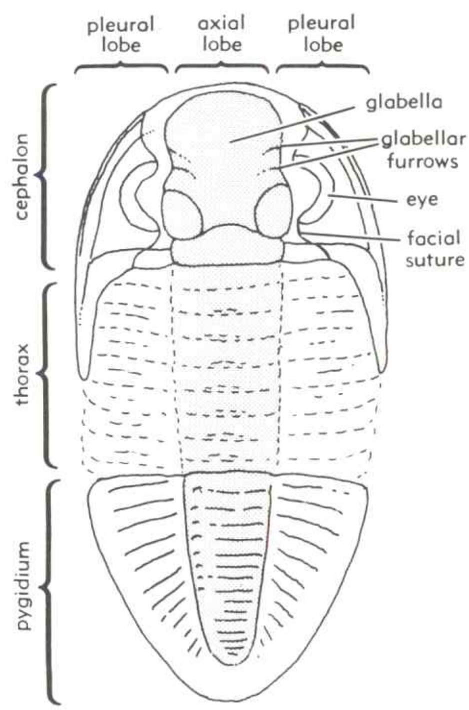
Figure 11 (Slightly enlarged). **Amphiscapha,** at the upper right, is another unusual snail. On the side hidden from view, the outer whorls or coils are raised leaving an inverted cone or depression, whereas on this side they are flattened; thus, rather than having an apex rising to a point as in most snails, it is depressed (Fig. 11a). These forms belong to the Superfamily Euomphalacea in which this distinctive coiling is common. (Coffeyville Formation, Upper Pennsylvanian)

Ameura, upper left, belongs to a long-extinct group of animals called trilobites. Classified with the arthropods (jointed legs) which includes spiders, lobsters, crabs, and insects, the Recent representative that most nearly resembles them is the horseshoe crab. Trilobites lived exclusively in the sea and were very complex animals. They developed as organisms without preservable hard parts many millions of years before the early Cambrian where they first appear as fossils. Trilobites receive their name from reference to the three longitudinal lobes (Fig. 11b) into which the body is divided, the axial or central lobe flanked on each side by pleural lobes. It was common for certain trilobites to fold or roll up upon death or when disturbed like the modern "pill bug." The photograph shows the pygidium, or last segment, and part of the thorax (middle segment) of an enrolled specimen. (Winterset Limestone, Upper Pennsylvanian)

Chaetetes, lower, is a common colonial coral of southeastern Kansas. Its thin-walled, polygonal tubes can be seen in this specimen. Classed among the tabulate corals, it commonly has platforms or tabulae within the tubes; these can be seen in the broken portion. (Pawnee Limestone, Middle Pennsylvanian)



11a



11b

FIGURE 10

Figure 10. Derbyia, a large specimen of which is at the upper left, is common in the Pennsylvanian and Permian rocks of Kansas. (See Fig. 3 for a further description of the genus.) This specimen is typical of Permian Derbyias which are substantially larger than its Pennsylvanian ancestors. (Florena Shale, Permian)

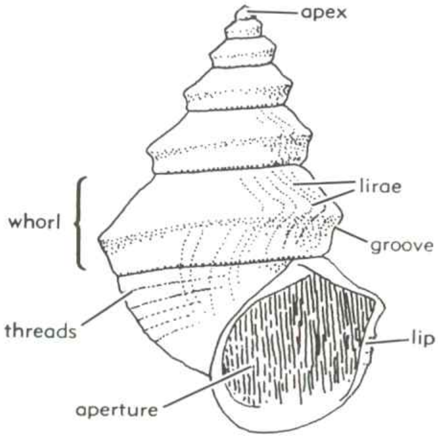
At the upper right is what is known colloquially as an "algal biscuit." It is found as lumps or nodules on rock out-croppings, or weathered free, and represents masses of calcium carbonate secreted by marine plants. (Wellington Formation, Permian)

Wilkingia is a clam, common and widespread in rocks of the Upper Paleozoic. Figured is a typical elongate specimen with concentric ridges. (Florena Shale, Permian)

FIGURE 9

Figure 9 (Slightly enlarged). **Schizophoria,** left and bottom, is an orthid brachiopod and is classified with **Rhipidomella** (Fig. 15) and **Enteletes** (Fig. 5) in the Superfamily Enteletacea. They have many similar internal features, but this genus commonly displays a low dorsal fold and ventral sulcus. (Stanton Limestone, Upper Pennsylvanian)

The snail **Hypselentoma,** upper right, can be identified by fine spiral thread-like lines on its sides and a shallow groove just below the outer edge of the whorls. Also seen on the uppermost slopes of the whorls are fine lirae (Fig. 9a). (Stanton Limestone, Upper Pennsylvanian)



9a

Figure 8 (Slightly enlarged). **Crania,** on the two shells in the upper left, and **Lingula,** lower right, are both inarticulate brachiopods, and thus lack interlocking hinge mechanisms, having the valves held together only by muscles. **Lingula** has a shell of calcium phosphate. Modern forms of this genus, which is found in the fossil record essentially unchanged back to the Ordovician, burrow in soft, muddy, dark-colored sediments and move up and down within their burrows on a long leathery or fleshy stalk-like extension (pedicle). They are found in marine or brackish water in poorly oxygenated estuaries and mud flats. (Ozawkie Limestone, Upper Pennsylvanian)

Crania is a genus also not yet extinct. As shown in the figure, this small calcium carbonate fossil is commonly found with the pedicle valve cemented to another organism, in this case to the shell of the articulate brachiopod **Composita.** It is also found cemented to other organisms such as crinoids and mollusks. As revealed by the animal to which it was attached, **Crania** lived in normal marine waters. (Ozawkie Limestone, Upper Pennsylvanian)

FIGURE 8

FIGURE 7

Figure 7 (Slightly enlarged). Two more brachiopod genera are shown in this figure, **Juresania** the top two and **Meekella** the bottom three. Both of these fossils have characteristics that are relatively easy to identify. **Juresania** is a productid type of brachiopod and as such has a spinose concavo-convex shell. The pedicle valve is typically highly convex. (Beil Limestone, Upper Pennsylvanian)

Meekella is quite easily recognized. Assigned to the strophomenids, the side view in the center reveals that it is biconvex, has a pronounced triangular interarea (lower right), and lacks spines, thus distinguishing it from the productids. **Meekella's** deeply conical pedical valve is distinctive, and it may have been cemented to the sea bottom. (Beil Limestone, Upper Pennsylvanian)

