STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY

BULLETIN 54

OHIO FOSSILS

BY
AURÈLE LA ROCQUE
AND
MILDRED FISHER MARPLE

COLUMBUS

NINTH PRINTING 1970

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Horace R. Collins, Chief

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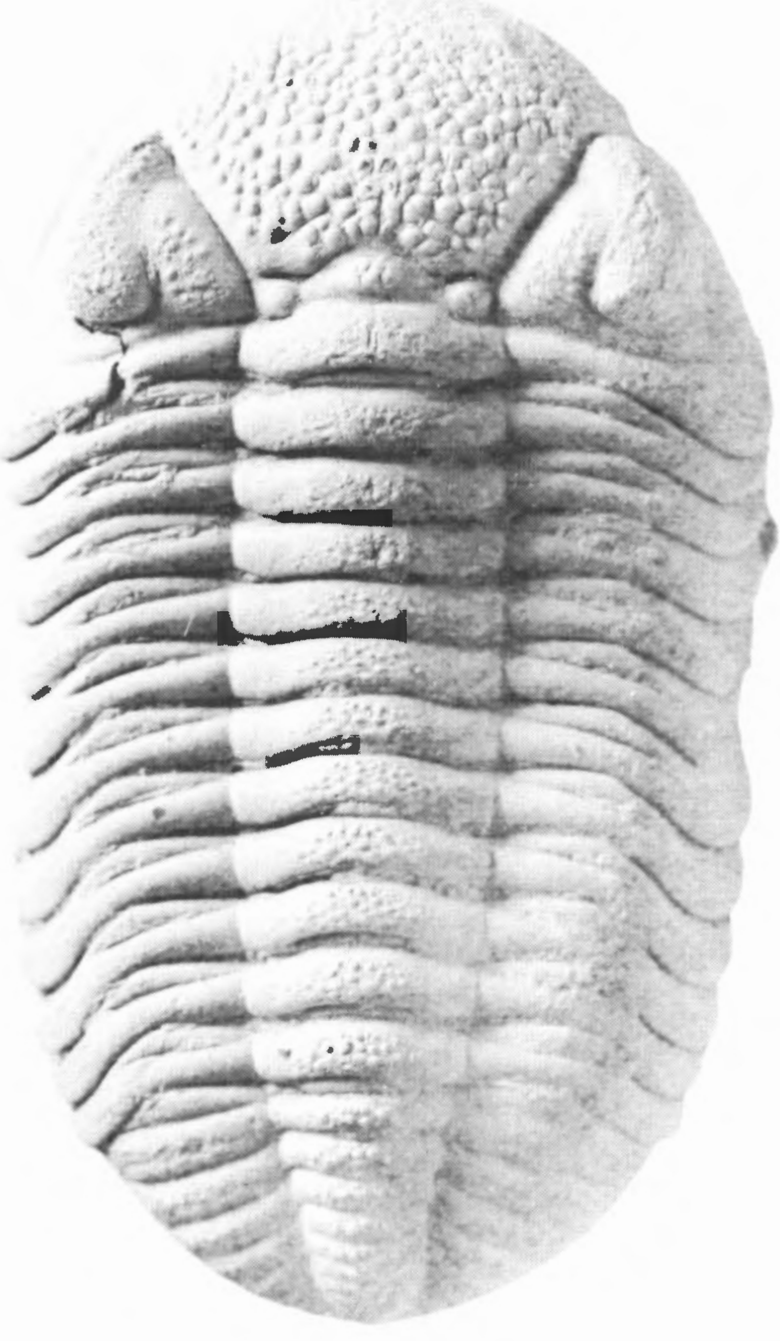

FRONTISPIECE. Phacops rana milleri, an almost complete specimen from the Silica formation near Sylvania, Ohio. X 2.75 (See page 92).

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PREFACE

Every year hundreds of people pick up fossils in Ohio and become interested in them. If their interest is more than casual, they want a book that will tell them something about their finds. Books about fossils are many, but most of them are written in disappointingly technical language. That is why we have tried to write one that would be understood by the non-professional. We hope this book will provide an introduction to the subject and answer the many questions usually asked about fossils. It is not meant to be a complete account of Ohio paleontology; it deals only with the commoner species, the ones that anybody is likely to pick up in Ohio. We hope it will at least open the door to the subject of paleontology, the study of fossils, a fascinating hobby that can be enjoyed without extensive training or equipment. To simplify searching, technical terms not usually found in dictionaries are explained in the text and listed in the index.

The "you" for whom this book is written and to whom it is addressed includes all Ohioans interested in fossils. May you have as much fun reading and using it as we had writing it.

During the preparation of this bulletin we have had much help and encouragement which it is a pleasure to acknowledge. Dr. J. E. Carman allowed us to draw on his thorough and detailed knowledge of Ohio stratigraphy and paleontology; his kindly and searching criticism of the manuscript is much appreciated. Mr. R. E. Lamborn and Miss Pauline Smyth of the Ohio Division of Geological Survey read parts of the manuscript and contributed information on topics with which they are particularly familiar. Mr. W. C. Brown, also of the Survey, gave us much good advice on many points important to the non-geologist. Dr. J. M. Schopf, of the United States Geological Survey, read the part of the text dealing with fossil plants and his advice on that subject is gratefully acknowledged. Mr. R. S. Bowman gave us much information on Silurian fossils. Dr. E. S. Thomas, Curator of Natural History at the Ohio State Museum, gave us his impressions of the text from the standpoint of a naturalist. Our colleagues in the department of geology at the Ohio State University, Drs. C. A. Lamey, J. O. Fuller, R. P. Goldthwait, H. J. Pincus, M. P. Weiss, and S. E. White, have read the manuscript in its final stages and have contributed useful information on many points.

Finally, we realize that in spite of much care and revision we may have made inadvertent errors or failed to mention or emphasize pertinent topics. We shall be grateful to anyone who will be good enough to call our attention to these faults and we shall endeavor to correct them in later editions of this bulletin.

ABOUT "OHIO FOSSILS"

The Ohio Division of Geological Survey published the first edition of "Ohio Fossils" in 1955. It was readily received by hobbyists and students and the demand necessitated reprintings in 1956, 1959, 1961, 1962, 1963, and 1965. With the 1966 and 1970 edition, the number of copies published totals over 30,000.

CHAPTER I. INTRODUCTION

WHAT FOSSILS ARE. Fossils are the remains of past life. The definition covers a wide field for it includes the bones and tusks of huge animals like the mastodon and mammoth and the tiniest shells of one-celled animals sometimes found literally by the millions in the rocks. Anything that is a clue to past life is included: trails and footprints, worm burrows, fossil leaves, tree trunks, and seeds, and the almost invisible spores of fungi.

WHERE FOSSILS ARE FOUND. In Ohio, fossils are around us everywhere. They are found in all 88 of the counties of the state; the only difference between one county and another is the age and type of fossils found and their abundance or scarcity. On city streets people walk on fossils every day, for some of the old sidewalks are made of slabs of limestone that contain fossils. Even in our buildings, fossils are present in numbers: the walls of the State House in Columbus contain fossils; the stone walls and chimneys of houses and the gravel in our driveways are often crammed full of them.

USES OF FOSSILS. Fossils are useful in three ways. To mankind in general, they are the evidence of animals of the long-distant past, the only clue to the nature of the life of millions of years ago. They show the appearance of different life forms one after another. Fossils are the documents from which development of life in the past can be traced.

Fossils have a practical use too. Different kinds of fossils are found in the successive layers of rocks. The rocks can be recognized by their fossils. Some beds can be identified by their fossils even though they are separated by miles of ocean or by areas covered by soil or glacial debris. Even the layers far under the surface of the earth, when they are penetrated by the drill of the oil seeker, can be identified as to age by the fossils they contain. Some of the fossils brought up by the drill are broken but others are so small and so numerous that they can be identified.

HOW FOSSILS ARE FOUND. In some parts of the state, fossils are so large and numerous that everybody knows about them. Elsewhere, fossils are not so obvious and they must be looked for with more care.

The terms abundant, common, and rare are used as a matter of convenience throughout this book. We realize that their meaning varies greatly, as we found out when we compared statements in other publications with our own experience on some of the species of Ohio fossils. It seems best, therefore, to define our particular understanding of these terms so that you will not be misled by our statements. For us, abundant fossils are those that are so numerous in a particular formation and so widely distributed that they are bound to turn up in the majority of collections. Common fossils are numerous at some localities and not at others; or they may be widespread in most localities but they do not form a high proportion of any collection. Rare fossils are those that are found only occasionally.

The main equipment of the fossil hunter is a pair of sharp eyes, a good stock of patience, and a few tools. The main tool is a hammer. It should be a fairly stout one, preferably with a chisel or point on one end of the head and a flat, square face on the other. A few cold chisels of assorted sizes may be useful in particularly hard rocks. The fossil hunter also needs a stout haversack to carry his finds, newspapers and tissue paper to wrap them in, and some pieces of paper to label them with. Cleaning and cataloguing of fossils are described later in this book.

WHERE AND HOW TO COLLECT. The most obvious place to go for fossils is the nearest quarry. Quarries are private property and PERMISSION TO ENTER THEM SHOULD BE OBTAINED FROM THE OWNER (fig. 1).

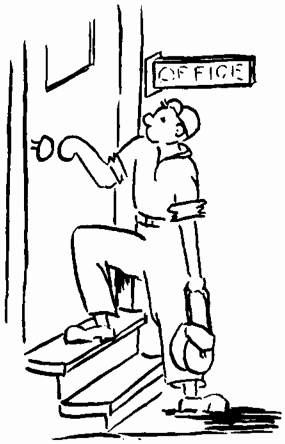


Fig. 1

This is not only common courtesy but a good safety precaution. In operating quarries, blasts of dynamite are set off from time to time, and heavy machinery may constitute a hazard. Quarry owners seldom refuse permission to enter their property unless there is a good reason. Abandoned quarries may be even more hazardous than operating ones. Asking the owner's permission to enter them will generally bring a caution about the hazards of a particular quarry. In any case, ASK FOR PERMISSION and be careful.

Railroad and highway cuts and fills are sometimes good collecting grounds also. The cuts are better since the rocks exposed in them are in place and those in the fills may have been brought from a distance.

Streams and gullies are good prospects too. If the streams have cut into fossil-bearing rocks, free specimens may be available in the stream bed and on its slopes and fresh ones can be dug out of the banks. Road ditches may not look too promising at first but they often yield a rich harvest.

Old strip-mine workings often make good collecting grounds, especially for fossil plants, but sometimes also for invertebrates. In working the coal seam, the strip miner leaves behind the rocks above the coal. These rocks break up by weathering and fossils can often be picked up without any digging. A search of the high wall of the mine will often serve to identify the exact stratum where the fossils occur in place.

In many places where the rock has been weathering out for a long time, well preserved specimens are found in residual soil and joint fillings.

In short, you can collect fossils almost anywhere in Ohio. A few of the better areas for particular kinds of fossils are noted in later chapters.

We repeat that almost anywhere you collect, you will be on private property and the owner's permission should be obtained before you start digging.

On a collecting trip, here are the things you should take with you. (1) A road map of Ohio which will permit you to locate the place you collect from. (2) A detailed topographic map of the area where you collect. All of Ohio has been mapped at a scale of about one inch to the mile; these maps are sold by the United States Geological Survey, Washington 25, D. C., at 20 cents each. (3) A bag to carry your collections. (4) Newspapers and soft tissue for wrapping specimens. (5) Labels, which can be 3 x 5-inch slips of paper, to identify each collection. They should be written in pencil, not ink, because ink runs if the label is damp. (6) Paper sacks of various sizes for packing loose samples. (7) A hammer and a few cold chisels. (8) A lens for examining small specimens in the field; an 8-power lens is convenient and not too bulky. (9) A notebook for recording your observations.

KINDS OF FOSSIL PRESERVATION. Some of the fossils you collect will prove a little puzzling. That is because fossils are preserved in different ways, and some knowledge of these processes will help you understand your specimens. The entire animal or plant may be preserved without alteration; this is called entire preservation. When minerals, precipitated from groundwater, fill the openings in shell or bone, long after the flesh of the animal has decayed, the shell or bone becomes heavier and harder; this process is called permineralization and many Ohio fossils are preserved in this way. The groundwater may dissolve away some or all of the mineral matter in bone or shell and replace it with other minerals that the water carries in solution. This is called replacement; many Ohio fossils have been replaced by pyrite and silica, a few with marcasite and other minerals. If the fossil is not replaced by minerals, it may be encased in rocks and all the liquids and oils in its body may be squeezed out; this process is called distillation. Many Ohio fossil fishes are preserved in this way. When plants are preserved by squeezing they are called compressions. The groundwater seeping through the rock may dissolve the shell or bone completely without replacing it with other minerals. In that case, if the rock has hardened before the fossil is dissolved out, the rock retains the imprint of the fossil, making a mold. Sometimes the mold is later filled with mineral matter, producing a cast, which is a replica of the original fossil in different material.

The tracks and trails made by animals on wet sand or mud are sometimes covered immediately by new layers of mud or sand. If these sediments harden into rock, the tracks and trails may be preserved. Tracks give us an idea of the size of the animal that made them, the number of its toes, whether it had claws or not, and many other details. Several tracks made by the same animal are called a trail; from it we can find out the length of the animal's stride, whether it walked on two or four legs, and whether the body or tail dragged on the ground or not.

Burrows of worms and other animals without backbones may be filled with material different from the muds or sands in which they have been dug. If these materials become rock, the shape and size of the burrow can be studied and sometimes the animal that made it may be found fossilized in its burrow.

Coprolites are fossilized dung. The word is derived from two Greek words meaning dung and stone.

HOW FOSSILS ARE NAMED. At first, you may be satisfied to know that you have fossil corals, clams, fish and ferns. You will soon collect fossils, however, for which there are no common names and so you will want to learn what names scientists have given them. The naming of fossils has been going on for a long time (before the seventeenth century and even in antiquity) but the system in general use is one invented by Carl Linné, a Swedish naturalist of the eighteenth century. His system is accepted because no one has thought of a better one and because it can be used by people speaking all modern languages. It would be very nice if we could have English names for our fossils; the trouble is that the same kinds of fossils are found in France, Germany, Russia, and China, where they might be given French, German, Russian, or Chinese names. Linné's system gives plants and animals, living or fossil, names derived from Latin and Greek which are acceptable to all.

Linné divided nature into three kingdoms: animal, vegetable, and mineral. The animal and vegetable kingdoms are divided into large groups, called phyla, each phylum into smaller groups called classes, each class into orders, each order into families, each family into genera, each genus into species. Plants and animals, fossil or living, are usually referred to by the name of the genus and species; the generic name is capitalized, the specific name is not. Since each genus belongs in a family and each family in a class, the system indicates the degree of relationship between species.


Fig. 2

The examples in Table I give an idea of the relationship between several kinds of animals. From it we can see that man and the dog are more closely related than they are to the frog; they belong in the same class and the frog belongs in another (fig. 2). Similarly, the oyster and the scallop are closer to each other than they are to the frog, man, and the dog. All five of them are closer to each other than they are to the plants, which belong in another kingdom.

Table I. Examples of classification of species in the Linnean system.

Divisions	MAN	DOG	FROG	OYSTER	SCALLOP
Kingdom	Animalia	Animalia	Animalia	Animalia	Animalia
Phylum	Chordata	Chordata	Chordata	Mollusca	Mollusca
Class	Mammalia	Mammalia	Amphibia	Pelecypoda	Pelecypoda
Order	Primates	Carnivora	Salientia	Anisomyaria	Anisomyaria
Family	Hominidae	Canidae	Ranidae	Ostreidae	Pectinidae
Genus	Homo	Canis	Rana	Ostrea	Pecten
Species	sapiens	familiaris	pipiens	virginica	islandicus

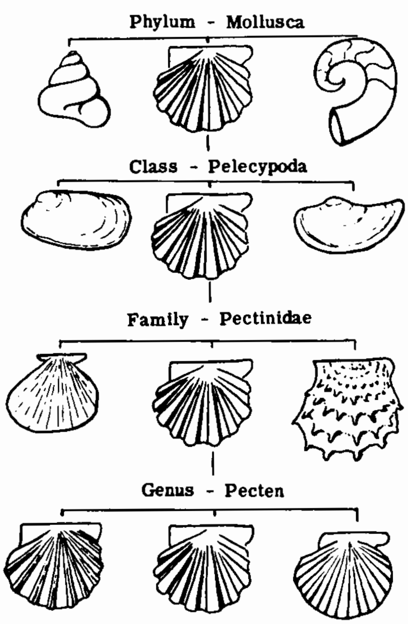


Fig. 3

The system has many advantages. For example, a doubtful specimen may obviously belong in the clams; it can be called a pelecypod until its exact name, i.e. the genus and species to which it belongs, is located. And it will be much more exact to say that the specimen is a pelecypod than to say it is just a fossil. Likewise, if the pelecypod looks like a scallop, it may be possible to say that it belongs in the family Pectinidae, a much more exact statement than just calling it a pelecypod. It may even be so much like a scallop that it can be referred to the same genus; it will be much more exact to say that it is a species of Pecten than to just call it a member of the family Pectinidae.

CLASSIFICATION AND IDENTIFICATION. Sooner or later, you will want to put a name on each one of your fossils. There are many ways of doing this: you can ask an expert to do it for you and that may be a good way at first. Later, you will want to do the job yourself - there is a certain amount of satisfaction in it. Some of the commoner forms can be identified from the pictures and descriptions in this book; the keys provide a systematic way of doing the work. In case you have never used a key before, the following instructions will start you off.

USE OF KEYS. You will soon be able to identify your specimens to phylum or class. Once you know you have a brachiopod, for instance, and know its approximate age, for example Silurian (see fig. 4, p. 8), use the "Key to the Commoner Silurian Brachiopods of Ohio" (p. 62) to find out the genus to which your specimen belongs. Start out with No. 1 and decide which one of the two choices fits your specimen. Go on to the number to the right of that choice and decide between the two new possibilities offered. Repeat the process until you come to a name instead of a number. The name should be that of your fossil. Look it up in the text and check with the description and figure to make sure you "keyed" it out correctly.

Don't be too surprised if your specimen does not "key out." It may belong to one of the scarcer forms and you may have to hunt it up in more advanced books. References to specialized books are given in each chapter. Finally, don't hesitate to bring your puzzling specimens to a specialist, but don't give up too easily. Most paleontologists are pretty good-natured about helping out and you may have found something really worthwhile that may interest him.

