LET'S STUDY FOSSILS!

A FIELD GUIDE TO THE IMPORTANT INVERTEBRATE FOSSILS OF KANSAS

Prepared for the use of 4-H geology groups

by

Lawrence H. Skelton

Kansas Geological Society

2015

Contents

LET'S STUDY FOSSILS

by Lawrence H. Skelton

The American Geological Institute's *Dictionary of Geological Terms* (revised edition, 1976) defines "fossil" as: "The remains or traces of animals or plants which have been preserved by natural causes in the earth's crust exclusive of organisms which have been buried since the beginning of historical time." The word "fossil" is derived from "fossus," a form of the Latin verb "fodere" which means "to dig up." In medieval times, a fossil was anything that was dug up from the ground and some texts of the time show drawings of mineral and ore samples and stone arrowheads, all labeled with the inclusive term fossil.

Fossil collecting has been practiced by humans since prehistoric time. Beads made from fossilized snail shells and crinoid columnals have been found in Cro-Magnon era graves. The ancient Greeks and Romans found fossil shells in rock layers high in the mountains and speculated how they got there. Through medieval times up to the mid-1700's, it was generally assumed that fossils were the remains of marine creatures stranded during the Old Testament deluge of Noah.

Collecting fossils became stylish in the early 1800's and as the science of paleontology advanced, collecting became the thing to do. This was especially enhanced by the first discovery of *Ichthyosaurus* and *Plesiosaurus* in 1820 and 1823 respectively, by amateur collector Mary Anning in England. By mid-century, every educated person possessed a "cabinet" of fossils. Such collecting is a superb way to learn about different forms of life—present and past. There is something about the ability to hold the remains of a creature that has been extinct for tens of millions of years and to realize that the rock outcrop in which you found it was a sea bottom at one time. For those who are squeamish, an added benefit of fossils is that unlike living sea creatures, fossils have no odor and don't decompose.

Fossil collectors should know a little about the specimens they collect. The author has met schoolteachers who think that fossil crinoids are the remains of plants. Not so! This publication is a result of those conversations. Its aim is to furnish the amateur collector with some basic knowledge about the more popular fossils collected, especially in Kansas and adjacent counties in surrounding states. All examples used are of fossils found in the State of Kansas.

There are several points to be observed by fossil collectors:

1. Collecting in state or national parks is forbidden. If you are caught doing so, expect a heavy fine and possible jail time.
2. Collecting vertebrate fossils (and Indian artifacts) on federal land is forbidden
3. Always get the landowner's permission before entering and collecting on private land.
4. Leave no litter in the collecting area.
5. Secure all gates behind you when entering and leaving.

6. There should be no smoking in the field. You don't want the responsibility for a range fire.
7. As you find fossils, label them as to location and date found. (A GPS device is handy to determine and record exact locations.) You may need small containers for your finds: plastic bags with labels, etc. Amateur collectors have made some very important discoveries and a specimen without an accurate or an incorrect discovery location is scientifically valueless. Do not "dump" specimens collected in one area into another area. This may be terribly misleading to other collectors.
8. Collect only enough for your collection. Leave some for other people.

How do fossils happen?

Fossils once were living creatures. Those found in Kansas' surface rocks range in age from the Pleistocene epoch to the Mississippian period and in size from single-cell fusulinids to huge plesiosaurs to wooly mammoths. Fossilization occurs in different ways:

1. Freezing: Cold preserves organic materials as we all know from the use of home freezers. In nature, Pleistocene aged mammals, other animals and plants have been found frozen in permafrost in Siberia and Alaska. One wooly mammoth found in Siberia reportedly was so well preserved that an identifiable buttercup flower was found in it. The well-publicized "Ice Man" found melting from a glacier in the Italian Alps may be considered a frozen fossil since he meets the pre-historical criterion.
2. Drying (desiccation/mummification): Fossil remains of dried animals have been found in the world's extreme desert areas.
3. Chemical preservation (tanning): Humans and other fossils have been preserved by tanning in peat bogs. Tannic acid (also used for tanning leather) derived from tree leaves and other vegetation in the bogs permeates the bodies that fall or are thrown in and preserves them from bacterial attack and oxidation. A similar form of preservation is to be seen in the La Brea Tar Pits in Los Angeles, California, where Pleistocene epoch animals were trapped by becoming stuck in tar and were preserved from oxygen and permeated with hydrocarbon compounds. Similarly, insects, small vertebrates and plant parts have been trapped in tree sap which has fossilized to amber.
4. Permineralization (petrifaction): The process in which the hard parts of an organism are preserved by having additional mineral material fill in their cells or pore spaces. Examples are fossil dinosaur bone and petrified wood in which the original cell structure is filled with silica but is still discernable.
5. Carbonization (distillation): This process probably is caused by the partial bacterial decomposition of an organism and distillation, by compaction, of its volatile fluids and gases leaving only a flat, black, thin film of carbon in the shape of the organism. Examples are fossil ferns and other plants, insects, graptolites and rarely, soft-bodied organisms such as jellyfish.
6. Replacement: Part of the original shell or skeletal matter of an organism is dissolved and replaced by a mineral. This process may destroy or preserve the microscopic structure of the organism. Minerals involved often are silica (chalcedony, chert, opal),

calcite, pyrite, hematite, limonite, siderite, dolomite and rarely rhodochrosite, malachite or carnotite.

7. Impressions (Molds and casts): Organisms buried in a sedimentary layer may have their soft parts decomposed and their hard parts dissolved and removed by groundwater, leaving a void or mold of the original exterior. When such a mold is filled in by natural minerals introduced by groundwater or by materials such as resins or rubber injected by people, a cast of the original organism is formed. Casts may preserve exquisite detail of the mold. Examples include blastoids (crinoid relatives) in which the original blastoid calyx or head is replaced with crystalline calcite. It should be noted that no interior structure is preserved in a mold except in the case of a half shell wherein the upper (outside) and lower (inside) surfaces are preserved.

A key need for fossilization is quick burial and protection from atmospheric elements such as weathering or consumption by scavengers, etc. The other key factor is the need for hard parts which are capable of preservation.

The chief limiting factors to studying fossils include:

1. Vast numbers of species that had no hard parts adapted for preservation and thus remain unknown.
2. Species with hard parts that may not have fossilized because they were not suitably and quickly buried.
3. Fossils that once existed but have been destroyed by erosion, metamorphism or sea-plate subduction.
4. Existing fossils which may be beyond the reach of humans are beneath the sea or under great depths on land.
5. Fossils that may occur at or near the surface, but are undiscovered because of a lack of rock outcrops or because outcrops are covered with erosion debris.
6. Fossils may occur in well-exposed formations but in geologically unexplored parts of the world.
7. Fossils found may be too fragmentary or too poorly preserved to show defining characteristics of the once-living organism they represent.

What's in a Name? – Classifying and Naming Fossils

In September of 2002, the cartoonist Johnny Hart in his comic strip *B.C.* addressed the naming of rocks by a "rockologist." The character "Dr. Peter" noted that he had named one rock "Hank." If only it were so simple! Presently, there are approximately 1.75 million known living species of organisms on the earth. The late paleontologist Stephen Jay Gould estimated that nearly 99% of all species that ever lived are extinct. If these numbers are factual, over the course of the existence of life on earth, there have been in the neighborhood of 175 million different living organisms (plants and animals). The need for a systematic and logical way to sort and name such large numbers of things is apparent..."Hank," "Bob" or "Georgina" just won't do.

The science of categorizing species into logical groups and naming them is taxonomy. It is based on grouping organisms on the same various identifiable traits they share in common. For example, the insect order *Diptera* contains about 120,000 different species of flies and mosquitoes. They are grouped into the same order due to the fact that all have only two wings. (Hence the name, diptera, which is from the Greek prefix "di" meaning two or a pair, and the word "pteron" meaning wing or feather.)

Organisms are grouped into increasingly larger categories on the same basis of generalized similarities. These are:

Kingdom
Phylum
Class
Order
Family
Genus
Species

An example using humans:

Animalia
Chordata
Mammalia
Primatida
Hominidae
Homo
Sapiens

Or brachiopods:

Animalia
Brachiopoda
Articulata
Telotremida
Spiriferidae
Spirifer
rockymontanus

A Swedish botanist, Carl von Linné, instituted an early form of the above system in the 1750's. He set out to name all known organisms with a genus and species name. The names were in Latin which was the recognized worldwide scientific language of the time. Linneaus' (his Latin name) system, now known as *binomial nomenclature*, has been adopted, with modifications, and is now used worldwide. It has created order from chaos and is now formalized in the International Code of Zoological Nomenclature. A similar code controls plant nomenclature. Both codes are administered by the International Union of Biological Sciences. The scientific name is always italicized or underlined. The genus (first) name is capitalized and the second (species) name begins with a lower case letter. These also are standard rules outlined in the Code.

The use of such a system insures that the same name is used to describe the same organism worldwide, that a new discovery is indeed that, a new one. The Commission has issued numerous rules such as the older of two names assigned to the same organism has priority. That is the reason that several years ago, paleontologists were told that *Brontosaurus*, the giant long-tailed, long-necked, popular dinosaur, was henceforth to be known as *Apatosaurus*. Someone had found and named the beast *Apatosaurus* before it was tagged *Brontosuarus*. Curiously, the same scientist, O. C. Marsh of Yale University discovered both specimens. In 1877, he found a 50 foot long saurian which he named *Apatosaurus*. Two years later, he found a 70 foot long saurian he named *Brontosaurus*. (Another rule: the discoverer has the choice of the name.) In 1903, Elmer Riggs of the Field Museum in Chicago studied both skeletons and determined that the Apatosaur was a juvenile Brontosaur and because it was named first, that its name had priority.

A final note on nomenclature and taxonomy: Traditionally, the hierarchy of classification of organisms has been based on physical similarities among various members of a group. In recent years, DNA and chromosomal analyses are giving reason to question some of the established relationships. In the future, we may, on that basis, see organisms long considered to be members of a particular genus, family, order, etc. reassigned to something quite different.

The Uses of Fossils

What value exists for a fossil? There are at least five purposes for which fossils are useful:

1. Aesthetic satisfaction: Humans seem to have a need to collect and sort things as well as to admire them for their beauty. Fossil collecting is one way to fulfill that need. Searching for and finding well-preserved fossils is a challenge that is possible to accomplish. It is thrilling to realize that the fossil nautiloid in your hand was a living animal a quarter-billion years ago and that you chipped it out of what was then a seabed replete with plants, fish and other marine creatures. Beads made of fossilized shells and sponges by Cro-Magnon, Neanderthal and arguably Homo Erectus (200,000 years ago, have been found with burials and in shelter remains in Europe and the Middle East.
2. Placement in time: Fossils allow determination of the relative age of sedimentary rocks. During the half-billion or more years that life has existed on the earth, many creatures having worldwide distribution have appeared, thrived, then become extinct. Their presence as fossils permits geologists and paleontologists to determine the relative age (younger or older than some other rock layer) of a rock layer on sight. For example: the Permian era is recognized and subdivided on the basis of different fossil fusulinids contained in strata of that age and the Cretaceous era similarly is subdivided on the basis of fossil ammonites. Note that this method doesn't provide the age in years. See the section on Geologic Time in this series for the difference between absolute and relative time.
3. Determining the natural succession or origin and evolution of organisms (phylogeny): Scientists generally accept the Darwinian theory of organic evolution in that within a given species, over time, natural mutations occur which may be either of advantage or be a disadvantage or neither to the species. Those with useful or harmless mutations continue in time while those organisms with a disadvantage eventually die out. Fossils have allowed the entire history of a few organisms to be completely worked out. Perhaps the best known example is the evolution of the horse from the little *Eohippus* about 55 million years ago to the present day horse

familiar to us. There are a few less familiar examples but overall, the fossil record of life has more missing parts than available fossils.

4. Correlation of strata: It is useful if not vital for the geologist to be able to trace one or more particular layers of strata over a distance. There may be miles between outcrops or the beds may be in the subsurface buried below other strata and accessible only with drill holes. Lateral changes in the lithology or other physical attributes of a widespread stratum (called facies changes - pronounced fay'shees) can make visual recognition of the same beds impossible. However, since fossils change over time, it follows that strata deposited in the same general type of environment at the same time will bear the same types of fossils. The ability to trace given beds or their chronological equivalents by fossil content is called *correlation*. By comparing tiny fusulinids, Permian age strata in Kansas can be compared to time-equivalent Permian age beds in Russia. Two specialized branches of paleontology, micropaleontology and palynology (respectively the study of microfossils and the study of fossil plant spores and pollen) are very useful in subsurface correlation since the small sizes of the subjects allow their recovery in well cuttings. The collecting of such small specimens by private or amateur collectors is not common since the tiny specimens require special preparation and equipment to view.
5. Interpretation of paleo-environments: Plants and animals live in certain environments: people and trees live on dry land, fish live in water, etc. With the exceptions of a few things (whales for example apparently started out as land dwellers), there is no reason to think that fossilized organisms lived in environments that were much different from where surviving members of the same families now live. For instance, living brachiopods, crinoids and starfish live in marine (sea) water and the same types of creatures hundreds of millions of years ago did likewise. By studying the fossils contained in rock layers and features such as mud cracks, ripple marks, etc. preserved in the same rocks, we can ascertain the environment in which the rocks were deposited and the organisms lived. An example may be observed in the Hamilton Quarry area in Greenwood County, Kansas. There, a mixture of fresh water, brackish water and marine organisms combined with terrestrial vertebrate remains and terrestrial plants has provided the interpretation of a late Pennsylvanian age estuarine or lagoonal complex affected by storm-washover deposits. Fossil insects, animals and plants from various sources are mixed in sediments that are indicative of those roiled up by a storm at the sea's edge. A modern day severe storm or hurricane striking land at the mouth of a tropical stream would leave a similar assemblage of organic remains and deposits of sediment. By making such comparisons, ancient environments may be identified and understood.

Extinction

In the course of time, orders, families, genera and species may become extinct leaving sometimes only few, if any, representatives of their phyla. Most of them left no fossil record or if they did, such fossils have not yet been discovered. The bright side, however, as previously noted, is that there still are approximately 1.75 million species remaining...one percent of all that ever lived according to Gould. We read almost daily about the speed with which species are being depleted but the news rarely mentions that new species are forming, although not as rapidly as they are disappearing. One of nature's rules seems to be that once a species or greater unit (genus, etc.) becomes extinct, it never is created again. Present day genetic tinkering eventually may be able to change that rule in which case a new definition of extinction will become necessary. For example, research has found the gene that controls the formation of teeth in chickens. Since the very early birds in Cretaceous times had teeth, perhaps science could retro-create and duplicate toothed birds. Such laboratory miracles, which yet have not materialized in the real world, were the thesis of the hit motion picture *Jurassic Park* in the 1990's.

There are two types of extinction: a single or a few species dying off over a few years or centuries such as we witness at present and the mass extinction, a more frightening event wherein a large percentage of species die out during a relatively short time, perhaps a few thousand to 10 or 12 million years or so. What causes these events?

There seems to be a critical population size and concentration needed in order to maintain positive population growth. This critical mass, as it were, especially seems to apply to larger organisms. When a population declines to a number below that level, reproduction cannot occur rapidly enough or in sufficient numbers to build up the population and the species dies out in a relatively short time. The original decline may have been caused by disease, an environmental change affecting the organism directly or its food supply, or over-hunting by predators (including humans).

Another slow-acting force is that of random genetic mutations wherein the genetically altered organism has a new attribute that provides it an "edge" in competing with its fellows. A particularly good example is the minority of people who have a natural immunity to the Auto-Immune Deficiency Syndrome (AIDS), a lethal disease in humans. The disease itself is spreading and may eventually engulf all humanity. If it is not contained, eventually the only human survivors will be those with genetically endowed resistance and their line of offspring. They will be, for all intents and purposes, a new species. On the opposite side, there are inherited ailments which are fatal if not treated. If the carriers, the offspring of afflicted persons, were not treated and reproduced only among their own kind, they and the malfunction they carry would be naturally deleted in a few generations. They would be out competed, reproduction-wise, by those persons without the trouble-causing gene, in effect, by another species. These are the kinds of changes that Charles Darwin had in mind when he wrote about "the survival of the fittest." Considered on a broad scale, such alterations do cause the slow extinction of many different species.

Mass extinctions, such as the demise of the dinosaurs, are a different story. They wipe out a broad spectrum of organisms. For example, the mass extinction at the close of Permian time eradicated 90% to 95% of known marine species and 70% of all terrestrial families. The mass extinction at the end of the Cretaceous deleted about 85% of all known species – marine and terrestrial. There have been seven known mass extinctions spread from the Precambrian into the Holocene (Recent) time. These deadly catastrophes seem to be somewhat cyclic. What causes them?

There are two causes for mass extinction—one from space and the other originating on earth. The space-sourced event is caused by the impact of meteors, comets or asteroids. Less likely and less explainable is a sudden sharp increase in solar radiation. Earth originating causes are large-scale glaciation and its accompanying sea level changes, large volcanic eruptions and accompanying climatic changes and plagues of animal and plant disease. It is possible that both earth and space originated causes occur near each other in time and act together.

The extinction at the end of Cretaceous not only killed off the dinosaurs but also eradicated about 85% of all species. It is thought to have been caused by the impact of an asteroid which formed the present Chicxulub crater, some 124 to 186 miles in diameter, situated near the Yucatan peninsula in the Gulf of Mexico. Not as well known is the 373 mile by 270 mile diameter Shiva crater located in the Arabian Sea west of Bombay, India. The Shiva impact also occurred near the end of Cretaceous time, perhaps within hours of the Chicxulub event, perhaps within years. Other smaller craters dated at about 65 million years old recently have been identified: The Boltysh crater in the Ukraine is some 15 miles in diameter and the 12 mile diameter Silverpit crater, in the bed of the North Sea may have been formed near or about the same time as the Chicxulub and Shiva craters. Another crater dated about 74 million years ago in late Cretaceous time is the Manson crater about 75 miles northwest of Des Moines in Iowa where a stony meteorite estimated to have been 1.5 miles in diameter left a 23 mile diameter crater. These events occurring either simultaneously or in sequence over a thousand centuries (a short time, geologically) could have caused environmental effects that rippled through all life, causing extinction of many families of organisms. Together, the effect would be devastating. Major links in the food chain would be destroyed; immense tsunamis (popularly, tidal waves) would sweep over coastal areas wreaking havoc in shelf areas and lowlands. There would be major atmospheric contamination caused by massive volumes of soil, pulverized rock and water vapor and soot and ash from forest and range fires ignited around the world all being injected into the atmosphere.

Among proposed earth-origin causes of mass extinctions, continental glaciation and massive lava floods are the most feasible. Interestingly, some of these phenomena correspond in time with mass extinction events. For example, the Deccan flood basalts in western India formed at the end of Cretaceous time, cover an area of nearly 200,000 square miles and are over 6,500 feet thick. The Siberian Traps which are about the same size and volume as the Deccan basalt flows formed very nearly at the Permian/Triassic boundary and although their eruption was spread over perhaps a few million years, about 80% of their volume may have been expelled over a period of 200,000 years or less. Eruption of such huge volumes of lava certainly affected the environment negatively in several different ways. It may be no coincidence that 95% of known life forms became extinct at the end of Permian time. Some had been declining for millions of years but some climatic disaster at the end of Permian time was the coup de grâce for many.

During the past few years, a theory has been proposed that between 750 million and 570 million years ago, a series of ice ages occurred wherein the entire earth, including the oceans, was covered with hundreds of feet or more of ice. This so-called "snowball earth" resulted in extinction of much of the single-cell algae and zooplankton then living and opened the environment to multicellular organisms which are found in the fossil record not long after the last freeze. Similarly, it seems that major glacier activity near the end of the Ordovician and Devonian periods contributed to major extinctions. One-third of known brachiopod and bryozoa genera became extinct at the end of the Ordovician along with other creatures. Continental glaciation during late Pennsylvanian and part of Permian time may have weakened or reduced many families that the later Permian volcanic activity finished off. Global cooling in early Oligocene time may have contributed to the extinction of a variety of large mammals.

After each massive extinction, life has flourished anew as previously under-represented species, now free from predators or competition expanded to fill vacated niches. New species evolved to occupy other vacancies. There are many unanswered questions about extinction. For example, both nautiloids and their cousin ammonoids had existed since Paleozoic time, but the ammonoids became extinct during the mass extinction at the end of the Cretaceous. Although both were predator, possibly their diets differed and the food supply of the ammonites was wiped out.

Many organisms survive one major extinction period only to be deleted by a later one. The conodont, a segmented worm with microscopic tooth-like structures, first found in late Precambrian strata, underwent a population boom in the Ordovician, survived all the Paleozoic extinctions, even the big event at the end of the Permian, then became extinct at the end of Triassic time.

TIME

by Lawrence H. Skelton

Let's think about time... a very important subject to us all. We wear wristwatches, fill our homes and workplaces with clocks and calendars, sleep and eat, conduct periodic celebrations and generally regulate our lives by time. Generally, the more important something is to a society, the more terms they have to define it. *Webster's New World Dictionary* contains more than 20 definitions of time. As we normally consider it, time is used to measure the duration between occurrance of events. We tend to calculate time in various units before or after now – the present. We think in seconds, minutes, hours, days, weeks, months, years, decades, centuries and millennia to name a few of the units.

Time is possibly the most important concept in geology. This is because many geological processes operate at a rate not discernable to human observation. Such processes, erosion for example, working over millions of years, can cause such huge changes as the removal of a mountain range. The first person to appreciate the geologic effect of limitless time seems to have been the Scotsman, James Hutton (1726 – 1797), whose comment about the earth "No vestige of a beginning; no sign of an end" stirred a hornets' nest of controversy that continues to this day. James Ussher (1581 – 1656) was a British theologian and scholar who, based on patriarchal generations named in the Bible, calculated that the earth was created on Sunday, 23 October, 4004 B. C. His work gained wide acceptance and with some "tuning" over the years is still accepted among some groups. Modern scientific thought, however, places the origin of the earth at about 4.5 billion years ago and the creation of the universe at about 15 billion years past.

Geologists work with two kinds of time – relative and absolute. Relative time concerns the time-relation between things – whether one is older or younger compared to the other. No actual years are involved. Determination of relative time depends on fossil or artifact content or on stratigraphic position among rock layers: i.e., in a normal (tectonically undisturbed) sequence of rocks, the upper layer is younger than the layer below it. That is common sense but wasn't recognized until 1669 when it was stated by Nicolaus Steno (1638 – 1686), a Dane. The fact that fossil content changes in rock layers makes relative time useful to geologists in that the same types of sedimentary rocks deposited during equivalent times contain the same type of fossils. The same fossil content, which may be unique to a given period of time, thus allows the geologist to deduce that geographically separated rock layers were deposited within the same time frame. For example, it is known that the dinosaur, *T. rex* lived during the Cretaceous Period and that small fossils called fusulinids lived during the Pennsylvanian and Permian Periods. The presence of one or the other in rock strata allows us to determine the relative age since we know that Cretaceous rocks are found above Permian rocks and therefore are younger. But how much younger?

How much difference in age is an absolute time – expressed in years. The answer to the above question is approximately 175 million years - the amount of time between the last portion of the Cretaceous and the end of Permian time. Absolute time is calculated by several methods, some more reliable than others. Counting varves or annual sediment layers in lakes is useful in determining how long some lakes existed. Rates of sedimentation or erosion have been used to calculate passage of time as has the amount of salt in the ocean. However, we know that those data are dependant on other factors which vary and are not constant through time. Counting tree rings is a good method especially if the tree is still growing or if we know when it died. Its age can be determined by counting the rings. If the tree is dead and fallen, though, we know how long but not necessarily when it lived. When it lived, how old the piece of wood is in years, can be determined with a fair degree of accuracy by radioactive dating, a method which takes advantage of the fact that radioactive elements lose their radioactivity at a given rate and become a different element. The amount of time required for a substance to lose half of its radioactivity is called its half-life. For example, the half-life of uranium 235 is 707 million years. In that length of time, it loses half of its original radioactivity; during the next 707 million years, it loses half the remainder, etc. The breakdown of radioactivity forms a new element which is referred to as a daughter element. The uranium 235 degrades to lead 207. Therefore, by determining the ratio of uranium to lead in a rock sample the age since the rock formed can be calculated. There are several elements used for dating. Potassium 40 has a half-life of 11.9 billion years and breaks down to argon 40. A popularly known radioactive dating method is with carbon 14 which is formed at a constant rate in the atmosphere and is contained in a fixed volume in all living or once living organisms. It spontaneously decays to nitrogen 14 during a half-life of approximately 5,568 years. The ratio of carbon 14 to the remaining (ordinary or non-radioactive) carbon 12 tells us how much time has expired since the original organism died. Carbon 14 dating is useful to about 46,000 to 50,000 years. After that much time has passed, insufficient carbon 14 remains to weigh accurately.

There are some arguments concerning accuracy of radioactive dating. For instance, since we've known about radioactivity for only a hundred years, how can we be sure that the radioactive decay of an element is a constant? Perhaps half a billion years ago, the rate differed. Carbon 14 forms in the upper atmosphere when cosmic rays strike nitrogen 14 atoms. How can we be sure that the amount of cosmic rays hasn't fluctuated through time? We can't be sure, but since the atomic particles involved in such reactions are the basic building blocks of the universe and all in it, it would appear arbitrary and capricious for there to be substantial variation. For now, radioactive dating seems to be the most reliable method yet discovered.