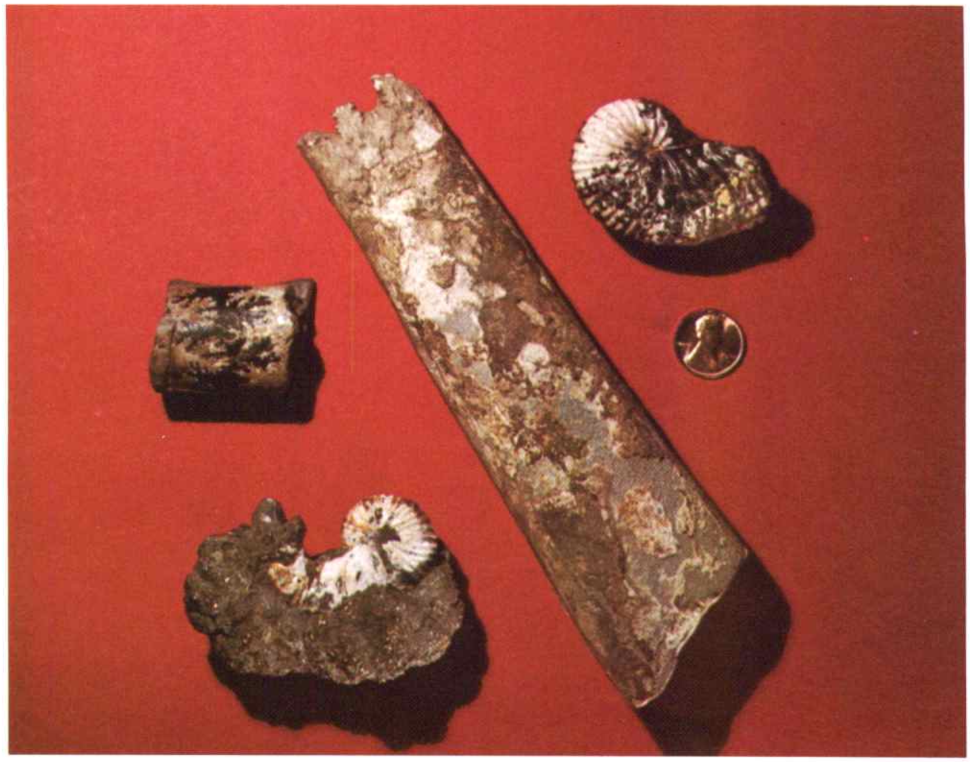


FIGURE 6

Figure 6. Baculites, the straight form in the center and upper left, and **Scaphites,** the coiled forms, are fossils related to present day squids and **Nautilus.** As such, they belong to the group of mollusks called cephalopods, and were very highly specialized, possibly even having an image-forming eye like us. They inhabited deep water and swam about freely by means of a form of jet propulsion, although **Baculites** probably was more adapted to life in the sea bottom. They were predatory, living on other animals such as crabs and shellfish. The specimen of **Scaphites** at the lower left is a smaller species than that in the upper right and has nearly reached maturity. When the scaphitids were fully developed, the living chamber, out of which protruded a squidlike head and tentacles, opened toward the coil at the other end.

Baculites ranged up to several feet in size, whereas **Scaphites** generally grew only to six or eight inches. These specimens of **Baculites** are only fragments of the entire long, tapering, slightly flattened shell, and the specimen at the upper left displays the intricate feathery pattern (artificially darkened for visibility) marking the line where the inner chamber walls intersect the outer wall of the shell. This fluting is similarly shown at the upper end of the longer specimen, where it broke along a chamber wall or septum.

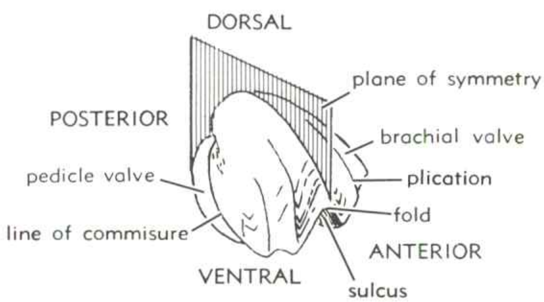
The golden crystals clinging to the **Scaphites** in the lower left are pyrite, an iron and sulphur mineral sometimes called "fool's gold." **Scaphites** is commonly found associated with clusters of concretions of this mineral in west-central Kansas. (**Baculites,** Pierre Shale, Cretaceous; **Scaphites,** Carlile Shale, Cretaceous)

FIGURE 5

Figure 5 (Slightly enlarged). **Nuculopsis** (1a-c in the photograph) is a small, shallow-water burrowing clam. Not yet extinct, it lives in muddy sediment and as a fossil it is therefore commonly found in shale. This figure is helpful in illustrating the differences in symmetry between pelecypods and brachiopods (Fig. 5a, b). Each valve of **Nuculopsis** (Fig. 5b) is nearly a mirror image of the other, so that the plane of symmetry lies along the line at which the valves join, called line of commissure. This is true of most clams. Brachiopods are quite different. Inasmuch as their valves are seldom similar, the plane of symmetry that divides the animal into mirror-image halves passes vertically down the midline of each valve (Fig. 5a), and is perpendicular to the line along which the valves join. **Enteletes** (3a-c in the photograph), an orthid brachiopod, demonstrates this difference in symmetry. **Enteletes** lived in moderately deep, clear, quiet waters and is thus found in light-colored pure limestone. (**Nuculopsis,** Lane Shale, Upper Pennsylvanian; **Enteletes,** Plattsburg Limestone, Upper Pennsylvanian)

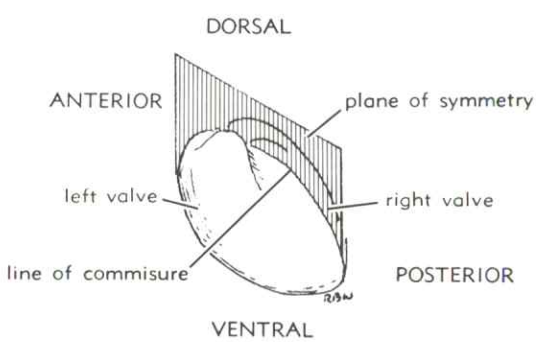
To the upper right (2a, b) are two peculiarly-shaped fossils. These distinctive rows of bead-like spherical chambers are the calcareous skeletal remains of the sponge **Girtyoceolia.** The entire animal, of which only small parts are seen here, lived in shallow clear water, attached to the bottom. They branched upward from the base, and bore numerous spoutlike openings on the outer walls of the chambers through which water currents passed, bringing in food and oxygen and carrying away wastes. (Hickory Creek Shale, Upper Pennsylvanian)

Equilateral Symmetry (Brachiopod)



5a

Bilateral Symmetry (Clam)



5b

Figure 4. Heliospongia on the left is a sponge although not bearing much resemblance to what most people think of when the word sponge is mentioned. Sponges belong to the phylum Porifera, meaning pore-bearing. They are nearly exclusively marine and are quite simple organisms, but vary greatly in form and size. Some are solitary individuals, and others occur in groups or colonies of individuals. They lack internal organs and circulatory and digestive systems. External holes or pores in the walls provide openings through which water carries food and oxygen into the cells, and a larger opening at the top (osculum) permits the water to flow out. Since all sponges live attached to the bottom, they must necessarily live in quiet waters, because sediment in agitated water would tend to clog these openings and to injure the delicate tissue within the organism. In general, there are two kinds of cells in the sponge body: one that lines the internal cavity and which, by making motions with hair-like flagella, creates food-carrying water currents; and another that forms the outer part of the body wall and sometimes secretes skeletal structures of silica or calcium carbonate called spicules. The spicules are what give the sponge its ability to be preserved as a fossil. The natural bath sponge is not commonly preserved as a fossil because it lacks hard spicules, but **Heliospongia** had a preservable skeleton. **Heliospongia** had lumpy siliceous spicules that interlocked to form its thick cylindrical wall. The pores were present along the outside of the cylinder, and the osculum at the upper end. (Hickory Creek Shale, Upper Pennsylvanian)