TECHNICAL TERMS. We started this book with the idea of using plain English as much as possible. That meant avoiding technical terms dear to the paleontologist's heart but puzzling to everybody else. So we used "tail shield" instead of "pygidium," "head shield" instead of "cephalon" for the trilobites. But we soon found out that we would have to use a minimum number of technical terms for which we could not find a simpler word. Technical terms are explained at the proper place in the text and the index at the end of the book lists them alphabetically. Learning these technical terms will be easier than it seems and it will help you when you go on from this book to more specialized ones. After all, no one learns to drive a car without absorbing a few technical terms in the process. Everybody knows what a steering wheel, choke, accelerator, and radiators are. So with fossils; they have special names for their parts too.

NAME CHANGES. Don't be surprised if you find a fossil called by one name in this book and by another name elsewhere. Name changes are the rule rather than the exception in paleontology. In several cases we have given the names used in older publications for the benefit of those who might consult them, but we have not listed them all by any means. You might well ask why paleontologists, people who study fossils, change their minds about names so often. There is a reason for it which can best be illustrated by an example.

In the early days, comparatively few species of straight cephalopods were known and they were all called Orthoceras (from the Greek ortho, straight and ceras, horn; because the shells are horn-shaped and straight.) Before long, the list of species grew to unmanageable size. Then it was found that these straight shells were very different from each other inside though they looked pretty much alike on the outside. So the genus Orthoceras was split up into a number of others, each genus recognizable by special characters and with fewer species in each. It is just as if we had lumped all South Americans together at first and then decided to separate the Chileans from the Brazilians, and the Colombians from the Venezuelans. There is an advantage to distinguishing these people according to the country they come from instead of lumping them all together.

In this book we have given the latest correct name known to us for each genus. The older names are given in parentheses after the one now in use.

CLEANING AND PREPARATION. Fossils brought in from the field may still have a lot of rock clinging to them and obscuring their detail. Much of this excess rock can be removed with hammer and chisel, large chisels for the coarser work, smaller and smaller ones for the finer detail. Mounted needles can be used for very fine detail. Much labor may be saved by using power tools, both grinding and chipping, for removing surplus rock from fossils.

If a fossil is broken in the field or during preparation it can be mended neatly with Duco household cement or a plastic cement of the same nature. Very fragile specimens may be backed with plaster of Paris or liquid plastic. If the surface of the fossil starts to crumble, it can be protected with a thin coat of dilute liquid celluloid. Clear nail polish is a handy form of this. Shellac or varnish should not be used for this purpose as they are hard to remove from fossils and they check or crack sooner than liquid celluloid.

If the fossil is preserved as a mold, you may want to make a cast of it, to see what the fossil looked like in life. If the mold has no undercuts, plaster of Paris may be used for this purpose. If it has undercuts (and most molds do) liquid rubber should be used for making the cast. Dental wax can also be used as it is much more flexible in relieving from a mold than plaster of Paris.

Using plaster of Paris is simple but you should not attempt it until you are thoroughly familiar with the steps involved. These cannot be described in detail here but a few words of caution may help. Plaster should be mixed where it won't matter too much if you make a mess; it can be a pretty messy business, especially on your first try. Plaster sticks to things, including fossils, so before you pour plaster on a good specimen, make sure that the specimen is well greased; ordinary motor or lubricating oil is good for this.

Mix the plaster in a bowl or cup and wash out the container immediately after use, before the plaster hardens in it. To mix plaster, fill the container about half full of water (leave room for the dry plaster) and then drop dry plaster into it slowly with a spoon; do not stir at this point. Let the water soak into the plaster until there is just a little "free" water on top of the mix. Let the mix stand for two minutes or so, then carefully pour off the excess water. Then stir the mix slowly so as not to get bubbles in your plaster. When the mix is like thick cream, pour it slowly into the mold. It is a good idea to pour in a little of the mix and move it about in the mold so that the plaster gets a good start before the rest of it is poured in. Next, pour in enough plaster to fill the mold and allow it to set. Wash out your container and spoon immediately.

Allow the plaster to set for at least one hour - overnight for a large cast - before attempting to remove the cast from the mold. Pry and tap the cast from the mold slowly and gently around the edges until the crack between the two widens. Strong-arm methods at this point will only result in a broken mold or cast - or both.

CATALOGUING. A fossil without a label has no scientific value; it is like a letter without an address. Good finds with potentially high scientific value are sometimes spoiled because they are unlabeled. To ensure that your collection will have some scientific use, you should carefully label each lot of fossils in the field. No matter how well you think you know your specimens and where they came from, you will soon forget most of this when other specimens are added to your collection. The field label should have the following information for each lot: a) locality, described exactly, with reference to a map and a landmark (town, river, lake, crossroads; or better, township, county, and state); b) formation if known (see Chapter 2, p.13 for explanation of this term; c) your name; d) the date of collecting.

When fossils have been cleaned they should be catalogued, even if they cannot be completely identified. A simple catalogue can be made from a bound notebook, so that the pages cannot be lost. The specimens should be numbered consecutively; this can be done with India ink. If the fossil is porous and the ink will not "take" on it, put a dab of clear nail polish on the side away from the specimen or on the poorer side of the specimen if it has no rock clinging to it; let the nail polish dry, then write the number on it with India ink. When the ink is dry, another dab of nail polish on top of the India ink will seal it in so that it cannot rub off.

Enter the numbers in your catalogue and for each one write down its name (if known) and the same information as on the field label (location, formation, collector, and date). Leave a few blank spaces after this for "Remarks" such as "specimen sent to..... for identification." If many specimens from a single locality are obviously identical, they may be given the same catalogue number; in that case, enter after "Remarks" the number of specimens in each lot.

The catalogue is a method of helping out your memory with details about your specimens. It also ensures that specimens will be connected with their exact data in case labels are mixed or specimens are jumbled together by accident.

BASIC REFERENCES. Remember that this book is only an introduction to the study of fossils. You will want to consult specialized books which are listed in the "References Cited" and referred to by author and year in the text.

Many publications on fossils have been issued by the Geological Survey of Ohio. They are referred to in the appropriate places in the text. Some of these publications have long been out of print, but others are still available, some free, others at a small charge. The Geological Survey issues a free list of publications (Watkins 1953) available on request, and a bibliography of Ohio Geology (Watkins 1953a). Their geologic map of Ohio (Bownocker, 1920) is indispensable Books that are out of print can usually be found in public libraries throughout the state. If they are not in your public library, they may be studied in college or university libraries; scarcely a single town in Ohio is more than 50 miles from a college library. Some of these books may be picked up from time to time in second-hand book stores.

For a general background in physical geology, you might like to read a good elementary text, such as Longwell and Flint (1955). You may also want a text on elementary historical geology, such as R. C. Moore (1949), C. O. Dunbar (1949), or R. C. Hussey (1944). Two texts that cover physical and historical geology in one book can be recommended; the "Yale Outlines" a condensation of Longwell and Flint, and Dunbar, or von Engeln and Caster (1952). The Boy Scouts of America Geology Merit Badge book (Cooper et al., 1953) is also useful.

A general text in paleontology, more detailed than this one and dealing especially with New York State, is Goldring (1929). You can choose one or more of the following elementary paleontology texts: Shrock and Twenhofel (1953) or Moore, Lalicker, and Fischer (1952), both rather expensive ($12.00) but very detailed. Perhaps at first all you will need will be Twenhofel and Shrock (1935) which is less expensive but out of date for certain groups of invertebrates. Shimer and Shrock (1944) is useful also but rather expensive.

For fossil plants, the best text is Arnold (1947); Andrews (1947) and Walton (1953) have good non-technical presentations. Janssen's (1939) "Leaves and Stems from Fossil Forests" is still available from the Illinois State Museum.

On vertebrates, the best text is Romer (1945) but Simpson (1953) "Life of the Past" is also valuable. Romer (1941) is a somewhat less technical text. Colbert (1955) has just published a new text on the evolution of the vertebrates which is excellent.

CHAPTER 2. THE STORY OF OHIO'S ROCKS

GENERAL. When we look at Ohio today and see all about us the achievements of man, the cities, the broad acres of farms and orchards, we take pride in the prosperity of our state and in the industry and ingenuity which made them possible. The historians tell us that Ohio was once densely covered with forest except for a few open areas and that the state was a happy hunting ground for a sparse population of Indians. But, before that, what was Ohio like? It is to geology that we must turn for an account of Ohio's distant past. For these events we cannot rely on written documents nor even on the remains of man, his weapons, and tools. We must turn to the record of the rocks, written in layers of mud and sand which consolidated into shale, limestone, and sandstone, and the fossils that they contain. They permit us to decipher, at least in their broader outlines, the events that preceded the coming of man in Ohio and to trace the history of the land from the very beginning of the earth to the present.

The Geologic Time Table

ERA	PERIOD	
CENOZOIC	PLEISTOCENE 1,000,000 years ago	Not found in Ohio
	TERTIARY 63 million years ago	
MESOZOIC	CRETACEOUS 135 million years ago	
	JURASSIC 181 million years ago	
	TRIASSIC 230 million years ago	
PALEOZOIC	PERMIAN 280 million years ago	
	PENNSYLVANIAN 310 million years ago	
	MISSISSIPPIAN 345 million years ago	
	DEVONIAN 405 million years ago	
	SILURIAN 425 million years ago	
	ORDOVICIAN 500 million years ago	
	CAMBRIAN 600 million years ago	
PRE-CAMBRIAN	Subdivisions not established.	

Fig. 4

The geologist cannot record events year by year, as the historian does, except in very special circumstances. Still, a number of kinds of evidence can be used to divide geologic time into broad segments and to fit events into a co-ordinated time-table which applies to the entire earth. The geologic time-table (see fig. 4) is divided into eras, periods, and epochs which can be dated approximately by methods which we shall examine in some detail. These methods are based on simple concepts.

The first and most important of these concepts is the "law of superposition." It states simply that older rocks are laid down before younger ones. Wherever layered rocks are exposed, for example in a river valley or in road cuts, we can be certain that the layers were laid down as mud or sand one on top of the other and that the rocks at the bottom are older than those at the top. This simple rule is one of the bases of all historical geology; the events that caused the rocks to be laid down can be arranged in their correct order only if we assume that the law of superposition is valid. The law is subject to a few exceptions. For example when rocks are intensely folded they may be overturned. But these exceptions do not apply in Ohio where the rocks are either flat-lying or only gently inclined.

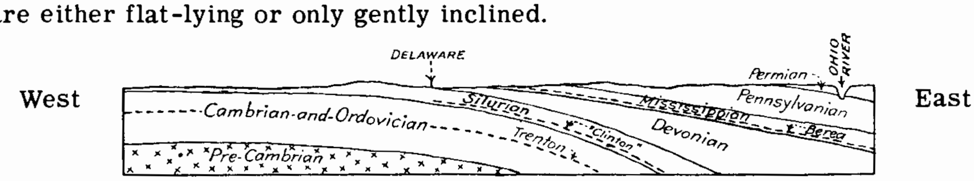


Fig. 5 Geological section across Ohio

With this in mind we could start in the Cincinnati region (see fig. 5) and see the nature of Ordovician limestones and shales. Traveling northward and eastward, we would notice, by the time we reached Dayton, Xenia, or Wilmington, that the rocks exposed in the quarries and streams were different. We would have crossed the boundary between the Ordovician and Silurian rocks which is usually termed the Ordovician-Silurian contact. Moreover, in good exposures, we could see that the Silurian rocks lie over the Ordovician ones. At New Holland, West Jefferson, and east of Tiffin, we would cross the Silurian-Devonian boundary and likewise see that the Devonian rocks lie over the Silurian ones. Similarly, we would go from Devonian to Mississippian, Pennsylvanian, and Permian rocks. In the northern and western parts of the state the rocks of the Paleozoic systems are covered by glacial deposits.

If we examine these rocks in detail, we find that many of them bear abundant fossils, which are not merely strangely shaped rocks but the remains of animals that once lived and died where we find them. Knowledge of the nature and significance of fossils gives us an idea of events that were taking place in Ohio as the rocks accumulated.

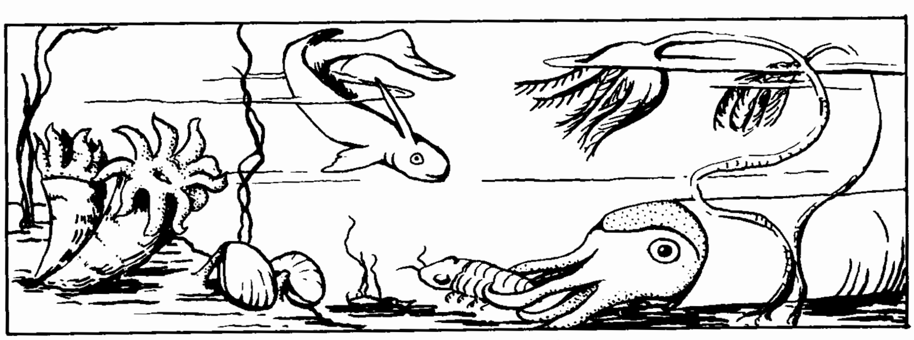


Fig. 6a Marine environment

We can recognize among the fossils of Ohio abundant remains of corals, sea shells, ferns, and tree trunks. Let us take a step further and see what these mean. First, it will soon be obvious that some rocks contain corals and sea shells but no fern leaves and tree trunks. Likewise, the rocks with ferns and tree trunks contain no corals or sea shells. The fossil collector will soon learn that if he wants ferns and tree trunks he must look in certain beds and that the corals and sea shells are abundant only in others. Also he will find that some of the rocks with corals and sea shells lie below those with ferns and tree trunks and others above them. (see figs. 6a and 6b).

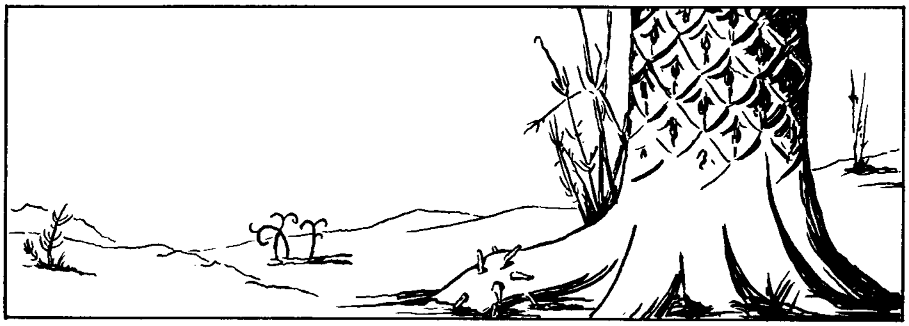


Fig. 6b Continental environment

Corals live nowadays in the sea and are not found in lakes and rivers. Ferns and trees obviously live on land or at most in swampy places. With these facts in mind, we are ready to take the next step which is to conclude that wherever we find corals and their associates in place, undisturbed in the rock, that spot was once covered by the sea. It is nothing short of staggering to realize what this means: the whole of Ohio was covered not only once, but several times by the sea and where now our broad highways run there once flourished great coral reefs teeming with marine life. Ohio was only part of a great inland sea that extended at times from the Gulf of Mexico to the Arctic. The expanse of water was broken only by scattered islands and by great land masses to the north in Canada and to the east in the region of the Appalachian Mountains.

In later times, as the fossils in younger rocks indicate, the sea withdrew from Ohio and the state was a vast swamp covered with abundant vegetation, some of which formed the coal beds which we find between layers of rocks carrying fern leaves and tree trunks.

Fossils can help us further in deciphering the events of the past. If we collect them carefully and note their position in the rocks we are soon struck by the fact that different layers of rock carry different kinds of fossils. Again using the law of superposition, we can see that the rocks record the changes in life through the ages. We can thus follow the changing pattern of life in the many different seas that covered Ohio in the past.

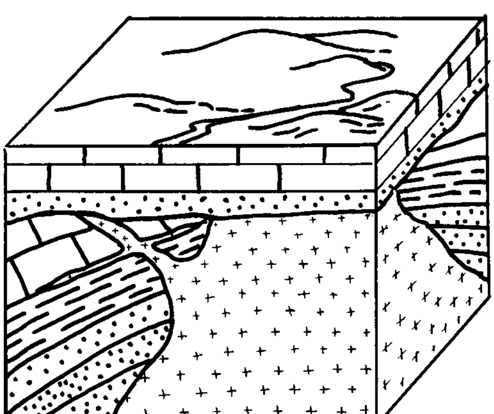
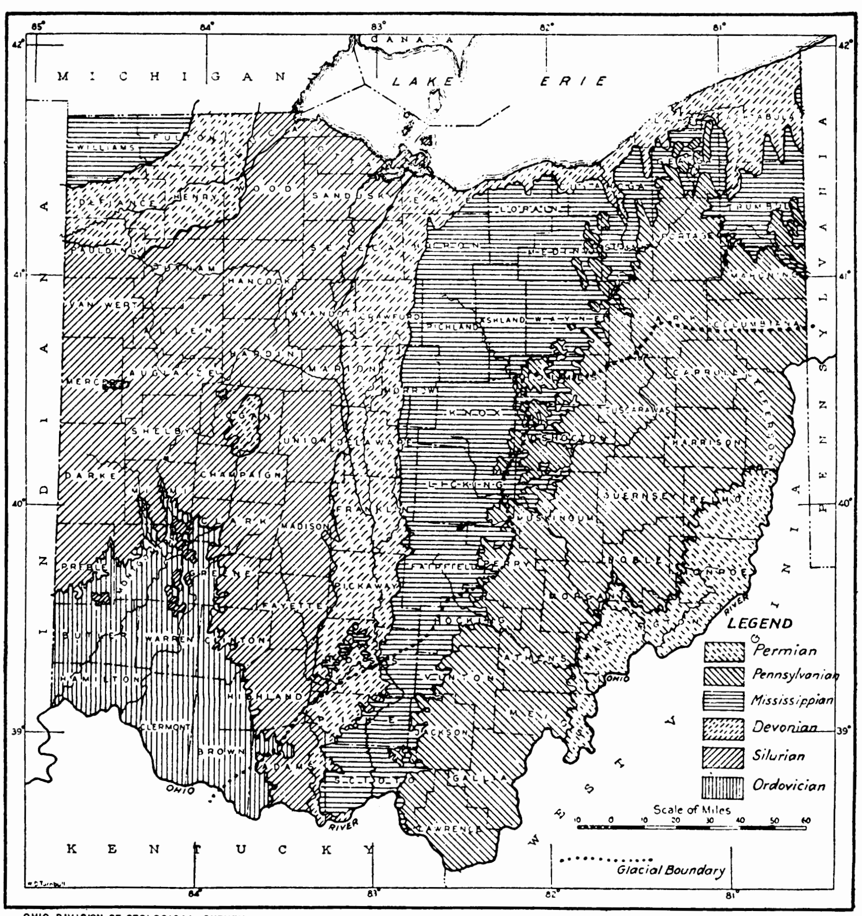


Fig. 7 Igneous intrusion cutting sedimentary rock layers

The rocks and their fossils can thus give us the order in which geologic events took place. For dates in years for these events, we must turn to other methods and other parts of the world. In many places on the earth the surface has been broken by great upwellings of molten rock from the depths below; the process in still going on in volcanic regions. As the molten rocks cool, either at the surface or in the channels through which they came to the surface, the minerals in them crystallize, separating from the molten mass according to their respective melting points and forming igneous rocks. It is obvious that wherever we find igneous rocks cutting through other rocks, the igneous rocks are younger than the rocks that they cut. If, for example, igneous rocks cut sedimentary rocks of Ordovician age, the material that formed the igneous rocks welled up through the sedimentary ones after the Ordovician rocks were formed (see fig. 7). Likewise, if these igneous rocks are overlain by Silurian rocks, we can say that they were intruded after the Ordovician rocks were laid down and before the Silurian ones were formed.