How much time has passed? How long has the earth existed? The oldest rocks which have been dated are zircon grains extracted from an ancient sandstone found near Mt. Narryer in Western Australia. Since zircon is a mineral that forms in granite magma, we can determine by relative time that the zircons had eroded from a rock that existed before the sandstone. Radioactive dating of the zircons gave their age to be nearly 4.3 billion years. The earth itself is estimated to have formed about 4.5 billion years ago, a figure which agrees with age determinations of meteorites believed to have formed along with the rest of the solar system. This vast time has been subdivided into smaller time units of eras, periods, and epochs and ages in descending order. The era names are from the Greek word, *zoion*, meaning animal with Greek prefixes: *palaios*, *mesos* and *cainos* which respectively mean ancient, middle and recent. The names were given according to the types of fossil animals found in rocks. Time before Paleozoic is termed Precambrian. Most of the period names are from geographic areas where representative rocks first were studied. For example, Jurassic is from the Jura Mountains in France and Switzerland; Permian from the Perm Mountains in Russia; Devonian from Devonshire, England and the Ordovician, Silurian and Cambrian eras were named for ancient Celtic tribes which lived in parts of Great Britain where rocks of those eras are found and were first studied. Outside the United States, our Mississippian and Pennsylvanian eras are respectively known as the lower and upper Carboniferous. The Cretaceous era is from the Greek word for chalk which abounds worldwide in rocks of that age. Separations between eras are based on differences in fossils and/or major wide-area erosion surfaces termed unconformities. A geologic timetable is below.

QUATERNARY - PRESENT TO 1.6 MILLION YEARS - LATEST GLACIAL PERIOD (PLEISTOCENE) & PRESENT POST-GLACIAL (HOLOCENE).

MAMMOTH, MASTODON, SABRE-TOOTH CATS, ASIAN LION, DIRE WOLF, WOOLY RHINOCERAS, MOOSE, CAVE BEAR, GRIZZLY BEAR, HORSES, PALEO AND MODERN BISON, YAKS, MUSK-OX, CAMELS, HYENAS, GIANT BEAVER, GIANT SLOTH & OTHER MODERN MAMMALS.

TERTIARY (PLIOCENE, MIOCENE, OLIGOCENE, EOCENE, PALEOCENE - FROM 1.6 MILLION TO 66.4 MILLION YEARS AGO - LASTED FOR 64.8 MILLION YEARS.

VARIOUS PRIMITIVE HORSES, TITANOTHERES, OREODONTS (PIG-LIKE HERBIVORES THAT RAN IN HERDS ON THE GREAT PLAINS), CREODONTS (ANCESTORS TO BOTH CAT & DOG FAMILIES), VARIOUS CAMELS, MERYCODUS (ANCESTRAL ANTELOPE), UINTATHERIUM, OPOSSUMS, MANY RODENTS, GLYPTODON (A GIANT ARMADILLO), MULTITUBERCULATES (ANCESTRAL GRAZING HERBIVORES, PRIMITIVE ARTIODACTYLS (PRIMITIVE CATTLE, ANTELOPE, PIGS, OTHERS) & OTHERS.

CRETACEOUS - 66.4 MILLION TO 144 MILLION YEARS AGO - LASTED FOR 77.6 MILLION YEARS.

FLOWERING PLANTS, GRASSES, INSECTIVORE MAMMALS, CROCODILES, DINOSAURS (NODOSAURUS [IN KANSAS], T. REX, TRICERATOPS, VELOCIRAPTORS, TROODON, MAIASAURUS (LAID EGGS IN NESTS & APPARENTLY NURTURED YOUNG), OTHERS), AMMONITES, TOOTHED PRIMITIVE BIRDS, PLESIOSAURS, MOSASAURS, FROGS, BUTTERFLIES, GIANT CLAMS, OTHERS. ENDED IN MASSIVE EXTINCTION!

JURASSIC - 144 MILLION TO 208 MILLION YEARS AGO - LASTED FOR 64 MILLION YEARS.

DINOSAURS (ALLOSAURUS, APATOSAURUS, DIPLODOCUS, STEGOSAURUS, BRACHIOSAURUS, COMPSOGNATHUS, PTERODACTYLS, OTHERS), ARCHAEOPTERYX (EARLIEST KNOWN BIRD), BELEMNITES, OTHERS.

TRIASSIC - 208 MILLION TO 245 MILLION YEARS AGO - LASTED FOR 37 MILLION YEARS.

PRIMITIVE DINOSAURS (IGUANODONTS & OTHERS), MAMMAL-LIKE REPTILES, FIRST CROCODILIANS, TURTLES, LIZARDS, SQUIDS, FERNS, CYCADS, OTHERS.

PERMIAN - 245 MILLION TO 286 MILLION YEARS AGO - LASTED FOR 41 MILLION YEARS. ENDED IN HUGE MASS EXTINCTION.

CONIFERS, CYCADS, HEXACORALS (EXTINCT), THE LAST TRILOBITES AND FUSULINIDS, DIMETRODON (GIANT LIZARD WITH "SAIL" ON BACK), MANY PREDECESSORS OF MODERN-TYPE INSECTS (INCLUDING GIANT DRAGONFLIES AND GIANT COCKROACHES), MOST MARINE INVERTEBRATES.

PENNSYLVANIAN - 286 MILLION TO 320 MILLION YEARS AGO - LASTED FOR 34 MILLION YEARS. TIME OF MUCH COAL FORMATION.

FIRST CONIFERS, GIANT SCALE TREES (LEPIDODENDRON & SIGILLARIA), LARGE & SMALL AMPHIBIANS, BRYOZOANS & BRACHIOPODS & FUSULINIDS FLOURISH, PRIMITIVE REPTILES.

MISSISSIPPIAN - LASTED FROM 320 MILLION TO 360 MILLION YEARS AGO - FOR 40 MILLION YEARS.

MANY FISHES - ESPECIALLY SHARKS. AMPHIBIANS, CRINOIDS, BLASTOIDS, BRYOZOA, BRACHIOPODS (ESPECIALLY PRODUCTIDS AND SPIRIFEROIDS), MANY FERNS, SCALE TREES, CALAMITES (HORSETAIL RUSHES) & CORDAITES.

DEVONIAN - 360 MILLION TO 408 MILLION YEARS AGO - LASTED 48 MILLION YEARS. THE "AGE OF FISHES."

VERY EARLY LAND PLANTS, (SEED FERNS, PRIMITIVE SCALE TREES), VARIOUS ARMORED FISH, LUNG FISH, SOME SCALED FISH, SOME JOINT-NECKED FISH, VARIOUS SHARKS, PROBABLY THE EARLIEST AMPHIBIANS, EURYPTERIDS (SOME > 6 FEET LONG), PEAK OF BRACHIOPOD DEVELOPMENT.

SILURIAN - 408 MILLION TO 438 MILLION YEARS AGO - LASTED 30 MILLION YEARS.

EURYPTERIDS PLENTIFUL, FIRST SCORPIONS, FIRST FRESH-WATER FISH, PEAK PERIOD OF THE NAUTILOIDS, PRIMITIVE FISH, BRACHIOPODS, MANY SPONGES, ETC.

ORDOVICIAN - 438 MILLION TO 505 MILLION YEARS AGO - LASTED FOR 67 MILLION YEARS.

IN ORDER OF TOTAL NUMBERS OF DIFFERENT SPECIES: GASTROPODS, BRACHIOPODS, BRYOZOANS, TRILOBITES, PELECYPODS, CEPHALOPODS AND GRAPTOLITES. STROMATOPOROIDS, CRYPTOZOON ALGAE. NO LAND PLANTS.

CAMBRIAN - 505 MILLION TO 570 MILLION YEARS AGO - LASTED FOR 65 MILLION YEARS.

TRILOBITES DOMINANT, BRACHIOPODS SECOND, GASTROPODS THIRD. ARCHAEOCYATHIDS (A REEF-BUILDING SPONGE?), SPONGES, ALGAE, NO LAND LIFE.

PRECAMBRIAN - 570 MILLION TO 4.5+ BILLION YEARS. TO CREATION.

BACTERIA, ALGAE, EDIACARAN FAUNA LATE IN PRECAMBRIAN. FEW FOSSILS OF KNOWN ASSOCIATION.

METHODS OF FOSSILIZATION

CARBONIZATION

MUMMIFICATION - FREEZING - DRYING

REPLACEMENT - PERMINERALIZATION

CASTS

MOLDS

ICHNOFOSSILS

BRACHIOPODS

by L. H. Skelton – Kansas Geological Society

Let's study brachiopods. Pronounced brack'-ee-o-pods, these shellfish are among the more frequently found fossils. Although they resemble clams or mussels at first glimpse, a closer look shows them to be substantially different. Brachiopods sometimes are called "lamp shells" because of their cross-section shape which is thought to resemble an ancient, Mediterranean-style oil lamp. The name, brachiopod, literally means "arm foot" and refers to two parts of the brachiopod's anatomy: the "armlike" feeding apparatus called a *lophophore* which is tucked inside the shell and the "footlike" pedicle, a muscular stem that exits the adult shell and attaches the creature to the sea bottom. This is not like a snail's foot which permits mobility. The lophophore and pedicle are only two of the anatomic features that make brachiopods different from clams.

Brachiopods have been on the earth since the Cambrian Period...a little more than half a billion years. All brachiopods throughout their history have shunned freshwater and have lived in marine environments. Very few living species are found at water depths past the continental shelf. Most presently live in depths less than 600 feet (100 fathoms). On that basis, we can assume that the fossil forms lived at similar depths during the past. Ancient forms thrived in warm, tropical waters, sometimes being found in fossil reef environments. Modern species, however, mainly inhabit cold waters and are far more restricted in occurrence than their predecessors. Three orders are found in early Cambrian strata, indicating that brachiopods may have existed during the Precambrian. One of the Ordovician types, the genus *Lingula,* still lives in modern seas, unchanged during the past 500 million years. In the geologic past, however, brachiopods were far more numerous than at the present. There are about 280 living species whereas there are about 3,000 fossil species that lived during the Ordovician and Silurian Periods. Nearly 30,000 fossil species from the Paleozoic and Mesozoic eras have been described.

Zoologists have sorted brachiopods into two classes: the *Inarticulate* and the *Articulate,* both ranging in time from lower Cambrian to present. The classification is based on how the two halves of the shell (each half is properly termed a *valve*) are held together. Simply explained, Articulate class valves have a "tooth and socket" arrangement along the hinge line. One valve is equipped with "teeth" which fit into corresponding "sockets" on the other valve. This permits the shells to pivot open and close on the teeth and yet maintain a precise fit. The opening and closing of the valves is performed by muscles inside the animal. Arrangement of the muscles differs between the two orders. The ends of the muscles attach to opposite shells and create muscle scars which are useful identification features if the inside of the shell is visible to view...often not the case with fossils. The shells of Articulate brachiopods are always calcareous; that is, composed of calcium carbonate. The Inarticulate brachiopods are more primitive and lack the tooth and socket arrangement. Their muscles are arranged to slide the valves over one another rather than to open them along a hinge as their more advanced Articulate relatives do. Shell material is also different. Inarticulate valves are usually a mixture of calcium phosphate and chitin (the same type of material forming the outside of insects, shrimp, etc.). One Family, the *Craniidae*, lacks the pedicle and is cemented to its base. Oddly, it also has calcareous shells.

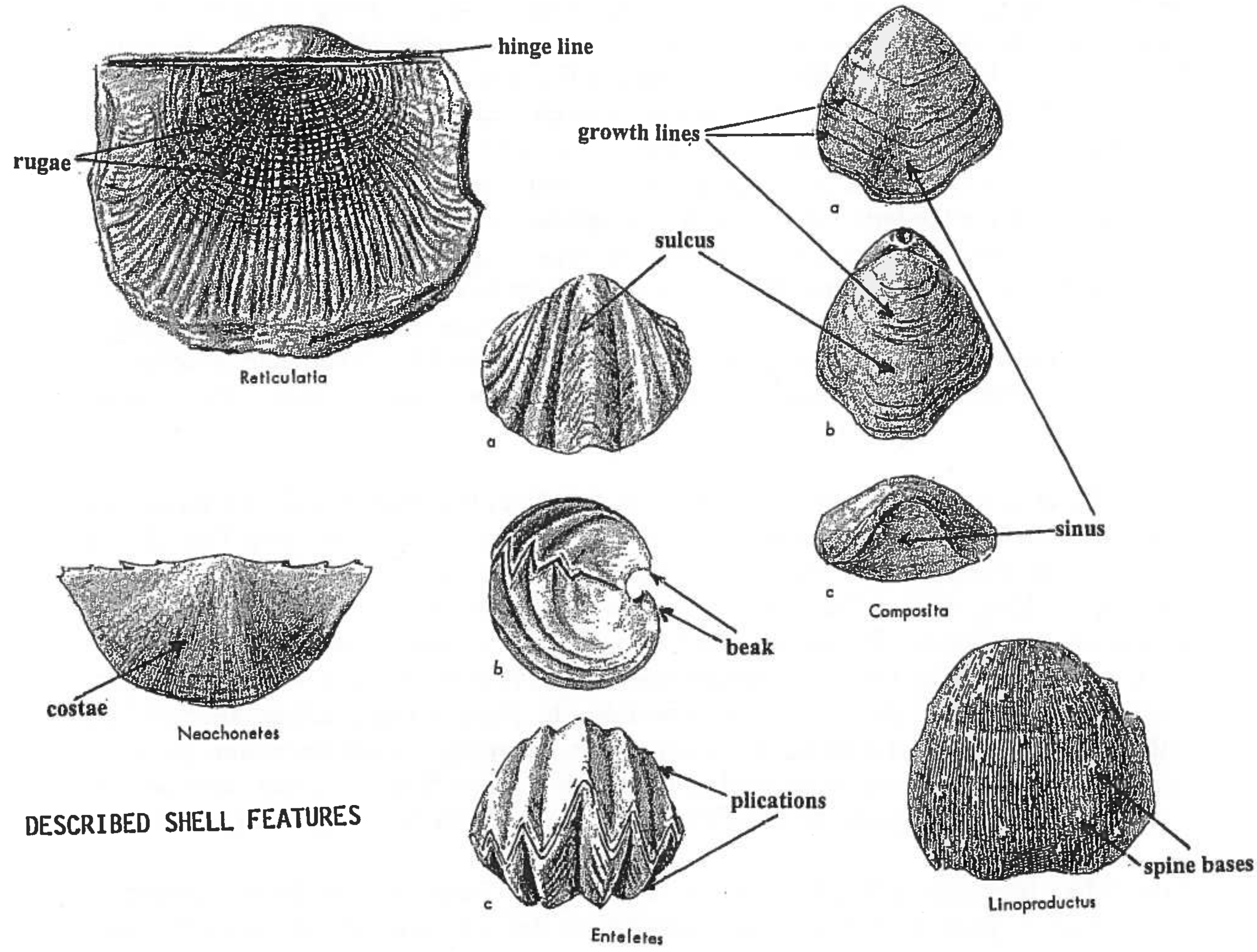
Unlike the shells of clams, which are bilaterally symmetrical (each valve is more or less a mirror image of the other), *each* valve of a brachiopod is bilaterally symmetrical to *itself*. That is, if a single valve were cut in half down the middle, each *half* would be a mirror image of the other. Also, whereas both valves of clams are convex, fitting together like cupped hands, the valves of brachiopods may be convex – concave, convex – flat, or both convex but to varying degrees. Brachiopod shells often show a feature referred to as a sulcus, which is a raised ridge, usually located on the bottom (pedicle or ventral) valve. A corresponding indentation or valley, the sinus, is found in the top (brachial or dorsal) valve. (If you have trouble remembering the difference between "dorsal" and "ventral," remember *Jaws* and all the shark movies you've ever seen…it's always "the deadly dorsal fin cutting through the dark water." That's the top fin – sharks don't swim upside down.) These features (sulcus and sinus) may be well-developed and very apparent.

The shell exteriors also may be ornamented with fine to coarse, concentric and/or radiating lines. Growth lines are concentric and show where new shell material has been added. *Lamellae* are overlapping concentric frills which may extend from the shell for a millimeter or more. They frequently break off when a fossil shell is removed from matrix. The shell may display either fine or coarse concentric ridges, respectively labeled *fila* or *rugae*. Radiating ridges may intersect the concentric ones, forming a netlike pattern. Small fine radial ridges are called *costae* and coarse heavy ridges are *plicae* or plications. Plications may be seen on both interior and exterior sides of a valve. Costae and plicae radiate back from the *beak* which is the pointed "nose" of the shell. Many fossil brachiopods also were ornamented with spines. Members of the productid superfamily in particular, are characterized by the presence of conspicuous spines covering the shell or concentrated along the hinge line or both. The spines usually are broken off of fossils but their positions may be seen in the remnant "stumps" (properly, spine bases) remaining on the shell. The spines are thought to have assisted the living brachiopod to keep its hold on the sea bottom and possibly had some protective value against whatever predators may have favored brachiopods. Spines that are separated from the brachiopod can be distinguished from echinoid spines in that they are solid whereas echinoid spines contain a lengthwise tube.

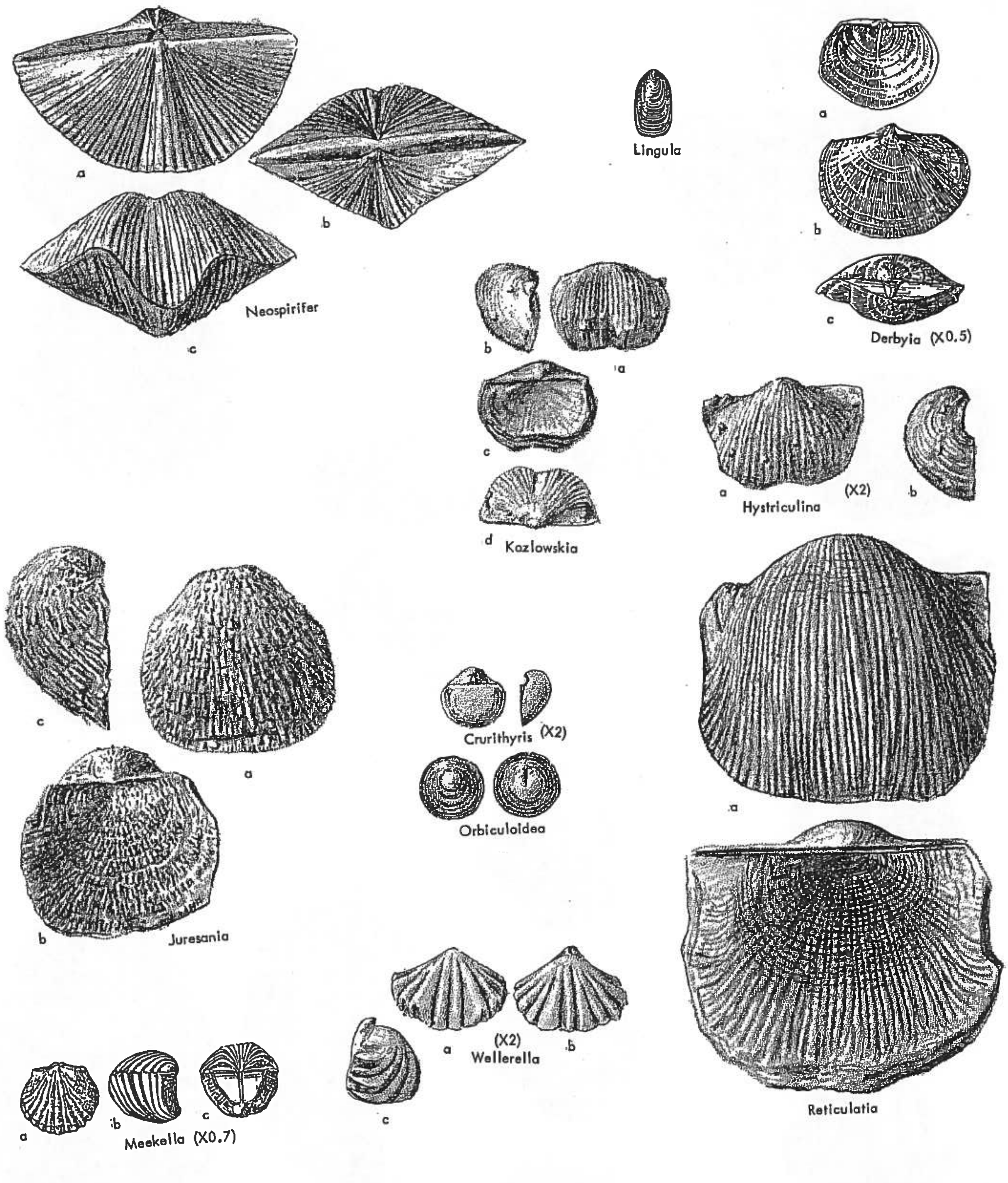
The shells of most fossil brachiopods range in size from less than ¼ inch to a bit greater than three inches. Some extreme sizes range from an adult brachiopod less than a millimeter in diameter to a few "giant" types about 15 inches wide. Some species of brachiopods have thick, robust shells. These generally lived in shallow water and were subject to wave action. Thinner-shelled varieties lived in deeper waters where they are not so subject to being ripped from their pedicle and beat by the surf. Brachiopods vary tremendously in shape, though, as a general rule, the shape is characteristic and constant within a given species. Likewise, the shell profile generally is constant within the same genus. The ventral or lower valve is almost invariable larger than the dorsal valve and the beak of the ventral valve usually projects upward and over the beak of the dorsal valve.

Inarticulate brachiopod fossils often are small, shiny black or dark-brown, display a flattened cone shape with concentric growth lines and are found in dark-colored rocks.

Most inarticulate brachiopods are simple in shape; circular or linguiform (tongue-shaped) in outline. The ventral valve of the craniate family often is flat and the animal is cemented to the sea bed. The dark-colored rocks in which the fossils are found indicates a high carbon content typical of stagnant or brackish water...perhaps a murky estuary or pocket isolated from currents. The tongue-shaped *Lingula* brachiopod which is among the most ancient of all living creatures is a burrowing type which selects foul mud for burrow sites. Many of its fossilized representatives are found in black shale though some are in coarse-grained sandstones. The Inarticulate craniate brachiopods which range in time from Ordovician to Permian are an encrusting variety that preferred to settle on solid objects such as other brachiopods, crinoid stems, etc. Some of them, such as the genus *Petrocrania,* copied the ornamentation of their host onto the top of their own shells. Thus, a *Petrocrania* brachiopod may display the striae of an underlying Articulate brachiopod or it may display lines emulating the joints beneath an underlying crinoid stem. Perhaps this ability had a protective camouflage value which helped avoid some predator that had a taste for *Petrocrania*. Or perhaps it indicates a soft, pliable, thin shell that molded to the substrate upon which it settled.