Orthomyalina, the clam on the right, is interesting in a number of respects. As can be seen from the interior of the right valve, the area about the pointed beak lacks the teeth or interlocking features that are common in most clams. This clam and others like it were held together by a ligament and muscle. The ligament area is that portion along the top of the shell (dorsal margin) bearing parallel striations or grooves. **Orthomyalina** is easily recognized by its relatively heavy, coarse shell and rectangular outline. It is commonly found in vast numbers crowded together in limestones or calcareous shales. It lived in relatively quiet shallow water, most probably attached to the bottom by numerous threadlike strands (byssal threads) that extended from between the shells in the incurved area along the front (anterior) margin like in its modern relative, the mussel. (Haskell Limestone, Upper Pennsylvanian)

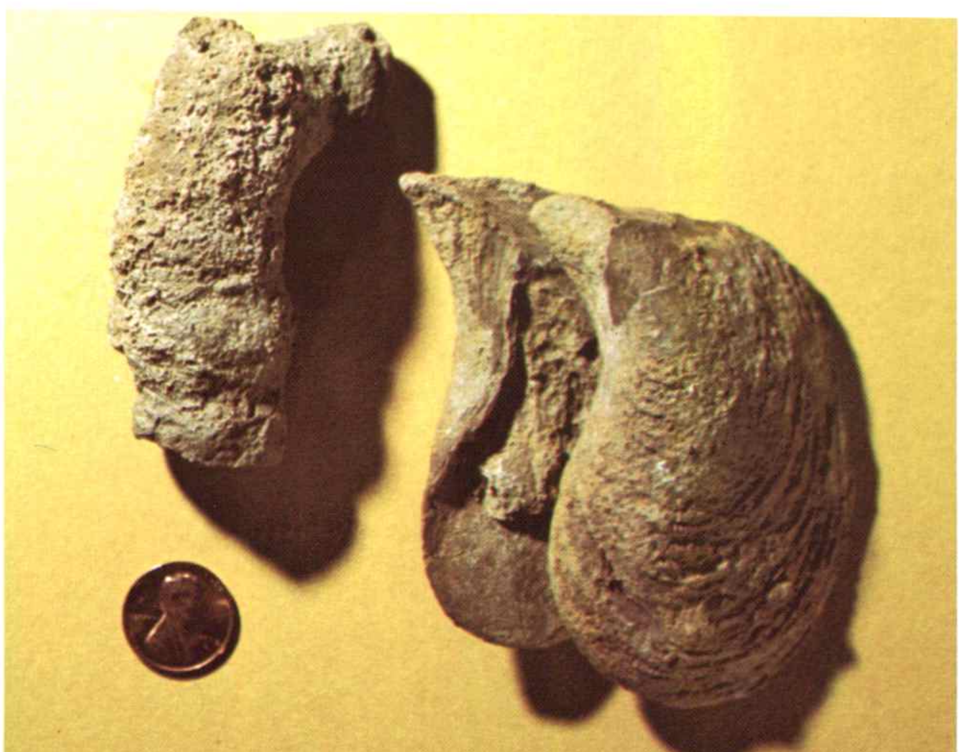


FIGURE 4

FIGURE 3

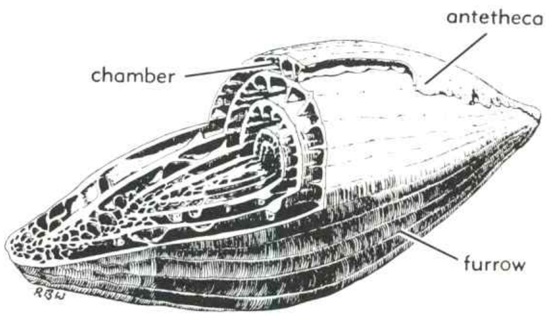
Figure 3 (Slightly enlarged). Figured at the left are two fossil corals. Corals are simple animals resembling sea anemones but they secrete a calcareous shell for protection and support. Some of these, such as the horn coral at the lower left, are large and grow in a solitary fashion. They have a complex internal structure, partly revealed near the base of the specimen where the outer wall has worn away, revealing the radial partitions called septa. Another form of coral is colonial, a simple example of which is auloporid at the upper left. Lacking in internal skeletal features, each successive trumpet-shaped individual or "corallite" directly builds from its parent predecessor in a manner termed budding. Thus, a common interconnected series of organisms arises, forming a colony. (See Fig. 11 for an additional example.) The auloporid is an especially simple form of colonial coral, and one may see the small circular openings in the specimen in which was contained the individual anemone-like polyp. (Horn coral, Lecompton Limestone, Upper Pennsylvanian; Auloporid, Beil Limestone, Upper Pennsylvanian)

Derbyia, at the upper and lower right of the photo, is a strophomenid type of brachiopod. It has well-defined interareas (the broadly triangular portion of the valves adjacent to the hinges). It is biconvex, with a convex pedicle valve and a nearly flat brachial valve. (Beil Limestone, Upper Pennsylvanian)

FIGURE 2

Figure 2 (Slightly enlarged). Appearing commonly in the rocks of eastern Kansas are small wheat-grain-like fossils called foraminifers. These amoeba-like animals secrete a hard skeleton and grow to amazing size for one-celled organisms. The foraminifers in the upper left are termed fusulinids, derived from the Latin word for spindle. They were exclusively marine, living in clear offshore water. The particular fusulinids in the photograph are **Triticites,** named from the Latin word for wheat. Along the side of the specimens may be seen a prominent line called an antetheca (Fig. 2a). This was the growing surface, and as the animal grew, adding chambers along the long axis, the antetheca extended forward. Starting as a small spherical shell, the animal added material, elongating the shell and developing longer and longer chambers, one at a time. As each chamber was added, a groove called a furrow was left on the outside leaving a trace of the previous antetheca. Many fusulinids resemble one another externally, and in order to properly identify them they must be cut and studied internally with a microscope. (Beil Limestone, Upper Pennsylvanian)

A piece of limestone at the lower right contains both a fusulinid and a fragment of the lacy type of bryozoans termed fenestellids, another specimen of which is at the upper right. Fenestellids grew in colonies of fan-shaped fronds cemented to an object on the bottom of the sea. (Beil Limestone, Upper Pennsylvanian)