Some igneous rocks contain radioactive minerals and these are important because of their peculiar properties. They decay slowly but at a uniform rate into other materials. For example, uranium changes slowly into lead and helium. The rate of this transformation has been measured by the physicists and chemists and it was found to be unaffected by heat, pressure, or the presence of chemicals. In undisturbed rocks, where neither the original material nor the end products (except helium) have escaped, it is possible to calculate the original amount of uranium present and the amount of lead and helium it has produced through the ages. With these data, it is possible to calculate the amount of time required for the observed transformation. The ages in years given in the geologic time-table (fig. 4) are based on these calculations.

For more recent fossils, those found in the glacial deposits in Ohio, for example, another method can yield ages in years. Living animals and plants absorb carbon and excrete it. But the physicists have found that there are at least two kinds of carbon atoms, one, the "ordinary" kind, has an atomic weight of 12; the other, radioactive carbon, has an atomic weight of 14. The proportions of carbon 12 and carbon 14 in a living animal or plant remain constant as long as they are living. When they die, no more carbon is taken in and the carbon 14 gradually decreases in amount as it changes to carbon 12. The rate of change appears to be constant so that again, knowing the usual amount of carbon 14 in a living animal and its rate of change, it is possible to calculate how long it has been since the animal or plant died. This, in turn, gives us an age for the sediments in which the animal or plant is buried. The method is useful only for comparatively recent materials like those of the Pleistocene. With these facts in mind, we can reconstruct the history of Ohio from the earliest times to the present.



OHIO DIVISION OF GEOLOGICAL SURVEY

Fig. 8

FIGURE 9 - SYSTEMS EXPOSED IN OHIO COUNTIES*

COUNTY	ORD.	SIL.	DEV.	MISS.	PEN.	PER.	PLE.	COUNTY	ORD.	SIL.	DEV.	MISS.	PEN.	PER.	PLE.
Adams	X	X	X	X	O	O	G	Licking	O	O	O	X	X	O	G
Allen	O	X	O	O	O	O	G	Logan	O	X	X	O	O	O	G
Ashland	O	O	O	X	X	O	G	Lorain	O	O	X	X	O	O	G
Ashtabula	O	O	X	X	O	O	G	Lucas	O	X	X	O	O	O	G
Athens	O	O	O	O	X	X	N	Madison	O	X	X	O	O	O	G
Auglaize	O	X	O	O	O	O	G	Mahoning	O	O	O	X	X	O	G
Belmont	O	O	O	O	X	X	N	Marion	O	X	X	O	O	O	G
Brown	X	X	O	O	O	O	G	Medina	O	O	O	X	X	O	G
Butler	X	O	O	O	O	O	G	Meigs	O	O	O	O	X	X	N
Carroll	O	O	O	O	X	O	G	Mercer	O	X	O	O	O	O	G
Champaign	O	X	X	O	O	O	G	Miami	O	X	X	O	O	O	G
Clark	X	X	O	O	O	O	G	Monroe	O	O	O	O	X	X	N
Clermont	X	O	O	O	O	O	G	Montgomery	X	X	O	O	O	O	G
Clinton	X	X	O	O	O	O	G	Morgan	O	O	O	O	X	X	N
Columbiana	O	O	O	O	X	O	G	Morrow	O	O	X	X	O	O	G
Coshocton	O	O	O	X	X	O	G	Muskingum	O	O	O	X	X	O	G
Crawford	O	O	X	X	O	O	G	Noble	O	O	O	O	X	X	N
Cuyahoga	O	O	X	X	X	O	G	Ottawa	O	X	X	O	O	O	G
Darke	O	X	O	O	O	O	G	Paulding	O	X	X	O	O	O	G
Defiance	O	X	X	X	O	O	G	Perry	O	O	O	X	X	O	G
Delaware	O	X	X	X	O	O	G	Pickaway	O	X	X	X	O	O	G
Erie	O	X	X	X	O	O	G	Pike	O	X	X	X	X	O	G
Fairfield	O	O	O	X	X	O	G	Portage	O	O	O	X	X	O	G
Fayette	O	X	X	O	O	O	G	Preble	X	X	O	O	O	O	G
Franklin	O	X	X	X	O	O	G	Putnam	O	X	X	O	O	O	G
Fulton	O	O	X	X	O	O	G	Richland	O	O	O	X	X	O	G
Gallia	O	O	O	O	X	O	N	Ross	O	X	X	X	X	O	G
Geauga	O	O	X	X	X	O	G	Sandusky	O	X	X	O	O	O	G
Greene	X	X	O	O	O	O	G	Scioto	O	O	X	X	X	O	N
Guernsey	O	O	O	O	X	X	N	Seneca	O	X	X	O	O	O	G
Hamilton	X	O	O	O	O	O	G	Shelby	O	X	O	O	O	O	G
Hancock	O	X	O	O	O	O	G	Stark	O	O	O	X	X	O	G
Hardin	O	X	O	O	O	O	G	Summit	O	O	O	X	X	O	G
Harrison	O	O	O	O	X	X	N	Trumbull	O	O	X	X	X	O	G
Henry	O	X	X	O	O	O	G	Tuscarawas	O	O	O	O	X	O	G
Highland	X	X	X	X	O	O	G	Union	O	X	X	O	O	O	G
Hocking	O	O	O	X	X	O	G	Van Wert	O	X	O	O	O	O	G
Holmes	O	O	O	X	X	O	G	Vinton	O	O	O	X	X	O	N
Huron	O	O	X	X	O	O	G	Warren	X	X	O	O	O	O	G
Jackson	O	O	O	X	X	O	N	Washington	O	O	O	O	X	X	N
Jefferson	O	O	O	O	X	X	N	Wayne	O	O	O	X	X	O	G
Knox	O	O	O	X	X	O	G	Williams	O	O	X	X	O	O	G
Lake	O	O	X	X	X	O	G	Wood	O	X	X	O	O	O	G
Lawrence	O	O	O	X	X	O	N	Wyandot	O	X	X	O	O	O	G

*O = Indicates that rocks of this age do not crop out in the county.
X = Indicates exposures of rocks of this age.
G = Indicates that all or part of the county was covered by ice during Pleistocene time.
N = Counties not covered by ice during Pleistocene time. Quaternary deposits in these areas are mainly lake and stream deposits.

CLASSIFICATION OF OHIO ROCKS. Fossil collectors should have some idea of how rocks are classified and the significance of this classification with regard to fossils. Rocks have been subdivided according to their nature and relative age, into systems, series, groups, formations, members, and beds. A general classification of rocks is given in fig. 4. Examination of this table will show that only Paleozoic and Cenozoic rocks are found in Ohio and that the Cenozoic is represented only by Quaternary rocks, the very youngest of the Cenozoic rocks. The geologic map of Ohio (fig. 8) shows the distribution of rocks by systems in Ohio. A more detailed geologic map of Ohio on a larger scale can be obtained from the Ohio Division of Geological Survey.

To indicate the relative age of rocks and the fossils in them, the same terms are used as those for identifying the rocks themselves. For example, rocks of the Ordovician system are said to be of Ordovician age and they were laid down during the Ordovician period. If fossils come from a particular subdivision of the Ordovician system, their age is given with relation to the subdivision. For example, fossils from the Richmond group are of Richmond age, and fossils from the McMicken formation are of McMicken age. Figure 4 should be consulted for the relationships of time and rock units in Ohio.

A quick way of finding out the ages of all the rocks exposed in a particular county is to consult figure 9 which lists the counties of Ohio alphabetically and indicates the systems represented in each county.

PRE-CAMBRIAN TIME: THE BEGINNING

The earliest history of the state is shrouded in mystery. Rocks from the very dawn of the earth's history are present under all of Ohio but they are everywhere concealed by younger rocks. Judging from pre-Cambrian rocks elsewhere - in Canada, for instance - pre-Cambrian time was very long for its record starts nearly two billion years ago. During that time, sediments accumulated in the seas that invaded the continents many times; there were other times when the crust of the earth was rent by great gashes through which molten rock poured out, covering the land with sheets of lava. These dislocations of the crust were accompanied by compression of blocks of the earth's surface which were folded into huge wrinkles. In making its way to the surface, the molten material from the earth's interior flowed into and through the sediments, searing and baking them and altering their composition. These altered rocks are called "metamorphic," that is, rocks that have been changed.

What little we know of the pre-Cambrian history of Ohio is learned from the records of deep wells. Six such wells have been drilled through the sedimentary rocks into the pre-Cambrian (Stout and Lamey, 1940). Conditions in Ohio were probably much the same as elsewhere during pre-Cambrian time for wherever the driller's bit brings up rocks older than Cambrian, they are like the pre-Cambrian rocks exposed elsewhere at the surface, for example, in Canada or the Adirondacks.

A considerable amount of time must have elapsed between the laying down of the pre-Cambrian rocks of Ohio and the beginning of Cambrian time, for everywhere these rocks were planed to an almost even surface before the invasion of the Cambrian seas. Great folds, as large as some of the mountain chains of the present day, were worn down to relatively flat surfaces, not by some mysterious forces but by the slow, almost imperceptible action of running water carrying off and dissolving the rocks from the mountains and filling in the valleys and the bordering seas with sediments. When the Cambrian seas slowly spread over the land, they covered a low, slightly rolling plain and deposited their sediments upon it.

No evidence of pre-Cambrian life has been found in Ohio but elsewhere on this continent obscure traces of the first life on earth have been recovered. They consist of lime-depositing colonial algae similar to some still living in the seas, and obscure and doubtful remains of lower invertebrates.

CAMBRIAN TIME: THE AGE OF TRILOBITES.

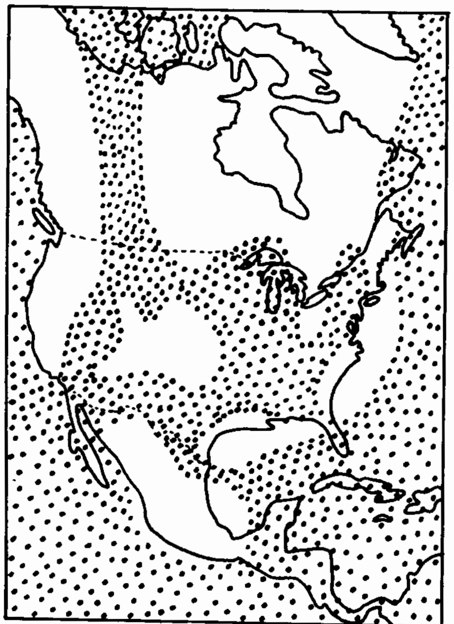


Fig. 10 Late Cambrian lands and seas

Some 500 million years ago, the area that is now Ohio was invaded by the Cambrian sea (fig. 10). We know little of the history of this marine invasion of the state for again, its sediments are buried under younger rocks. Only in a few deep borings have Cambrian rocks been penetrated.

At the base of the Cambrian in Ohio is a deposit of almost pure sandstone some 135 feet thick, overlain by about 600 feet of dolomitic sandstone and sandy dolomite.

Elsewhere in the world, Cambrian rocks have a record of abundant life and we can reasonably suppose that the Ohio area was also thickly populated with marine animals.

For much of Cambrian time Ohio was out of water. It was only towards the end of Cambrian time, when the seas reached their widest extent, that Ohio was covered by their waters. The sea drained from most of North America towards the end of the Cambrian period but in most places the retreat was a comparatively brief one, followed by a re-invasion.

ORDOVICIAN TIME: THE AGE OF BRYOZOAN REEFS.

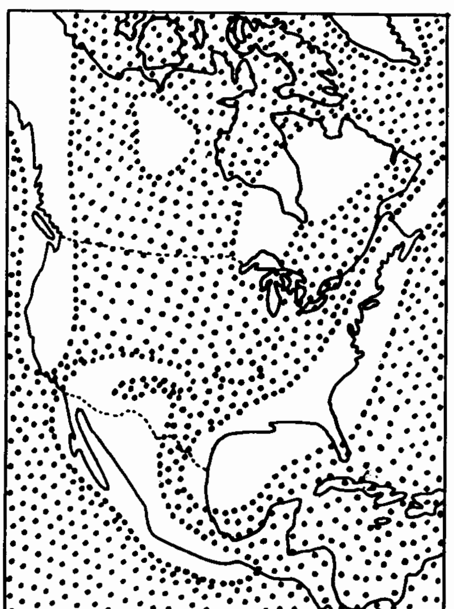


Fig. 11 Middle Ordovician lands and seas

If we could be privileged to travel back into time to the middle of the Ordovician, and either cruise over the inland seas of America (fig. 11) or examine them from the air, we would be struck by the differences between the appearance of Ohio in this far-distant time and its present aspect. We could find little to orient ourselves by, for the entire state was under the sea. The sites of our major cities would be under water and the familiar landmarks, such as the Ohio River and the Great Lakes would still be far in the future. Instead of the land area of the present day, we would see nothing but a mighty arm of the ocean, stretching from the present region of the Gulf of St. Lawrence far to the south and west, joined on the north by two other great inland seas reaching from Ontario, Minnesota, and North Dakota to the Arctic Ocean. The sea was fairly deep - about like those around the margins of the continents at the present time - over eastern Ohio. It became shallower in the western third of the state. At times during the Ordovician, the western third of the state emerged above the sea as low muddy islands but never as high, mountainous land.

The nature of the Ordovician rocks of Ohio gives us some idea of the kind of environment in which they were laid down (fig. 12). The majority of our Ordovician rocks are limestones and shales and these accumulate under very special conditions. Limestones are precipitated out of sea water far from shore or near low-lying lands, generally in mild or tropical climates.

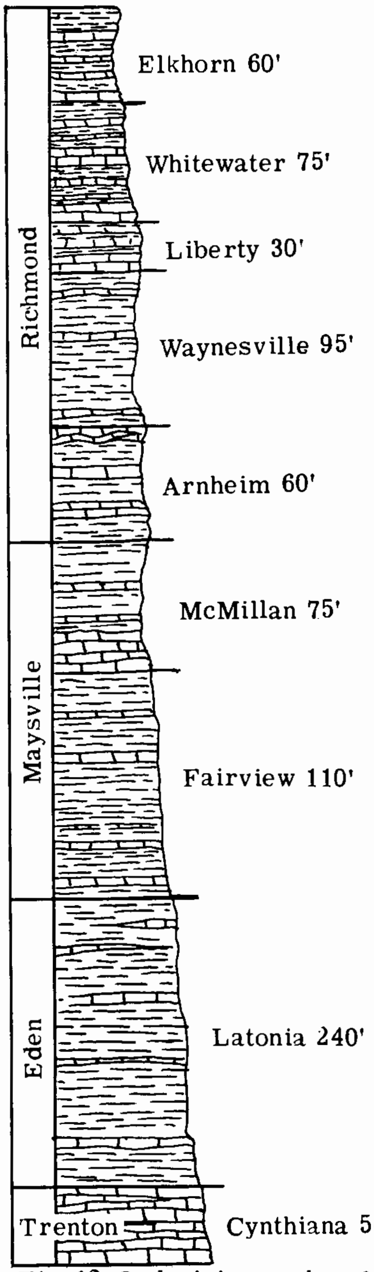


Fig. 12 Ordovician rocks of Ohio

Such accumulations of limestone are forming, for example, around the Bahama Islands at the present time and the climate of Ohio in Ordovician time may be compared to that of these islands. Shales are clastic rocks (i. e. rocks formed by the breaking up of other rocks) and they are extremely fine-grained. When rocks are disintegrated by weathering, the resulting particles are transported by streams to the sea, then by currents in the sea, until the currents can no longer carry them. When that happens, the particles settle down to the bottom and form sediments later consolidated into rock. Swift streams can carry particles of all sizes, even large boulders. As their energy decreases, the streams can no longer carry the larger particles, i. e. the boulders and pebbles, so these are dropped and form gravels which are consolidated into conglomerate. Next to be dropped are the sand-size particles which eventually form sandstones. Last to be dropped are the finest particles, which form muds and eventually harden into shales.

Some parts of the rock are dissolved in the water, for example, calcium carbonate or lime. Materials in solution are carried much farther than undissolved particles; therefore, limy muds are deposited much farther out at sea than shales. As we look at a section of Ordovician rocks in Ohio, we see limestones alternating with shales. In some places they are of great thickness, in others very thin beds of the two kinds of rock, alternating in thick sequences.

From these deposits, we can surmise that during lime deposition the sea was clear and only minute flakes of lime were settling to the bottom, far away from shore. During shale deposition, either the shore was closer to the area of the section or else the land was fairly high, so that muds and clays were being washed into the sea. When we encounter a bed of sandstone in a section (sandstone is rare in the Ordovician of Ohio) we must conclude that sand was being deposited near shore and that the water above it was muddy, but that currents could still carry away the mud to deposit it elsewhere.

Under the waters of the Ordovician sea marine life teemed in abundance that can scarcely be matched in the world today (fig. 13). Some of these marine creatures would look familar; there were seaweeds, clams, and snails and lobster-like animals in great numbers, built on patterns very similar to those of present-day seas. But there were also some strange animals - strange because they have long been extinct - and the marine biologist would miss some of the more familiar creatures of the present-day seas.

Among the more peculiar forms of life in the Ordovician seas were the graptolites (see Chapter 3) and large relatives of the squids and devilfish, the nautiloid cephalopods, which were abundant in the Ordovician seas. Most of the nautiloids had straight shells. Among the largest of the straight nautiloids in Ohio was one form which attained a length of 3 feet but even it was dwarfed by a giant of the same group, found in the Ordovician rocks of Montreal, Canada which reached a length of 15 feet and a diameter of one foot.