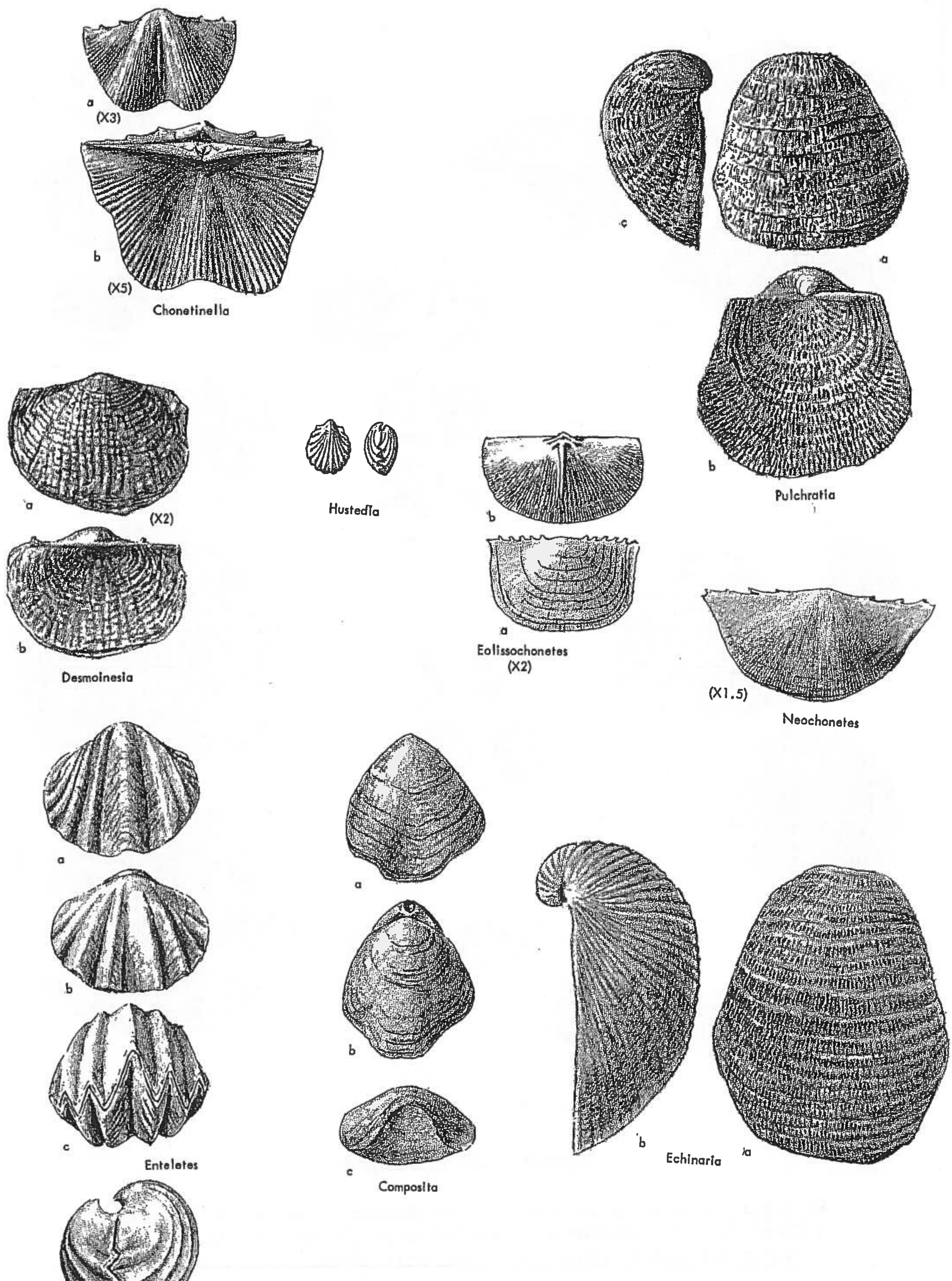


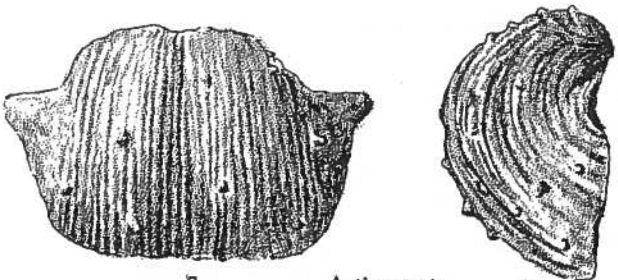
DESCRIBED SHELL FEATURES



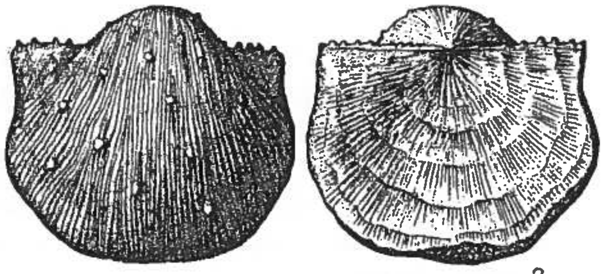
Typical Kansas Brachiopods

All illustrations are natural size unless otherwise indicated. Lower case letters represent different views of the same specimen. Illustrations are taken from: Kansas Geological Survey Bulletin 169, volume 1 and from Illinois Geological Survey Bulletin 95.


a
(X3)
b
(X5)
Chonetinella
c
a
b
Pulchratia
a
(X2)
b
Desmoinesia
Hustedia
b
a
Eolissochonetes
(X2)
(X1.5)
Neochonetes
a
b
c
Enteletes
d
a
b
c
Composita
b
Echinaria
a



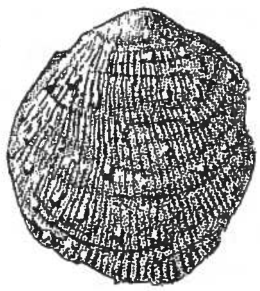
a Antiquatonia b



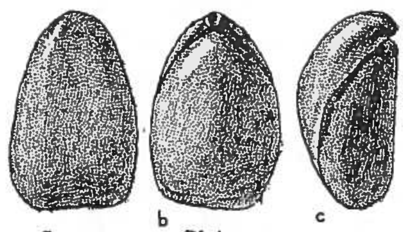
Linoproductus . 2/3

Beecheria X 4/3

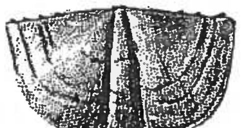
Punctospirifer
X 4/3



Cancrinella
(X2)



a b c
Dielasma
(X1)



(X2)
Mesolobus

Isogramma

(X2)
Lissochonetes

BRYOZOANS

by Lawrence H. Skelton – Kansas Geological Society

Let's study bryozoans--the "moss animals. These minute animals, whose name is derived from Greek words, *bryon* meaning moss and *zoon* meaning animal, have been on the earth for about a half billion years. At present, there are approximately 4,000 different, living species, none of them readily visible to the naked eye. The animal itself is microscopic, the whole organism being no more than a single millimeter in diameter. There are some 1500 fossil species known from the Paleozoic era and about 1000 from Mesozoic time.

Bryozoans are predominately marine or ocean-dwelling creatures, although there are a few hundred known freshwater species. Bryozoans are all colonial and live in groups which may contain as many as two million individuals. The colonies assume one of several forms – twig-like, lacy, encrusting or biscuit-like--depending on the type of bryozoan which constructs them. Such colonies can form a substantial part of reefs. People who are not acquainted with bryozoans sometimes confuse them with corals which are quite different animals. Bryozoans are one of three phyla which are grouped together as lophophorates or animals bearing a lophophore, a specialized food-catching organ. (The other two phyla are *Phoronida* (unsegmented, marine, worm-like animals) and *Brachiopoda*. The brachiopods are of particular interest to fossil collectors and paleontologists).

The bryozoan colony is referred to as a *zoarium*. The animal itself lives in a *zooecium*. A zooecium is a separate living chamber and is part of the zoarium. Each separate animal, which is termed a *polypide* adds to the colony or zoarium by building its own zooecium inside which it spends the rest of its life. The zoarium may display a variety of forms but the form generally is constant within a species and almost always constant within a genus. Among the frequently encountered shapes are: *ramose* – an upright, basically twig-like form which may branch repeatedly like a small tree or shrub; *lacy* or fenestrate which is upright and resembles a delicate trellis-work fan; *encrusting*, a sheetlike growth which encrusts shellfish, other organisms, rocks, wooden or metal pilings, etc. and often may be 3 or 4 millimeters (0.12 to 0.15 inches) thick; *elevated discoidal* or biscuit-shaped which is a very common form; *massive* – large, irregular lumps; and *stolonal* or creeping which are flat "runners" and are sometimes imbedded in their host's surface.

The body details of a bryozoan animal is not visible to the human eye. The zooarium or colony is covered with zooecia, "cells" in each of which lives an individual animal. A feature common to all bryozoans is a *lophophore. A lophophore* is a retractable, tentacle-bearing muscle ring that extends outward from the aperture or mouth of the zooecium. There may be 8 to 30 or more moveable tentacles all of which have one side covered with cilia or hairs which move back and forth and push food grains down the tentacle to the mouth. The interior cavity of the polypide contains a "U-shaped" intestine, a tentacle sheath to hold the tentacles when withdrawn, muscles to withdraw and extend the tentacles, and reproductive organs. There is a nerve system which extends into the tentacles and through the body from a ganglion or mass of nerve cells. Bryozoans reproduce by budding at the edges of encrusting forms or at the end of branched or ramose forms, thus extending the colony. The same creatures may also reproduce sexually and form eggs which hatch into free-swimming or current-distributed larval forms. A single such form attaches to some surface within a short time, secretes a calcareous zoarium and begins a new colony.

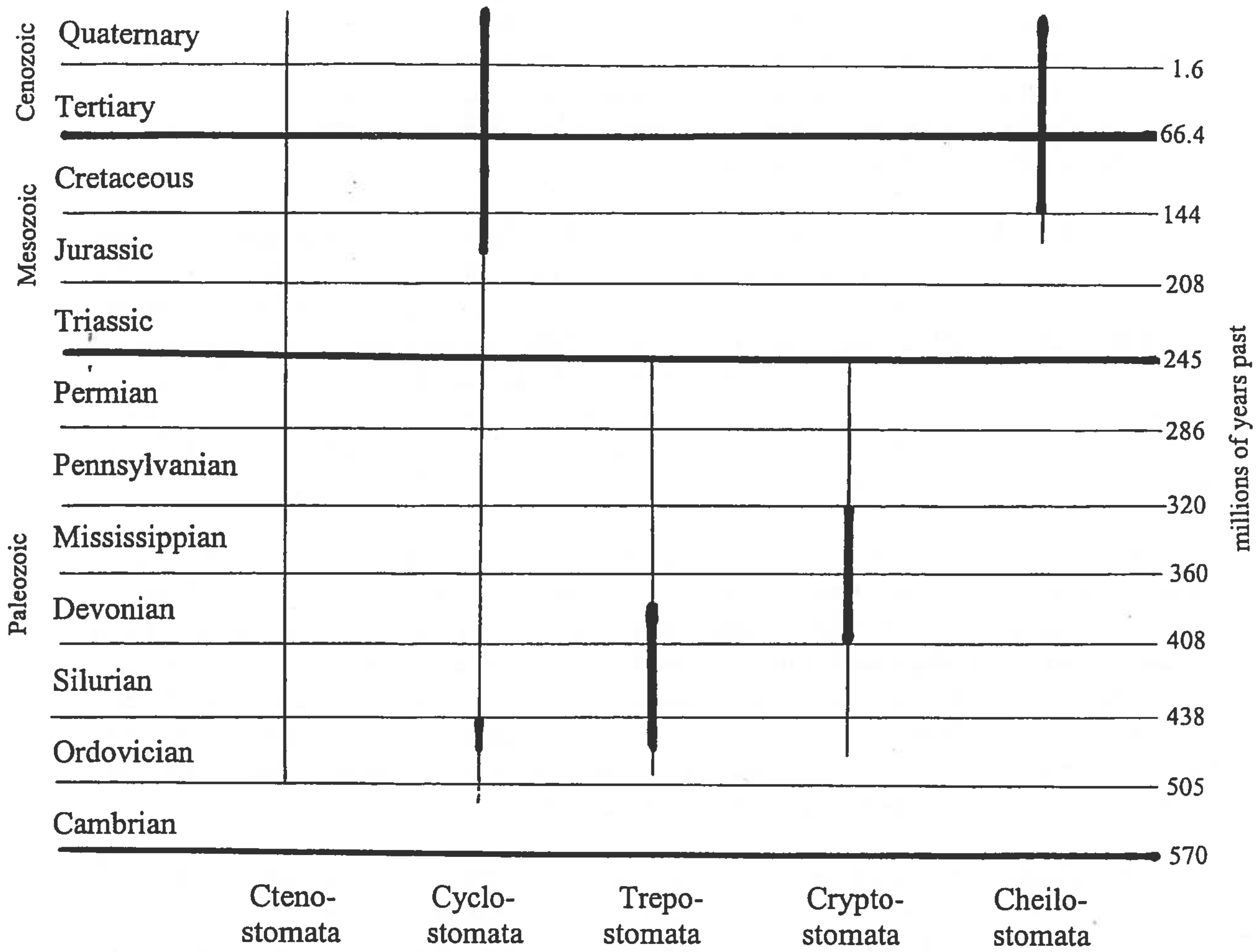
Some individual polypides are constructed differently than the majority of the colony and are adapted to meet different needs of the colony; needs such as protection and "housekeeping". Some may be structurally modified to form root-like structures, attachment discs or other useful and needed parts. Others include a modified form, named an *avicularium,* which can move a little and is a beak-like structure which "snaps" at intruders or transgressors of the colony. Another specialized form is the *vibracula*, which is equipped with a long bristle that is used to sweep away "trash" or settling larvae. These features are found on many varieties of cheilostome [see below] bryozoans.

Living bryozoans comprise a major animal phylum which is divided into three classes. One of these, *Phylactolaemata,* is confined to freshwater and contains only about 50 species. It reproduces by forming enormous numbers of a minute, cyst-like feature which is viable even under dry conditions. Like dust, the cyst may be transported by wind and when placed in water, will rupture and begin new colonies. The phylactolaemates form a gelatinous, slimy colony and since the "larval" forms may be air transported, they may become a major nuisance by clogging air conditioners and cooling towers. The two remaining classes are *Gymnolaemata* and *Stenolaemata.*

The classification used by paleontologists is a bit different. Understandably, the fossil classes are based on differences in the hard parts or living-chambers secreted by the animals since the soft part or actual creature is never preserved. Two classes are recognized: *Entoprocta* and *Ectoprocta.* The entoproctid class has about 40 species among living bryozoans and no known fossil forms. The ectoproctid class is divided into two subclasses: *Phylactolaemata* and *Gymnolaemata.* The divisions are based on the presence of certain mouth or feeding parts. Since the gymnolaemates usually have calcareous, limestone-like skeletons which are living-chambers, they are preserved as fossils; so almost all the known fossil forms are included among the gymnolaemates. There are five orders within the *Gymnolaemata* subclass: *Ctenostomata, Cyclostomata, Trepostomata, Cryptostomata* and Cheilstomata. (These words sound difficult but are easy to understand as explained below). These divisions are based on differences in fossilized zooecia; differences which are best seen by microscope examination of longitudinal and transverse sections which have been ground almost to transparency (such prepared fossils of any phylum (or rock) which are mounted on microscope slides are called "thin sections"). A time distribution chart and brief description of each order follows:

Geologic Time Range of Bryozoa

(Heavy vertical lines indicate time of dominance)



Ctenostomata – Are tiny, fragile and easily overlooked during collecting. Although they range over a long time, they were not plentiful at any time (or perhaps were not readily preserved). The name, *Ctenostomata,* means "comb mouth" and refers to a fringe or comb-like covering over the mouth or opening of the zooecium.

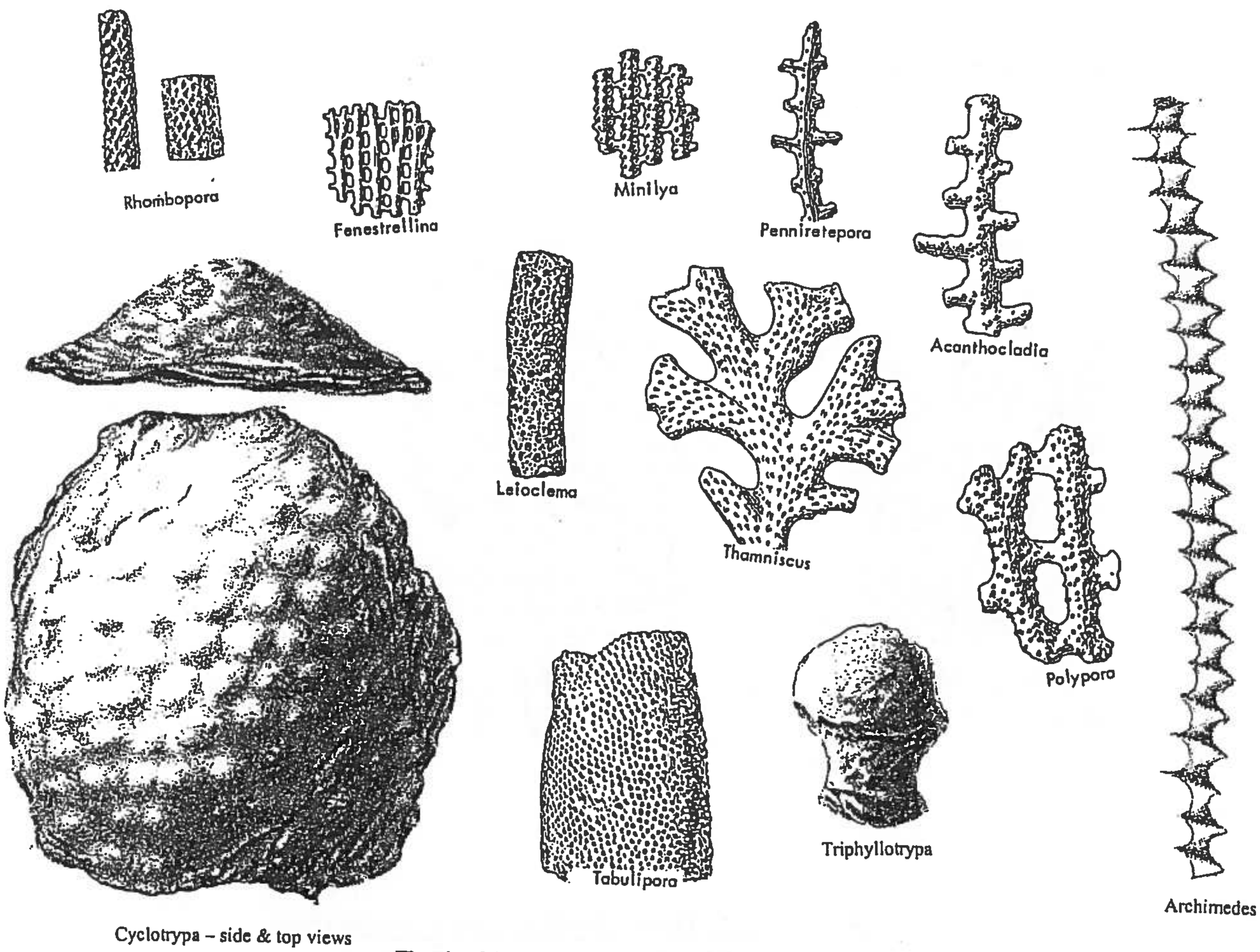
Cyclostomata – An important order that was particularly abundant in the Devonian Period and again during the Cretaceous Period. The mouth of the zooecium is invariably round or ovate hence the name *Cyclostomata* which means "round mouth." An important family of cyclostomes is the Fistuliporids which form massive, irregular colonial growths and may be found in Pennsylvanian strata of Kansas.

Trepostomata – These are the "stony bryozoa." The zoaria are multiform but very frequently are ramose or twiglike. Tabulipora, a ramose form, may be found in

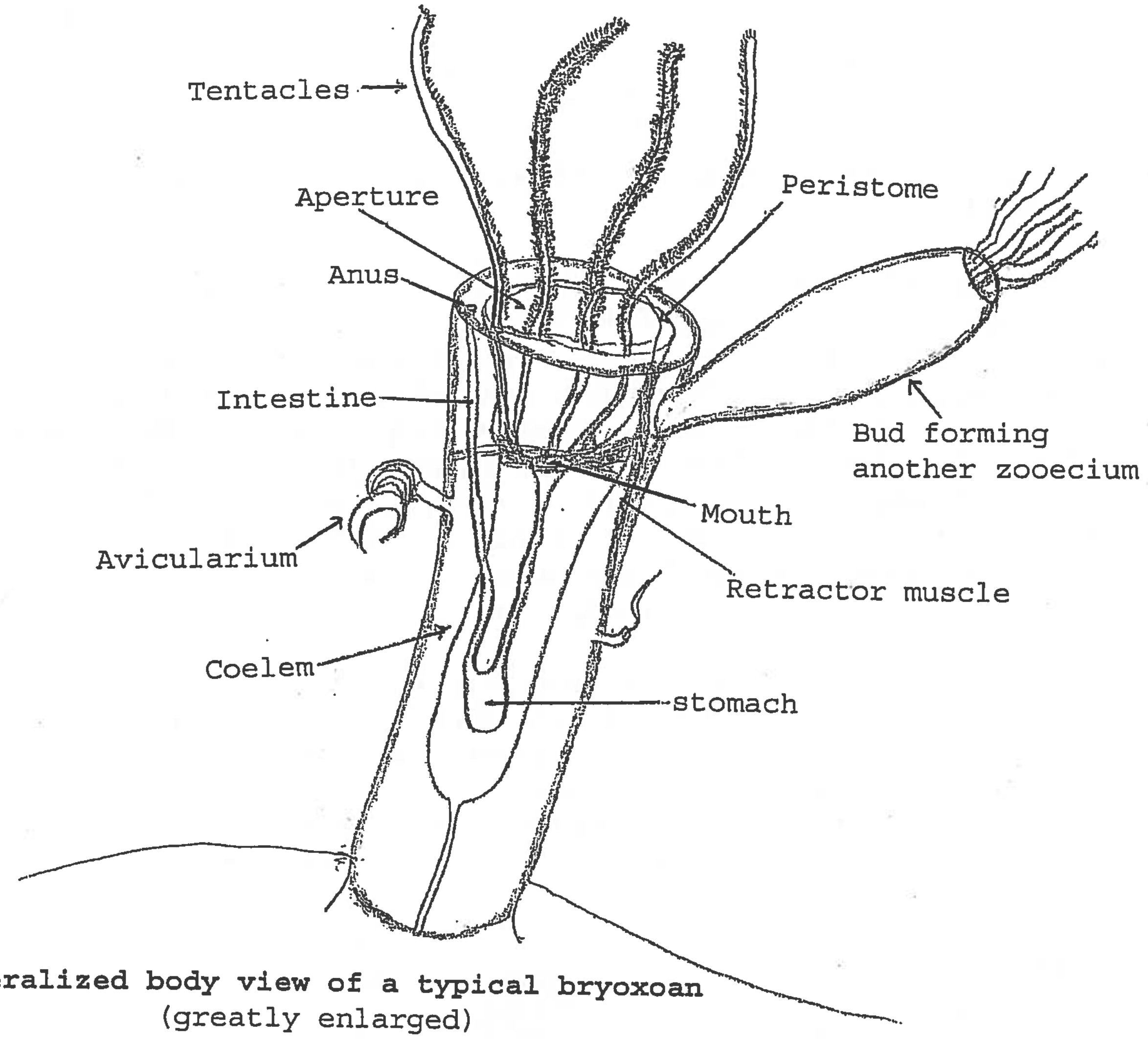
Pennsylvanian and Permian Period rocks in Kansas. The name, *Trepostomata*, signifies "turned mouth."

Cryptostomata – The cryptostome mouth sits at the bottom of a "vestibule" or shallow well-type structure at the top end of the zooecium and is hidden or is not readily observable. The name means "hidden mouth." The top of the mouth or aperture tend to be linearly aligned in the colony. *Rhombopora, Fenestrellina* and *Archimedes* are popular representatives of this order of bryozoa. *Rhombopora* form in ramose (branching) shapes and *Fenestrellina* (meaning "little windows") forms in lacy sheets or fans. The *Archimedes*, of which only the core is usually found, is a spiral wherein lacy sheets extended from the rims of the spiral. The fenestrae or "windows" in the lacy forms are thought to have allowed passage of water currents. This helps to keep the colony or zoarium from being easily broken by moving water.

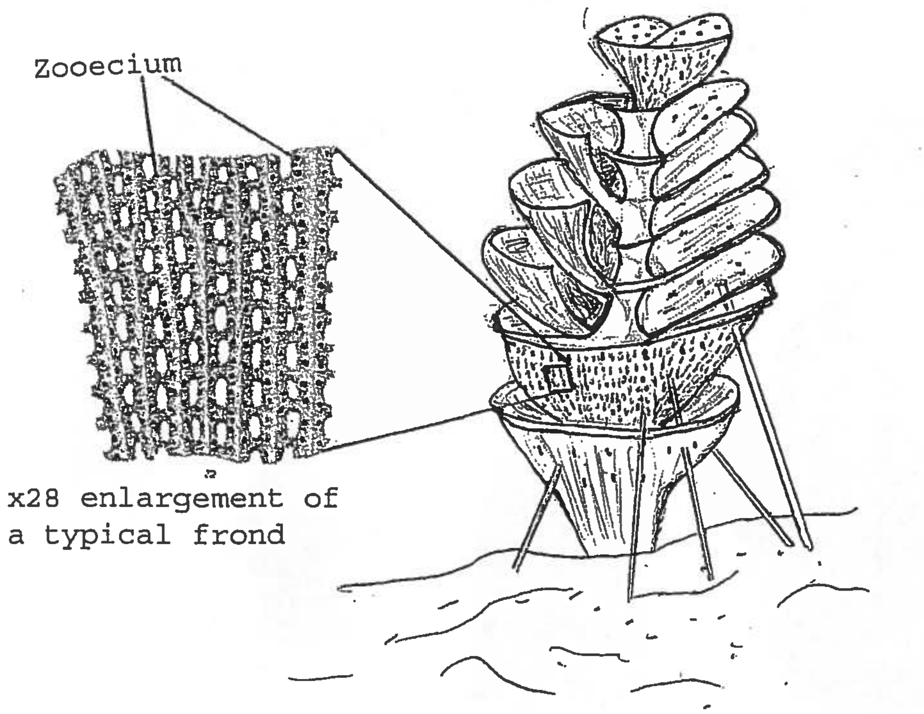
Cheilostomata - This is the most thriving group of bryozoa living in modern seas. They may be found encrusting shells or algae ("seaweed") in turbulent, near-shore water and about 120 species may be found among the organisms that foul the hulls of ships. Some forms occur on the bottom of quiet, deeper water up to 600 feet deep. Cheilostomes are equipped with a hinged lid which when the tentacles are withdrawn, closes down on a narrow rim surrounding the mouth. *Cheilostomata* means "rimmed mouth."