2a

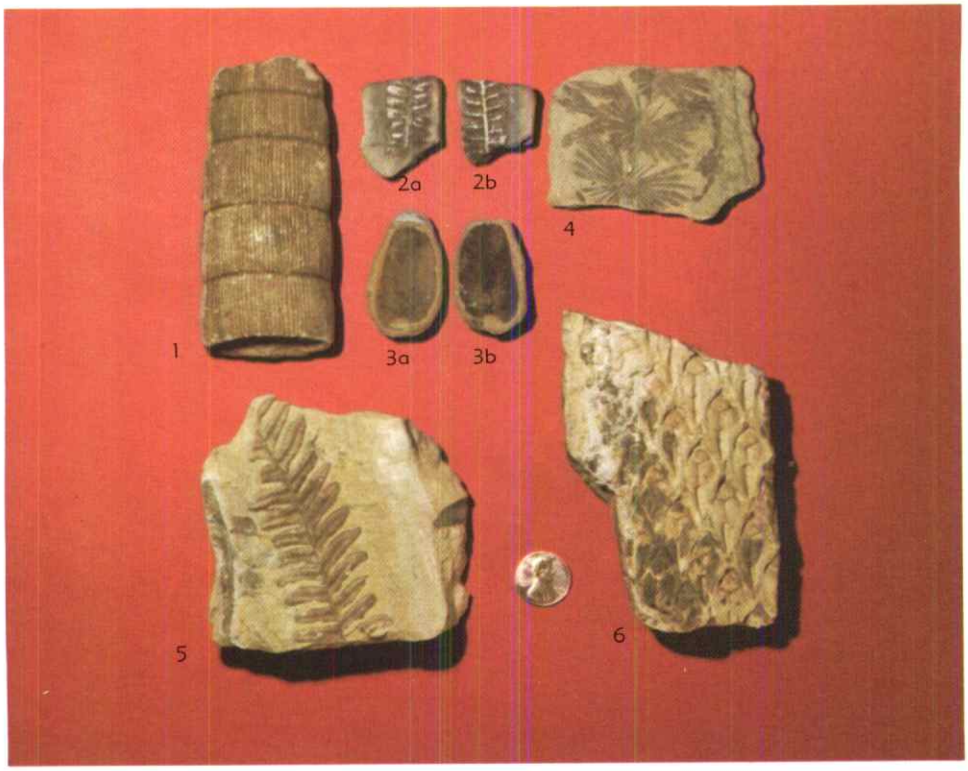
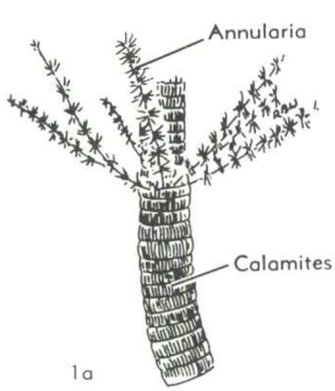


FIGURE 1

Figure 1. All of the specimens in this figure are Pennsylvanian plants. They grew in swampland forests which were populated not by the deciduous trees we know today, but by large, soft-tissued trees represented now by the small ground pines and scouring-rushes.



Calamites (1 in the photograph) was a giant (to 30 feet high) scouring-rush or horsetail. From the horizontal joints in the stem (Fig. 1a) grew a whorl of simple leaves of which **Annularia** (4), is an example. Plentiful also in the forests were huge scale trees such as **Lepidodendron** (6). Their leaves left scars resembling scales. Some of these scale trees reached 100 feet in height and exceeded four feet in diameter.

Pecopteris (2a, b), **Neuropteris** (3a, b) and **Alethopteris** (5) were all Pennsylvanian ferns. **Alethopteris,** a seed fern, and **Pecopteris,** a true fern, differ from **Neuropteris,** another seed fern, in that the bases of the pinnules, the leaflike portions of the frond, are broadly attached to the stem, whereas in **Neuropteris,** the pinnules are constricted to a point at the bases. (All Upper Pennsylvanian, eastern Kansas)

Common Fossils of Kansas*

12

* All photographs and line drawings are original, with the exception of line drawings numbers 9a, 11b, 12a, 16a, and 16b, which are modified after illustrations from **Treatise on Invertebrate Paleontology,** Parts I, N, O, and H, courtesy of Geological Society of America and The University of Kansas (Press).

assigning a number to each specimen and describing with the greatest amount of accuracy the exact location from which the specimens are taken. A description of the rock strata should be included, referring to the rocks above and below, the thickness of the rock layer and its color, other fossils in the same rock, the date and so forth. The same specimen number should be written on the specimen in indelible ink. In this fashion, you will always have a record of the specimen, and this record can be passed on should you wish to trade or donate your find. The exact name of the fossil is not the most important, because the name may change as our knowledge increases, but the locality where it was found will not.

Never remove or destroy fossils if you are not interested in them. If you feel that your find is particularly important, especially with regard to fossils of animals with bones or unusually large exposures of delicately preserved specimens, note the locality with precision and contact the nearest college or university natural history museum, or contact the Kansas Geological Survey. In this fashion, the specimen may be properly extracted for the greatest benefit to all. Never disturb remains or artifacts that you may suspect to be of human origin. (It may even be against the law!)

Whether you are on a picnic and discover a fossil, or are a student exploring the curiosities of nature, or are just having some fun in the field trying to find fossils, it is hoped that the following pages will help you gain an idea of what to look for, or what it is that you have found.

at any one time we will find different kinds of organisms that are typical of different environments. For example, the plants that grow in open meadows merge with different plants that grow on the woodland borders, and these in turn are different from those that grow deeper in the forests. Similarly, if one were to picture an ocean shoreline such as that of the Gulf of Mexico, there are certain organisms that live at considerable depths far offshore, a somewhat different assemblage of organisms that live near the shore, another on the shore between high and low tide lines, another well up on the beach or sand bar, another in the shallow lagoon that may be present behind the sand bar, and so on. By studying the rock and the assemblage of fossils within it, it is commonly possible to describe the ancient environment. Importantly, and this is a difficult concept, we may be able to describe different environments that existed at the same time but in different areas. We shall not go into this here, except to mention that the Kansas rocks are very important in giving the geologist information about ancient shallow-sea environments by virtue of the plentiful and well-preserved fossils of different kinds easily found over much of the state.

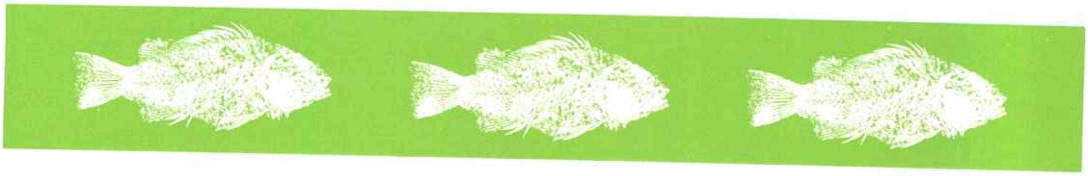
On the following pages are illustrations and brief descriptions of many of the common fossils found in Kansas. No attempt has been made to use the most perfect of specimens, for they are not the most common. The fossils shown here, on the other hand, are typical of what one may expect to find on a casual outing.

Where may one find fossils in Kansas? Over much of the state, one must merely look at the ground to find them. Do not search on vegetated surfaces, but rather look where the rock is exposed, or nearly so. Look at rocks where the highway has been cut through, or along river banks or in fields where the rocks crop out. Commonly, the action of rain, frost, and wind etches the rock matrix away from the fossil and leaves it exposed in relief, or sometimes frees the fossil entirely so that it simply lies loose on the surface.

A note of caution. One should not carelessly gather fossils, separate them from the rocks, and then discard them. Fossils are important tools to the researcher and are of value to the serious collector. If you find specimens that you wish to collect, they should be wrapped and labeled. You should keep a notebook

We think of fossils as being in rocks, or at least as being objects that are dug up, or unearthed. This is appropriate, for the word fossil means something dug up. They are also most commonly considered as part of the rock or earth from which they are extracted, and therefore are the same age, or as old as the rocks within which they are found. This is a very important point, because it is the idea that the fossils are of the same age as the rocks that contain them that makes fossils the valuable tools with which the geologist works. Why is this so? In simple terms, the animals and plants that existed at any one time in the history of the earth, have not existed before or since. Sometimes, very unique forms of life existed over very short spans of time, and simply by finding one such unique form one may determine the age of the rock it is found in. Most commonly, however, we find a number of different kinds of fossils which, taken all together, occurred at only one time, although the individuals may have existed with no observable change over longer spans of time. An example of the former method may be where a person was born and died within a year, and simply by seeing his name as being present, we know what year that was. An example of the latter method is where we see a list of a family gathering, with great grandmother and great grandchild, each of whom lives to 100 years. We cannot pinpoint with accuracy the time of the gathering knowing only that the great grandmother lived, say, from 1772 to 1872, or only that the great grandchild lived from 1871 to 1971, but taken together, we may pinpoint the time of the gathering at the years 1871-1872, the only time during which the lives overlapped. Thus, when we find several fossils in one place whose time spans of existence overlap, the group can tell us how old the enclosing rock must be. The geologist may find similar assemblages of fossils in rocks separated by considerable distances, even oceans, and thus be able to say that rocks from different localities in different states, or even on different continents, are of similar age. This is called correlating the age of the rocks.