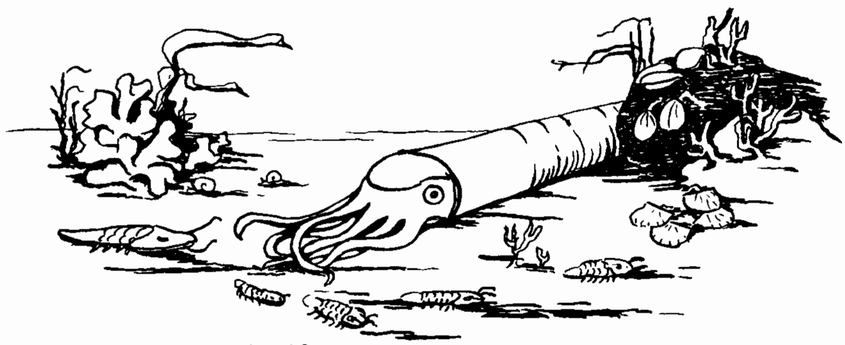


Fig. 13 Ordovician sea bottom

The trilobites (see fig. 14 for a typical trilobite) of the Ordovician would naturally attract attention. Most of them were small, 2 to 3 inches long, but they are abundant in some of the Ordovician beds around Cincinnati. The largest of the Ordovician trilobites (genus Isotelus) attained a length of 18 inches.

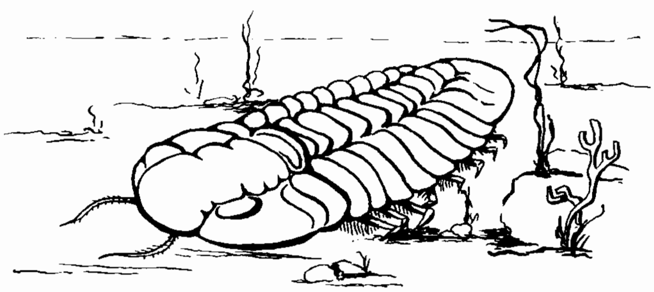


Fig. 14 An Ordovician trilobite
Calymene meeki

The majority of Ordovician trilobites have little ornamentation; not so for some of the rarer forms which have abundant spines and tubercles.

The most abundant forms of Ordovician life might at first be mistaken for clams; they are brachiopods, whose bivalve shells are very abundant in some Ohio beds. For the difference between brachiopods and clams (pelecypods), see p. 36. Unlike the puny Cambrian brachiopods, some of the Ordovician ones attained fair size, as much as 2 inches across, and had sturdy, thick, limy shells. They vary greatly in shape and ornamentation from the nearly flat strophomenoids (see p. 50) to the ribbed Platystrophias (see p. 49) and the tiny, highly ornamented Rhynchotremas. The brachiopods of the Ordovician are not equalled in variety and abundance in any other rock unit in Ohio.

The bryozoans first became abundant during the Ordovician. At times, the bottom of the Ordovician sea in Ohio was covered with these microscopic animals in huge colonies occupying every available surface.

Corals were abundant at times in the Ordovician but they did not form the massive reefs characteristic of their present-day relatives. Most of them were solitary and formed a horn-like cup - hence the name horn-corals - in which a single animal lived. There were only a few colonial corals.

The echinoderms (starfish and their relatives) were well represented in the Ordovician seas. Complete specimens are rare because the dead animals were often washed to and fro on the bottom of the sea and their fragments accumulated in groups in low spots.

The vast hordes of larger marine animals of the Ordovician must have fed, as their living relatives do, on microscopic plants and animals of all kinds. Microscopic animals must have been extremely abundant in Ordovician seas but owing to their lack of hard parts, they are not often preserved.

Some of the animals and plants of the Ordovician have been preserved for us in another way: their soft parts produced oil which has accumulated in the rocks and has been trapped there. The Ordovician rocks of northwestern Ohio have produced large quantities of oil. Maximum output was in 1896 when a total of 20,757,138 barrels was produced. Production is much less at present. All this oil - and oil from other rocks as well - is derived from the bodies of animals and plants, by complex changes through long periods of time in the depths of the earth.

As Ordovician time came to a close, the waters of the sea retreated from Ohio but they soon returned to cover the state again in Silurian time.

SILURIAN TIME: THE RISE OF THE CORALS

In the early part of the Silurian period Ohio was dry land. The advance of the Silurian seas, both from the south and the north, was slow, and in the western part of the state low islands existed from time to time (see fig. 15). In Middle Silurian time, however, the

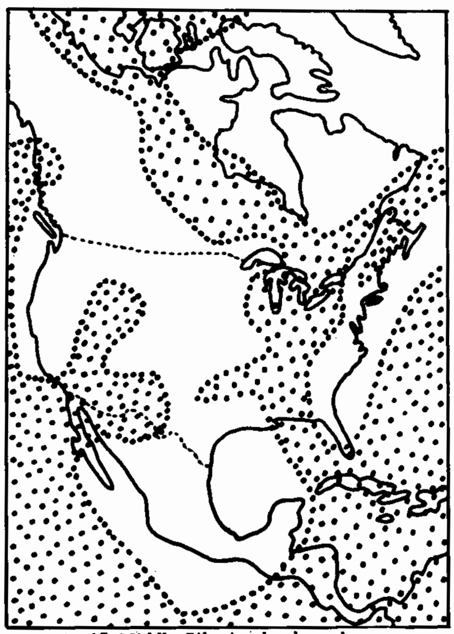


Fig. 15 Middle Silurian lands and seas

seas reached Ohio and soon covered most of it. They were sometimes muddy, sometimes clear, resulting in the accumulation of shales, limestones, and dolomites in our Middle Silurian section (fig. 16).

Ohio generally ranks second among the states in the production of limestone and dolomite. The Brassfield formation supplies some of the high calcium limestone. Most of the dolomite quarried in Ohio is of Niagaran age. Some of the stone is used in its natural condition, some is heated in great kilns to convert it into lime. Thus we have both high calcium lime, from limestone, and magnesian lime, from dolomite. Ohio is the nation's greatest lime producer. The many quarries of the western half of the state produce rock for building stone, roads, railroad ballast, concrete aggregate, blast furnace flux, agricultural lime, Portland cement, bonding materials for silica brick, ceramic bodies and glazes, dolomite refractories, water softening, sugar refining, and a dozen other uses.

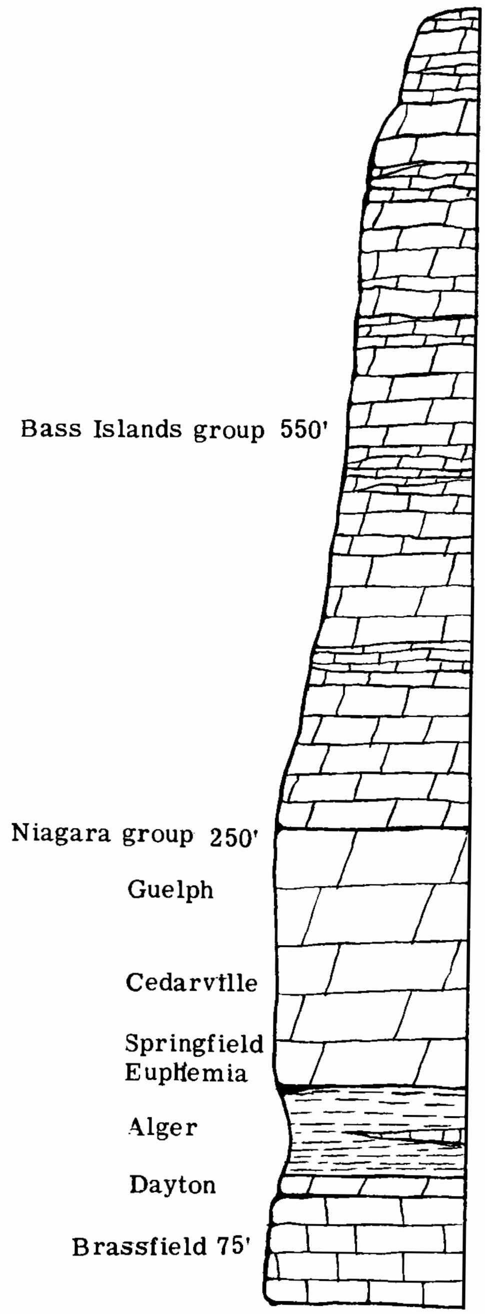


Fig. 16 Silurian rocks of Ohio

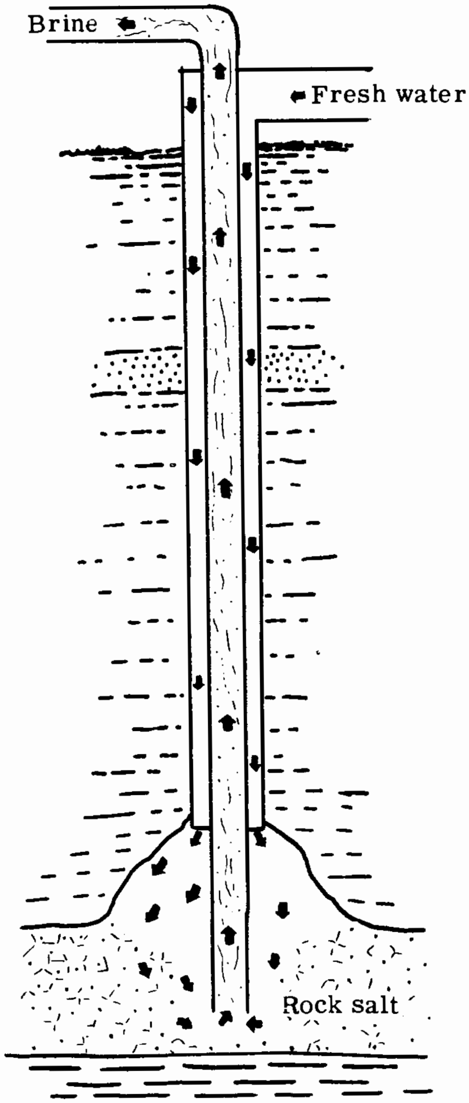


Fig. 17 Diagram of a salt well

Late in Silurian time, the sea in the northern part of the state was of a peculiar character, shallow and sometimes cut off from the main body of the sea. Great accumulations of salt were deposited as the sea water evaporated. They were preserved when muds covered them over. The beds of rock salt underlie an area of 9,000 square miles in northeastern Ohio. They vary in thickness from 2 feet to nearly 50 feet and they are separated from each other by beds of dolomite and shale. The uppermost salt bed in the Cleveland region is under about 1,300 feet of younger rocks; to the south and east it may be as far down as 4,767 feet. Salt is extracted from these beds by pumping fresh water into wells, where it dissolves the salt, and pumping out the brines which are then evaporated or used directly by Ohio's great chemical industry (fig. 17). The salt industry in Ohio goes back to 1889. For a more complete account and references, see J. F. Pepper (1947). Salt is combined with the Silurian limestones and dolomites to manufacture soda ash, caustic soda, chlorine, and many other products.

The salt basins were cut off from the main body of the sea as it slowly withdrew from the continent in late Silurian time. There was complete withdrawal of the sea from Ohio between latest Silurian and earliest Devonian times.

The marine animals which lived in the Silurian sea were very much like those of the Ordovician. Many genera and some species persisted from Ordovician to Silurian time and were accompanied by others which had recently evolved. Some of the latter are characteristic of Silurian rocks and are described later (Chapter 5).

The most striking feature of the Silurian seas was the abundance of coral reefs. Coral reefs had existed in Ordovician time, but they did not become widespread until the Silurian. Our reefs are the southern extension of a great reef that bordered the Michigan Basin and extended from western Ontario into Michigan, Wisconsin, Illinois, Indiana, and Ohio. A variety of animals and some lime-secreting algae helped build up the reefs. The great accumulation of animals with soft tissues probably was the source of the oil which is now found stored in the porous structure of the reefs. No Silurian reef production is yet on record for Ohio, but the Clinton sand of this age is the great gas-bearing stratum of the state. Reef production is still a possibility where the Silurian rocks are buried deep under the surface.

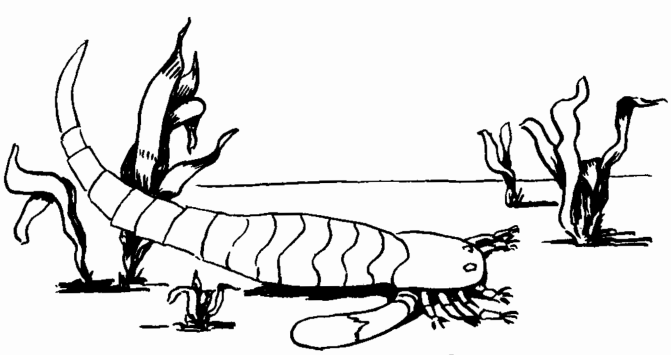


Fig. 18 Eurypterid

The Silurian seas swarmed with nautiloid cephalopods (see fig. 13 for typical nautiloids), both straight and coiled, some of large size, others highly ornamented. Along the margins of the late Silurian seas, perhaps in brackish-water pools and lagoons, the eurypterids (fig. 18) abounded; they are scorpion-like in appearance, except for the tail, which does not bear a sting. They may be ancestral to the scorpions.

Primitive plants were beginning to invade the land surfaces of the globe during late Silurian time. None of them was large and they were probably localized in certain areas of the globe. Their remains have been found in Australia and Scotland. The land was almost uninhabited by animals also for the only record of a Silurian land animal is of a rare scorpion of which there are only four known specimens from the Upper Silurian of Scotland.

DEVONIAN TIME: THE RISE OF THE FISHES.

Ohio was land during early Devonian time. No rocks of this age have been preserved here. The Middle Devonian seas covered most of the state except the low islands in its western third (fig. 19). The seas brought with them marine animals from the south, north, and northwest. During this time the seas were shallow and clear, bordered by low lands from which little sediment was being washed, and apparently they were warm, if not subtropical, judging by the abundance of corals in them. Coral reefs flourished over parts of the state and they are now preserved in our Devonian rocks.

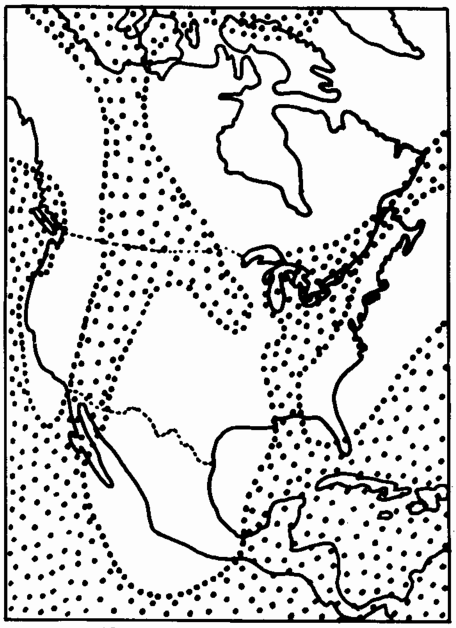


Fig. 19 Middle Devonian lands and seas

As might be expected, the sediments deposited in these seas are limestones and shales (Figs. 20a and 20b). The topmost ones are thick beds of black shale with a high carbon content in which fossils are few and of a peculiar character; they are floating and swimming forms but there are almost no bottom dwellers.

The Devonian limestones of Ohio are particularly pure and some of them, for example the Columbus limestone, are thick-bedded and suitable for building stone. In the early days of settlement in the state, the limestones were used as building stone; the state Capitol in Columbus is built of Devonian Columbus limestone and so are many of the fine early stone houses of central Ohio. The limestones are used for lime in great quantities, and also for crushed stone and agricultural lime wherever they can be quarried profitably.

The Middle Devonian seas of Ohio swarmed with innumerable animals whose fossils can be gathered literally by the bushel from some parts of the Columbus and Delaware limestones and the Silica formation (fig. 21). Their most remarkable feature, as compared with Silurian fossils, is the presence of great numbers of fish fragments in the "bone beds" (see p. 74) of the Columbus and Delaware limestones. Some of these fishes reached great size, for example the placoderm Dinichthys with a length of 25 feet; others were of more familiar aspect, for example the shark Cladoselache found in our Upper Devonian black shales. During the Devonian the fishes had invaded the seas successfully and many different groups evolved during that time. Notable among these were the lungfish and their relatives which gave rise, during Devonian time, to the Amphibians.

The invertebrates were even more numerous than the fishes in the Devonian seas of Ohio. Even the tiny Foraminifera were represented and they may have been much more numerous than has been so far suspected (see Stewart and Lampe, 1947). Sponges are not conspicuous in the Devonian of Ohio but spectacular finds of glass sponges have been made locally. The corals were among the most abundant of the inhabitants of the Devonian sea. Worms were undoubtedly present in much greater numbers than the record indicates; only a few kinds, which had a limy tube, have been preserved. These tubes are either coiled or straight and are found attached to brachiopods and other shells.

Bryozoans were common around coral reefs and elsewhere in the Devonian seas. Some of them built wavy, fan-like colonies which have the appearance of lace. The brachiopods were very abundant during the Devonian and some of the forms are easily recognizable, for example the Spirifers, Strophomenas, Atrypas, and Leptaenas. During the Devonian, there was a sprinkling of spiny brachiopods, the productids, which became much more important in the next period, the Mississippian.

Pelecypods were not common in the Devonian seas, except locally. Round clams, the long clam, and scallop-like forms are among the commonest. The snails are conspicuous in the Devonian fauna: large, top-shaped forms, long, thin-spired forms, and the curious, partly uncoiled, sometimes spiny snails called *Platyceras*. Cephalopods are locally common in our Devonian; there are both straight and coiled nautiloids, some of the latter strikingly ornamented with successvie frills around the shell, and a few coiled ammonoids.

The trilobites of the Devonian include some very large forms such as *Coronura* whose tails are fairly common in parts of the Columbus limestone. Smaller forms such as *Phacops* with compound eyes and *Proetus* with neatly margined head and tail are locally common as well as some species with cheek spines. At times, ostracodes swarmed in the Devonian seas and many genera and species have been described.