Typical Fossil Bryozoa (magnification: x 1)



Generalized body view of a typical bryoxoan
(greatly enlarged)



A Generalized Archimedes Bryozoan
on Sea Bottom (x1.6)

SPONGES

by Lawrence H. Skelton – Kansas Geological Society

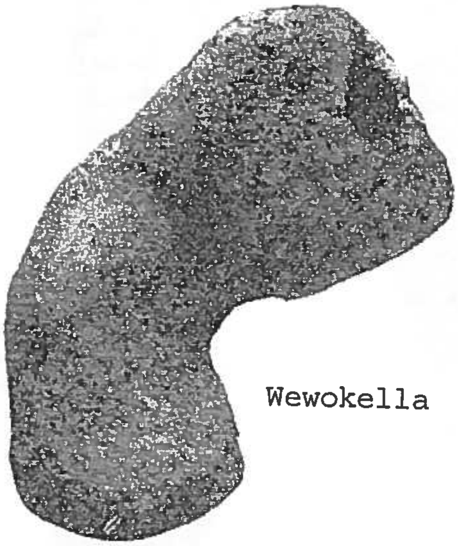
Let's talk about sponges. Sponges form the phylum *Porifera* which in Latin means "bearer or carrier of pores." At times during the geologic past, these strange creatures, which are the most primitive of multi-cellular animals, were present in such large numbers that they formed what now are layers of rock. Unlike other invertebrates, indeed, unlike all other animals, sponges have no actual tissues or organs and their individual cells are independent to a point that they sometimes change shape and function. There is no nervous system although individual cells may react to local stimulus. Modern sponges have been pushed through a fine strainer and broken into individual cells which when replaced in sea water, regrouped and reformed themselves back to a sponge structure. The sponge feeds by individual cells capturing microscopic-size plankton and bacteria from a water stream which enters the sponges canals through *incurrent pores* and exits through a central opening, the *osculum.*

There are more than 900 fossil sponge genera and about 5000 known living species which include some 150 fresh water types. Most sponges are marine, that is, they live in the ocean and all are *sessile* or permanently attached to something solid. The solid point of attachment may be the sea bottom, a shell or coral or any other solid object. Sponges live in water depths ranging from tens of feet to abyssal depths of several thousand feet. The geologic range of sponges is from Late Precambrian time to the present – some 600 million years. Most sponges contain small reinforcing parts called *spicules* which are generated in special cells in the sponge and are made either of calcium carbonate (the mineral, calcite) or of hydrous silica (opal). Spicules form in a variety of shapes which are constant within a species. The sponge phylum is subdivided into classes which are based on the composition of the spicules: The class *Calcispongiae* consists of sponges with calcareous spicules which may have several shapes. These sponges usually are no more than 10 centimeters (4 inches) high and flourish in relatively shallow coastal waters. Calcispongiae range in time from the Cambrian period to the present with peaks in the later Pennsylvanian and Permian periods and again in Lower Cretaceous time. Fossil representatives found in Pennsylvanian rocks of Kansas include *Amblysiphonella* and *Girtyocoelia.*

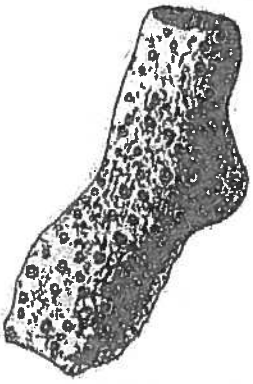
The *Demospongiae* class contains 95 percent of known living forms and spans geologic history from Precambrian to present. Its spicules are of silica or instead of spicules, it may be reinforced with fibers of *spongin,* a coarse fibrous protein also found in vertebrate cartilage and bone. Some of the demosponges have both spicules and spongin. The largest living sponges, which may exceed a meter in both diameter and height belong to this class as do the encrusting, boring sponges that cut grooves in and penetrate coral and shells of other marine animals such as clams. Fossil shells marked with such grooves and holes sometimes are found and indicate the long-ago presence of a boring sponge. Modern "bath sponges" also are members of the demosponges. They lack spicules entirely, depending only on spongin fibers to hold them in shape. The *Hyalospongiae* or *Hexactinellida* class of sponges which are popularly known as glass sponges, have existed from the earliest Cambrian to the present. They were at their peak in Upper Devonian time about 370 million years ago and then declined until the Cretaceous period when they underwent a revival which has lasted through modern time. Unlike other sponges, members of this class live in deeper water between about 1500 and 3000 feet. During Late Devonian time, 90 or more species of these sponges lived in a stretch of sea then covering modern southern New York and northern Pennsylvania. Analyses of the rocks in which those fossils are found indicate that the water was about 300 feet deep. Migration to deeper water apparently began in Mississippian time for reasons unknown but doubtless some environmental change. The hyalosponges are cup or vase-shaped. Their six-rayed spicules frequently are fused into a siliceous mesh or long fibers, causing the sponge's "skeleton" to resemble "spun glass" or fiber-glass. A modern representative is the Venus'-flowerbasket sponge. A fourth class, *Sclerospongiae*, has an internal skeleton of siliceous spicules and spongin fibers with an outer casement of calcium carbonate. There seem to be no fossil representatives of this class unless it may be the Devonian age *Sphaerospongia* which is classified among the Receptaculitids, a puzzling somewhat sponge-like group of uncertain classification.

The same species of sponge may occur in a variety of shapes which apparently are adapted to the environment or the base of attachment. For that reason, much identification and classification is on the basis of spicules. If the spicules are fused, the shape of the entire animal may be preserved as a fossil. However, if the spicules are strewn through the sponge's tissues which resemble rubbery jelly, they are scattered on the sea bottom when the animal dies. If the sponge has no spicules and only spongin, as in the modern bath sponge, there is ordinarily no fossil record unless it be a carbonized imprint. As written above, spicules are either calcareous or siliceous in composition and the composition remains the same within a species. However, during or after the fossilizing process, one composition may replace the other; that is, a calcareous spicule may dissolve and be replaced with silica or vice versa. Spicules range in size from a fraction of a millimeter to several millimeters. They sometimes are matted so shapes are indistinguishable. There are six basic types: monaxons which form a single straight or curved ray which may have knobs on either or both ends and be either smooth or spiny; triaxons consist of three rays which may be equal or different in length and may lie in a plane or intersect and form a shape similar to a child's toy jack; the tetraxon has four rays which may be joined in a variety of ways; polyaxons have many rays forming a spiked cluster; birotules appear to be a modification of the monaxon, they have two button-like plates connected by a rod; sigmas also may be a monaxon alteration consisting of a "c" or "s"- shaped rod. Since spicules are constant within a species, they may be useful in correlating Lower Paleozoic Era strata. Their small sizes lend to their recovery from subsurface drill cuttings.

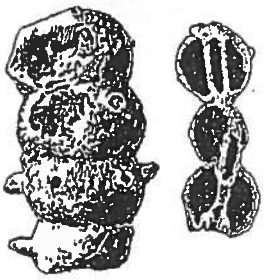
**Pennsylvanian and Permian Sponges
Found in Kansas**



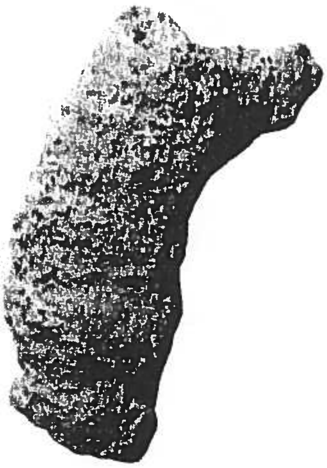
Wewokella x1



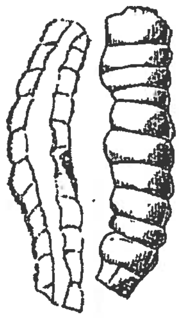
Maeandrostia x1



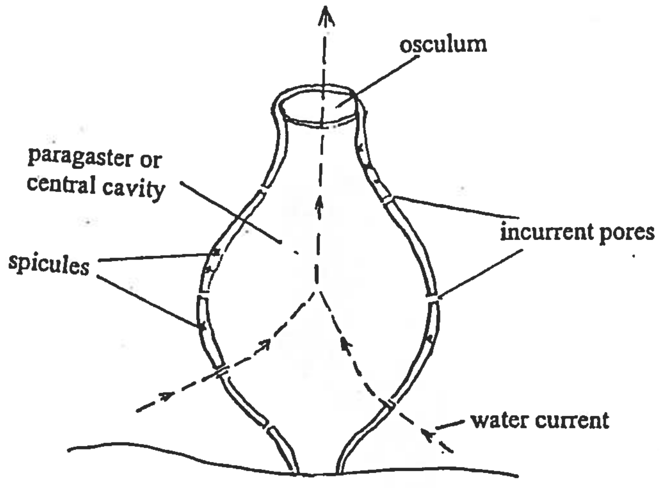
Girtyocoelia x1.3



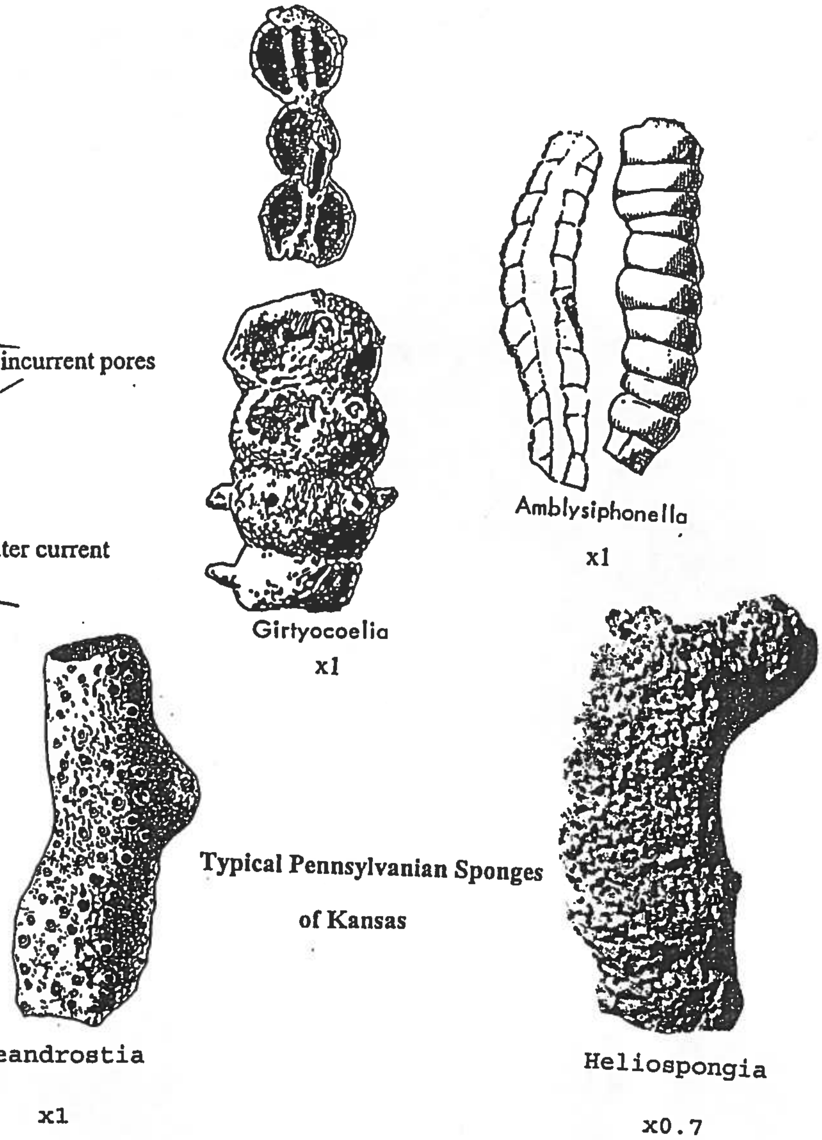
Heliospongia x1



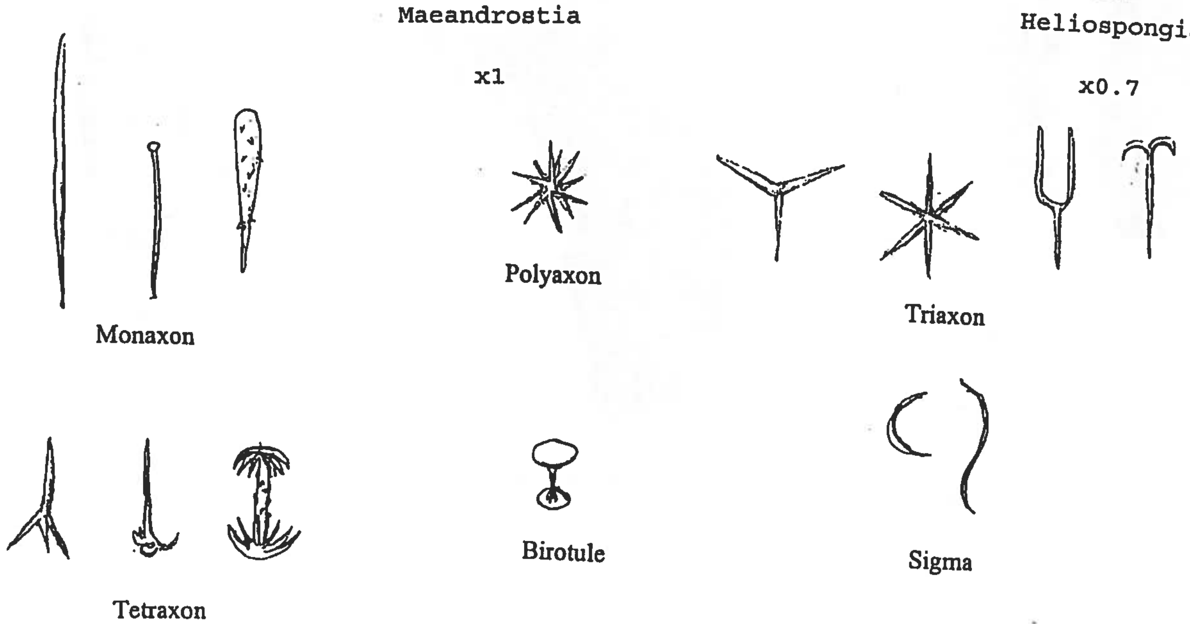
Amblysiphonella x0.7



Generalized cross section of a typical simple sponge



Typical Pennsylvanian Sponges of Kansas



Typical sponge spicules
No scale – greatly magnified

CRINOIDS

by Lawrence H. Skelton - Kansas Geological Society

Let's study crinoids. These strange animals that grow on stems have been around for about 460 million years. The name crinoid comes from two Greek words *krinon* (which means lily) and *oides* (which means similar or like); so the name means "like a lily" which refers to the crinoid's general shape. Crinoids often are called "sea lilies," even though they are not plants. Crinoids are members of the phylum *Echinodermata*, a term meaning "spiny-skinned." Other echinoderms are starfish, sea cucumbers, sea urchins (or echinoids), and sand dollars. Some extinct members of the phylum included blastoids and cystoids which somewhat resemble crinoids in appearance. All echinoderms are marine animals—they live in saltwater.

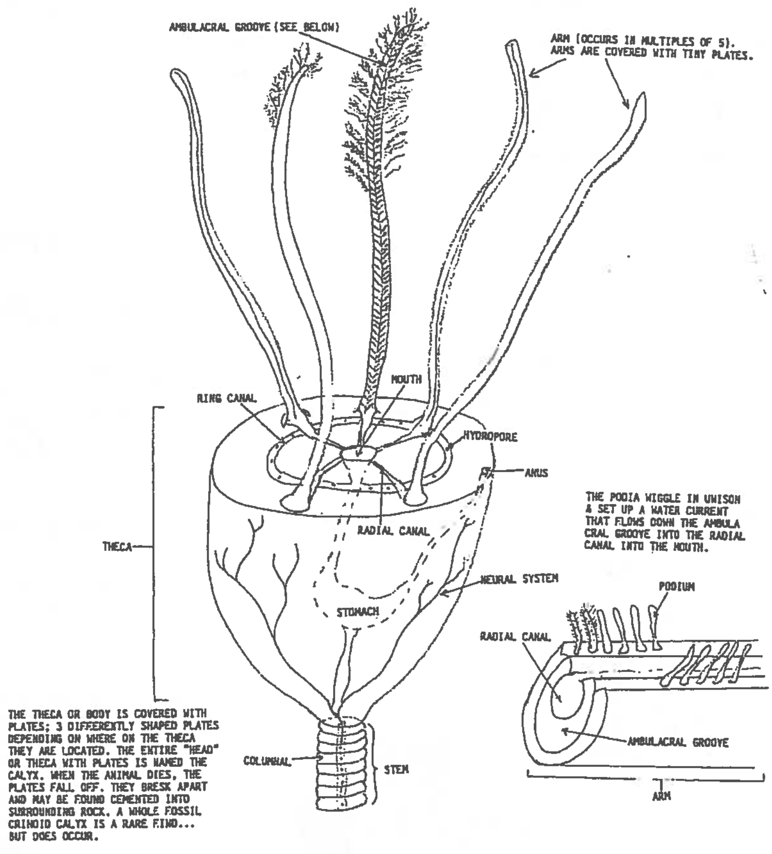
Crinoids first appeared in early Ordovician time and have survived to the present. More than 6,000 fossil crinoid species have been described from Paleozoic era strata. Like most other invertebrate sea animals, crinoids begin life by hatching from eggs in the form of free-swimming larvae which lack any skeleton or hard body parts. These swimmers soon attach themselves to the sea bottom where they grow to adulthood. When adults, some types of crinoids, like other echinoderms, detach themselves and become free swimmers again. Of the 600 or so living crinoid species, 85 percent are non-stemmed types. Other types remain attached to the sea floor by their stems. Adult crinoids range in size from a fraction of an inch including stem and arms to sixty feet or more.

Crinoids live in all depths of the sea. They are found mainly in shallow water a few feet below the surface but have been found growing as deep as 13,000 feet below the ocean surface. They are found in all oceans from the warm tropics to cold polar seas. They seem to colonize and remain in one area for a long time. Occasionally, their parts pile up and create beds of limestone ranging from a few inches to more than a hundred feet in thickness. Such limestone is made almost entirely of crinoid parts, mainly columnals and stems and some dissociated plates. These are the parts commonly found by fossil collectors. A whole calyx or one with attached arms is rarely found.

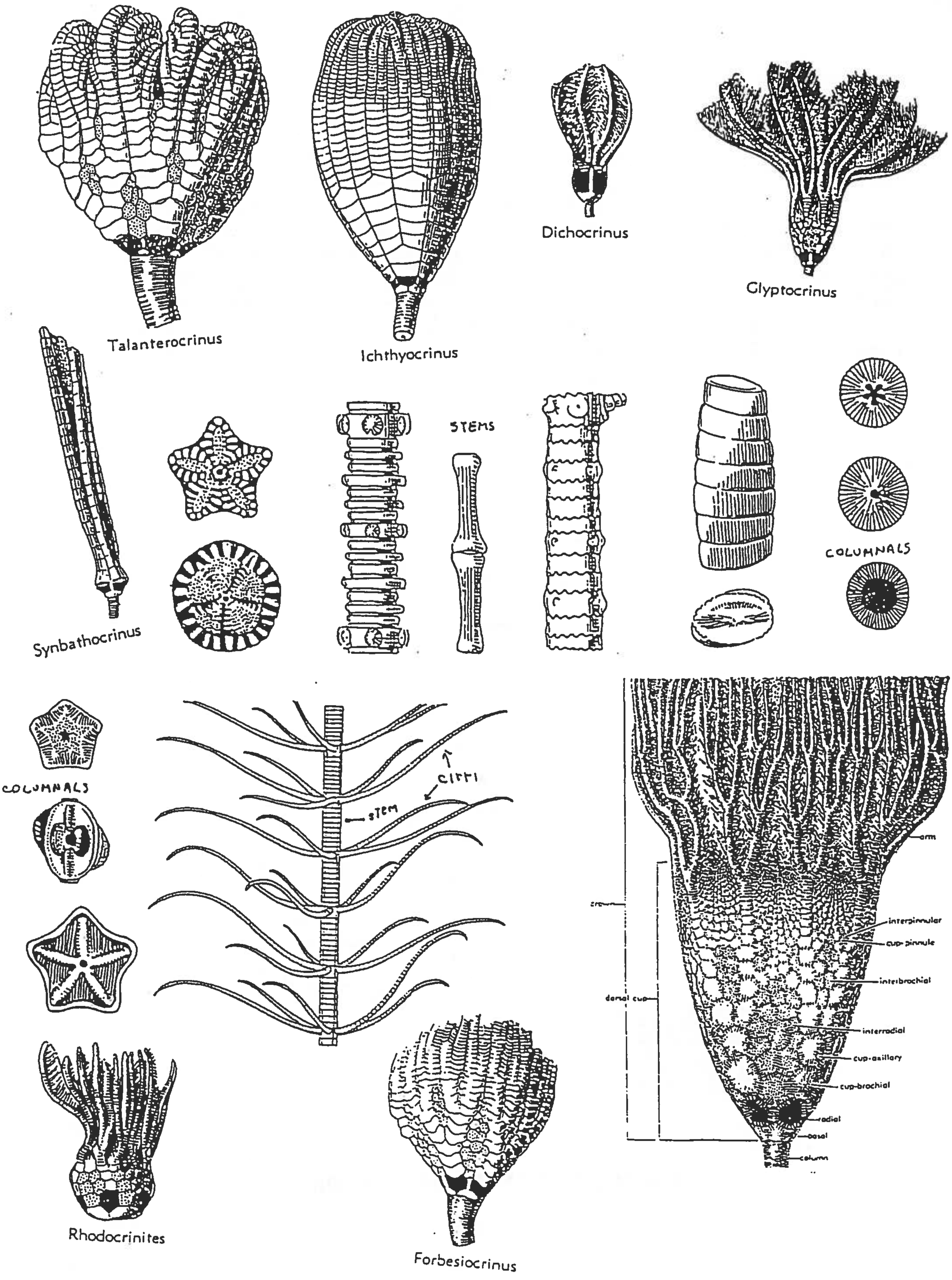
How are these animals constructed? The main part of a crinoid's body is called the calyx (pronounced kay'-lix) which sometimes is referred to as the "head." This is the hard part of the body but rarely is fossilized because the plates which cover the outside come apart and fall off when the animal dies. The remainder of the body and the arms are covered with thousands of minute calcareous plates. The upper body part usually is covered with a thin leathery sac which is reinforced with plates made of calcium-magnesium carbonate (which also composes shells in some other animals). At the top of the body are a number of arms. Each arm has branches referred to as *pinnules* which have minute tube feet along their rims. The tube feet snare passing food particles and flick them downward into a open groove that extends the length of the of the pinnule and arm. Once in the groove, the food particle is swept along by minute hairs into the mouth at the top of the calyx. The food consists of a variety of single-celled organisms, algal cells, larva of invertebrates, etc.

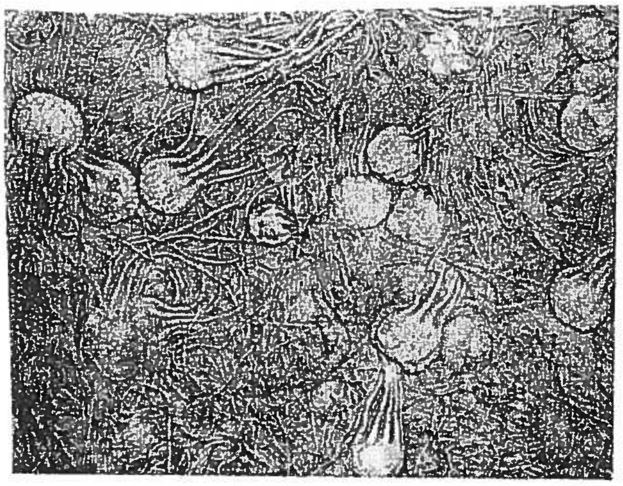
The stem is a curious part of a crinoid and is the part most often found fossilized. The average maximum length of complete stems is less than 3.25 feet. However, one stem found in the Pennsylvanian age Nowata Shale near Tulsa, Oklahoma, measured the remarkable length of 10.83 feet with both ends missing. Such a height would have allowed it to avoid feeding competition with other crinoids in its vicinity. The stem is made of button-shaped parts called *columnals* that are stacked on top of one another. The calyx is attached to the top of the stem and the bottom is attached to the sea floor. Some crinoids have root-like branches (called a holdfast) that spread out from the base of the stem and help hold it to the floor. The top and bottom of each columnal is covered with fine ridges to help hold them together without slipping (like some checkers.) Columnals may be round, oval, pentagonal or shaped like a five-rayed star, depending on the species of crinoid. The center of each columnal contains an opening which may be round, pentagonal or star-shaped, again depending on the type of crinoid. Nerves and nourishment supplying vessels from the calyx pass through the openings. Some stems have arms, called *cirri* (pronounced seer'-eye) which radiate out from them. The cirri move constantly and can wrap around other objects. The stem, cirri and root part together make up the *pelma*. The cirri also have openings in the center like those in the columnals.

The star-shaped or pentagonal opening in the columnal points out one of the most important characteristics of the crinoids and indeed, of all echinoderms. That characteristic is the five-fold radial symmetry. (Most animals have some sort of symmetry. When you put your palms together, one hand fits against the other – it is its opposite image. People are bi-laterally symmetrical. That is, the right side of a person is a nearly mirror image of the left side.) Crinoids and the other echinoderms begin their life with a sort of bilateral symmetry but later develop a strong five-fold symmetry radiating from a center. This can be seen in the five-rayed star on sand dollars, the starfish with its five (or multiples of five) legs, in the pentagon-shaped cross section across a crinoid calyx and in the star-shaped or pentagonal holes in columnals.