As well as the age of the rocks, fossils may be used to tell us about the environments in which the organisms lived and thus in which the rocks were deposited. We observe organisms every day that live in certain areas and not in others, and we can readily understand that



Fossils

What is a fossil? The answer to this question is largely a matter of what a person thinks it should be. People that work with fossils, called paleontologists (pay-lee-on-tol-o-gists), use them to obtain an understanding of ancient environments and life processes, and from this understanding can better describe the history of the earth. Thus fossils, in whatever form they appear, may be regarded as evidence of past life. Fossils may be preserved shells or bone or wood, or they may consist of material that has replaced the original organic substance, while preserving its original form. They may be the hard parts of the organism itself, or simply an impression left by the organism. Organic activity such as the footprints left by the dinosaurs or the trails of crawling insects, or burrows of worms, may be preserved in the rock and be regarded as fossils. (Will the footprints of astronauts on the moon be regarded as fossils someday?) Fossils may be very large, as most persons know from pictures they have seen of large dinosaurs, or very, very small, detectible only through the study of rocks under electron microscopes. Fossil spores and pollen of plants millions of years old are commonly studied, as are minute sea organisms dating back to the dawn of life. These small fossils are not noticeable in the field, but can be seen only by examining the rocks with a microscope in the laboratory.

The geologic history of Kansas, then, is largely an alternation of more or less prolonged times of sedimentary deposition and times of erosion during which various volumes of previously formed rocks were destroyed. What effect did this succession of geologic events have on the surface of Kansas as we know it today?

The rock layers are not perfectly flat-lying, but have been tilted slightly and eroded, so that some of the older rocks can be seen at the surface. The accompanying geologic map of Kansas and the cross section from the western to the eastern border of Kansas show how the gentle deformation has caused rocks of different ages to crop out in different parts of the state. The older rocks, those of Cretaceous age and earlier, have been tilted and the younger rocks have been eroded or worn from above them. Now the Cretaceous and older rocks are exposed in areas that have the form of broad strips with irregular margins. The older rocks (Mississippian and Pennsylvanian) occur in the eastern quarter of Kansas; the rocks of Permian age—next younger than Pennsylvanian—crop out in a north-south belt across central Kansas, and the Cretaceous and Tertiary rocks are found farther west. The indentations made by valleys that have been cut into the rocks make the pattern of the outcrops irregular. In the northeastern corner of the state evidence of the southern limit of the glaciers may be seen. Most of the Pleistocene deposits are not shown on the map or cross section because they are so widespread, forming a thin cover over most of the older rocks. If they were indicated, very little else would show.

The map indicates the age of the rocks in each county. If you live in the western part of the state, you will be nearest to the rocks and fossils described as occurring in the Tertiary and Upper Cretaceous deposits. If you live in the eastern part, the rocks of Pennsylvanian age will be nearest to you. If the central part of the state is your home, then you can expect to find rocks and fossils of Permian and Cretaceous age nearby.

Man has been in Kansas only a few thousand years, and yet he already has an understanding of the 4.5 billion year history of the state, an appreciation of the origin of the many types of rocks, and the ability to make use of the many fossils to interpret the geologic history of the state. Anyone who has the interest and the time can gain a knowledge of the state's fossils and rocks.

which, being overloaded with sediment, dropped their excess sand and gravel along the river valleys. Gradually the valleys were filled with these sediments, and finally the hills themselves were covered. In some places there were lakes in which freshwater limestones were deposited. Before deposition stopped, a broad, gently sloping plain had been formed. The existing remnants of this plain extend from Colorado east through the western one third of Kansas, and from South Dakota southward into Texas. Today this entire area is called the High Plains.

When deposition of sand and gravel in what is now the High Plains area stopped, there was a long period of stability, followed by another interval of erosion before the glaciers of the Ice Age or Pleistocene Epoch invaded Kansas in the Quaternary Period. The glaciers advanced and receded at least four principal times. Only the northeastern part of Kansas was covered by glaciers. Consequently, the rocks carried by the glaciers and dropped as the ice melted are found only in that part of the state. On the outskirts of this glaciated area are many river gravels containing pebbles and boulders washed out of the glacier by the streams of water from the melting ice. The many rust-colored or pink boulders seen in the northeastern part of the state were carried here from north of Kansas by the glaciers, and left when the ice receded. A wind-blown dust called loess (yellow on the map) was deposited around the edges of the glacier area, on the High Plains surface and in the valleys of western Kansas far from the ice sheet. River gravels and dust from later ice advances that did not extend as far south as Kansas were deposited both on top of the glacial boulder clay and on the earlier loess.

Many geologists class the time in which we are now living as part of the Pleistocene Epoch because the climate and nature of sedimentary deposits closely resemble those that prevailed between advances of the glaciers; the time since the melting of the last ice sheet from the northern part of the United States is probably less than 25,000 years. It is a period marked by conditions as we know them today, including the erosion or deposition of sands and gravels along river valleys, the formation of sand dunes, and also of dust or loess deposits by wind action. During this time in Kansas there has been more erosion of the land surface than deposition, as the main geologic forces that are active today in this region are those which are wearing away the older rocks.

deposited over the salt, gypsum, and shale; these interesting Permian deposits include the redbeds of south-central Kansas. The sand and silt were washed down from the distant mountains and deposited along the shores of the retreating Permian sea. The redbeds have some gypsum, salt, and dolomite interbedded with them.

Following the Permian Period, there was a long interval of non-deposition and erosion in Kansas. There may be some Triassic rocks in Morton County, but the age of these has not been definitely determined. Jurassic rocks are present in the subsurface of the western part of the state.

The next rocks laid down in Kansas are those of Cretaceous age (light green on the map). The sea again came over the region, this time leaving a succession of sands, muds, and chalks, alternating with coastal stream, swamp, and beach deposits. The well-known chalk of Kansas is of Late Cretaceous age. Another famous Cretaceous deposit of Kansas and adjoining states is the Dakota Formation, which is frequently called a sandstone because the most prominent beds—those that cap the hills and stand out as cliff formers—are sandstones. These sandstone layers are the source of water in many wells in the central and western part of the state. About 80 percent of the Dakota Formation, however, consists of clays of many colors. Also, the formation contains beds of lignite, which, though not a high-grade fuel, was used by the early pioneers for heating their homes and for other purposes.

Exceptionally good fossil specimens found in the upper Cretaceous beds have made Kansas rocks world-famous among the fossil experts. These fossils include fishes (Fig. 21), batlike flying reptiles, the sea serpents called mosasaurs (cover), and toothed swimming birds.