The crinoids must have been very abundant in parts of the Devonian seas, judging by the huge accumulations of their stems which are found in parts of the Columbus limestone. Several genera and species of crinoids have been found in the Devonian of Ohio. The curious, nut-like blastoids were sometimes abundant

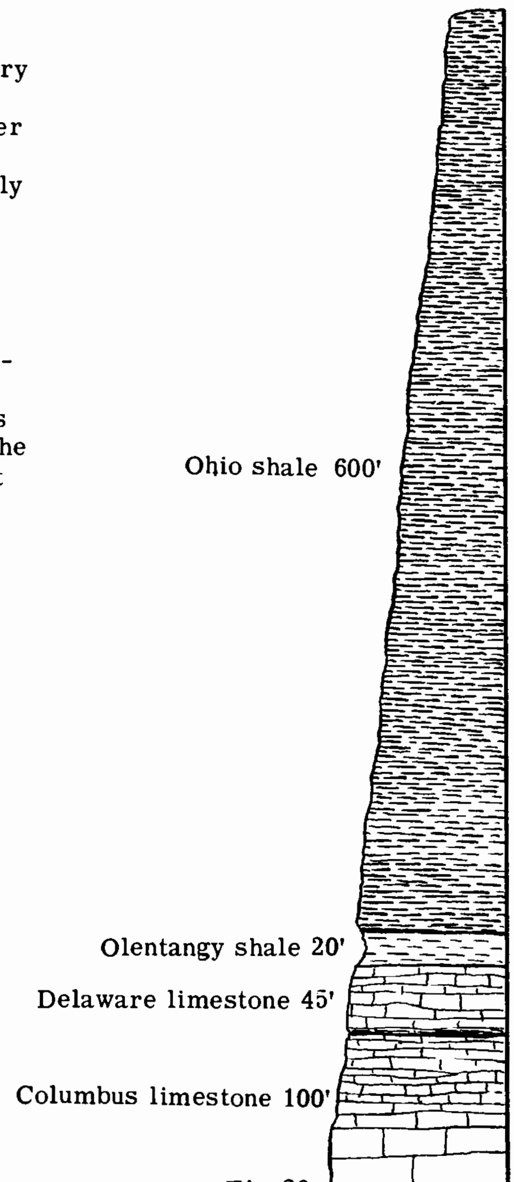


Fig. 20a
Devonian rocks of central Ohio

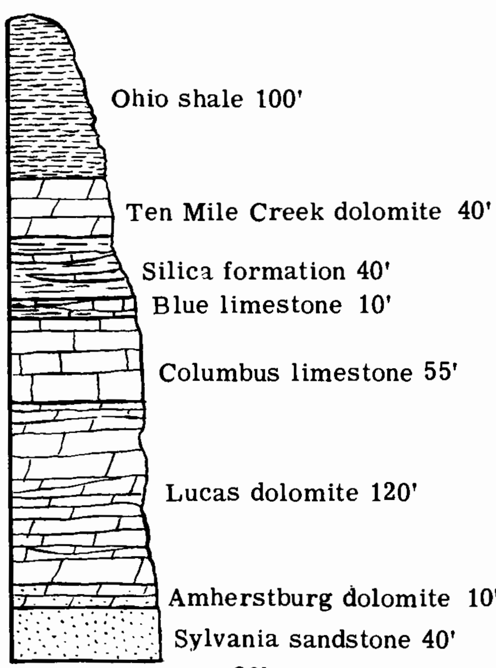


Fig. 20b
Devonian rocks of northwestern Ohio

in our Devonian seas but their environmental requirements were such that we find them in numbers or not at all. Devonian starfish and sea-urchins are known but were evidently scarce in Ohio.

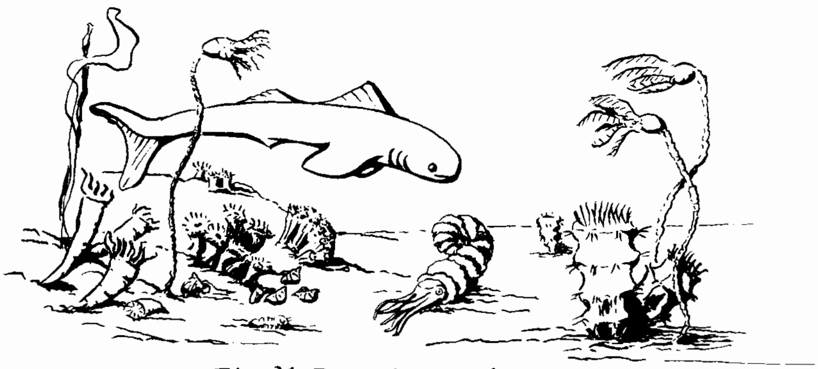


Fig. 21 Devonian sea bottom

The Devonian lands were beginning to look less desolate than those of the Silurian. There were abundant algae in fresh water and sometimes their spore-cases were blown out to sea and preserved. True land plants were beginning to appear, as witness tree-trunks as much as 5 feet in diameter, floated out to sea and preserved in our black shales, and fern-like plants preserved in the same way.

Of Devonian land animals, we have a sure record only for amphibians, of which actual skeletons have been found in Greenland. The scorpions of Silurian time undoubtedly had Devonian descendants but no trace of them has been found nor, for that matter, of any Devonian land invertebrates.

MISSISSIPPIAN TIME: THE GREAT SANDY DELTAS

At the beginning of the Mississippian period black shales continued to accumulate in northern Ohio (fig. 22). Gradually, the black muds gave way to silts and fine sands which sometimes became coarser and graded into gravels which have consolidated into conglomerates. In central and southern Ohio, sand and silt were accumulating instead of black shales. This was followed by a period of clear seas during which limestones were deposited. Rocks deposited in the latter half of Mississippian time are not found in Ohio and therefore we can only suppose that the state was dry land in late Mississippian time.

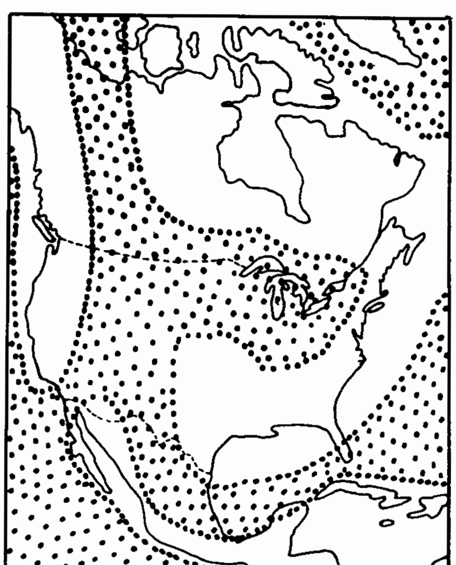


Fig. 22 Mississippian lands and seas

The Mississippian rocks of Ohio (fig. 23) have yielded a variety of economic products. Oil and gas, derived from fossil animals and plants, are found in several Mississippian beds. Shales of the same age are used in the manufacture of pottery and other ceramic products. Some Ohio Mississippian limestones have a high calcium content and are used in the manufacture of lime. Mississippian sandstones were early used for building in Ohio and are still extensively quarried for that purpose. The Berea and Black Hand sandstones are used for foundry, filter, ferrosilicon, and silicon and for silica refractories. They are washed clean of impurities for glass and potter's flint.

The animal population of the seas remained as high in Mississippian as in Devonian time. This is not always evident in the Mississippian rocks of Ohio for some of the sandy beds of our section yield few fossils. Glimpses of the abundant life of the sea in this time are given us in the limy and shaly parts of our section in which brachiopods and pelecypods are especially abundant. Many Devonian forms persisted into the Mississippian and were joined in time by newly-evolved forms.

Ohio's Mississippian seas were not as clear as those of the Devonian so coral reefs and even individual corals were not as common; their place was taken by mud-loving brachiopods, pelecypods, and gastropods with a sprinkling of bryozoans.

The characteristic brachiopods of the Mississippian and of the succeeding Pennsylvanian and Permian are the productids (see figs. 242, 246, 247) whose shells bore spines which are sometimes preserved but ordinarily only the broken spine bases can be seen on the shell.

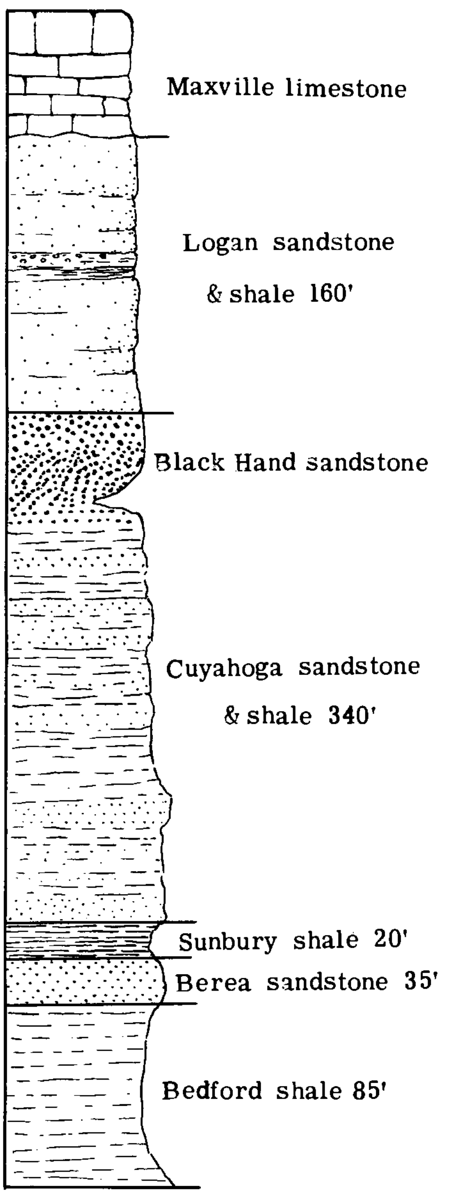


Fig. 23 Mississippian rocks of Ohio

Some of the pelecypods of the Mississippian have a surprisingly "modern" look. Scallops (see fig. 254) are abundant in some beds. They are only distantly related to the living forms. Small, nut-shaped clams (genus Nucula) are so much like the living species that they are placed in the same genus.

Cephalopods are rather scarce in our Mississippian rocks; the few that have been found are about evenly divided between ammonoids and nautiloids. The trilobites are much rarer in Mississippian than in Devonian beds but some of them are highly ornamented with knobs and spines (see fig. 271).

Some of the most interesting of our Mississippian fossils are the tiny conodonts which are thought to be the teeth of fish-like, primitive animals. They are quite abundant in some of our Mississippian black shales and are very useful to the geologist as index fossils. They are seldom collected by anyone but professionals because of their microscopic size; searching for them is well worth while, both because of their variety of form and their scientific value.

Fishes of many different kinds were abundant in the Mississippian seas. More than 400 species of ancient sharks have been described, some of them very large. Dinichthys and Cladoselache survived from the Devonian and their remains are abundant in some Mississippian formations. Another group of fishes, the ganoids, with shiny plate-like scales, was also abundant in Mississippian seas; they are related to the living garpike.

On land, amphibians existed and perhaps reptiles also. No fossil remains of these two groups have been found in Ohio; Mississippian amphibians have been found in Europe and their tracks and footprints in North America.

The record of land plants becomes increasingly abundant in the Mississippian. Even the most barren beds of siltstone and sandstone bear fragments of land plants and in some beds tree trunks and logs are well preserved. Both seed ferns and true ferns have been found. In Ohio the evidence of their existence consists mainly of spores, which are abundant in some beds, and of fragments of fronds and stems. The much greater quantities of plant material indicate that in Mississippian time the earth was extensively clothed with vegetation. Coal beds of this age in Virginia foreshadow the widespread coal swamps of the Pennsylvanian.

Upper Mississippian rocks are not present in Ohio. Rocks of this age in other parts of the country, for example in western Kentucky, record the change in animals which took place during this time. The sea may have covered parts of Ohio late in Mississippian time but if so, the sediments which it laid down were washed away before the beginning of Pennsylvanian time. The surface of the land was carved extensively during this time as shown by the earliest Pennsylvanian deposits which filled hollows in the Mississippian surface.

PENNSYLVANIAN TIME: THE COAL FORESTS.

So far, the rocks have provided us with abundant evidence of the nature of the seas and the life that inhabited them. It gave us only occasional glimpses of land life. The Pennsylvanian record is almost equally divided between the land and the sea (fig. 24). This unique situation is due to the peculiar state of the surface of parts of North America during this time. It was low and almost flat, especially east of the Mississippi and lay very near to sea level. The relative level of the sea and land changed often during Pennsylvanian time so that short invasions of the sea, alternating with deposition of non-marine sediments, occurred many times during the period. When the lowlands were not under the sea, they were covered by dense swamp forests which supplied the materials for coal beds.

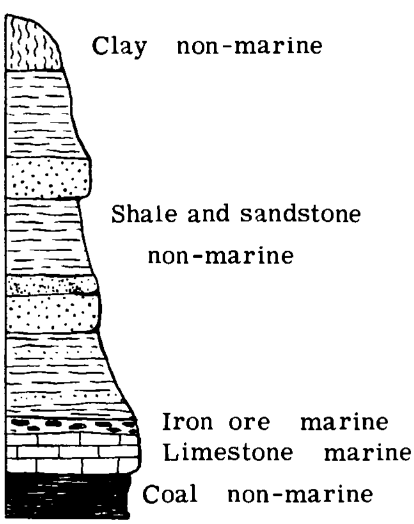


Fig. 24 Diagram of a typical "Cyclothem" or group of rocks recording one cycle of submergence and emergence.

The most remarkable feature of Pennsylvanian rocks, in Ohio and elsewhere, is the presence of coal beds, some of them very thick. This valuable fuel owes its origin to the accumulation of plants under swampy conditions. Time after time, between invasions of the sea, parts of Ohio looked like the great Coastal Plain swamps of today: low-lying marshy areas, densely covered with trees and other plants, growing right to the edge of the sea. Great thicknesses of plant debris accumulated in these vast swamps. Gradually, sea level rose. Salt water crept into the swamps, killing the trees. The swamps were buried under sand and mud whose weight compressed the plant debris which underwent slow chemical changes and became coal. Coal may not look much like plant material but under the microscope its true nature is apparent; the plant fibers and sometimes their cell structure are clearly revealed.

The beginning of coal mining in Ohio goes back to 1803. Coal-bearing rocks in 30 counties of Ohio cover 12,340 square miles and the total value of coal mined in the state in 1952 was $132,000,000.

The seas that invaded Ohio in Pennsylvanian time came from the west and south. Their pattern changed many times during the period and the coal swamps were either retreating before the sea or advancing to occupy its shores. The rocks laid down in Ohio are therefore marine and non-marine, chiefly shales and sandstones with layers of clay and coal, and thin but comparatively persistent limestones and iron ores.

Sand from the Pennsylvanian beds is used for silica refractories, foundry, filter, ferrosilicon, and silicon. They are washed clean of impurities for glass sand and potter's flint. Several Pennsylvanian sandstones produce oil. These are the so-called "shallow sands" of eastern Ohio.

For many years Ohio has been the leading producer of clay and clay products. This is largely because of the abundance of fire clays and clay shales of Pennsylvanian age. These are used for the manufacture of brick, tile, sewer pipe, fireproofing, and refractories such as glass pots and furnace brick.

Pennsylvanian limestones are thin, but because of their location can compete with the Silurian limestones of western Ohio for use in the manufacture of Portland cement, and for roads and agricultural lime.

The Pennsylvanian seas swarmed with animals whenever living conditions were favorable. Many kinds of sea animals survived from the Mississippian and many others first appeared in Pennsylvanian time.

Among the most interesting of Pennsylvanian fossils are the fusulines, a family of Foraminifera exceedingly abundant in some limestones. They are small, the largest about a quarter of an inch long, and shaped like rice grains (see fig. 285). The fusulines are rare in the late Mississippian, abundant in the Pennsylvanian and Permian. They died out in late Permian time.

Pennsylvanian corals are about as rare as Mississippian ones and some of them have peculiar characteristics. For example, one of the horn corals (Lophophyllidium, fig. 286) has a raised central axis. A few colonial corals also occur in the Pennsylvanian.

Crinoids in great variety have been described from Pennsylvanian rocks but complete specimens are rare in Ohio. The same may be said of starfishes and sea urchins. Scattered plates and segments of crinoid stems and the spines of sea urchins, however, are abundant in the limestone layers.

As in the Mississippian, the most striking brachiopods are the productids which developed heavily-spined, large forms in the Pennsylvanian but there are also spectacular spiriferids, large flat forms (Derbyia, fig. 250), and a host of small fat brachiopods.

Fig. 25 Stegocephalian

Among the pelecypods, scallop-like forms were abundant in Pennsylvanian seas. They were accompanied by ancestors of the pearl-oyster (Myalina, fig. 312), and many other less spectacular kinds.

The gastropods were exceedingly varied and included long-spired forms as well as the curious bellerophontids (see fig. 334) and several kinds of limpets.

Both nautiloid and ammonoid cephalopods are present in Pennsylvanian strata. The ammonoids expanded rapidly during Pennsylvanian time, foreshadowing their culmination in the Mesozoic.

On the other hand, Pennsylvanian trilobites are rare. Ohio's Upper Pennsylvanian rocks are non-marine; therefore we cannot expect to find trilobites in them. In other parts of the world, fewer and fewer trilobites survived as Pennsylvanian time progressed, an indication of their eventual extinction in Permian time.

No great changes are to be noted in the fishes of Pennsylvanian time. They were not abundant in the seas but swarmed in fresh water, where they were represented by sharks, ganoids, and other bony fishes.

Amphibians were abundant in the Pennsylvania swamps (Fig. 25). Some of them reached large size - ten feet or more - but they were unlike the living amphibians for they had a bony covering over the skull which gave them their name, stegocephalians (meaning roof-skulled).

The first true reptiles have been found in Pennsylvanian rocks but they were puny beside the giant amphibians for they were only one or two feet long and lizard-like in appearance.

Where the water of the coal swamps was reasonably fresh or even brackish, it was populated by a characteristic group of freshwater clams with thin shells (Naiadites, fig. 313, and other genera) which are found in great numbers in some Pennsylvanian shales. More often than not, they are accompanied by clam-like arthropods (Leaia and Estheria) and ostracodes by the thousand. A few kinds of freshwater snails have also been found in the Pennsylvanian.

Tree stumps are sometimes found in Pennsylvanian rocks. They look so much like tree stumps of the present day that some geologists had the idea that they might have served then, as they do now, as hiding places for small animals. The suspicion proved correct and these ancient tree stumps, when broken apart, sometimes reveal skeletons of ancient lizards and amphibians, fossil land snails, spiders, and millipedes which had died within their shelter (fig. 26).

Long before the end of Pennsylvanian time the sea had withdrawn from Ohio. The seas advanced and retreated unevenly over the state; in general each advance was a little less than the preceding one, and the land was slowly lifted up higher and higher. The climate became drier and coal-swamps occupied smaller and smaller areas. They continued into the Permian but after a time they disappeared entirely and their place was taken by forests of hardier plants able to endure a more rugged climate.