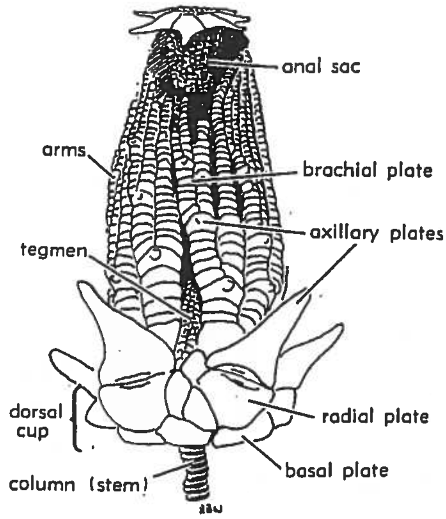


GENERALIZED BODY PLAN OF A CRINOID

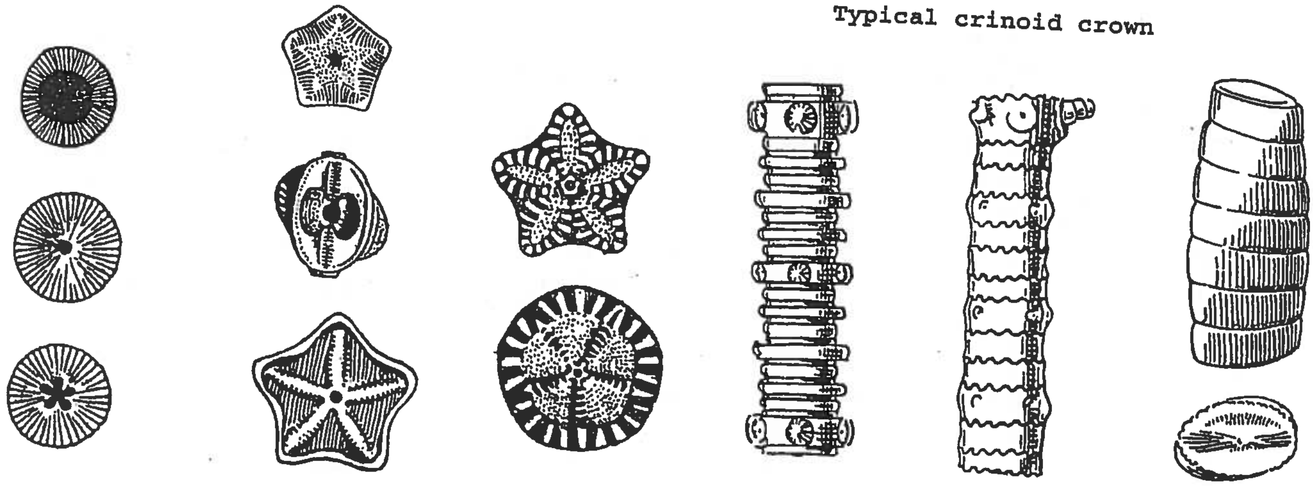

Talanterocrinus
Ichthyocrinus
Dichocrinus
Glyptocrinus
Synbathocrinus
STEMS
COLUMNALS
COLUMNALS
cirri
stem
arm
crown
interpinnular
cup-pinnule
interbrachial
dorsal cup
interradial
cup-axillary
cup-brachial
radial
basal
column
Rhodocrinites
Forbesiocrinus



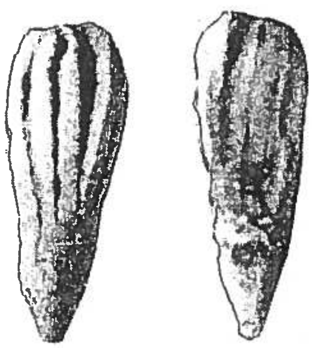
Uintacrinus
(free swimmer)



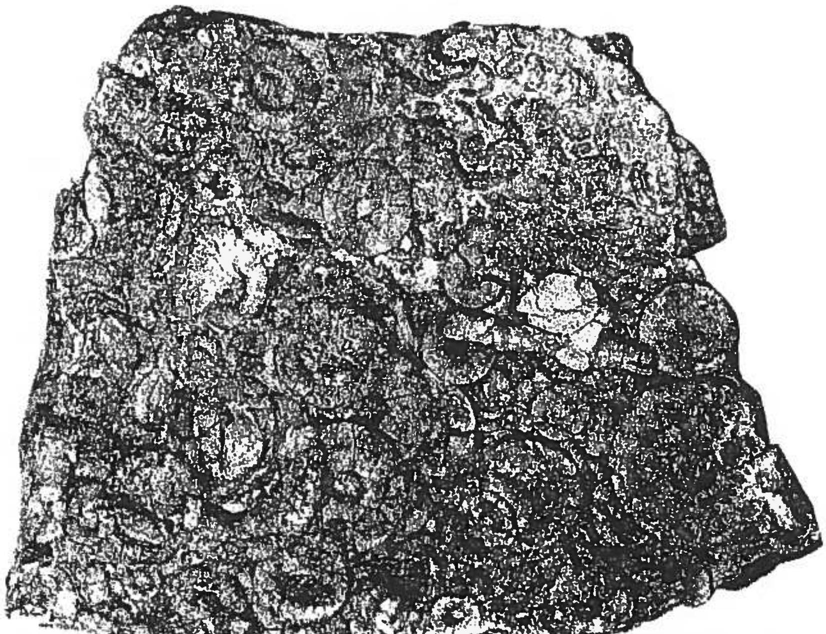
Typical crinoid crown



Crinoid stems and columnals



Planacrocrinus x3.5



A mass of columnals & stem fragments x1.0

CORALS

by L. H. Skelton - Kansas Geological Society

Let's study corals. These interesting animals are members of the Class *Anthozoa* which is a division of the Phylum *Cnidaria* (pronounced nid-air'-ee-ah) The phylum name was formerly Coelenterata. The term "Anthozoa" is derived from two Greek words which mean "flower animal" and Cnidaria comes from the Greek term for a stinging nettle; tall members of the phylum typically being possessed of tentacles bearing microscopic sting capsules used for defense and offense. On the offensive side, all cnidarians are predators.

There are about 9,000 known living species in the phylum Cnidaria. Their fossils first are found in Late Precambrian (Proterozoic) age rocks and the different classes continue to the present although some orders have become extinct. Most members of the phylum are soft-bodied (jellyfish and hydras for example) and are not readily preserved. The Anthozoa class, or corals, however, makes hard parts which are very well preserved and well represented in the fossil record beginning in the Ordovician Period about 505 million years ago. Possible Cambrian corals have been described but whether they are truly corals remains a subject of debate. The subclass *Zooantharia,* which is subdivided into six orders, contains most "true" corals.

Five of the six orders of corals are extinct. Of the five, the *Rugosa* and *Tabulata* are the most important to fossil collectors. Both range in time from Lower Ordovician to the end of the Permian Period—a span of 260 million years. The Tabulate corals are all colonial. Rugose corals may be either colonial or solitary. At this point, a few physical features of the two orders need defined:

Calyx - the bowl-shaped depression in a corallite where the polyp lives.

Corallite - the skeleton produced by a single polyp. A single individual, alone or within a corallum.

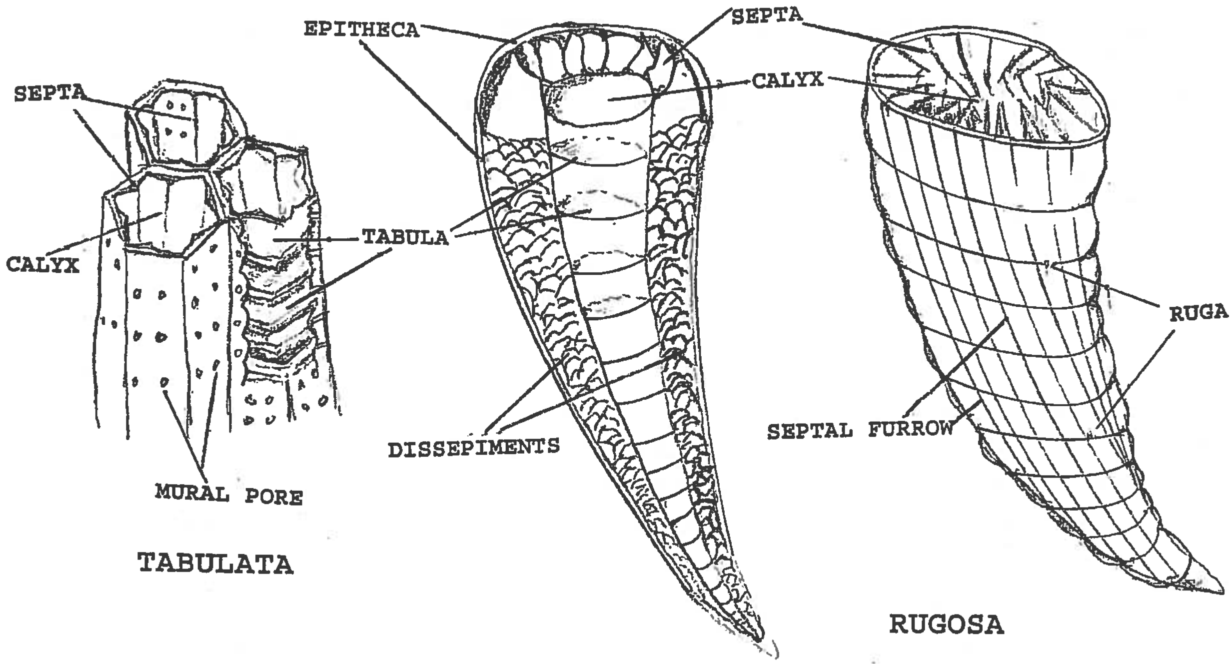
Corallum - the coral colony.

Dissepiments - overlapping, convex plates which form around the inside edge of the corallite. Abut the tabulae.

Polyp - the animal living within the corallite.

Septum (plural: septa) - vertical blades radially arranged within the calyx.

Tabula (plural: tabulae) - a horizontal partition or floor within the calyx. Tabulae lie one above the other and the polyp has its base on the top or uppermost tabula.
These and a few other terms are illustrated below.

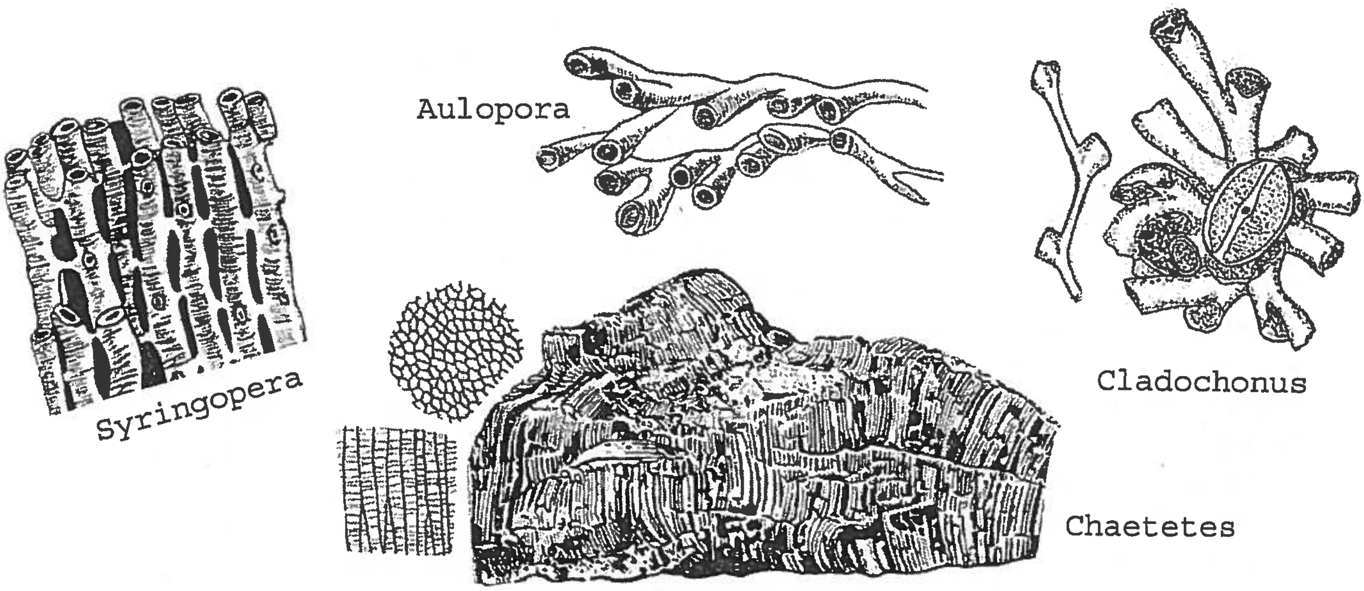


Some Coral Parts and Nomenclature

As noted, the tabulate corals are all colonial. They either lack septa or if present, the septa are short and inconspicuous. Examples which may be found in Kansas include: *Aulopora, Chaetetes, Cladochonus, Michelinia,* and *Syringopora*.
Rugose corals may be colonial or solitary. The word "rugose" means wrinkled or corrugated and the outside or epitheca of rugose corals is covered with septal furrows and growth lines. The encircling growth lines are termed *ruga* (plural: *rugae*) These corals are characterized by conspicuous septa which occur in multiples of four, a characteristic which gives rise to the term *Tetracoralla*, a synonym for Rugosa. Examples in Kansas include: *Caninia, Dibunophyllum, Heritschiella,* and *Lophophyllidium*. *Lithostrotion* is a colonial rugose coral that may be found in Mississippian or Pennsylvanian strata in Kansas. These are not the only rugose and tabulate corals that occur in the state but are among those frequently found.

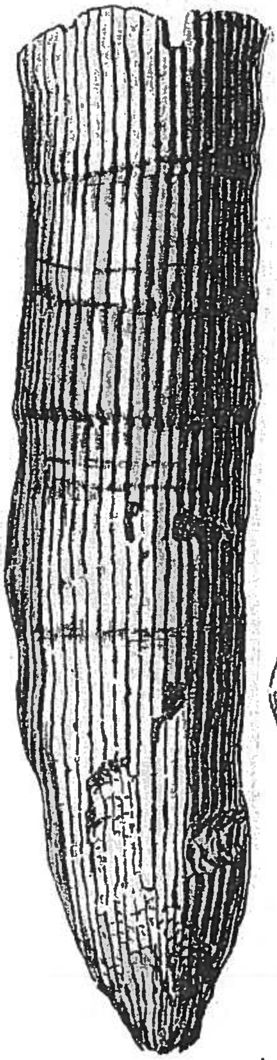
Both *Tabulata* and *Rugosa* orders became extinct at the end of the Permian Period. Their environmental niche was filled by Scleractinian corals (also known as Hexacorals) which first are found in middle Triassic age strata and continue to the present. All modern true corals are members of the Order *Scleractinia*. There are several anatomical differences between these and the Paleozoic Era corals. The most visible is that Scleractinian corals have six or a multiple of six (12, 18, 24, etc.) septa. This trait gives rise to the older alternate group name, *Hexacoralla*. There are other important differences in anatomy which require magnification to see. The simplest way to distinguish the orders is to remember that if the fossil coral is Triassic Age or younger, it is a scleractinian; if of Permian Age or older, it is a rugose or tabulate coral.

Scleractinian corals may be colonial or solitary and accordingly are assigned to different suborders. The reef-building members usually are colonial and the non-reef-builders generally are solitary. The apparent scarcity of fossil corals in Kansas' Cretaceous strata may have been caused by the nature of the chalk beds that are thought to have been thick beds of soft, limy, mud when forming. Corals require a hard substrate to form on and such spots were apparently rare on the sea bottom here. Excepting the possible presence of a few hard spots on the sea floor, environment of deposition of the intervening shale layers such as the Blue Hill Shale or Pierre Shale would have been too muddy. Corals require clear water to thrive.

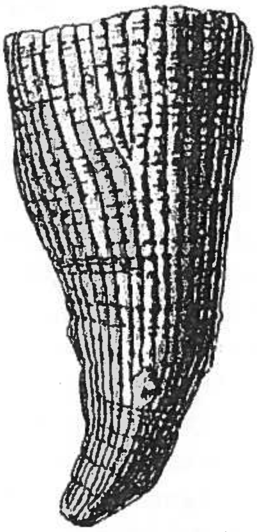


SOME TABULATE CORALS OF KANSAS
X 2.5

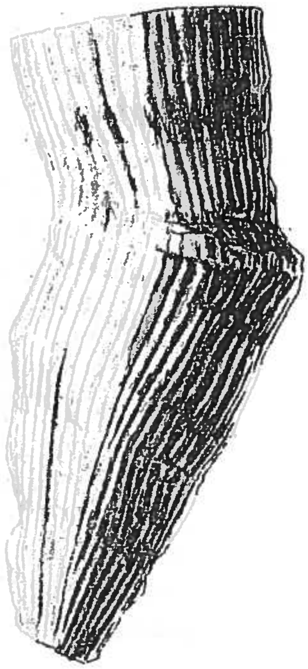
RUGOSE CORALS OF KANSAS
X 3.0



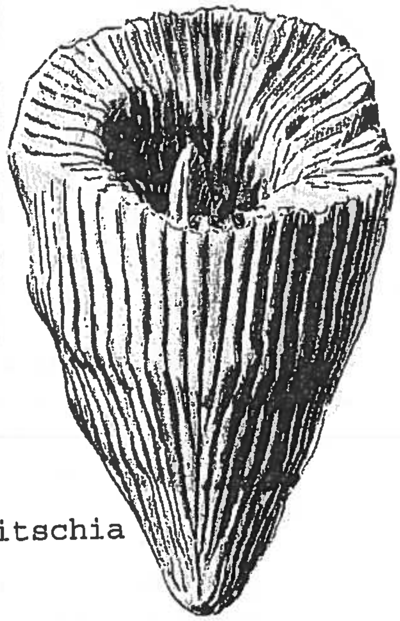
Stereostylus



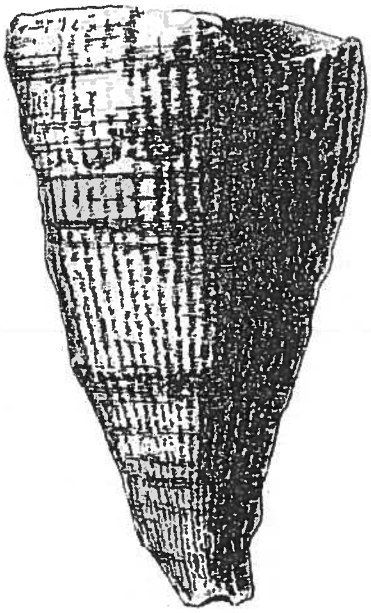
Lophophyllidium



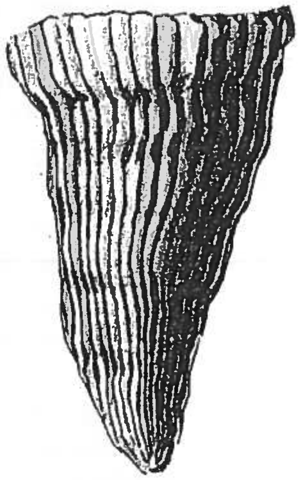
Lophamplexus



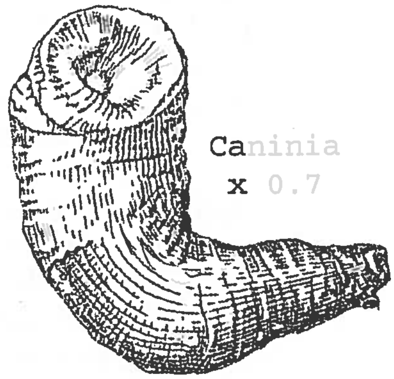
Heritschia



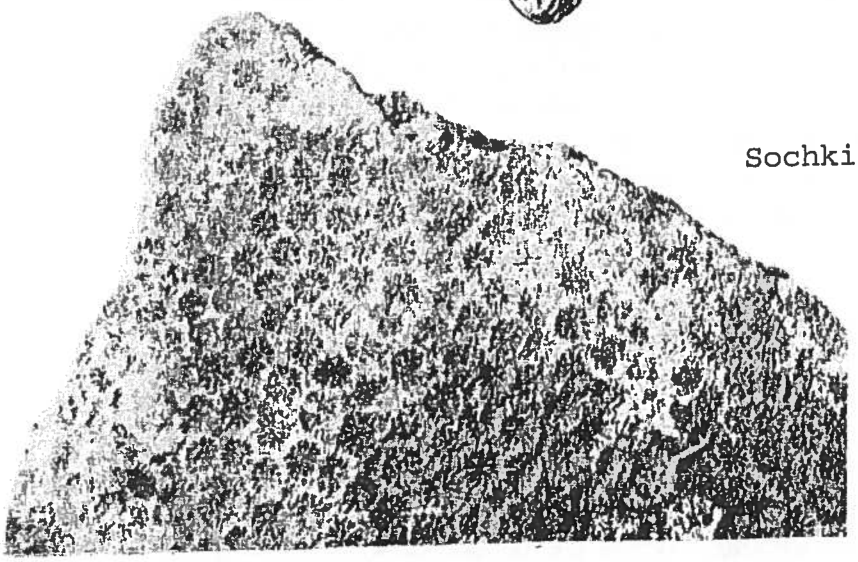
Sochkineophyllum



Malonophyllum



Caninia
x 0.7



Astrocoenia

A KANSAS SCLERACTINIAN CORAL
X 3.1

TRILOBITES

by L. H. Skelton – Kansas Geological Society

Let's study trilobites. The name, which refers to the three lengthwise lobes into which their bodies are divided, is pronounced with a long "I" in the first syllable which also is accented. More than 3900 species of these popular fossils have been described. Trilobites first show up in the fossil record in sedimentary rocks of Cambrian age and they became extinct by the end of the Permian Period--a 325 million year tenure. Trilobites were most common during the Cambrian Period and comprise almost half of known kinds of Cambrian fossils. In fact, the Cambrian is subdivided into three smaller units (epochs) on the basis of trilobites. Trilobites seem to have been most numerous and most diverse during the Cambrian and Ordovician Periods. It is theorized that their decline may have been caused by the rise of cephalopods (squid-like mollusks) during the Ordovician and the appearance of large numbers of fish during the Devonian Period. Both of those creatures were predators and probably found trilobites to be easy and tasty prey. A few trilobite fossils show distinctive bite marks and punctures.

Trilobites are the most primitive of known arthropods. Three classes of trilobites have been found in strata at the beginning of Cambrian time, so their subphylum must have existed prior to then. Arthropods are a phylum comprised of at least 750,000 different species – more than three times all other known animals combined! Arthropods seem to have evolved from annelid worms or something similar and all members of the phylum possess a few common body traits: metamerism which is the tendency for the animal's body to be divided into longitudinal segments; a three-layered exoskeleton (the shell on lobsters and insects) which is divided into plates and cylinders to allow growth and movement, and jointed segmented appendages used for movement, either crawling or swimming. Arthropods also have sense organs – eyes, antennae and often, spines or bristles which may function as chemical detection receptors.

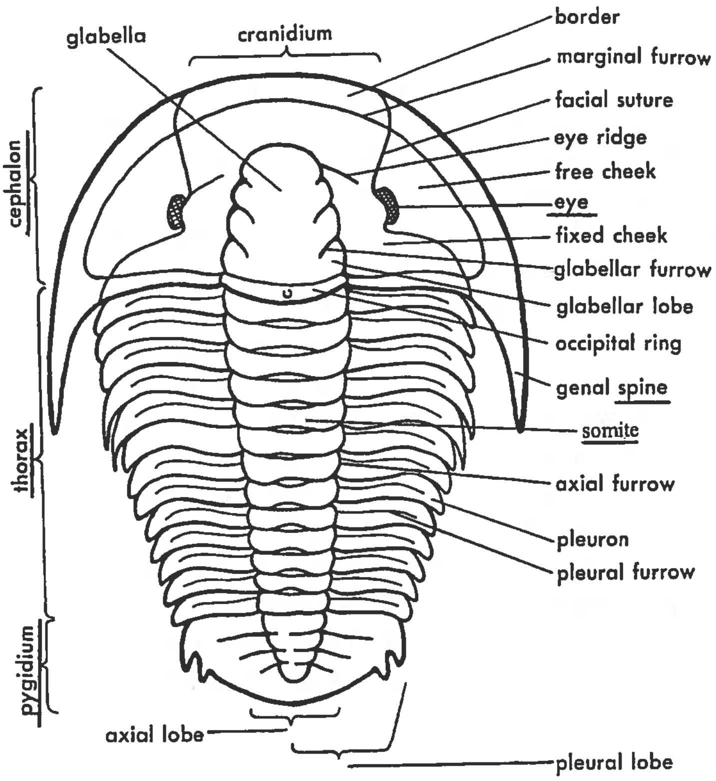
The biological classification or taxonomy of arthropods is somewhat in a state of flux. Traditionally, arthropods have been sorted into two subphyla depending on their type of feeding mechanism. More recent classification separates the arthropod phylum into four subphyla, one of which, *Trilobitomorpha*, (usually seen as *Trilobita*) is the fossil trilobites. Other subphyla include horseshoe crabs, scorpions, spiders and ticks; crustaceans (lobsters, shrimp, crayfish, etc.); insects, centipedes and millipedes). The subphylum Trilobitomorpha is divided into five, six or eight orders depending on which taxonomist one desires to follow.

Trilobites, as their name implies, were shelled creatures which are divided into three lengthwise, furrow-separated lobes. Laterally, their bodies consist of three parts, a head or *cephalon*, a *thorax* or trunk area and a *pygidium* or tail. The whole body is covered with a flexible, chitinous layer (the "shell" material that covers a shrimp is chitin) which is covered by a calcareous or limy layer. The shell covers the dorsal (top) side and curves around the edge overlapping more shell which covers the ventral (bottom) side. The shell is divided into lateral plates, termed *somites*, which are connected by an underlying chitinous layer. This permitted the trilobite to be flexible, even to roll into a ball for protection. A modern shell analog is the crustacean isopod, *Armadillidium*, popularly known as the roly-poly, sow bug or pill bug. Its shell is flexible and it curls into a sphere when threatened. Since fossilized trilobites are sometimes found in similar rolled-up balls, we know that in that respect, they were similar to their distant isopod cousins. As trilobites grew, they molted their shells and grew new, larger ones. The cast off shells sometimes are found as fossils. When seen in cross section in thinly ground rock specimens observed through a microscope, the cast off somites resemble a shepherd's crook, the bent part being where the shell bent and curved under the ventral side.