After the close of Cretaceous time, the surface of Kansas was uplifted and subjected to prolonged erosion. The Rocky Mountains were formed by deformations of the earth's crust that occurred at intervals from late in Cretaceous time until well into Tertiary time. The deposits next younger than Cretaceous that are found in Kansas are the late Tertiary sands and gravels of the Ogallala Formation (brown on the geologic map). The Rocky Mountains were being worn down by the action of water and wind, and the sands and gravels were carried eastward by the rivers,

GENERALIZED GEOLOGIC MAP OF KANSAS

EXPLANATION

QUATERNARY SYSTEM
- Loess and river valley deposits
- Sand dunes
- Glacial drift deposits
- Limit of Kansan Glacier

TERTIARY SYSTEM

CRETACEOUS SYSTEM

JURASSIC SYSTEM

PERMIAN SYSTEM

PENNSYLVANIAN SYSTEM

MISSISSIPPIAN SYSTEM

SILURIAN-DEVONIAN SYSTEMS

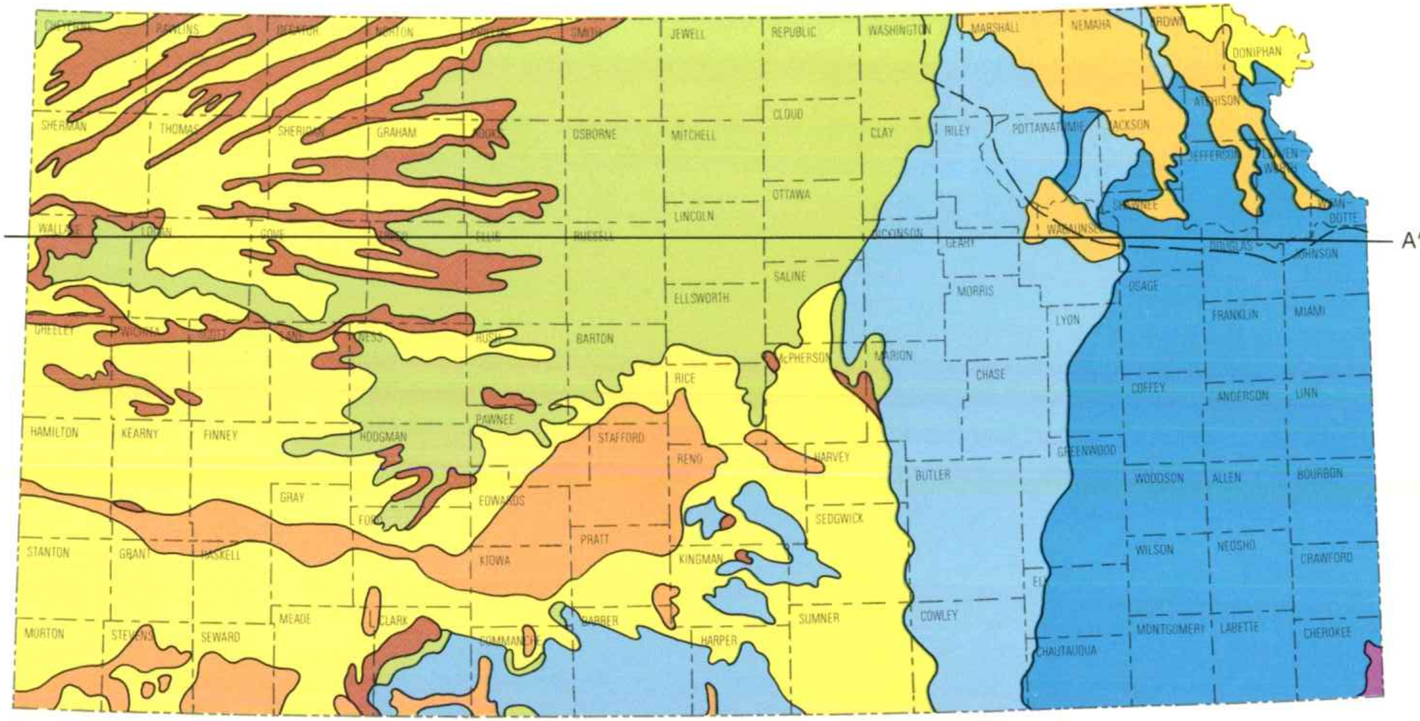
CAMBRIAN-ORDOVICIAN SYSTEMS

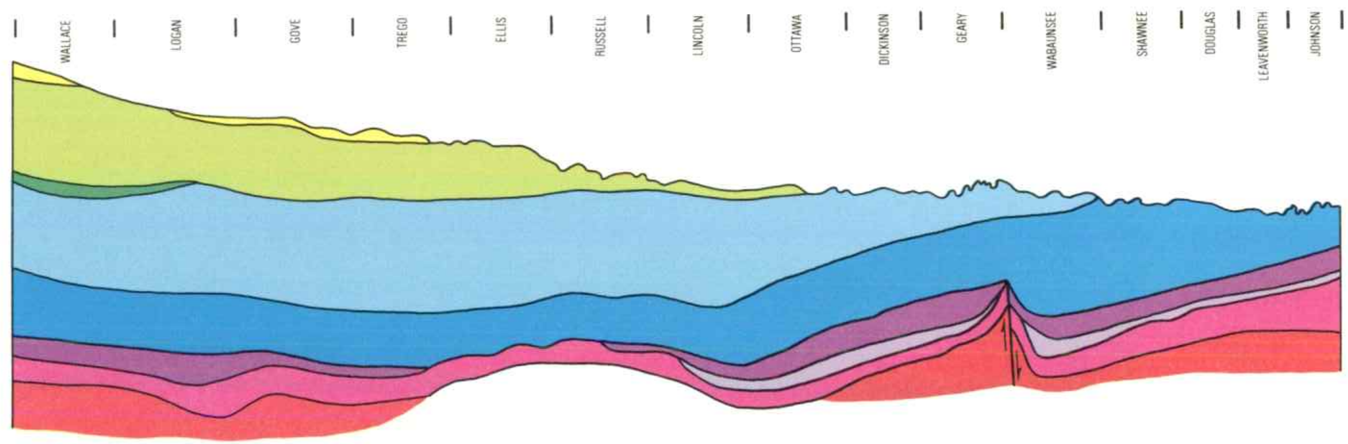
PRECAMBRIAN SYSTEM

A—A′ Line of cross-section

0 50 100
Scale in miles

0 50 100
Scale in kilometers





Geologic cross-section below I-70

Kansas Geological Survey
1930 Avenue "A", Campus West
The University of Kansas
Lawrence, Kansas

learned by studying the samples collected during the drilling of wells. This is true of all periods up to the Mississippian, the oldest period with rocks exposed at the surface, in the southeast corner of Kansas (purple on the geologic map). Subsurface samples have shown that during the early Paleozoic, Kansas was undergoing alternate depression and elevation of land. When the land was lowered the sea advanced, but when the land was raised the sea retreated and erosion set in. These conditions lasted through the Mississippian Period.