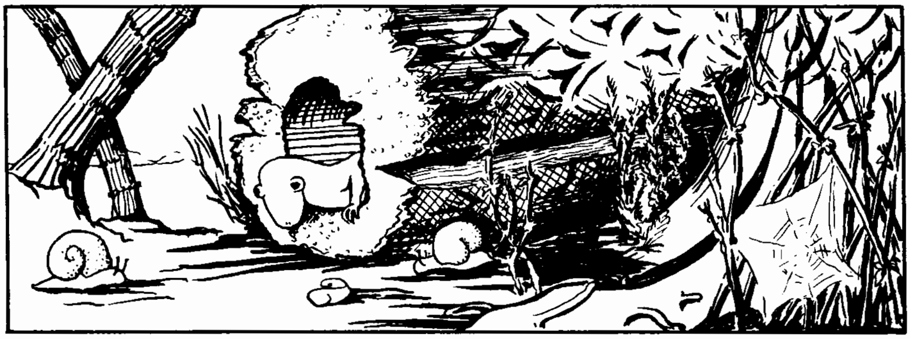


Fig. 26 Life in the Coal Forest

PERMIAN TIME: THE END OF THE SEAS IN OHIO

The record of Permian time in Ohio is incomplete. Only the lowest Permian series is represented in our state, hence we can only speculate on Permian events after that time. For early Permian time the rocks indicate that conditions in Ohio had not changed greatly since the close of the Pennsylvanian. Coal swamps still existed although their extent and their duration were much reduced.

During Permian time as a whole, the seas covered only a relatively small portion of North America and interest shifts naturally from marine to non-marine life. This is especially true in Ohio for here, in the Washington formation, are the remains of fresh-water and land animals together with abundant plant remains very similar to those of the Pennsylvanian. Fishes were abundant both in fresh and in brackish water; their remains have been described by Stauffer and Schroyer (1920, pp. 146-147). In the Permian coal swamps amphibians existed but no skeletons or bones have been found in Ohio. The only indication of their presence is indirect: coprolites (fossil droppings) described by Stauffer and Schroyer (1920, p. 147). Sailfin reptiles were scarce in Ohio during the Permian; a single neural (back) spine was found by Stauffer and Schroyer (1920, p. 147).

Besides the coals, which are poor and mined only locally in small quantities, our Permian rocks yield a few economically important products. Unique among these are the hard sandstones, five of which have been used in the past for making grindstones. They are also locally used as building stone. The Permian limestones of Ohio have been used for road material and the shales for making brick.

The remainder of Permian time has been recorded in the rocks of other parts of North America and of the world. The absence of younger Permian rocks in Ohio indicates either that they were not laid down in the state or else that they were laid down and then removed by erosion during the time (more than 200 million years) between the early Permian and the Pleistocene. That tremendous gap in the record of the rocks deserves special treatment.

THE GREAT GAP IN THE RECORD

It may well be that late Permian and Mesozoic sediments were deposited in Ohio and it is probable that animals and plants lived in the area. All trace of any such sediments has been destroyed by long erosion.

It is very likely that dinosaurs lived in Ohio during Mesozoic time but it is almost certain that their remains will never be found here. Like all other animal remains of their time, they would have been swept away by streams. Collectors should be cautious about identifying large bones from Ohio; the chances are practically zero that they will turn out to be dinosaurs. More likely, the large bones belong to the large mammals that lived in the state during the Pleistocene. The dinosaurs became extinct at the end of Mesozoic time. We can be sure of this because the Tertiary period, which followed the Cretaceous, lasted for 60 million years and no Tertiary bed has yielded dinosaur bones.

Tertiary beds, if they ever existed in Ohio, have not been preserved here. It is only towards the close of Cenozoic time that the record of the rocks is again preserved in Ohio.

PLEISTOCENE TIME: THE GLACIERS

About a million years ago, the climate of North America slowly cooled by some 5 or 10 degrees. A cooling of that sort at the present time would mean that in the higher parts of Canada some of the snow that falls each winter would remain unmelted during the following summer. As more snow fell during the following winters, it would pile up to enormous thicknesses and pack down into ice. As the ice got thicker, it would begin to move outward and we would say that the glaciers - there are still a few in the mountains - are growing. Besides that, huge ice fields would slowly form in places where there is no ice now.

As the edges of glaciers reach warmer regions or lower levels they begin to melt. In this way, glaciers are always being fed at the source, moving outward from it, and melting along the edges.

Cool climate of this sort lasted for a long time during the Pleistocene so that glaciers formed in known centers to the north of us and gradually spread until they covered most of Canada and the northern United States (fig. 27). In Ohio they reached across more than half of the state, along a line roughly from Brown County in the southwest to the middle of Columbiana County in the northeast. One ice invasion of this sort would be spectacular enough, but the record shows that during Pleistocene time the ice advanced and melted back at least four times.

In their advance across the land, the glaciers picked up sand, soil, pebbles, and boulders which they moved great distances. For example, many of the boulders in glacial material in Ohio are completely different from the bedrock of the state but are identical with bedrock far to the north in Canada. When the glaciers moved over the land, the thousands of stones frozen into the bottom of the ice scratched the surface of the rock. In places, these "scratches" are so large, 3 or more feet wide and as deep, that they are called grooves. The material picked up by the glaciers was dropped when the ice melted.

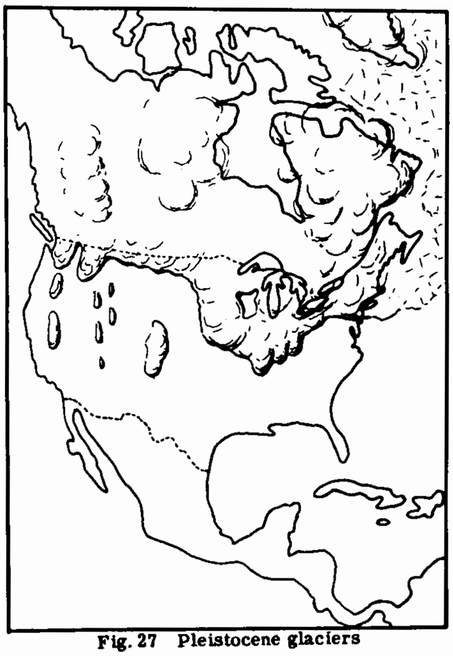


Fig. 27 Pleistocene glaciers

The glaciers scoured and altered the surface of Ohio as far as they went, but their effects were felt even farther. The meltwater from the ice poured down the river valleys in much greater quantities than the rivers were accustomed to carry. This increased the erosive power of the streams, deepening and widening them. Moreover, these waters bore along with them quantities of clay and silt which were deposited far from the glacier's edge. This explains why some Ohio rivers seem too small for their valleys and why some of these valleys are floored thickly with deposits of dirt into which the modern streams are cutting.

Some of the scenic features of Ohio are due to the work of glaciers and glacial streams. Their story need not be repeated here as it has been told in detail by Carman (1946), Hall (1953), and Marple (1954). The pre-Pleistocene drainage of Ohio was considerably modified by the passing of the glaciers. Some valleys were buried deep under glacial materials; in others, the direction of flow was completely reversed. Some streams were dammed, forming lakes which have long since disappeared.

The most radical changes of the drainage resulted in the formation of the Great Lakes. Stout, Ver Steeg, and Lamb (1943, pp. 44-48 and map opposite p. 44) have described the several stages of Lake Erie and given a map showing lake beach ridges in Ohio. For details on other drainage changes, see the same reference, chapter 2, and Merrill (1953) and Marple (1954).

Judging by the fossil record, the animals of the Pleistocene, with very few exceptions, were much like those of today. The exceptions are discussed in detail in chapter 10.

Only one feature, other than the ice sheet, set the Pleistocene landscape apart from ours. This was the presence of a different group of animals. Some of these are now extinct. Some had migrated into the region. During an ice advance northern animals moved southward ahead of the ice: moose andeven musk-ox andthe great mammoths and mastodons. As the ice melted back, these animals retreated northward and their place in Ohio was taken by the ground sloth, now extinct, and other animals, such as the peccary, now living only far to the south.

As each new ice sheet advanced, it destroyed many of the surface features left by the preceding one. It covered the remainder with more glacial material. Those of the latest and, we hope, final ice sheet have been somewhat modified or masked by erosion and soil-making in the thousands of years since the ice melted. Some of the bones and shells buried in post-glacial deposits we can call fossils, but post-glacial time passes gradually into historic times and it is almost impossible to set a boundary between the two. It is in this shadow zone between the past and the present that the geologic story ends and the historical account begins. Geologic processes continue to shape the land and to preserve in sediments fossil evidence of the times.

Pleistocene deposits are extremely important economically for the rich soils of Ohio are mostly glacial in origin. When the farm lands of the northwestern two-thirds of the state are compared with the poorer ones of the southern third, we have a striking illustration of the riches brought to us by the glaciers, riches which far overshadow the value of the sands, gravels, and clays derived from Ohio's Pleistocene deposits.

CHAPTER 3. THE MAIN KINDS OF FOSSILS

THE PLANT KINGDOM

General

The plant kingdom is subdivided into nine phyla and many classes. In Table II and the discussion of the phyla and classes which follows, only groups important in the fossil record are included. Botanists and paleobotanists use a more elaborate classification than this one. Several text books of botany contain good discussions of fossil plants. Fuller and Tippo (1949) and Transeau *et al*. (1953) are especially recommended.

Table II. A Classification of the Plant Kingdom

Phylum Thallophyta (plants lacking distinct roots, stems, and leaves).
  Class Schizophyta (one-celled plants; bacteria)
  Class Algae (seaweeds, pond scum, and diatoms).
  Class Fungi (mushrooms and molds).
Phylum Bryophyta (mosses and liverworts).
Phylum Pteridophyta (ferns).
Phylum Arthrophyta (horsetails and scouring rushes).
Phylum Lepidophyta (scale trees and club-mosses).
Phylum Pteridospermophyta (seed ferns).
Phylum Cycadophyta (cycads and their allies).
Phylum Coniferophyta (cone-bearing trees, evergreens).
Phylum Angiospermophyta (flowering plants).

Phylum Thallophyta

This phylum consists of plants of simple structure, without vascular tissue (the tissue that conducts water from one part of the plant to another), whose nature can best be understood by reference to examples, i.e. the bacteria, algae, and fungi. Each of these groups constitutes a class of the Thallophyta, treated separately below.

CLASS SCHIZOPHYTA. The bacteria are one-celled plants with no hard parts; their fossil record is therefore very scanty. Bacteria are found in the sea, in fresh water, and in other organisms. No bacteria have been recorded from the rocks of Ohio.

CLASS ALGAE. The class Algae includes the diatoms and the seaweeds and the "pond-scum" of inland waters. These two groups are very different from each other and will be treated separately.

The diatoms are also one-celled but they secrete a siliceous shell which can be preserved in the rocks. They are very abundant in the sea at present and their shells accumulate in billions as diatom ooze on the bottom of the sea. Ancient diatom ooze is called diatomite and may form deposits many feet thick. The oldest recorded diatoms are Jurassic in age. Diatoms are exclusively aquatic and live in both salt and fresh water. They should be found in Pleistocene lake-bed deposits of Ohio, but so far we know of no record of this kind.

Most of the algae (seaweeds and pond-scums) rot too easily to leave anything more than a shapeless mass of material as fossils; only a few kinds leave recognizable remains that can be referred to the Algae. Among these are the calcareous algae which precipitate calcium carbonate in a fine film over successive layers of the living algae. The limy films retain the imprint of the algal cells and show some of their characteristics. As much as 25 percent of a coral reef may consist of calcareous algae. Fresh water forms are the "water-biscuits" of certain lakes and the "lake reefs" formed in the same way as marine reefs but by other kinds of algae. Fossil algae have been found sparingly in the rocks of Ohio.

CLASS FUNGI. The class is best known through the mushrooms and bracket or shelf fungi that grow on trees and rotten logs. Other less familiar forms are numerous and varied in appearance and habits. They include the molds that form on bread, cheese, and other foods and some microscopic forms that live in fresh water and are able to capture and eat protozoans and other microscopic animals. Some molds are parasitic on animals, even man. Penicillin and other antibiotics are produced by fungi.

The part of the fungus that we usually see is the fruiting body of the plant. The fungi produce enormous quantities of tiny spores (reproductive parts of the fungus) which are borne by the wind. When a spore lands in a favorable environment it produces a network of fine threads (called the mycelium) which is the feeding system of the fungus. Later the mycelium produces a fruiting body which perpetuates the life cycle of the plant.

Most of the fungi feed on other plants, either within the dead or living plant or in the ground, where the mycelium reaches out in all directions for decaying plant material. Some fungi attack living or dead animal material; for example, athlete's foot is caused by a fungus.

Fossil fungi have been recorded in Devonian and younger rocks. Injury caused by fungi has been recognized in fossil wood. There are several records of this sort for Ohio Pennsylvanian plants; spores, possibly of fungi, have been recorded in Devonian and younger rocks in Ohio.

One of the most interesting groups of the algae is that of the Charophytes. They produce small calcareous fruiting bodies that are solid enough to be fossilized. Fossil charophytes are known in Ohio Devonian rocks and they should be found also in younger rocks, including Pleistocene deposits.

Phylum Bryophyta

The mosses and liverworts, which make up the phylum Bryophyta, are commonly found in shady, damp places. The most familiar example is the moss that grows on roofs and on rocks. The bryophytes lack vascular tissue, like the thallophytes, and reproduce by means of spores. The spore capsules can be recognized in living mosses; they are borne on stalks that are a little taller than the green moss and both the stalk and the spore-capsules are usually reddish brown.

Phylum Pteridophyta

The Pteridophyta or ferns have well developed vascular tissue and distinct roots, stems, and leaves. They include small, low plants, such as the familiar ferns found in this country, and the tropical tree ferns which may be as much as 50 feet tall. Ferns reproduce by means of spores borne on the underside of the leaves and on specially modified leaves, a character which distinguishes them from the extinct seed-ferns (see Pteridospermophyta). The leaves, stems, and roots of ferns are well preserved in the rocks, sometimes in great abundance. Fossil ferns are known from the Devonian to the present.

Beautiful examples of fossil leaves of ancient ferns may be found in the shales above coal beds of Ohio. Collecting is especially good on some mine dumps and on strip-mine spoil banks not weathered too long. Our Devonian rocks have yielded no ferns as yet and fern collecting in the Mississippian rocks of Ohio is poor.

Phylum Arthrophyta

The horsetails or scouring rushes have a hollow stem, separated into segments, and they look rather like bamboo. Note that the bamboos are not Arthrophyta; they are related to the grasses. The horsetails reproduce by spores. In the late Paleozoic the horsetails (fig. 28) were at their peak and some of them reached the size of trees, with trunks up to a foot in diameter. The present-day horsetails are small and inconspicuous relatives of these Paleozoic giants. The stems, cones, and leaves, the latter borne in rings around the "joints" of the stem, are found as fossils. The best collecting ground for fossil horsetails in Ohio is in Pennsylvanian rocks, as for the ferns.

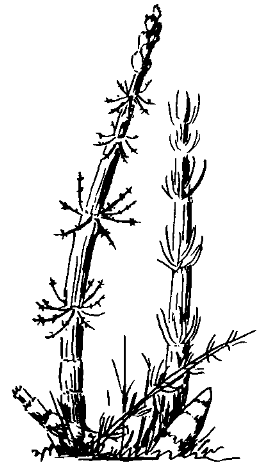


Fig. 28 Calamites

Phylum Lepidophyta

The club-mosses of our present-day woods are not well known plants for they are small and inconspicuous. They are trailing, green plants, with here and there a short stalk with a terminal cone 6 or 8 inches long; the terminal cone gives the stalks the appearance of a club (hence the name, club-mosses). Like the horsetails, they are the descendants of much larger forms of the same group, the scale trees, that were abundant in the late Paleozoic forests.

In the scale trees, the leaves were long and strap-like, attached directly to the stem. When the leaves fell off they left a seal-like scar on the trunk. The pattern of leaf-scars helps to identify fossil scale trees; their remains are not uncommon in the Pennsylvanian rocks of Ohio. Fossil Lepidophyta are known from the Upper Devonian to the present.

Phylum Pteridospermophyta

These are the seed ferns, distinguished from the true ferns by the fact that the spores are retained and dispersed within special nutritive and protective structures known as seeds, instead of being liberated without this nutritional advantage as in free-sporing plants. The phylum flourished from the late Devonian to the late Paleozoic, when they died out, but not before they had given rise to other kinds of seed-bearing plants ancestral to those now living.

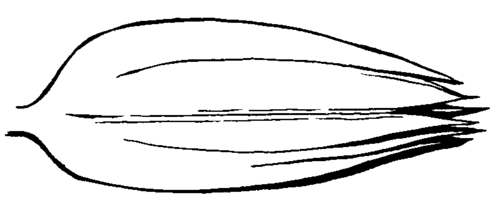


Fig. 29

Seed ferns are found in the Pennsylvanian rocks of Ohio; their leaves cannot be readily distinguished from some of the true ferns unless they can be associated with their reproductive organs (fig. 29). This has happened now and then; when it does the plant may be identified as a seed fern.

Phylum Cycadophyta

Living examples of the Cycadophyta or cycads are the sago palms which have long feather-like leaves springing from a short, squat trunk. They bear seeds which are carried in many kinds of cones. Extinct cycadophytes are abundant in Triassic and Jurassic rocks and may represent one persistent line of descent from the seed ferns. No fossil cycads are recorded for Ohio rocks.

Phylum Coniferophyta

The conifers or evergreens of the present day need no description to characterize them. Usually, their needle-like leaves and seed-bearing cones are distinctive. One group of conifers, most unlike others in habit, is that of the ginkgos which shed their flat, two-lobed leaves (fig. 30) in winter and look very much like hardwood trees. The ginkgos appeared in the late Paleozoic and have continued to the present. They used to be found nearly all over the world but they are scarce now, except as cultivated trees. Ginkgos have been planted as ornamental trees because of their attractive growth form and because they are tolerant of the smoke of large cities.

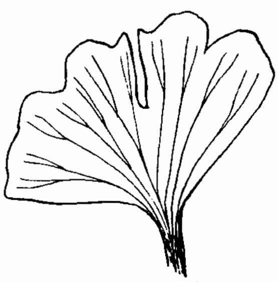


Fig. 30

Other ancient groups of conifers appearing at the beginning of Mesozoic time are the pines and araucarians. The araucarians are now found only in the southern hemisphere but used to flourish in the western part of this country. Various kinds of fossil conifer wood (spruce and tamarack) are found in Pleistocene deposits in Ohio. Some of these unimpressive logs have helped to determine the exact age of the deposits in which they are found through the use of the radiocarbon technique (see chapter 2).

Older still were the Cordaites (Mississippian to Permian) which were common trees in the late Paleozoic forests of Ohio. Their leaves were large and strap-like and their seeds were loosely arranged in bunches instead of in compact cones. Cordaitean wood, leaves, and seeds have been recorded from the Pennsylvanian of Ohio.

Phylum Angiospermophyta

These include the hardwood trees and other true flowering plants. The adaptations found in this group are the most specialized and for this reason they are often regarded as the most advanced of all plants. In all of them the seed is protected inside a closed covering. The Angiosperms became the dominant group of land plants in late Cretaceous time and have continued to increase in numbers and kinds to the present day. The ancestry of the Cretaceous angiosperms still remains one of paleobotany's most perplexing problems.