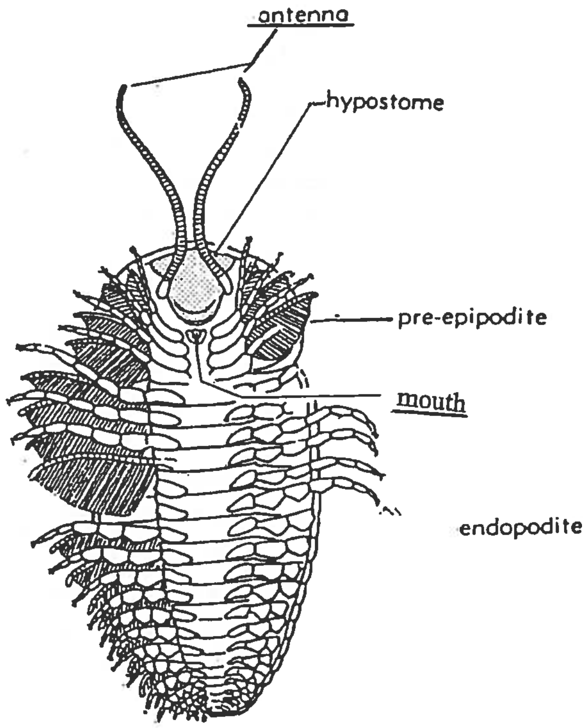
The cephalon or head of trilobites was divided into at least five fused segments, the most distinguishing feature of which often was a set of apparently compound eyes. X-rays of the fossil eyes show a structure similar to the compound eyes of living arthropods. The rarely found underside of the cephalon bore a mouth and five sets of appendages which were variously modified to be antennae, jaw processes or filtering, burrowing or swimming devices, depending on the family. Some species had a shovel or plow-shaped cephalon which apparently was adapted for burrowing. The thorax or center part consisted of several somites, the number being constant within the same species. The underside of each somite bore a pair of appendages which apparently functioned for both, gill devices and mobility purposes. The somites which are calcareous in composition, were hinged by the underlying chitinous layer, thus permitting the living animal to be flexible. The pygidium or tail was comprised of fused segments. In some species, some of the tail segments were modified, probably for some special uses, possibly such as moving or sweeping bottom sediments or to assist in swimming. Some or all three parts of many trilobites were decorated with spines. As different genera were continued through time, there was an increase in their spinosity with the peak degree attained shortly before extinction of each class. One eyeless form had a long spine projecting forward from the cephalon, apparently as a navigation aid. Other uses seem to have been in swimming or floating (they would increase body area with little increase in weight) or for protection. It has been theorized that some spines may have functioned as chemo-receptors to detect changes in environment or the presence of edible carrion as spines do on some modern crustaceans. The surfaces of many species also were granulated; small grain-size protuberances covering all shelled parts. As expected from such a large number of species, trilobites ranged greatly in size. Some apparently planktonic forms were only half a millimeter in length while the largest found to date is a little less than a meter or around three feet in length. The average size ranged from two to seven centimeters (0.8 to 2.7 inches) in length by one to three centimeters (0.4 to 1.2 inches) in width.

The oldest known trilobites, which are found in Lower Cambrian strata, seem to have lacked both - eyes on the front end and a pygidium on the rear. That order, one of five or six into which trilobites are subdivided, became extinct at the end of Early Cambrian time. Just two orders survived until Middle Mississippian time and of them, only one, the *Opisthoparia*, survived until the Late Permian when all trilobites became extinct. The most abundant Opisthoparian family were the *Proetids* which first appeared on the scene during Ordovician time. During the family's life, it had 65 known genera of which 15 are known from the Permian time. The genus *Ditomopyge*, a trilobite found in Permian rocks in Kansas is of this family as is *Anisopyge,* which is found in Middle Permian strata of west Texas and is the youngest genus of trilobites found in North America.

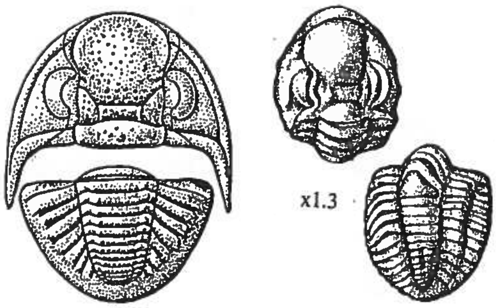
The cause of trilobite extinction is unknown as is the case with many other organisms. They were successful, ranged world wide and comprised more than half of known Cambrian-age fossils. They seem to have inhabited every marine environment: they were burrowers, bottom crawlers, swimmers and floaters transported by currents. However, their numbers declined through their long history until only a few species remained during Permian time about 255 million years ago. A world-wide mass extinction of uncertain cause occurred at the end of the Permian. It has been estimated that from 80 to 96 percent of all species became extinct at the end of the Permian. Marine creatures were especially hard hit. Whatever caused the mass extinction was too much for a group already in decline and the trilobites were wiped out. Other arthropods, including the horseshoe crab which had existed as long as the trilobites, survived.



Dorsal shield terminology of a trilobite. Parts described in this text are underlined. (From "Invertebrate Paleontology" by W. H. Easton, Harper & Bros.)

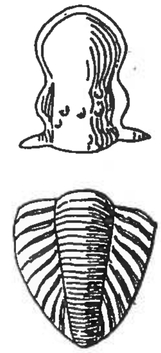


Ventral side terminology of a trilobite. Parts mentioned in this text are underlined. (From "Invertebrate Fossils" by Moore, Lalicker, & Fischer, McGraw – Hill.)



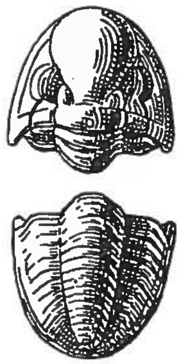
x2.7

Ditomopyge
Ᵽ - P

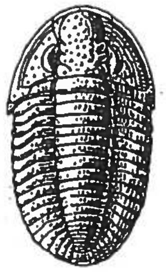


Anisopyge
P

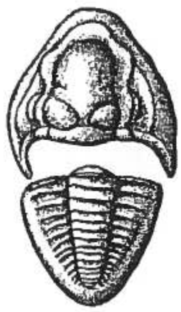
Griffithides
M – P



Kaskia
M



Phillipsia
M – P



Ameura
x1.3
Ᵽ - P

Some Kansas Trilobites & their Geological Time Range. (Magnification is x1 scale unless otherwise indicated.)

M = Mississippian (SE KS)
Ᵽ = Pennsylvanian
P = Permian

MOLLUSKS

Lawrence H. Skelton - Kansas Geological Society

Let's study mollusks. This phylum is comprised of seven classes which all differ remarkably in their external appearance. The internal or soft parts are sufficiently alike, however, that the genetic relationship of the seven classes is apparent. In terms of numbers and varieties, mollusks form the second most successful group of invertebrate fauna...exceeded only by arthropods. There are more than 100,000 living species and some 35,000 fossil species of mollusks. Six of the seven classes are found as fossils: Gastropoda (snails), Pelecypoda or bivalves (clams, oysters, mussels, etc.) and Cephalopoda (ammonites and nautiloids) are the most important. The three other classes which are found as fossils are the Scaphopoda ("tooth shells"), Polyplacophora (chitons) and Monoplacophora. The class Monoplacophora was thought to be extinct with fossils found in rocks of Cambrian and Devonian age. However, in 1952, living specimens were dredged from a deep ocean trench off the Pacific Ocean coast of Costa Rica. Since then, seven different species have been found in ocean depths ranging from about 6,600 feet (2,000 meters) to nearly 23,000 feet (7,000 meters). All the living species of monoplacophorates are assigned to the genus *Neopilina*. The seventh class is Aplacophora (solenogasters) which is not represented by fossils.

Mollusks of one class or another inhabit environments from great ocean depths to high mountains. They live in fresh water (mussels and snails) or in marine waters. Some types of gastropods (snails and slugs) even live on land. Mollusks occur as fossils from early Cambrian time, about a half-billion years ago, to the Pleistocene epoch. Well-formed examples from lower Cambrian strata indicate the phylum originated during Precambrian time. Some physiological similarities to annelid worms suggest they and mollusks may have evolved from a common Precambrian ancestor.
Zoologist Robert D. Barnes described a hypothetical Precambrian ancestral mollusk as inhabiting shallow marine waters and resembling a somewhat flattened oval. It would have been bilaterally symmetrical (that is, if cut in half, each half of the shell would be a mirror image of the other - like humans' hands) and probably would have been about one centimeter(half an inch) in length. Its shell would have

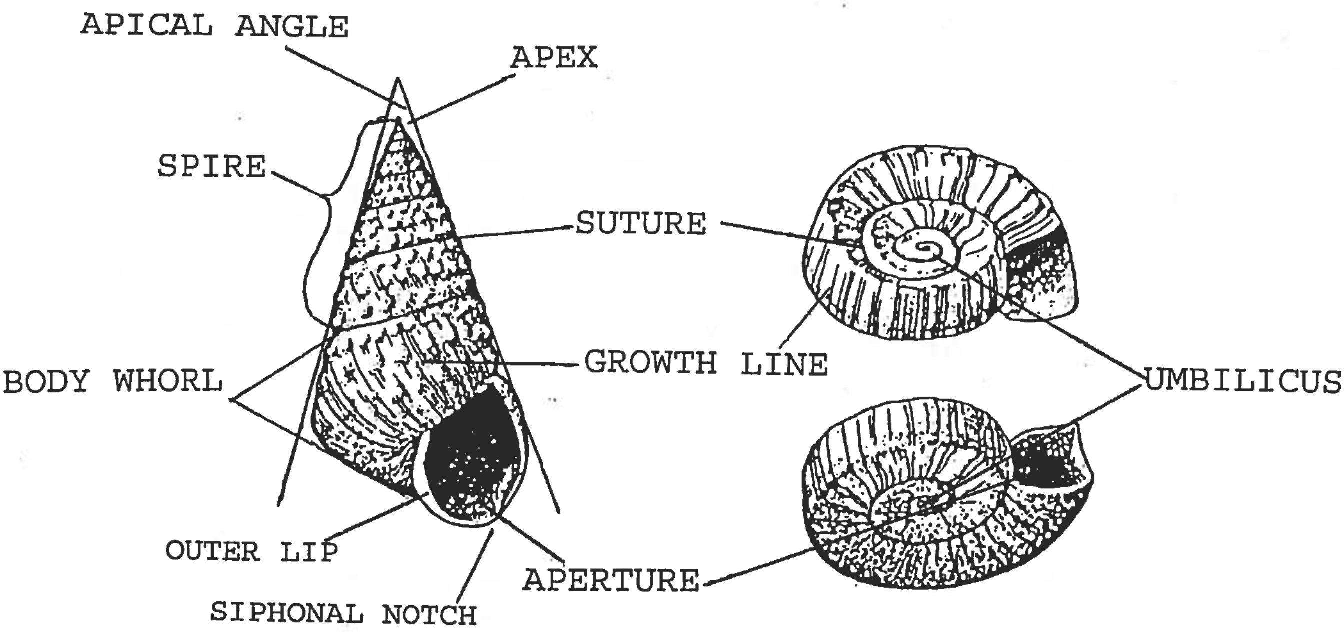
been made of conchiolin, a horny protein material manufactured by mollusks and analogous to hooves or nails in vertebrates. By Cambrian time, mollusks were reinforcing such a shell with calcium carbonate extracted from sea water. Here, we will discuss separately the main classes of mollusks which are found as fossils.

GASTROPODS

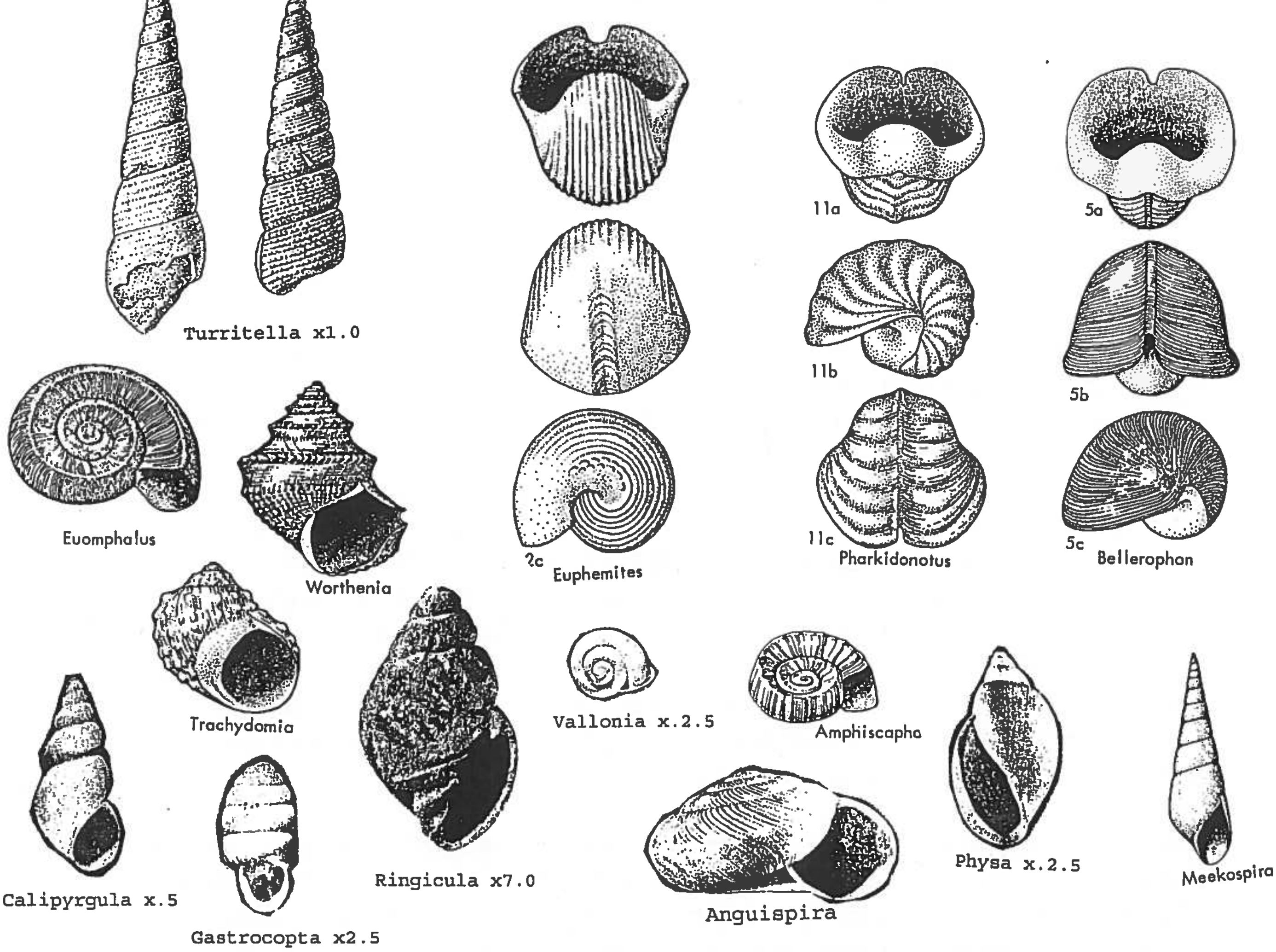
Let's first study the class Gastropoda…the snails. In numbers of species it is and probably always has been the largest class, comprising two-thirds of all known living and fossil mollusks. At present, more than 75,000 species are living and some 15,000 species are found as fossils. Snails occur with coiled or uncoiled shells or may be lacking shells as in the case of slugs. The average size shell is 25mm (nearly one inch) in length or diameter but sizes of fully grown adults range from 0.5mm (0.02 in.)to approximately 60cm (2 feet). The typical shell is coiled in the form of a spiral either in a flat plane or in a cone shape.

Snails first made their appearance in the early Cambrian Period, 550 to 570 years ago. They were not commonly occurring at that time but at least nine identified families were living during the Cambrian Period. Fossils of pulmonate snails (types with a lung rather than gills; dwelling on land or in fresh-water) first are found in the Pennsylvanian Period. The majority of fossil pulmonate forms, however, is found in strata of the late Cretaceous and Tertiary ages. Fossil gastropods are classified into four subclasses and 12 families. Three of the subclasses(Pulmonata being the exception) originated in Cambrian time. One family (the Heteropoda)which is grouped with the Prosobranchia subclass, is found only from the beginning of Cretaceous time onward and three of the Prosobranchia families became extinct at the end of the Permian Period.

Paleontologists understandably classify snails mainly on the basis of their shells or *conchs*. The animals themselves which form the basis of classification of living forms are rarely if ever preserved as fossils. In addition to the conch, many snails have a hard mouthpart or *radula* which is



PARTS OF A GASTROPOD SHELL



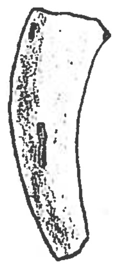
Some Fossil Gastropods of Kansas

a fleshy tongue-like process studded with rows of hard teeth. Many snails also are equipped with an *operculum*, a small "door" which pulls into and closes the opening when the animal withdraws into its conch. Opercula (plural) rarely are preserved with the conch and usually cannot be identified with the specimens to which they were attached when living. The same problem occurs with radulae (plural). The tiny tooth "studs" fall off when the animal dies and deteriorates. Except in living forms, the radula teeth,like the operculum, cannot be identified to a particular species even if they are found and recognized.

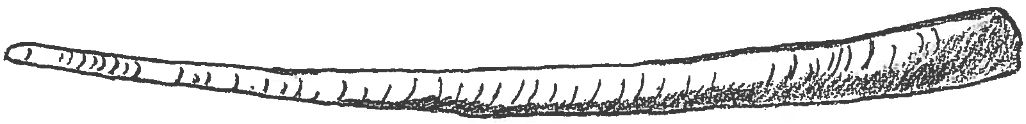
Snail shells usually are identified as "right-handed" (dextral) or left-handed (sinistral). Most (about 90%) are dextral. "Handedness" is constant within species and a sinistral form of a normally dextral species (or vice versa) is regarded as a mutant. The "handedness" is determined by holding the shell with the *apex* or pointed end upward and observing the location of the *aperture* (shell opening). If the aperture is on the viewer's right, the shell is dextral. If it is on the viewer's left, it is sinistral. Paleontology books frequently use special terms when describing a conch. Some of the terms are identified here.

SCAPHOPODS

Scaphopods are a small class of mollusks which first are found in Ordovician aged strata. About 350 species of these burrowing marine creatures still exist; so the class has been around for about a half-billion years. Popularly referred to as "tusk shells" or "tooth shells", scaphopod shells are elongate, slender, slightly curved, tapered tubes which are open at both ends. Living varieties are bi-valves when larval; the shells fusing to form a tube as the animal matures. Living varieties also possess a radula, similar to a gastropod. Scaphopods live buried in mud or sand with the large (head) end downward and the narrow end extended above the sea bottom into the water. They live in depths ranging from two feet (61 cm) to more than 14,400 feet (4,400 m). Their shells may be striated lengthwise or striated and ridged at right angles to the long axis. Although fossils scaphopods may be found in post-Cambrian Paleozoic Era strata, they do not become common until the Cretaceous.



Scaphopoda, genus unknown, X2



Scaphopoda, Genus *Dentalium*, X4

PELECYPODS

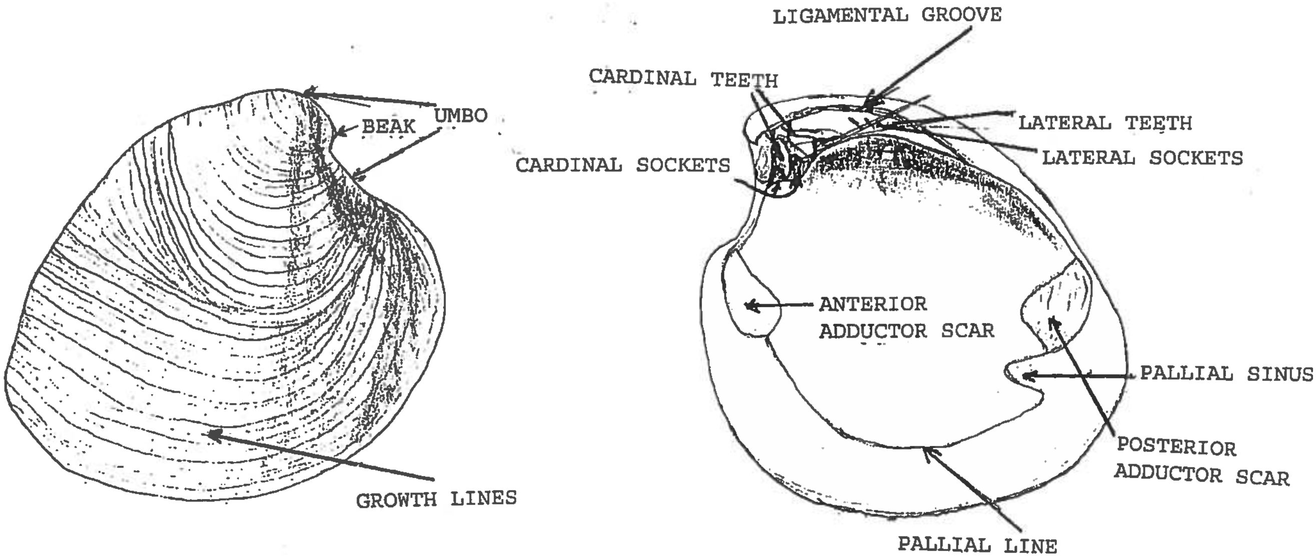
Next, let's study the mollusk class Pelycypoda...the clams, oysters and mussels, which frequently are called bivalves because their shell (properly referred to as a "*valve*") is comprised of two separate pieces. The pelecypods live in marine, brackish and fresh water; unlike their gastropod cousins, there are no land-dwelling varieties. Some species are bottom dwellers and others (the majority) live burrowed beneath the bottom. Most of those living *on* the bottom are attached to it by a *byssus* (a group of tough, horny threads secreted by a gland) or are attached by one valve being cemented to the selected base with calcium carbonate. A few types are mobile and move by dragging themselves or by swimming in short jumps. Scallops (Pectinoids such as the Shell Oil Corporation logo) are examples of the swimmers.

The fossil record of pelecypods begins in the Cambrian Period; however, the class was somewhat rare then. Numbers of species increased from Ordovician time onwards. Only marine species are found in strata older than Devonian during which time brackish and fresh water forms entered the fossil record. Species numbers began to increase from the middle Triassic Period and accelerated from the Middle Cretaceous onward. At present, there are some 20,000 living species. Surprisingly, those species include all of the major subclasses or comparable higher level divisions from Ordovician time. Pelecypods are the only major invertebrate group to claim such a record.

Living pelecypods range in size from 2mm (0.08 inch) to greater than one meter (Over 36 inches) across the shell. The biggest varieties may weigh more than 1100 kg or approximately 500 pounds. The shell comprises most of the weight and the soft parts may weigh only about 55 kg or 25 pounds. Fossil varieties display a similar size range. The Cretaceous Period *Inoceramus* clam which is found in western Kansas in addition to other places has a shell which measures a meter (3 feet) or more across but less in depth and thickness than shells of the living "giants" which are of a different family.