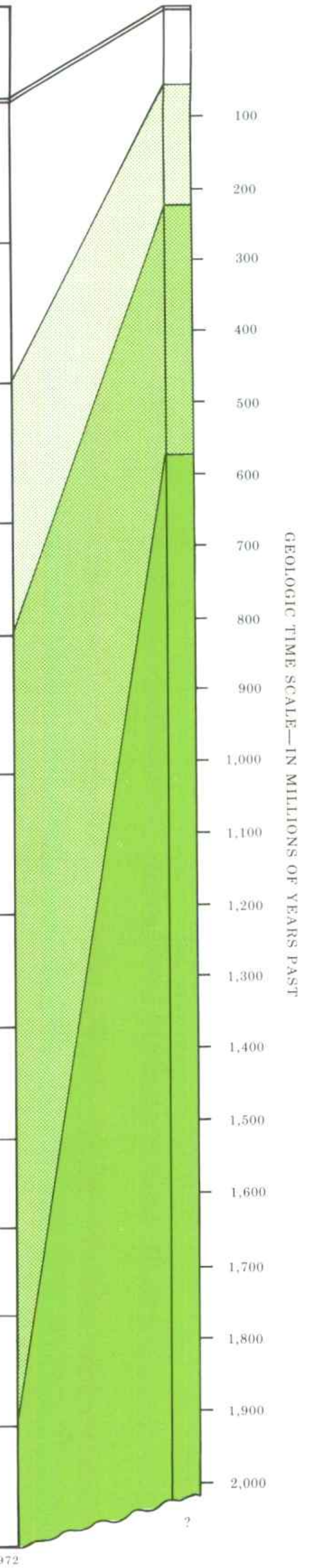
During the Pennsylvanian Period (blue on the map), the land was flat and near the sea level. The deposits of the period are unusual in that they show a regular alternation of marine deposits (limestones and shales). with nonmarine deposits (shales, sandstones, and coals). There are many fossils in the deposits, and some of the limestones consist almost entirely of the shells of sea animals. Pennsylvanian coal deposits are common. The coal was formed from the remains of plants (Fig. 1) that lived in swamps; these plant remains were buried by later deposits as the sea came over the region, and were converted into coal during compaction of the sediment. This coal has been mined throughout eastern Kansas, from small pits near Topeka to large, open-pit strip mines near Pittsburg. Good exposures of Pennsylvanian rocks showing alternations of shale and limestone exist in many places in eastern Kansas.

The early part of the next period, the Permian (light blue on the map), was very much like the Pennsylvanian, although during most of this time the sea covered the region, and little coal was formed. Sometime during the Permian, however, the sea water began to change in composition. Because sea water contains large quantities of dissolved salts such as calcium carbonate, calcium sulfate, and sodium chloride in solution, a residue of salts is left behind when the sea water evaporates. The Permian sea in Kansas apparently became partly separated from the main body of the ocean, and the water in this sea left layers of sodium chloride (which we call simply salt) and calcium sulfate (gypsum and anhydrite) many feet thick. There must have been a supply of water coming into this inland sea from the ocean in order to provide enough salt to form deposits so thick. These thick salt deposits are mined in central Kansas, notably near Hutchinson. At times the sea was drained, and the sand and silt were

GEOLOGIC TIMETABLE AND KANSAS ROCK CHART

(Not scaled for geologic time or thickness of deposits)

ERAS	PERIODS	ESTIMATED LENGTH IN YEARS*	TYPE OF ROCK IN KANSAS
CENOZOIC 65,000,000	QUATERNARY (PLEISTOCENE)	1,500,000	Glacial drift; river silt, sand, and gravel; dune sand; wind-blown silt (loess); volcanic ash.
	TERTIARY	63,500,000	River silt, sand, gravel; fresh-water limestone; volcanic ash; bentonite; diatomaceous marl; opaline sandstone.
MESOZOIC 160,000,000	CRETACEOUS	71,000,000	Limestone, chalk, chalky shale, dark shale, varicolored clay, sandstone, conglomerate. Outcropping igneous rock.
	JURASSIC	59,000,000	Sandstones and shales, chiefly subsurface. Siltstone, chert and gypsum.
	TRIASSIC	30,000,000	
PALEOZOIC 345,000,000	PERMIAN	55,000,000	Limestone, shale, evaporites (salt, gypsum, anhydrite), red sandstone; chert, siltstone, dolomite and red beds.
	PENNSYLVANIAN	40,000,000	Alternating marine and nonmarine shale, limestone, sandstone, coal; chert and conglomerate.
	MISSISSIPPIAN	25,000,000	Limestone, shale, dolomite, chert, oolites, sandstone and siltstone.
	DEVONIAN	50,000,000	Subsurface only. Limestone, predominantly black shale; sandstone.
	SILURIAN	45,000,000	Subsurface only. Limestone.
	ORDOVICIAN	60,000,000	Subsurface only. Dolomite, sandstone.
	CAMBRIAN	70,000,000	Subsurface only. Dolomite, sandstone, limestone and shale.
PRECAMBRIAN ERA		4,600,000,000 +	Subsurface only. Granite, other igneous rocks, and metamorphic rocks.



Kansas Geological Survey

*Geological Timetable by F.W.B. Van Eysinga Elsevier Publishing Company, 1972

Mere dividing and subdividing are not enough. Each of the eras and periods, and the rock formations made during these parts of geologic time, must be given a name so that one person can recognize any unit referred to by another person.

The names of the eras seem long and complicated, but each one describes the life that existed during its span. The oldest or first eras (Archeozoic and Proterozoic) are sometimes called Cryptozoic, meaning obscure or hidden life, and very few fossils are found in these rocks. Archeo- means ancient, and protero- means before, or former. The Cryptozoic is also called the Precambrian. The succeeding eras, in order of their age, are the Paleozoic Era (early life), the Mesozoic Era (middle life), and the Cenozoic Era (recent life).

Periods have been named in a different way and, unfortunately, the method used has not been consistent. Some were named from large geographic features; for example, the name Pennsylvanian was chosen for one of the periods because many rocks of that age are found in Pennsylvania. The word Cretaceous, on the other hand, means chalk-bearing, because rocks of Cretaceous age in many places are made of chalk.

Formations are always named from some geographical feature—a town, a river, a mountain—in the region where the particular rock units are well exposed. Thus the Wellington formation, deposited during the Permian Period of the Paleozoic Era, was so named because it is well exposed in the region around Wellington, Kansas.

Some of the eras were much longer than others, and the periods, likewise, were not of equal length. The shortest period, the Quaternary, began one or two million years ago, and the longest lasted about 80 million years. The geologic timetable, or column, (page 3) lists the eras and periods with the typical rocks of each as found in Kansas; the estimated length of each period is also included.

In general it can be said that the oldest rocks, which were deposited first, lie below the younger rocks that were laid down later. Consequently, on geologic timetables it is customary to put the oldest rocks at the bottom and the youngest rocks at the top.