Angiosperms of various kinds (wood, leaves, seeds, and pollen) have been found in Pleistocene deposits in Ohio.

THE ANIMAL KINGDOM

General

The animal kingdom is subdivided into many phyla; some of them, e.g. the Arthropoda, contain many kinds of generally familiar animals with an abundant fossil record; others are so scarce and have such a meager fossil record that they are unknown to all but the specialists. In the following table, a few phyla and many classes and orders have been omitted because they are not generally known, have few representatives, and a poor fossil record.

TABLE III. A CLASSIFICATION OF THE ANIMAL KINGDOM

Phylum Protozoa: one-celled animals
- Class Sarcodina:
  - Order Foraminifera: Protozoa with many-chambered shells.
  - Order Radiolaria: Protozoa with siliceous, unchambered shells.

Phylum Porifera: the sponges, many-celled.

Phylum Coelenterata: many-celled animals with definite body cavity.

*Class Hydrozoa: the hydroids and conularids.
Class Stromatoporoidea: the stromatoporoids, extinct, coral-like animals.
*Class Scyphozoa: the jellyfish.
Class Anthozoa: the corals and sea anemones.
*Phylum Platyhelminthes: the flatworms.
*Phylum Nemathelminthes: the threadworms.
*Phylum Trochelminthes: the rotifers or wheel-animalcules.
Phylum Bryozoa: the moss-animals.
Phylum Brachiopoda: the lamp-shells or brachiopods.
Class Inarticulata: brachiopods without "teeth" (locking devices) on the hinge of the shell.
Class Articulata: brachiopods with "teeth" (locking devices) on the hinge of the shell.
Phylum Mollusca: soft-bodied, highly organized invertebrates.
*Class Amphineura: the chitons or coat-of-mail shells.
Class Pelecypoda: clams, oysters, scallops, and their relatives.
Class Gastropoda: the snails and their relatives.
*Class Scaphopoda: the tusk-shells.
Class Cephalopoda: the squids, devilfish, octopus, pearly Nautilus, ammonites, and their relatives.
Phylum Annelida: the segmented worms.
*Phylum Onychophora: a small group of animals with both annelid and arthropod characteristics.
Phylum Arthropoda: segmented animals with jointed appendages.
Class Crustacea: the lobsters, crabs, crayfish, and their relatives.
Subclass Ostracoda: minute bivalved crustaceans.
Class Arachnoidea: the scorpions, spiders, and eurypterids.
Class Trilobita: the trilobites, an extinct group.
Class Insecta: the insects.
Phylum Echinoderma: animals with a skeleton made up of limy plates.
Subphylum Pelmatozoa: stemmed echinoderms.
*Class Edrioasteroidea: seat-stars, extinct.
Class Cystoidea: the cystids and blastoids, an extinct group.
Class Crinoidea: the crinoids or sea-lilies.
Subphylum Eleutherozoa: stemless echinoderms.
Class Stelleroidea: the starfish and their relatives.
Class Echinoidea: the sea urchins.
*Class Holothuroidea: the sea-cucumbers.
Phylum Chordata: animals with a dorsal nerve cord.
Subphylum Hemichordata: tongue worms and their relatives.
Class Graptozoa: the graptolites, an extinct group.
Superclass Pisces: the fishes and their relatives.
Class Agnatha: the jawless fishes.
Class Placodermi: primitive, extinct, plate-armored fishes with jaws.
Class Chondrichthyes: cartilaginous, jawed fishes; sharks, skates, rays.
Class Osteichthyes: bony fishes.
Superclass Tetrapoda: chordates with a backbone and 2 pairs of limbs.
Class Amphibia: salamanders, frogs, and their relatives.
Class Reptilia: the reptiles; turtles, snakes, alligators, lizards, dinosaurs, flying reptiles, sea-going reptiles, and their relatives.
Class Aves: the birds.
Class Mammalia: the mammals.

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*Groups with little or no fossil record.

Phylum Protozoa

The Protozoa are the simplest of animals and consist of a single cell. Most of them are microscopic and leave no trace of their existence after death. Two exceptions are the orders Foraminifera and Radiolaria which form part of the class Sarcodina.

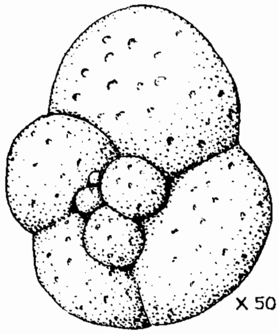

Fig. 31

ORDER FORAMINIFERA. In this order the shell is commonly of calcium carbonate and made up of a number of microscopic chambers. Some of the Foraminifera are very abundant in the sea and the accumulation of their shells forms a limy ooze on the bottom. Some 50,000,000 square miles of the sea floor are covered to an unknown depth with a layer of Globigerina ooze, named after the genus which is its commonest constituent (fig. 31). During early Tertiary time, shells of the genus Nummulites accumulated in the same way in the Mediterranean area. Tertiary limestones containing abundant Nummulites were used to build the Pyramids of Egypt. Foraminifera are almost exclusively marine, that is, they live only in the sea; a single family lives in fresh water. They have been recorded doubtfully from the pre-Cambrian and are certainly known from the Cambrian to the present.

The Foraminifera most easily seen in Ohio rocks are the fusulines, spindle-shaped shells not more than three eighths of an inch long. Some of our Pennsylvanian limestones contain abundant fusulines.

ORDER RADIOLARIA. These protozoans build their shell of silica. They are not chambered like the Foraminifera but instead appear under the microscope as globes and pyramids of glass pierced by numerous holes and ornamented with spines. They are exclusively marine and have been recorded doubtfully from the pre-Cambrian, certainly from the Cambrian to the present. They have not as yet been recorded from Ohio rocks.

Phylum Porifera

These are the sponges, which look like plants but are really many-celled animals. The cells are loosely organized and have little specialization. The sponges secrete a skeleton which may be either mineral (calcium carbonate or silica) or organic (spongin, a substance allied to silk). The skeleton, when it consists of mineral matter, is made up of tiny elements called spicules which are shaped like rods, clubs, disks, and other forms too complex to describe here. Sponges may be preserved entire (fig. 32) or the spicules may be scattered after death and preserved individually or in groups. Sponges are found both in the sea and in fresh water. Their geologic range is from the pre-Cambrian to the present. Sponges have been found in most of the Paleozoic rocks of Ohio but they are not common.

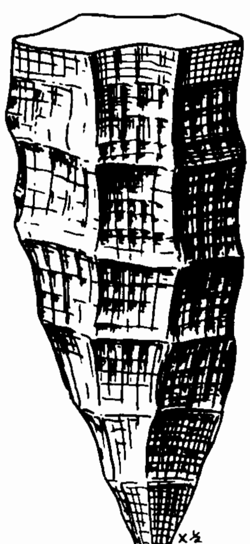
Fig. 32

Phylum Coelenterata

In this phylum, the many cells of the body are specialized and there is a definite body cavity, that is, a space between the body wall and the lining of the digestive cavity. The space is filled with a fluid which contains many dissolved substances which nourish the body cells. The phylum includes the hydroids, corals, jellyfish, and two extinct groups, the conularids and stromatoporoids.

CLASS HYDROZOA. These are the hydroids which have a circle of muscular tentacles around the mouth, with which they capture their food, and stinging cells, with which they paralyze other animals which they capture and eat. Few of them secrete hard parts capable of preservation but fossil examples are known from the Lower Cambrian to the present. The majority of the hydroids are marine but there are a few freshwater forms.

A curious group of fossils called Conularida (see fig. 235) were probably an extinct offshoot of the Hydrozoa. The shell is like a sharp cone or pyramid with regular transverse ribbing. They are generally scarce from the early Cambrian to the Triassic but are common enough in some formations to attract attention.

CLASS STROMATOPOROIDEA. This is an extinct group of coral-like animals in which the skeleton is made up of layers of calcium carbonate perforated by minute holes. The stromatoporoids were exclusively marine and lived from Ordovician to Cretaceous times.

Stromatoporoids are common fossils in the Silurian areas of western Ohio. Some colonies have become silicified, entirely or in part, and they weather out of the rocks as rounded masses the size of a baseball up to that of a football. The interior of these colonies may be stained bright red and brown. They are also abundant in the Devonian limestones and contributed much material to the Devonian reefs.

CLASS SCYPHOZOA. These are the jellyfish, umbrella-like animals with a fringe of tentacles but no hard parts. Most of the jellyfish are marine but there are a few freshwater representatives; one of the latter is sometimes common in Ohio ponds at the present time. The jellyfish first appear in the Lower Cambrian and they are preserved under exceptional circumstances in other parts of the geologic column.

CLASS ANTHOZOA. This class includes the corals and the sea anemones. Most of the living corals are colonial but a large number of the fossil ones were solitary (fig. 33). The colonial forms need no description; the solitary forms secreted a cup-like shell which is divided internally by radiating partitions, called septa, characteristic of the class. The shell of the coral is solid enough to be preserved; fossil corals are abundant in many sedimentary rocks and some of them are good index fossils. The Anthozoa are exclusively marine and are found from the Ordovician to the present.

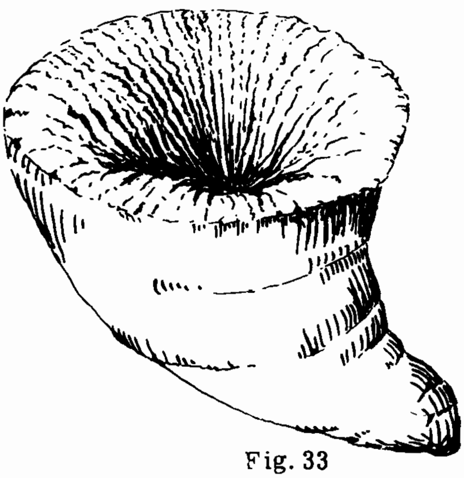

Fig. 33

In Ohio, corals are most abundant in the Ordovician, Silurian, and Devonian rocks. They are rarer from the Mississippian to the Permian and are not found, of course, in the Pleistocene deposits, which are entirely non-marine.

Phylum Platyhelminthes

All worms are not like the earthworm that everybody knows. The animals we call "worms" are so diverse that they make up several phyla of which the Platyhelminthes, or flatworms, are only one. The flatworms are common at present, both in the sea and in fresh water, or as parasites of other animals, including man. They have no hard parts that could be preserved and therefore their fossil record is very scanty. No fossil flatworms have yet been found in Ohio.

Phylum Nemathelminthes

The threadworms are distinct enough from the flatworms and other worms to be set apart in a phylum of their own. Like the flatworms they have no hard parts and their fossil record is negligible. There are no records of fossil threadworms for Ohio.

Phylum Trochelminthes

These are the "wheel-animalcules" or rotifers, common in fresh water and rare in the sea. They have no fossil record in Ohio or elsewhere. The three "worm" phyla just mentioned are very different from the segmented worms which belong to the phylum Annelida (see below).

Phylum Bryozoa

The moss-animals form colonies in which the individual is almost microscopic in size. The colonies are usually small and attached to the sea bottom. Many bryozoans look like miniature corals, from which they may be distinguished by the much smaller diameter of the tubes. The animal is much more complex than the coral animal. Most of the bryozoans are marine but there are a few freshwater forms; one of the latter builds globular colonies of huge size (up to 3 feet in diameter) but without calcareous skeleton. Most of the marine forms secrete calcareous colonies which may be stemlike, leaflike, massive, or encrusting. The oldest known bryozoans are late Cambrian in age and the phylum has survived to the present.

The Paleozoic rocks of Ohio contain bryozoans in abundance. This is especially true of the Ordovician rocks of the Cincinnati region and the Devonian rocks in both areas of outcrop within the state.

Phylum Brachiopoda

The brachiopods, or lamp shells, have a shell of two pieces, called valves. The two valves are hinged together at one end and enclose the soft part of the animal. Brachiopods look a little like clams, but they can easily be told apart by looking at the shells (fig. 34). In most brachiopods a line drawn from the pointed end, or beak, to the opposite margin of the shell separates the valves into two halves that are just alike. In a pelecypod shell the beak is nearer one end. In most brachiopods one shell is thicker than the other and the beak of one valve rides over the beak of the other. In some forms the shell has a depression called a sinus which corresponds to a fold on the opposite valve (see fig. 35). All brachiopods live in the sea. They attach themselves to the bottom by means of a fleshy stalk, called a pedicle, which grows out through a hole near the beak of the shell. We find fossil brachiopods in rocks of all ages from the Cambrian to the present time, and brachiopods are living in the oceans of the world today. Judging by the fossils we have found, there were more brachiopods during the Paleozoic than at any time before or since.

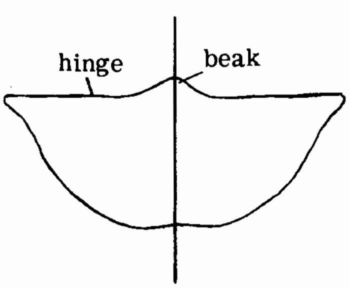

Fig. 34

The brachiopods are divided into two classes, the Inarticulata in which the valves are closed by muscles alone, and the Articulata in which the valves are held together by muscles and various devices which cause the shell to lock together.

Both classes of brachiopods are abundant in the Paleozoic rocks of Ohio but the articulates are by far the most numerous.

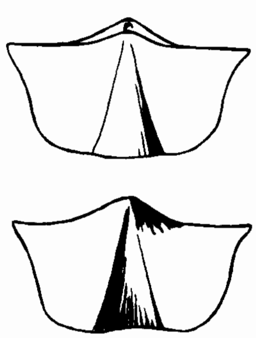
Fig. 35

Phylum Mollusca

<u>GENERAL.</u> This phylum includes the clams, snails, devilfish, squids, octopus, and related animals. The Mollusca have a soft body, enclosed in a fleshy mantle, and move about by means of a foot; the animal is commonly enclosed in a solid, limy shell. The phylum contains five classes of which two, the <u>Amphineura</u> (chitons or coat-of-

mail shells) and the Scaphopoda (tusk-shells) are unimportant as fossils. The other three classes are discussed separately.

CLASS PELECYPODA. These are the clams, oysters, scallops, and their relatives. Typically, the body is enclosed in a shell of two valves, like the brachiopod's, but in the clam the valves are equal but not bilaterally symmetrical (fig. 36). The outline of the shell varies greatly. Some are almost round, others are much longer than high, others have one or two wing-like projections (see fig. 37) and are referred to as "winged" shells. The valves are locked together by projections of the hinge which are called teeth. The small teeth under the beak are called cardinals and the long teeth parallel to the hinge are called laterals (see fig. 38). The animal pulls the valves shut by means of a pair of muscles. The muscles are attached to definite areas of the shell which are called muscle scars (see fig. 38). The front one is the anterior muscle scar and the rear one is the posterior muscle scar.

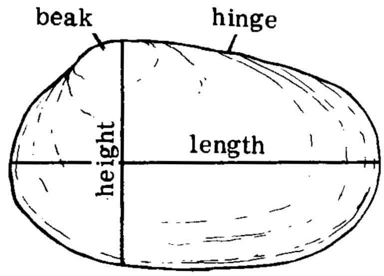

Fig. 36

Most pelecypods crawl on the bottom of the sea, rivers, and lakes and move with their fleshy foot. A few kinds are able to swim by clapping their valves open and shut; the scallop is one of these swimming pelecypods. Still others live all their adult lives attached to the bottom either by silken threads or directly by cementing one shell to a solid object; the oyster is one of these attached pelecypods. Most of the pelecypods are marine but a few groups live in fresh water. Pelecypods are known from the Ordovician to the present.

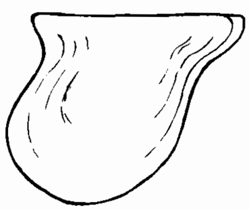
Fig. 37

The Paleozoic rocks of Ohio have yielded many genera and species of pelecypods but they are usually scarce and poorly preserved. One exception to this rule is the excellent preservation of pelecypods in the Logan formation (Mississippian).

CLASS GASTROPODA. The snails usually have a spirally coiled shell (fig. 39) which is typically carried on the back of the animal. When the animal is disturbed, it can withdraw completely into the shell and in some forms the shell is then closed by a horny or limy lid, the operculum. The spire may be coiled in one plane or it may coil downward after the first whorls and form a pointed, high-spired shell. Loosely coiled shells have a central depression, the umbilicus (fig. 40), in the base of the whorls. Gastropods are found in the sea, in fresh water, and on land. Their geologic range is Cambrian to present.

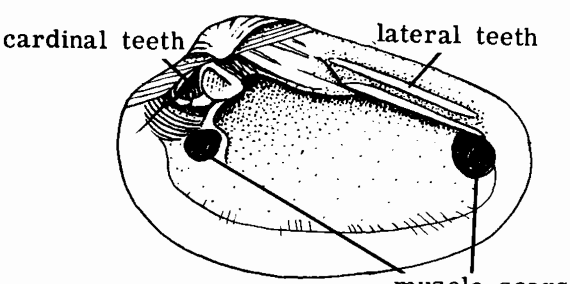

Fig. 38

Fossil gastropods are found in all the exposed rocks of Ohio, including the Pleistocene lake, pond, and river sediments. In the Paleozoic rocks the shell is usually poorly preserved but there are exceptions in which the ornamentation of the shell is beautifully sharp and clear.

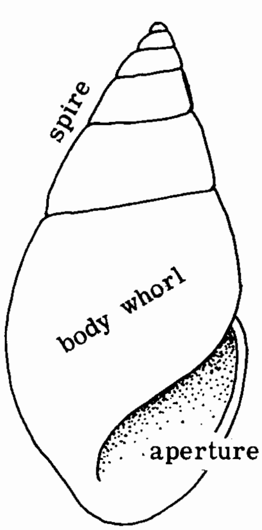

Fig. 39

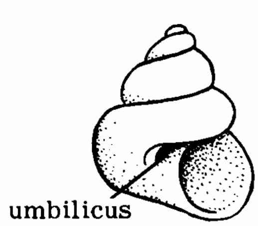

Fig. 40

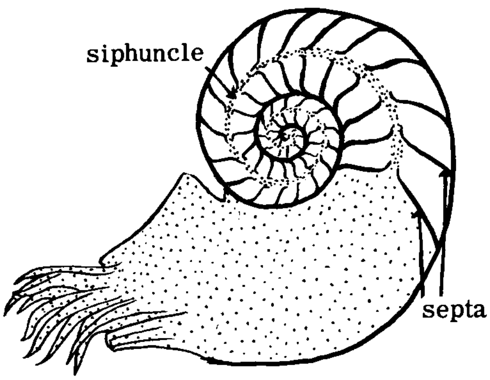

Fig. 41

CLASS CEPHALOPODA. The squids, devilfish, octopus, and their allies are not numerous in present-day seas. In the Paleozoic and Mesozoic seas they were much more numerous and varied. One living form, the pearly Nautilus, has a coiled shell which is externally like a snail shell but internally is divided into compartments by walls (septa) which the gastropods do not possess. The septa are pierced by round holes through which a tube-like organ, the siphuncle (fig.41), passes. The cephalopods are exclusively marine. Their geologic range is Cambrian to present. The three subclasses are discussed separately.