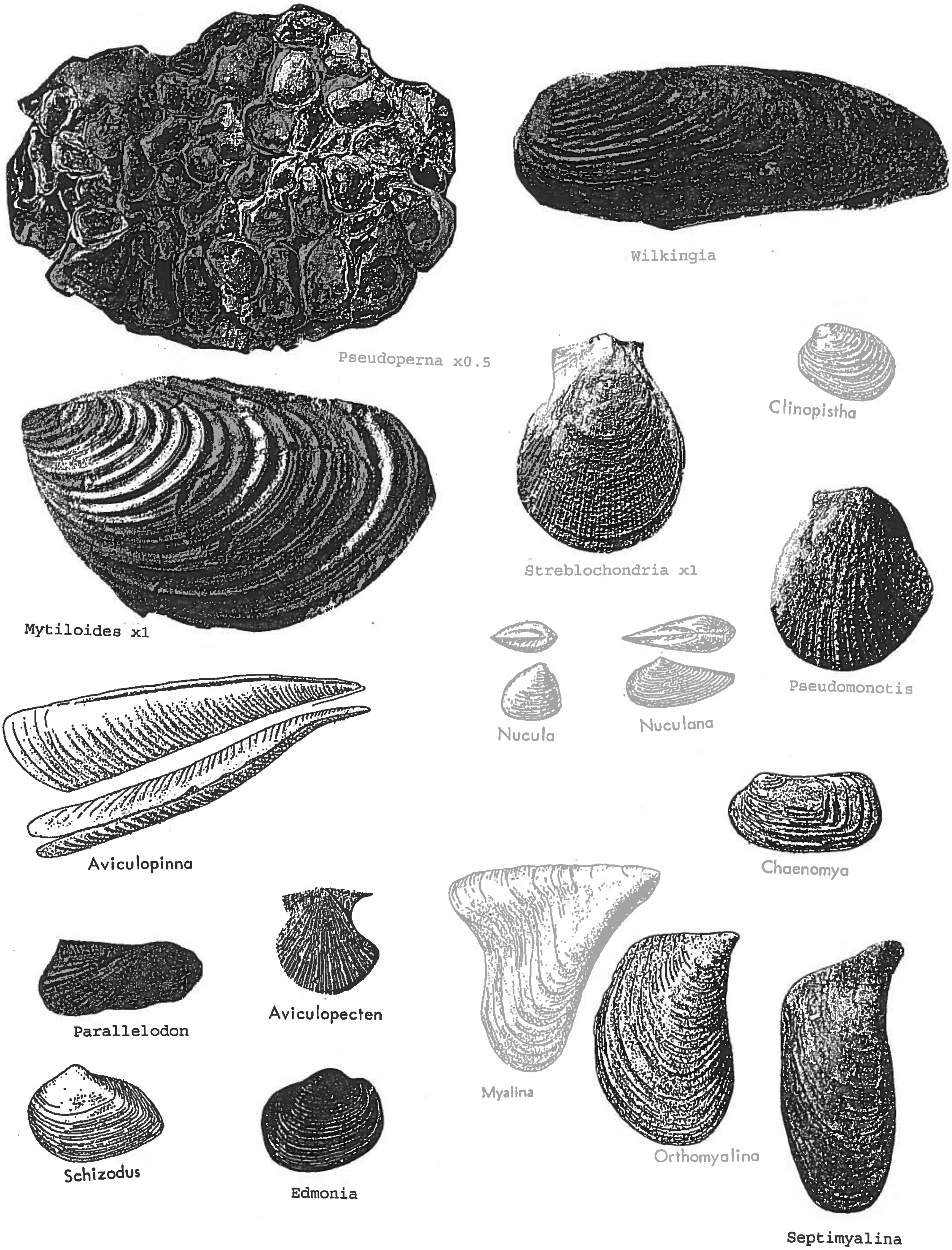
As noted, pelecypods may either live on a soft bottom of the seabed or stream, or may burrow into and live in a soft bottom or may cement themselves to a hard surface. The majority of modern species are burrowers which live buried in mud. The boring (such as "ship worms") and burrowing types are referred to as *infaunal*. Some live partially buried and anchored by byssal threads and are classified as *semi infaunal* and *endobyssate*. It is estimated that 40% of Ordovician Period pelecypods were endobyssate. Epifaunal varities live on top of the water-sediment interface and are referred to as *epifaunal*. They may be attached to a rock. another shell or some other hard surface by a byssus (*epibyssate* forms) or they may be cemented where the lower valve has assumed the form of the object to which it grows - a condition frequently seen in species of oysters and one which causes the two valves to differ in shape.

Construction of the pelecypod shell merits description since parts are usually preserved. Fossil pelecypods commonly are preserved as molds or casts of the exterior shell. Since specific identification frequently relies on internal shell features, such fossils are of little use as guide fossils. Soft tissues are important to zoologists in classifying pelecypods but since they are rarely if ever preserved in fossil form, paleontologists instead use shell or valve features. Among these features are teeth and sockets in the hinge area; used to keep the valves from sliding across each other; muscle scars where the adductor muscle used to close the two halves was attached to each valve; a pallial line which marks the delineation of the mantle's valve attachment and a pallial sinus which is an indentation in the pallial line and marks the site where the siphon tubes (used to draw in and expel water from above the sediment) are withdrawn into the shell. These key features and some important exterior terms are illustrated below.



PARTS OF A PELECYPOD SHELL

A few words about pearls. Fossil pearls are rare but are found, especially in the Cretaceous strata of western Kansas. All mollusks can form pearls but generally, only those formed by pelecypods are used as jewels. Fossil pearls



Typical Kansas Fossil Pelecypods
(Pennsylvanian, Permian & Cretaceous)

have lost all their "pearly" luster and are useless for decorative or gem purposes. Present-day gem pearls usually are produced by two species of the oyster genus *Pinctada*. Pearls are formed when a grain of sand or other small foreign object lodges between the nacreous layer (the innermost iridescent layer) of the shell and the *mantle* (a tissue layer that lines the shell interior and secretes shell material). The mantle coats the irritant with layers of nacre. A cyst-like grain, the pearl, is created as more layers of nacre are added. It is common for the pearl to have a base contoured to the shell rather than be "free floating."

CEPHALOPODS

The cephalopods are represented by squids, octopi, cuttlefish and a single nautiloid genus among the 650 living species. There are about 3,000 known fossil genera and about 10,000 fossil species, the most common subclasses being nautiloids, ammonoids and belemnoids.

Nautiloids, the most ancient subclass, first appear in the stratigraphic record during the Cambrian period. The ammonoids are present in Silurian time and the belemnoids first are found during the Mississippian period. The nautiloids are still living (three species); ammonoids and belemnoids became extinct respectively at the end of the Cretaceous period and during the Eocene epoch of the Tertiary period.

All three classes have shells which are divided into chambers by the presence of shell walls (properly called *septa*). The animal itself lived in the outermost chamber. Like their living relatives, the three different animals had tentacles (living nautiloids have tentacles and it is presumed that the ammonoids and belemnoids also had them but the soft parts needed for proof are rarely or never preserved. Earliest nautiloids possessed straight, cone-shaped shells. The shell became coiled in a plane in later varieties. The septum of all nautiloids is a straight or slightly curved wall. It forms a line (the *suture*) where it intersects the sides of the shell. A tube (the *siphuncle*) pierces each wall thus connecting the chambers. The animal, which lives in the outermost chamber, can "pump" seawater through the siphuncle into or from the chambers to adjust its vertical location in the sea - analogous to a submarine taking on or expelling seawater ballast. The only living nautiloid genus, the Chambered Nautilus, is known to range from near the surface to about 1700 feet (500 m.) below it. They come to feed near the surface at night.

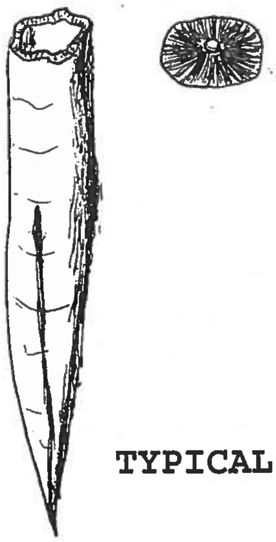
Nautiloid shells or conchs range in shape from a straight cone to a tight, planar coil. The earliest forms during Cambrian time were straight cones, one of which was the longest invertebrate known - its shell was nearly 16 feet (5m) long. As time progressed, some nautiloid shells became bent in mild arcs and some coiled up. "Loose" coils where the whorls don't touch each other as well as the tightly coiled forms such as the modern type are known. In some types, the tail (small) end of the shell is coiled and the remainder is straight; similar to the shape of a walking cane. Other than the oldest forms being straight or slightly bent and having a tendency to coil as geologic time advanced, none of the shell forms were exclusive to a particular time.

Ammonites, "cousins" of the nautiloids, first appeared in Silurian age strata, about 425 million years ago, and became extinct at the end of Cretaceous time. They are distinguished from the nautiloids by the shape of their sutures which among the ammonites, changed over time. Since the shells are quite alike in shape and function, it is assumed that the animal itself was similar to the living nautiloid species. Ammonites, however, had a stronger tendency to coiled shells than seems to have existed among nautiloids. The ammonite subclass of cephalopods is subdivided into three orders on the basis of the sutures. The Goniatitida, which are found in strata from lower Devonian through the Permian, display sutures which are broadly sinuous and may have angular, V-shaped lobes (the part of the suture pointing toward the narrow end or center of a coiled shell). Ceratitida occured first in late Devonian strata and became extinct before the end of Triassic time. Their sutures are characterized by serrate lobes. The Ammonititida order first appeared in Early Triassic time and became extinct at the end of the Mesozoic Era. Their sutures display complex folding and serration of bith lobes and saddles (the forward pointed parts of sutures. Some Ammonititida also became uncoiled and others developed odd twisting shapes; even coiling snail-like into

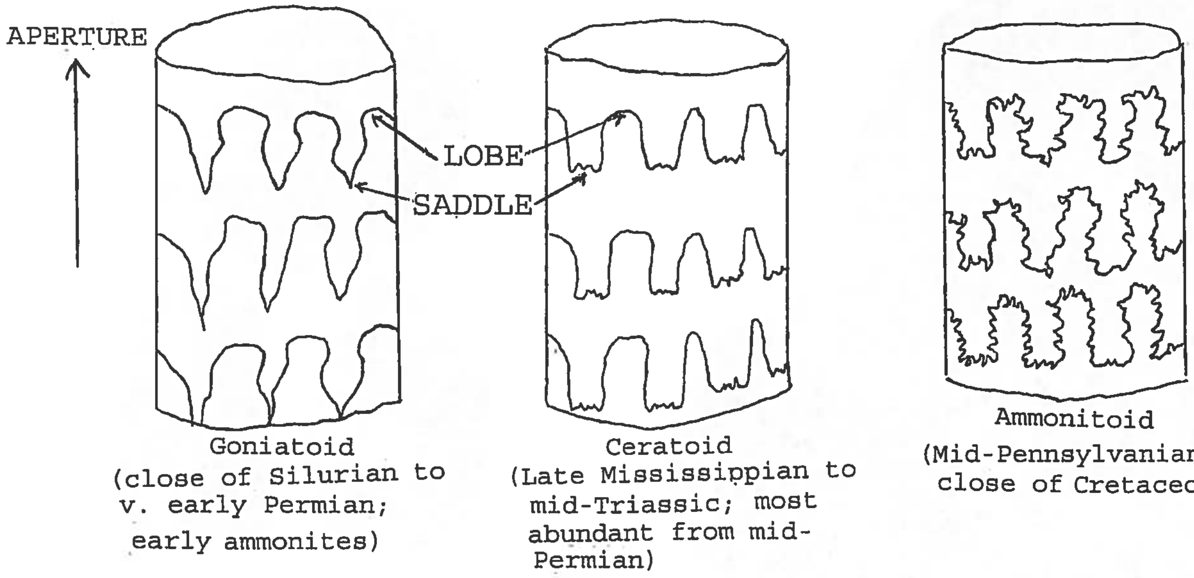
a helix shape. Their shells generally were more ornamented with ridges and nodes than the other two orders.
Keeping in mind that the suture is the intersection of the septum with the shell wall, it is obvious that the septum became more convoluted or crinkled as cephalopods evolved through time. As the septum provided successively larger chambers for the animal to live in, its bends and convolutions made for a stronger partition (just as corrugated cardboard is stronger than plain cardboard), perhaps allowing the ammonites to live at greater depths under greater pressures or to withstand rougher shallower waters than their nautiloid relatives. Perhaps both. Similarly, the heavier ornamentation occurring in ammonites would contribute to shell strength.

BELEMNOIDS

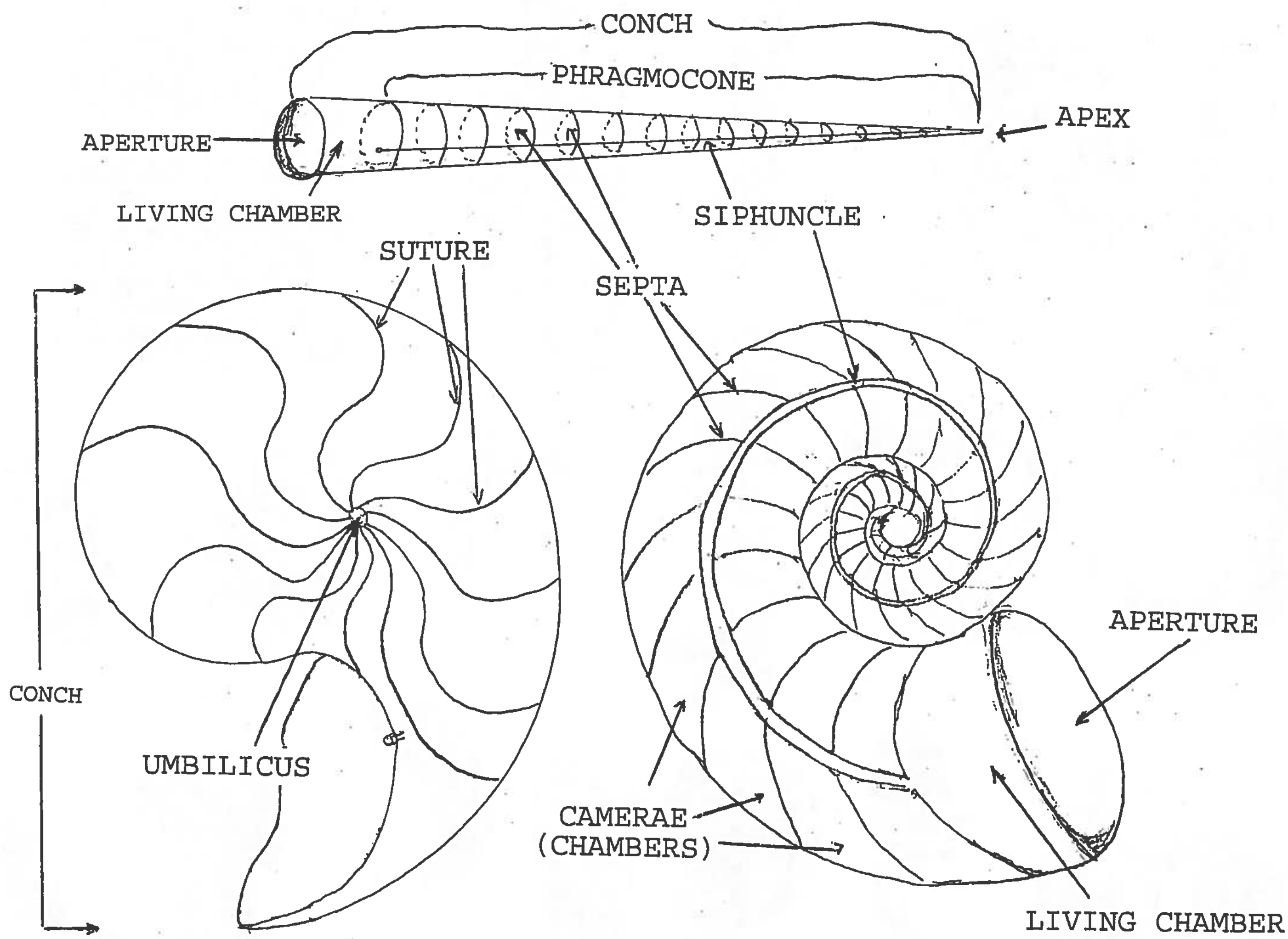
The belemnoids are subclass of cephalopods that flourished in the Mesozoic Era. Although they first occurred during Mississippian time, only a few specimens of Mississippian and Permian ages have been found. The fossils are an elongate cone, closed at the narrow end, and partitioned by slightly concave forward septa. They could be confused with the nautiloid *Bactrites* except that the belemnoid siphuncle is near the ventral margin of the shell rather than a sub-central location. A distinguishing characteristic of belemnoids is a radiating calcite crystalline structure. Near the living chamber, the crystallized area forms a ring around an opening but further back, it is solid, radiating outward from the long axis of the shell. The belemnite population reached its zenith during the Jurassic and Cretaceous Eras and became extinct during the Eocene stage of the Tertiary Era.



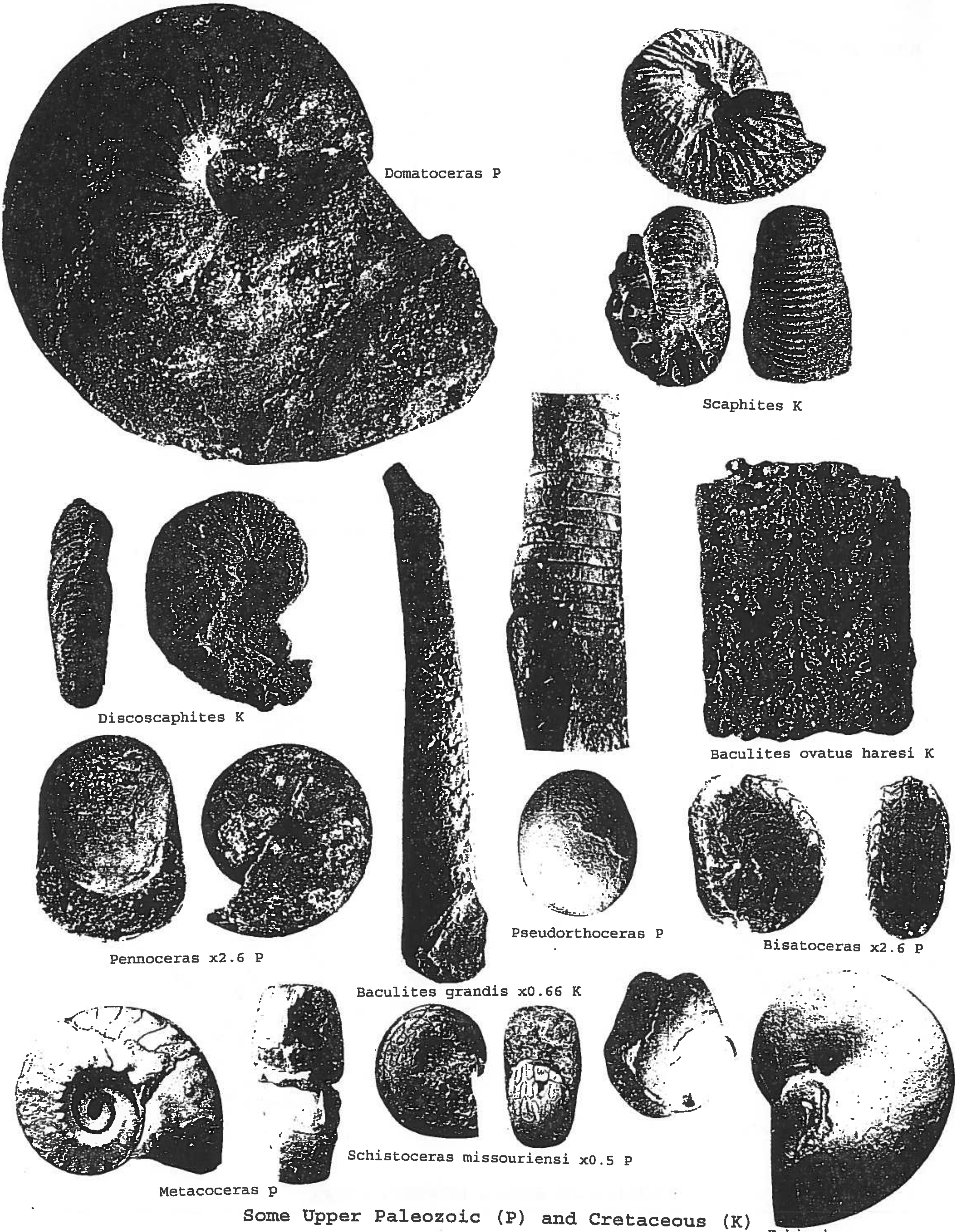
TYPICAL BELEMNOID X1



Types of Sutures



CEPHALOPOD SHELL NOMENCLATURE



Some Upper Paleozoic (P) and Cretaceous (K) Cephalopods of Kansas. (All x1 unless noted)

Ichnofossils

by L. H. Skelton
Kansas Geological Survey

The definition of the word "fossil" on the first page of this booklet contains the phrase "...the remains or traces of animals or plants...." Trace fossils or ichnofossils (pronounced "ik'no..." and from the Greek word *ichnos* meaning "footprint") are literally traces of past life rather than the preserved life form itself. Such traces may be trails, tracks, burrows, nests, pellets and coprolites (fossilized dung), in fact, any trace of animal or plant activity which leaves a mark.

The degree to which organisms disturb or plow through sediment is often unappreciated. All signs of stratification may be destroyed by creatures burrowing beneath sea or lake beds and stirring the sediments while doing so. Burrows may be straight, curved, or "U" shaped if used as dwellings and feeding structures may display a variety of regular or irregular shapes.

The value of ichnofossils to the professional or amateur paleontologist or geologist is that their presence helps interpret the local environment at the moment the creatures were actually making tracks or leaving other signs. An advantage accruing from trace fossils is that unlike their makers, i. e., the animal itself, trace fossils rarely are transported from where they were made. This in-place record permits the interpretation of the actual environment.

Trace fossils of soft-bodied creatures such as worms, slugs, etc., may be preserved more often than the bodies of the actual animals leaving the traces. Furthermore, the quantity of tracks, trails, or other trace fossils may belie the abundance of the organism making them: one animal can make and leave a large quantity of tracks, to which anyone cleaning cat paw prints from a car can attest.

Recognition of trace fossils, rather than identification, is the theme of the section of this book. Trace fossils may be difficult to identify insofar as what made them. For example, trilobites left three types of trails: resting, crawling and walking, which may grade into each other. Perhaps unfortunately, each type has been assigned a name: *Rusophycus, Cruziana* and *Diplichnites* respectively. The names refer to the type of track and *not* to the kind of trilobite which made them. Unless a fossil trilobite is discovered at the end of the trail, there is no way of determining what kind it was; just as in the above car/cat analogy. Unless caught in the act, you can't tell whether it was yours or the neighbors' cats that left the tracks.

There are many types of trace fossils:

- Burrows are excavations made in unconsolidated or unlithified soil, sand or mud. The burrow, which later may have been filled with sediment, made have been made for shelter, during the process of digging in search of food, or both. A frequently encountered example is the burrow of the common earthworm which is both, a feeding burrow and shelter. Many mollusks, crustaceans and insects make burrows and such burrows frequently are found as ichnofossils in lithified strata. Vertebrate-made burrows less often occur as ichnofossils. This is probably because such features usually are made on land and the earth's land surface historically is less than its undersea surface.
- Tracks are imprints on a sedimentary rock surface which were made by an animal with legs, i.e. a walking organism. A string or series of tracks is called a track-way. Tracks may have been made by any walking—as opposed to crawling—creature: insects, birds, lizards, and dinosaurs being the most often encountered.
- Trails are imprints left in sediment by a crawling creature—a worm or snail for example. Such animals are legless and drag their bodies across the surface, leaving a shallow furrow.
- Borings are holes or excavations made in a solid substance such as wood or a shell by some creature drilling in to make reach food or make an egg deposit. Examples of "worm holes" may be seen in petrified wood and various fossilized shells often are perforated by holes made by predators (often snails) boring a path through the shell to reach the edible contents.
- Coprolites are fossilized excrement or dung. Generally, the source or maker of a coprolite cannot be specifically identified other than a good guess based on size and contents of the coprolite. If the contents are remains only of plant material, the originating animal was an herbivore—a plant-eater. If they consist of teeth, crunched bone fragments, scales, etc., the originator was a carnivore. The size or volume of the coprolite relates to the animal depositing it. As anyone who has walked through a pasture knows, the larger the animal, the

larger the dropping. The majority of coprolites have been left by vertebrates…fish, sharks, dinosaurs and other reptiles and mammals. Some dinosaur coprolites (as well as mammals') have been found to contain burrows which are very similar in size and pattern to those made by modern dung beetles (scarabs)…a trace fossil within a trace fossil. Coprolites are useful in that they afford an idea of the range of particular types of animals and their diet. In sufficient quantity, they may allow an estimate of population density. In the case of plant-eaters, preserved plant fragments, seeds, etc permit interpretation of the types of plants growing in the area where the coprolite was found. Most of the "bezoar stones" thought to have magic and curative powers by medieval Europeans were coprolites. Limestone sometimes contain large numbers of small oblong or cylindrical pellets which are invertebrate coprolites. These are referred to as fecal pellets and formed by invertebrate animals eating through the bottom mud and excreting the inorganic or indigestible parts. Depending on the animal that made them, fecal pellets range in size from very fine to very coarse sand. They are of interest mainly to sedimentologists and stratigraphers.

- Eggs and nests are just that. Both occasionally are found as fossils. Dinosaur nests and eggs, even if identifiable to a specific type of dinosaur are considered trace fossils. Fragments of eggshells are more common than whole shells. Fossilized termite nests closely resembling those made by living termites have been found. Since many varieties of living animals make nests or some sort of styled egg-depositing place, one can safely assume that similar extinct creatures made them also.

Ichnofossils of all types may be found in rocks exposed in Kansas and surrounding states. The key to collecting them is recognition. It is easy to pass over a worm trail and a small animal's footprints may be very shallow and easily ignored.

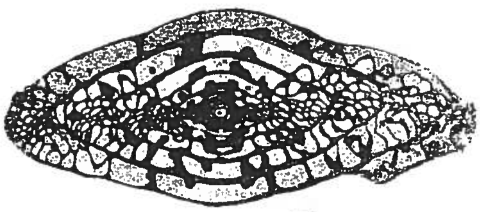
Other Fossils You May Find

by Lawrence H. Skelton – Kansas Geological Society

There are many kinds of fossil organisms which have not been nor will be discussed in this book. It is intended to include the more important and frequently found fossil representatives which may be collected in the Pennsylvanian, Permian and Cretaceous age strata of Kansas and the adjacent states.