From this timetable it is evident that Kansas has had a long and varied history. Much of the early history is known only from subsurface data, that is, information

The Geologic History of Kansas[†]

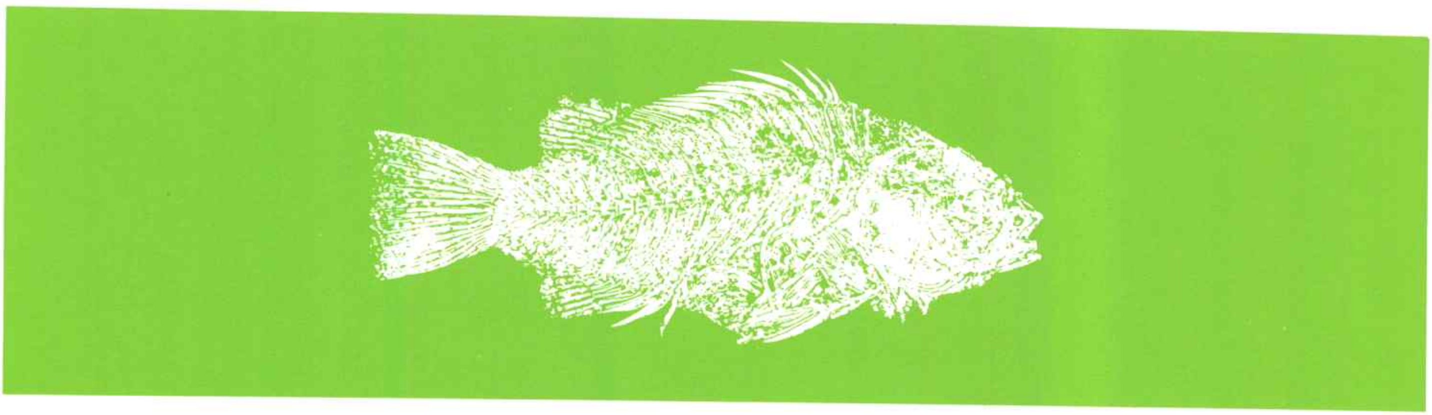
Geologists estimate the age of the earth to be at least 4.5 billion years, and in this time many things have happened. Mountains have been raised and eroded, then raised again. Seas have advanced over the land; layers of sand, mud, and calcium carbonate* have been deposited on the sea floors, and the waters have retreated, leaving strata of rock thousands of feet thick. Volcanoes have erupted, just as they are doing in many places today, and lava fields have formed. Volcanic dust or "ash" has settled to the earth, sometimes in lakes or ponds, burying whatever lay beneath. Great glaciers, formed during long cold periods, at times have covered a large part of North America, but have melted back with the coming of a warmer climate.

All these events have taken place during the geologic history of the earth. Just as human history is divided into major segments, like the Stone Age and Bronze Age, the 4.5 billion years of earth history have been divided into large units of time called eras. Eras have been divided into smaller units called periods and these in turn have been divided into epochs.

The layers of rock beneath the earth's surface also are compartmentalized into convenient segments. A formation is the fundamental rock unit used in mapping, and consists of an essentially uniform rock type that can be distinguished from adjacent, underlying or overlying rock units at sight. Two or more formations that are in some way related, such as in origin or location, may be called groups.

* A very extensive vocabulary which explains almost all of the terms used is included at the end of this publication.

† Adapted from Ada Swineford and Laura Lu Tolstead **Kansas Rocks and Minerals,** 3 ed., 1957.



Contents

The cover.

Platecarpus was a mosasaur, a very large marine lizard that flourished in the Upper Cretaceous seas. Note how the paddle-like limbs, ending with webbed feet, adapted this large reptile to a life of swimming in the deep sea. This specimen was one of the earliest collected by the Museum of Natural History at the University of Kansas and is now on display there. It was located in 1890 in Graham County, west of Hill City in the Niobrara Formation.

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Ancient Life Found In Kansas Rocks

AN INTRODUCTION TO COMMON KANSAS FOSSILS

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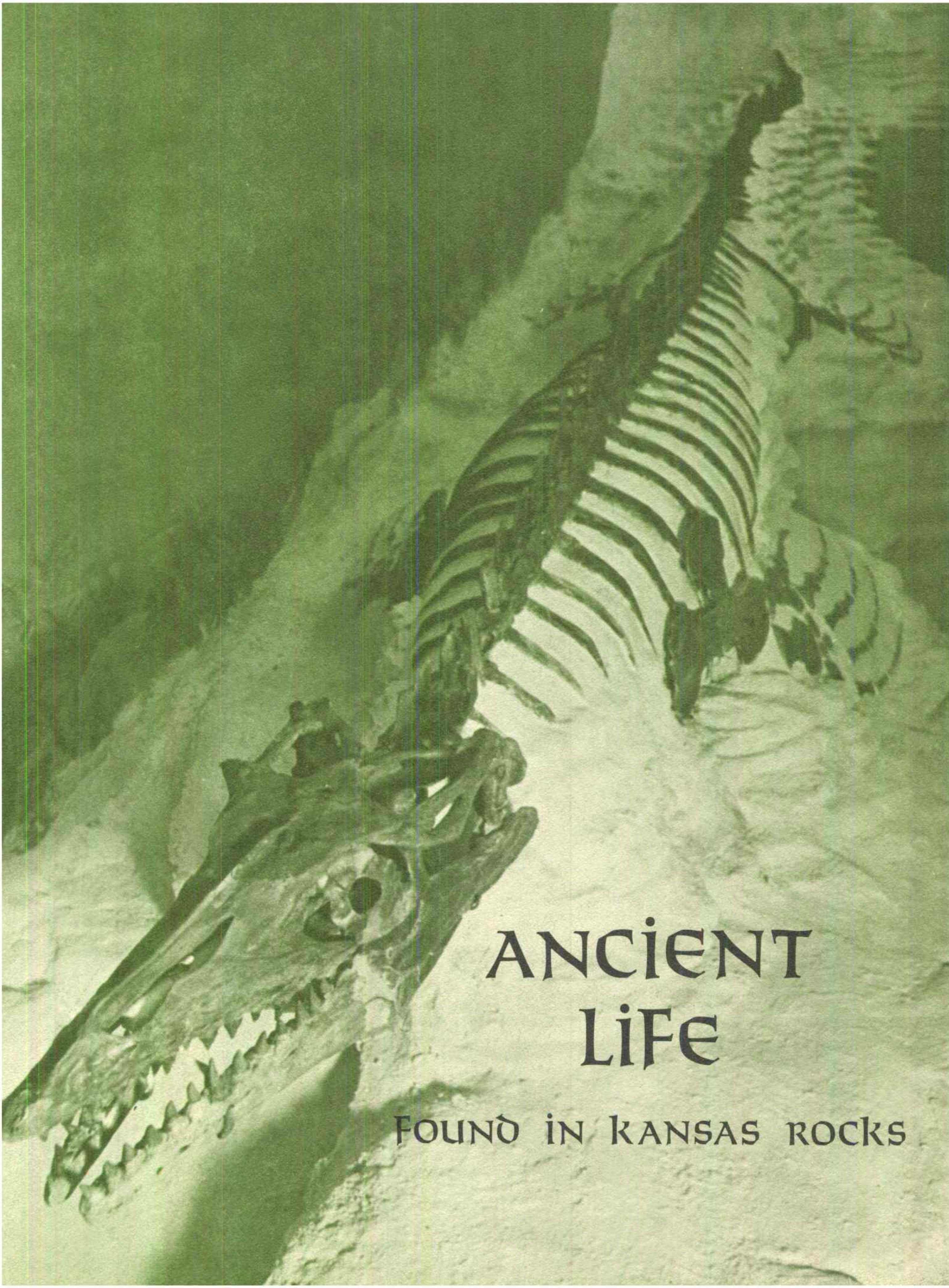
Kansas Geological Survey, 1975



ANCIENT LIFE

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