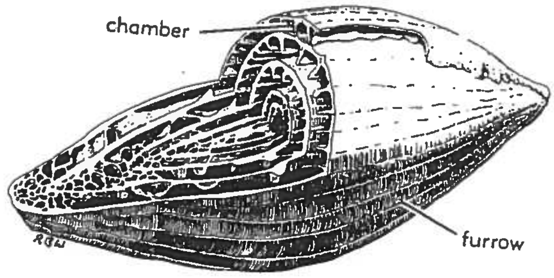
However, there are a few types of fossil invertebrates which are found often enough to merit some discussion. Also, there are many excellent plant fossils. This portion of the book will describe some of these often ignored organisms.

Fusulinids: Fusulinids are extinct protozoans (single-celled animals) which are members of the order *Foraminiferida*, Kingdom *Protista*. (For readers over the age of 50, protozoans formerly were a phylum in the Animal Kingdom but biological research during the past several decades has found sufficient differences between protozoans, bacteria, algae etc. and the rest of the Animal Kingdom to establish a separate kingdom, (Protista)for them. Fusulinids, which are named for the Latin word *fusus*, meaning spindle, are big for protozoans. They are visible to the eye and range from one to twelve millimeters in length and one-half to three millimeters in diameter. They have a fusiform shape, that is, like a spindle or a wheat grain. Fusulinids are first found in strata of late Mississippian age. They thrived during Pennsylvanian and Permian time, becoming extinct during the massive extinction event at the end of Permian time. World wide, more than 3600 species of fusulinids have been identified. Fusulinids thrived in clear, marine tropical seas far from shore. When they died, they floated to the surface where wind and sea currents gathered and concentrated them in immense numbers. Some limestone deposits are composed virtually of fusulinid tests (shells) and they can be collected in shovelfuls on such weathered strata. When alive, fusulinids extruded themselves through pores in the shell, enveloped smaller edible things such as small bacteria, algae cells, and other micro-invertebrates, digested them and then withdrew through the same pores back into the shell. Fusulinids have a complicated shell made of calcium carbonate which they extracted from sea water. The septa (dividing walls) within the shell are rolled into complex shapes and the animal itself probably filled all the volume not occupied by shell material. Their small size and large numbers of species makes fusulinids difficult to identify other than as "fusulinids." Precise, accurate identification is done by microscope study of crosswise and lengthwise thin sections ground and lapped flat for that purpose. Fusulinids evolved rapidly during their 105 million year tenure on earth and as a group display three important trends: 1) They grew larger over time, 2) Fluting and folding of their septa became increasing complex, 3) The structure of their shell wall changed. These rapid changes during 105 million years combined with their worldwide distribution and small size allowed their preservation in large numbers and make them an excellent index fossil. In fact, the Permian System worldwide is subdivided and correlated with the use of fusulinids. Their small size allows their recovery whole from drilled well cuttings and makes them extremely useful to petroleum geologists and those studying subsurface stratigraphy.



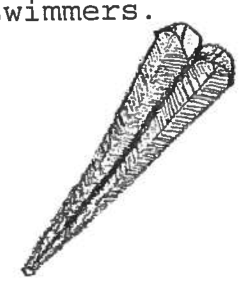
Longitudinal (above) & vertical (right) cross section of fusulinid x12.0

Fusulinids in Cottonwood Limestone x1.0



Cut-away view of Fusulinid x16.0

Conularids: These are strange, extinct creatures that resemble a square ice-cream cone or a narrow, steep pyramid. They generally range from one to six inches in length. Conularids historically have been a problem to classifiers and have been considered variously as mollusks, worms or members of some unknown phylum. Presently, they are included among the Scyphozoa (jellyfish) class within the Cnidaria phylum. Conularids range in age from Middle Cambrian to Triassic and are found in shale, limestone and sandstone. They even seem to have thrived in anaerobic, phosphatic black shale. More than 125 species of conularids spread through a dozen or so genera have been identified. All of them have a usually dark-colored, thin, four-sided, pyramid-shaped shell composed of chitin-phosphate material. The shell may be square or rectangular in cross-section with pronounced grooves present on each of the four edges. The four v-shaped plates between the corners may be slightly depressed down a center-line and each is covered with fine parallel ridges. The shells usually are found empty or filled with sediment; that is, no trace of the actual animal remains. Conularids are thought to have been attached to the sea bottom or some solid object early in life then possibly have broken away to become free swimmers.



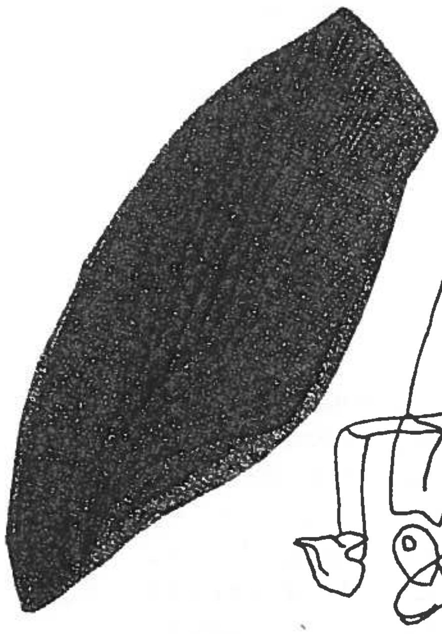
Conularid
x1.0

Insects: Boasting of 751,000 living species, insects are the most diverse and largest group of living animals and probably have held that distinction since Devonian time when they first appear in the fossil record. Devonian strata have yielded both, a crawling insect fossil and that of a "primitive" winged variety. The existence of such basic diversity during the Devonian points to an even earlier origin. The bristle-tail, a primitive wingless insect, has been found in upper Silurian strata and representatives of the dragonflies, damselflies, mayflies and silverfish date from the Devonian. Modern dragonflies and damselflies prey on other insects so it may be assumed that their Devonian precursors did likewise. The yet omnipresent cockroach first appeared during Mississippian time and the ancestors of today's 300,000^{+} species of beetles are found first in lower Permian strata. Beetles seem to have increased in variety along with and in response to a similar increase in flowering plants which began in Permian time.

Kansas and Oklahoma are well known for fossil insects in Permian age strata of the Wellington Formation and Greenwood County, Kansas is home to a famous insect deposit of Pennsylvanian age. Permian age deposits in Dickinson County have yielded some 93 genera and 149 species of fossil insects including one dragonfly with a wingspread of approximately 29 inches. Representative fossils of four

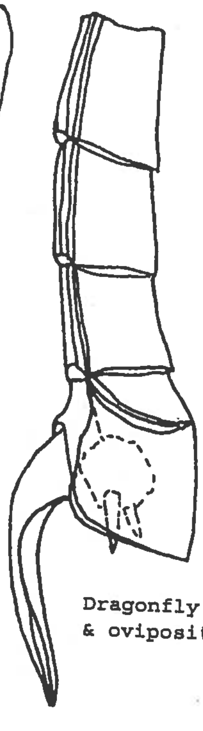
orders of Pennsylvanian age insects have been found in Greenwood County and of two orders in Anderson County.
Insects have chitinous bodies so fossils often are preserved by carbonization. Fossils of a whole insect are more uncommon than preserved parts. Wings and wing covers probably are the most commonly fossilized parts followed by legs or leg segments.
The most interesting story about fossil insects is the tale they tell about paleo-environments. A Devonian age silverfish probably scurried about under decaying vegetation eating what debris it fancied just as its descendents now do in a bookcase. A two-and-a-half foot wide dragonfly flitting over a Pennsylvanian or Permian pond or shoreline would have been a sight to see especially if they had shown the metallic colors displayed by their modern relatives. Such giantism was not confined only to dragonflies. Many other types of insects were much larger than their modern descendents. One theory to account for the big sizes is that there may have been a much higher oxygen content (up to 35%-- today's is 21%) which permeated insects and encourage their growth. There are some problems with that theory, not the least of which would be generally increased flammability of the environment in a more oxygenated atmosphere.

When searching for insect fossils, one needs to remember that insects crawl on or fly over land, not the sea, and search for corresponding strata from lakes, ponds, deltas or other muddy areas where insects could get stuck and quickly covered with sediment.

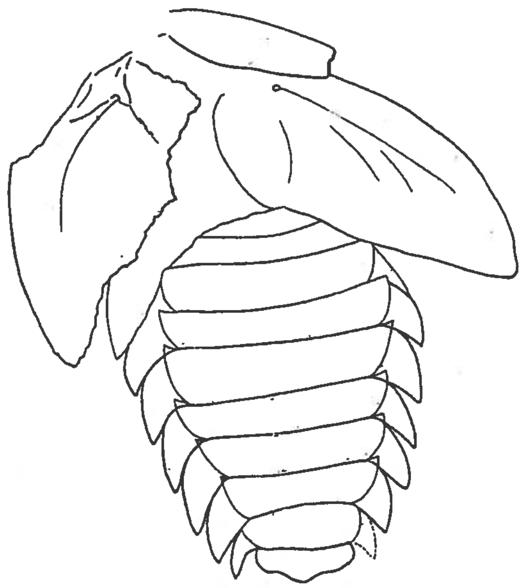


Cockroach wing
x1.0

Cricket wings, head, legs
x1.0



Dragonfly abdomen
& ovipositor x1.0



Cockroach nymph
x1.0

Fossil Plants

The original intent of this book was to discuss only invertebrate animals that occur as fossils. However, since fossil plant remains frequently are found in the Pennsylvanian, Permian and Cretaceous aged strata of the mid-continent and are popular among collectors, it seems useful to include them here. After all, plants probably preceded animals onto the land surface of the earth and furnished cover and food for those first animals to creep out of the seas.

The earliest land plants known grew during late Silurian time about 420 million years ago. They were well established by Devonian time although modern flowering plants (angiosperms) would not appear until Jurassic or Cretaceous time. Geologists can show that the part of the North American continent where Kansas is located was positioned about 12° north of the equator during Pennsylvanian and Permian time from about 314 million to 250 million years ago. Swamps and jungles thrived in the tropical environment (as they do now) and their lush vegetation accumulated over time and formed what would be future coal deposits in much of the world. As time progressed, the climate changed and plant groups reflect the changes. During Permian time, the world more or less "dried-up" relative to the preceding Pennsylvanian era. Of course, there were plants that grew inland or in highlands which, then as now, differed from their marsh-loving relatives. An extraordinary abundance of fossil spores of wood-rotting fungi found in strata marking the Permian/Triassic boundary point at some worldwide kill off of trees and land vegetation at that time. The timing coincides with the marine mass extinction which occurred then. The differences and the numbers in which plant fossils are found allow interpretations of paleo-environments and topography.

The plant kingdom is divided into five major groups, three of which are of interest to fossil collectors: gymnosperms, angiosperms and pteridophytes. The remaining two groups, thallophytes and bryophytes, are of interest mainly to botanists and paleobotanists. Simply put, gymnosperms are those plants with their ovules or reproductive elements borne in open scales, usually cones. Living (and fossil) examples are: conifers, seed ferns, cycads and gingkos. Angiosperms are plants with seeds produced within a closed pod or fruit. These comprise the flowering plants and trees. Pteridophytes are those plants with vascular systems, roots and leaves, like the other two above, but which reproduce by means of spores. These include ferns, living and fossil lycopods, and equisetums (horsetail rushes).

Fossil plants are named according to the rules of binomial nomenclature which have been discussed. A problem with such plants is that their different parts, if not found together, may be assigned different names or form genera. For example, if separated, the seed, cone, bark, leaf, limb and stem of a single tree may each have been discovered separately and each assigned a name. Later on, if the same type of leaf is found still attached to a branch, the junior name is deleted and both parts are given the older name although in some name systems, they still retain their original names when in separate parts. That is why current reference books are necessary to avoid confusion with names of plant fossils (although animal fossils may encounter similar problems with isolated body parts and adult and infant forms).

A brief description of frequently discovered plant fossils:

Lepidodendron and *Sigillaria* were genera of giant club mosses of the subphylum or subdivision Lycopsida. They were tree-like plants, some types of which were more than 134 feet high and possessed trunks up to six feet in diameter. Lepidodendrons display diamond-shaped leaf scars on their trunk, the long axis of the diamond being horizontal or parallel to the ground. It is possible that the patterns varied on the same tree according to height above ground and/or layer of bark. Cones were borne at the tips of some branches, the branches apparently being confined to the upper fifth of the tree. *Sigillaria* were tall trees with vertically ribbed trunks which bore rows of narrow elliptical leaf scars on each rib. Trunks of some varieties were without ribs but the leaf scars allow them to be identified. one needs to remember that plant stems, trunks and limbs were originally round (as they still are) but may have been flattened or crushed to an oval cross section by the weight of later sediment deposits.

The subdivision Sphenopsida includes the often encountered *Equisetum* and *Calamites*. The *Equisetum* (horsetail or scouring rush) with 25 living species, has been present among the earth's flora since Pennsylvanian time. The living plants generally reach the height of small shrubs with stems near pencil diameter. One tropical variety achieves a height of approximately 30 feet. Fossils range within the same sizes, stems an inch or more in diameter being ordinary. The stems are ribbed on the exterior and separated by nodes or dividing lines which are perpendicular to the stem length. A casual look in the field may result in confusion with some fossil horn corals but closer examination quickly rules out that choice. Equisetum ribs but against each other at the node point. Leaves, which usually are not preserved with the stem, are arranged in a whorl around the stem immediately below the nodal line. *Calamites* which resembles *Equisetum* is a larger plant which first is found in Devonian strata and during Pennsylvanian time, reached its maximum size, up to 90 feet tall and several feet in diameter at the base. It too was segmented by nodal lines and had leaves arranged in whorls. It leaves were longer and wider than the more needlelike Equisetum leaves. The whole plant could be said to resemble a gigantic bottle brush. Unlike *Equisetum*, the *Calamites* is completely extinct.

The Gymnosperm class of plants which has "naked" seeds rather than being enclosed in a fruit, is represented in fossil and living forms by conifers (550 living species), gingkos (one living species) and cycads (50 living species). Seed ferns and *Cordaites*, both extinct, complete this group which began in Pennsylvanian time and with the two exceptions noted, continue to present.

Cordaites which is named for an Austrian botanist, A. K. J. Corda, flourished from late Devonian into Triassic time and were prevalent during the Pennsylvanian and Permian. Although now extinct, are distantly related to modern conifers. They grew into tall trees reaching heights of 100 feet with branches near the top. Depending on the species, leaves ranged in shape from needle-like to wide, strap-shaped with parallel veins and lengths up to three feet. The long wide leaves now often are found in coal.

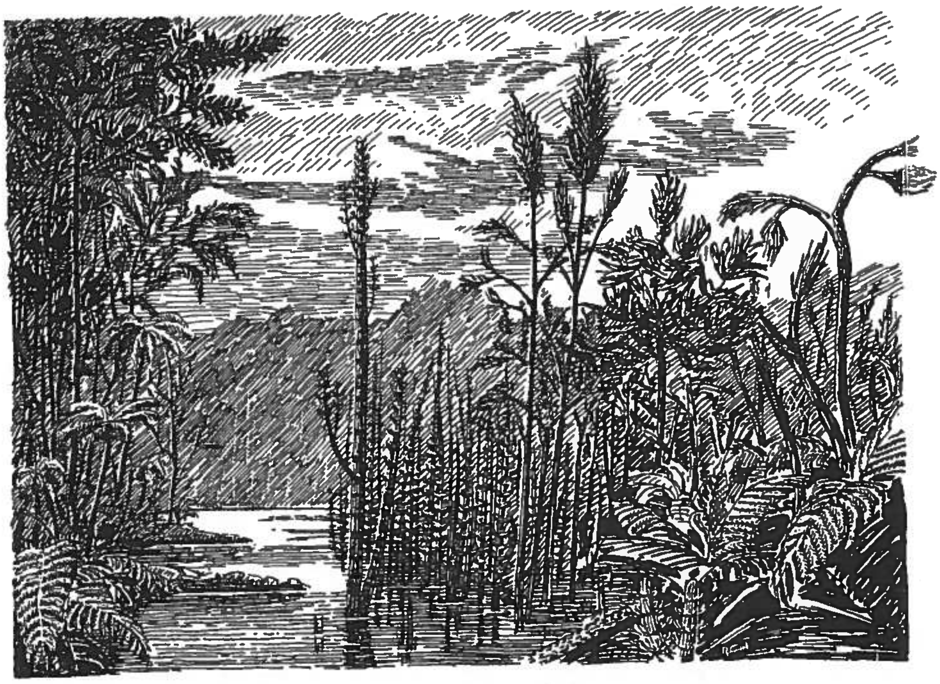
Cycads first are found in the fossil record near Pennsylvanian/Permian transition time and still exist. They were prominent through the Mesozoic and have been estimated to comprise as much as one-fifth of all flora during the Triassic and Jurassic. Various beetles are an important vector in the pollination process of living cycads and the "boom" in cycads in Triassic time may have initiated the accompanying increase in beetle varieties…or vice versa. Living cycads are confined to tropical and subtropical climate zones and they probably always have been confined to such areas. Cycads somewhat resemble, but definitely are not, palm trees although one popular variety of living cycad is called "sago palm." Cycads possess large compound leaves which are clustered around the top of a short, stout truck. As the trunk grows upward from the top, new leaves are added and the older, lower ones fall off leaving a scar.

Gingko trees have existed since Permian time but presently are reduced to a single species which is native to China. The name derives from the Chinese words *yin kuo* which mean "silver fruit." Gingko trees attained their greatest diversity during Cretaceous time and fossil species are identified by geographic distribution and leaf anatomy. Gingko leaves, fossil and modern, have a distinctive fan shape which may be notched in the middle of the edge.

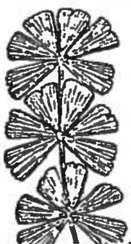
Seed ferns (Pteridosperms) are extinct fern-like gymnosperm plants which were abundant during Mississippian into Jurassic time. They possessed leafy fronds which gave them the appearance of true ferns. Some were the size of trees and others were small with thin stems. As gymnosperms, they reproduced by seeds rather than by spores as do true ferns. *Neuropteris* and *Sphenopteris* are among typical seed fern genera which are illustrated in the accompanying figures. They frequently are found in coal deposits in eastern Kansas.

Angiosperms, seed-bearing, flowering plants with enclosed seeds tentatively have been found in late Triassic rocks. They definitely occurred during Jurassic time and flourished during Cretaceous and on into modern time. Leaves frequently are found in continental strata and actual flowers are rare occurrences. The leaves resemble those of modern deciduous plants and often are recognizable representatives of such families as maple, sassafras and willow. The Cretaceous age Dakota Formation in Kansas is well-known for beautifully preserved fossil leaves. The Dakota contains beds of lignite, a low grade "proto-coal" comprised of plant materials with many recognizable reeds, stems, leaves, etc. Amber, a fossil tree-resin, has occasionally been found in or close by the lignite. Younger fossil plants of Tertiary or Quaternary ages may possibly occur is volcanic ash beds, Pleistocene lake beds or even the Ogallala formation. Pollen from many varieties of plants has been recovered from such strata. With proper conditions, a leaf or branch could be preserved for the collector to find.

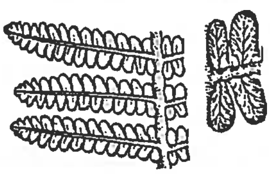
Kansas Fossil Plants (all Pennsylvanian age except as noted)



VISUALIZATION OF LATE PENNSYLVANIAN (ABOUT 303 MILLION YEARS AGO) SCENE NEAR LAWRENCE, KANSAS. [BY R. C. MOORE.]



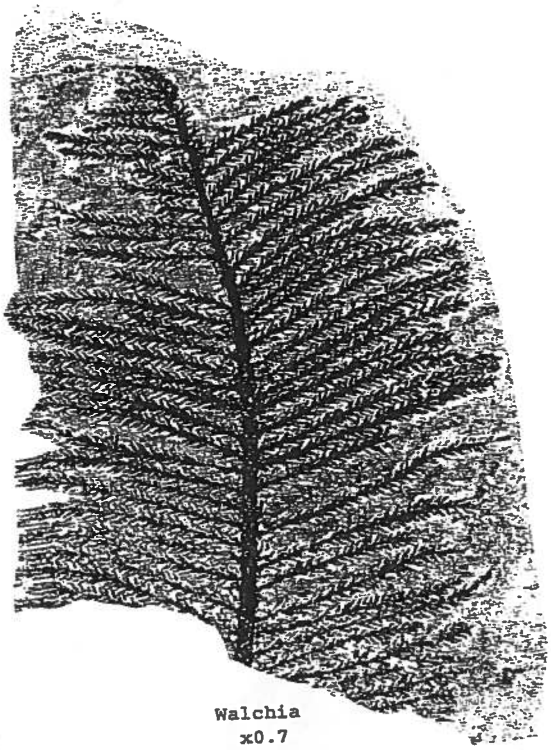
Sphenophyllum



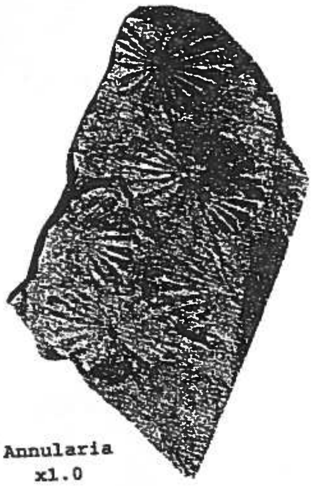
Pecopteris

Mariopteris

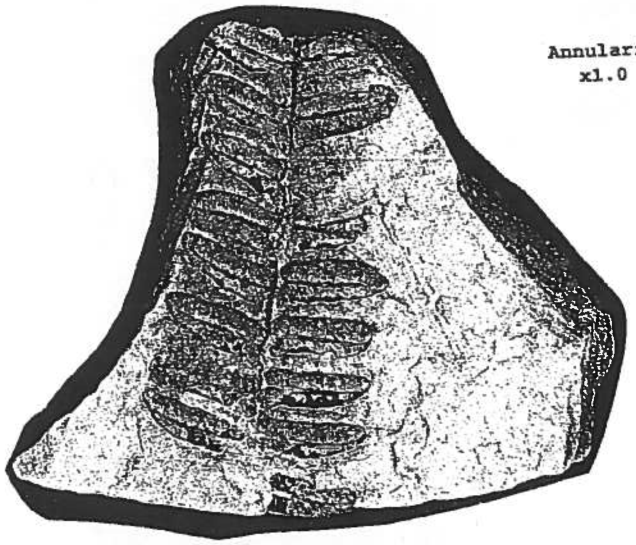
Portion of deciduous leaf; x1.0; Cretaceous



Walchia
x0.7



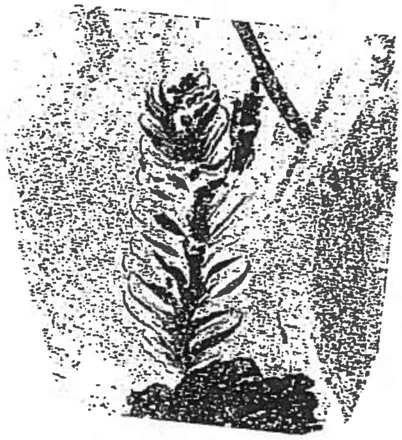
Annularia
x1.0



Alethopteris
x1.0

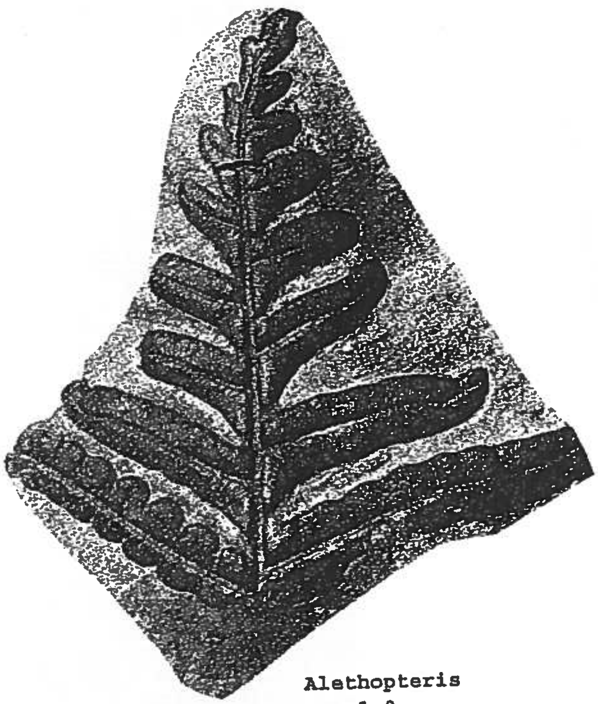
Mariopteris
x1.0

Cordaites leaf
x1.0

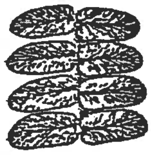


Lecrosia
x1.0

Callipteris
mm. scale on left
Permian

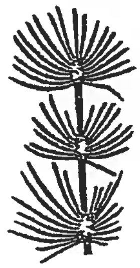


Alethopteris
x1.0



Neuropteris

Sphenopteris
mm. scale on left



Asterophyllites

Acknowledgments

- Lawrence H. Skelton is Assistant Director Emeritus of the Kansas Geological Survey Wichita office. The Kansas 4-H Geology leaders are grateful for the voluntary educational contributions that Mr. Skelton has provided for many years; especially the composition and donation of this worthwhile publication.

- The printing of this publication was financed through the generous contribution of SCS Aquaterra, a national environmental and engineering firm.

- All proceeds from the sale of this publication will benefit the Kansas 4-H Geology Scholarship Fund.

- The majority of images in this publication are public information provided by the Kansas Geological Survey, Lawrence, KS.