Subclass Nautiloidea. In this group the animal lives inside the shell which is straight or coiled, and divided into compartments whose edges (sutures) are simple (fig. 42). The nautiloids are found from the Cambrian to the present. They are not abundant in any of the Paleozoic rocks of Ohio but a variety of genera and species, some of them spectacularly large, are found in all marine formations.

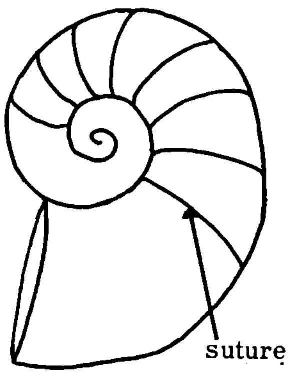

Fig. 42

Subclass Ammonoidea. The ammonoids also have a straight or coiled external shell which is divided internally into compartments but in this group the sutures are complex, that is the septa are crinkled and their edges (sutures) are wavy. This is an extinct group which first appeared in the Devonian and died out before the end of the Cretaceous.

Ammonoids are scarce in the Devonian of Ohio; they are found sparingly in the Mississippian and Pennsylvanian of the state.

Subclass Coleoidea. In the squid and its allies, which constitute this subclass, the shell is inside the body and may be shaped like a cigar or a shoe horn. Coleoids are found from the Mississippian to the present but were specially abundant in the Jurassic. They have not been recorded from the Paleozoic rocks of Ohio.

Phylum Annelida

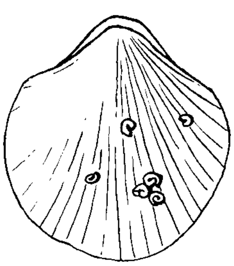
Fig. 43

The segmented worms have left little fossil record but it begins with rocks as old as Cambrian. It includes such indefinite evidence as trails, tracks, castings, and burrows, as well as scolecodonts, the jaws and denticles (teeth) of some worms. Some segmented worms secrete a calcareous tube, which may be straight or coiled, and fossil tubes of this nature, attached to brachiopods or other objects (fig. 43) are abundant in some rocks. The Annelida are marine, freshwater, and terrestrial. The earthworm is the best known example. Calcareous annelid tubes have been recorded from the Paleozoic rocks of Ohio.

Phylum Onychophora

This group of caterpillar-like creatures would scarcely deserve mention here but for the fact that two fossil genera may belong to this phylum. If the fossil representatives are correctly placed in this phylum, its geologic range is Cambrian to present. There is no record of fossil onychophores in Ohio.

Phylum Arthropoda

GENERAL. In all of these, the skeleton is external, jointed, and consists of chitin, sometimes strengthened by calcium carbonate. The most familiar are the insects, spiders, lobsters, and crabs; less familiar are the scorpions, barnacles, and extinct groups such as the trilobites and eurypterids. The phylum contains many classes of which only those most important as fossils are discussed.

CLASS CRUSTACEA. These are the lobsters, crabs, crayfish, and their relatives; most of them are marine but the crayfish lives in fresh water and some of the crabs can live on land. The geologic range of the class as a whole is Cambrian to present. Fossil crustaceans are not abundant in the Paleozoic rocks of Ohio. Fossil crayfish may be expected in the freshwater Pleistocene beds.

Subclass Ostracoda. The ostracodes are among the oddest of the crustaceans. They are all small and the best way to examine the living ones is under a low-power binocular microscope. At first the ostracode looks like a tiny clam with its valves shut; if it is left alone, it will open its valves and poke out its jointed legs - proof that it is an arthropod. Fossil ostracodes are abundant in some formations and are among the best index fossils for subsurface beds. Some Ohio Paleozoic beds contain abundant ostracodes.

CLASS ARACHNOIDEA. This group includes scorpions and spiders, which have a scanty geologic record, the horseshoe crabs, and the eurypterids, an extinct group (Ordovician to Permian) most abundant during Silurian and Devonian times. Eurypterids have been recorded from Ohio rocks but they are never abundant.

CLASS TRILOBITA. This is another extinct group (Cambrian to Permian) which can be recognized by the two grooves running from head to tail which divide the body into three distinct areas (fig. 44). The threefold division may be obscure on the head and tail of some trilobites but it is always clear in the thoracic (mid-section) segments. The trilobites were exclusively marine; their remains are fairly common in some formations.

The Paleozoic formations of Ohio have yielded many and varied kinds of trilobites. The Ordovician beds at Cincinnati are famous for the abundance of trilobites in some of them and the Silica formation (Devonian) is equally famous for good specimens. Some of our Mississippian and Pennsylvanian trilobites, though very small, are highly ornamented with spines and beautifully perfect specimens are sometimes found.

CLASS INSECTA. The insects are a very ancient group, distinguished from the other arthropods by the fact that they have a distinct head, thorax, and abdomen, not more than three pairs of legs, and in the adult of most groups, one or two pairs of wings.

Some of the most spectacular insects are those of the Pennsylvanian; during this period cockroaches up to 4 inches long and dragonflies with a wingspread of 30 inches lived in the coal forests. Many kinds of fossil insects have been recorded from Ohio, mostly from the Pennsylvanian.

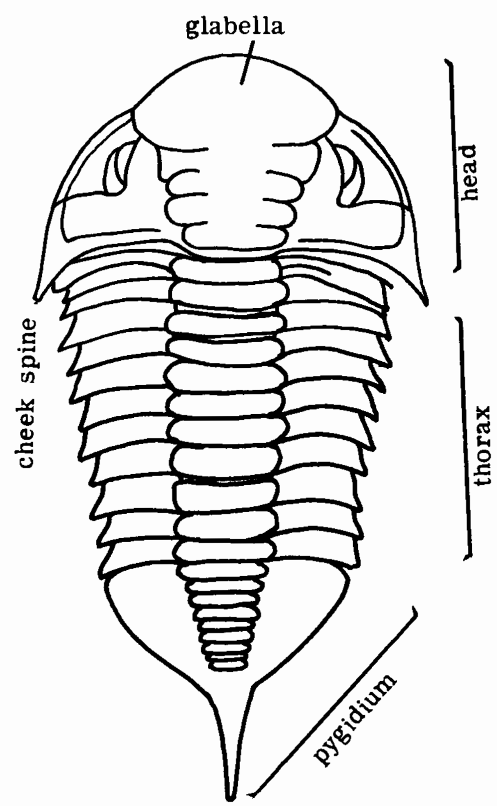

Fig. 44

Phylum Echinoderma

GENERAL. The starfish, sea-urchins, and their relatives are familiar examples of this phylum which includes also many less familiar animals. The echinoderms all have five-fold symmetry; they are all built on a pattern of five rays, though this is considerably modified in some cases. The whole body may have the form of a five-pointed star, or there may be only a pattern of five grooves on a round body, or the mantle may be surrounded by five arms, or arms in multiples of five. They may be attached to the bottom directly or by a stem (subphylum Pelmatozoa, including among others, the classes Edrioasteroidea, Cystoidea, and Crinoidea) or may be free-moving and stemless (subphylum Eleutherozoa, including among others, the classes Stelleroidea, Echinoidea, and Holothuroidea). Only the more important classes are described in detail here. The echinoderms are exclusively marine; their geologic range is Cambrian to present.

CLASS EDRIOASTEROIDEA. These are the seat-stars which look like starfish attached to a cushion-like disk covered with plates. They are only distantly related to the starfish, much more closely related to the cystids and crinoids. They are an extinct group which lived from early Cambrian to Mississippian times.

CLASS CYSTOIDEA. This group of extinct (Ordovician to Permian) echinoderms with or without stem, may be distinguished from the crinoids (see below) by their poorly developed arms. The subclass Blastoidea, formerly considered a class, have regularly arranged plates and perfect five-fold symmetry in the arrangement of the food grooves.

The irregular cystids are seldom abundant but many kinds have been found in the Ordovician and Silurian rocks of Ohio. The regular forms (blastoids) are fairly common in some Devonian beds of Ohio. None has been found in the Pennsylvanian or Permian rocks of the state.

CLASS CRINOIDEA. Most crinoids or sea-lilies have a stem, which anchors the animal to the bottom; there are a few free-swimming or, more exactly, floating forms. Crinoids (fig. 45) have a globular body or cup to which are attached five arms which may branch several times and which may be much longer than the cup. After death, the plates of the body are often scattered and the stem is preserved in sections or separated into pieces (called columnals or ossicles); crinoidal limestones are made up of dissociated plates and columnals. The geologic range of the crinoids is Ordovician to present; they were much more abundant and varied in the Paleozoic than in the Mesozoic and Cenozoic.

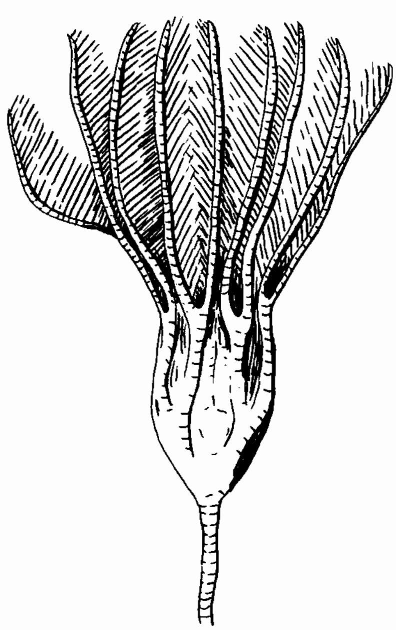

Fig. 45

Complete crinoids are a rarity everywhere; a few good specimens turn up now and then in the Ordovician, Silurian, and Devonian of Ohio. Crinoidal limestones are found in all systems, with the exception of the Permian and Pleistocene.

CLASS STELLEROIDEA. These are the starfish and their relatives. They are characterized by the star-shaped body with a central disk and five rays or arms covered with plates. They are rare as fossils and range from the Ordovician to the present.

Complete starfish are even rarer than crinoids except in a few favored localities. A few specimens are found from time to time in the Ordovician, Silurian, and Devonian of Ohio.

CLASS ECHINOIDEA. The sea-urchins are echinoderms with a globular or disk-shaped body which is covered in life with movable spines. Fossil sea-urchins (Ordovician to present) are rare in Paleozoic, more abundant in younger rocks.

The record of fossil sea-urchins in Ohio consists of abundant spines in the Pennsylvanian limestones. No complete specimen has yet been found.

Phylum Chordata

The most advanced animals are those with a backbone and a spinal cord; they are placed in the phylum Chordata which also includes other, more primitive animals without a backbone but with a nerve cord (notochord) running down the length of the body from head to tail. Only the most important of these lower chordates from the standpoint of the fossil record (Class Graptozoa, subphylum Hemichordata) are mentioned in this manual. The chordates with a backbone are subdivided into two superclasses, Pisces (fishes and their relatives) and Tetrapoda (four-footed animals). The geologic range of the phylum as a whole is Cambrian to present.

SUBPHYLUM HEMICHORDATA.

General. The living representatives of this subphylum are the tongue worms which combine chordate and nonchordate characteristics. They are included here because the graptolites, formerly considered as coelenterates, are now placed in this subphylum.

Class Graptozoa. This is an extinct group (Cambrian to Lower Mississippian) of colonial animals abundant in some black shales, scarcer in other kinds of sediments. Superficially, they look like pencil marks or tiny sawblades (fig. 46); actually, they are colonies of individual animals arranged in rows along a common axis.


Fig. 46

Few graptolites have been recorded from the Paleozoic rocks of Ohio, partly because black shales are not abundant in our Ordovician and Silurian, partly for lack of collecting. Our most abundant graptolites are Silurian in age.

SUPERCLASS PISCES.

General. The animals generally called fishes include many classes which are as different from each other as birds are different from mammals. They are related in that they are cold-blooded, breathe primarily by means of gills, and have paired side fins and a tail fin. The four classes of Pisces are described separately.

Class Agnatha. These are the jawless fishes, of which a modern representative is the lamprey. The early members of the class had bony armor which covered the front part of the body. The jawless fishes are doubtfully represented in the Cambrian and are certainly known from the Ordovician to the present.

Agnatha abounded in the Devonian and Mississippian seas of Ohio, along with fishes of other classes. Complete skeletons are sometimes found. The most abundant remains are those found in the "bone beds" of the Devonian but these are all fragments of teeth, spines, and armor.

Class Placodermi. This is an extinct group of jawed fishes which first appeared in the Silurian and persisted into the Permian, when they became extinct. Some of them bore extensive bony armor (fig. 47); in others there were bony plates only on the head. The class includes the so-called spiny sharks and the arthrodires or jointed-necked fishes which sometimes attained giant size.

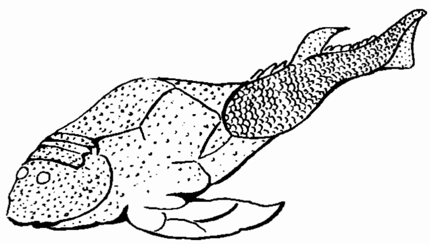
Fig. 47

Ohio has long been famous for its fossil fishes. The Devonian and Mississippian rocks of the state have yielded abundant and sometimes spectacular specimens of this group, including complete skeletons. Collecting is still possible in favored localities and will probably yield new forms of this group of fishes.

Class Chondrichthyes. Modern representatives of this class are the sharks, skates, and rays. They all have skeletons made of cartilage which contains less lime than true bones. The geologic range of the class is Devonian to present.

True sharks have been found in the Paleozoic rocks of Ohio but they are far overshadowed in size and numbers by the Placoderms.

Class Osteichthyes. These are the bony fishes, characterized by the possession of jaws and a skeleton of true bone. The majority of them are covered with scales but there are some exceptions (e.g. the catfish). It is from one group of these fishes that the Amphibians developed in Devonian time. The range of the class is Devonian to present.

Devonian and later Paleozoic rocks of Ohio have yielded several kinds of bony fishes but they are not generally common in the rocks of our state.

SUPERCLASS TETRAPODA.

General. The most advanced chordates are those with two pairs of limbs; they include the amphibians, reptiles, birds, and mammals, each described separately below.

In Ohio, fossil amphibians and reptiles are found sparingly in Upper Paleozoic rocks. Mammals and rare bird bones are found in Pleistocene deposits. It is unfortunate in a way, that the rocks of Ohio do not contain dinosaurs, for that group includes some of the most spectacular land animals that ever lived. They undoubtedly roamed across what is now Ohio during the Mesozoic but there are no deposits of this age in Ohio and therefore no record of dinosaurs.

Class Amphibia. Living representatives of the amphibians are the frogs, toads, and salamanders. They are cold-blooded animals, that is, their blood is at about the same temperature as the air or water around them. They undergo metamorphosis, a change from a swimming, fish-like animal with gills to an air-breathing land animal. The early amphibians include a group called Labyrinthodonts because the enamel of their teeth was folded into complex patterns. They are sometimes called Stegocephalians, which means "roof-headed," as the larger ones had heavy bony armor plates on their heads. Some were only a few inches long, but others were as big as crocodiles. The range of the class is Devonian to present.

Fossil amphibians have not yet been recorded from the Devonian or Mississippian rocks of Ohio but footprints and trails of some of the rarest and most interesting forms of the class have come from the Pennsylvanian rocks of the state. There are no Permian records and Pleistocene records are of amphibians like those of the present.

Class Reptilia. Reptiles are cold-blooded, like the amphibians, but they do not undergo metamorphosis. Reptile eggs are more complex than amphibian eggs and the embryo develops into an air-breathing land animal before hatching. The living reptiles, odd as they may sometimes seem, are much less diverse than the Paleozoic and Mesozoic representatives of the class. Four extinct groups deserve special mention though we do not find them fossilized in Ohio. The class as a whole ranges from Pennsylvanian to present.

The dinosaurs appeared in Triassic time and were extinct by the end of Cretaceous time. Some of them were sluggish amphibious forms of huge size, others were peaceful plant-eaters with bizarre armor. Large flesh-eating dinosaurs preyed on their less aggressive relatives.

During the "age of dinosaurs" (the Mesozoic) some reptiles developed the ability to fly.

Some of these flying reptiles attained a large wingspread, more than 26 feet in one form. They lived in Jurassic and Cretaceous times.

Also during the Mesozoic, a group of reptiles took to the sea. Some of these sea-going reptiles were very large, about 50 feet long but they too are extinct.

Theromorphs (fig. 48) are the mammal-like reptiles and, to us, the most important of the extinct reptiles for they form a link between the reptiles and the mammals. Theromorph reptiles have not as yet been recorded from Ohio but they may well have roamed the state in Permian time.

Class Aves. The birds are rare as fossils; the earliest known birds are Jurassic in age. These ancient birds, although fully feathered, still retain reptilian characteristics, such as teeth, scales on the lower part of the legs (as in modern birds), and a peculiar arrangement of the tail feathers, which are in two rows, one on each side of the long tail, instead of being arranged like a fan, as in modern birds.

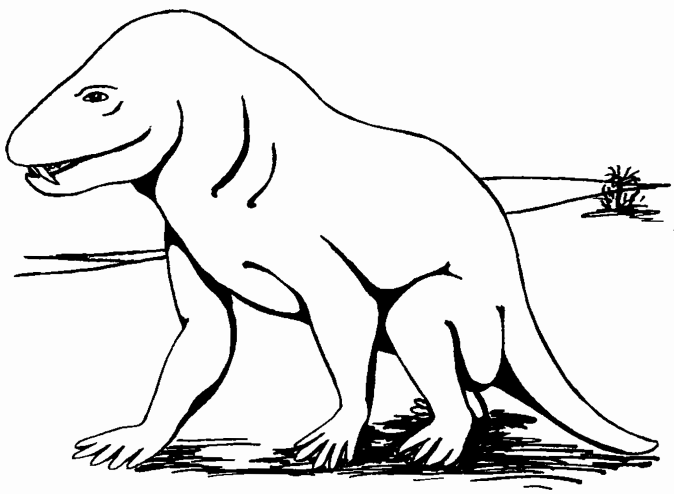

Fig. 48

Fossil birds are unknown in Ohio except for bird bones sometimes found in Pleistocene deposits.

Class Mammalia. The mammals are warm-blooded animals that bear their young alive, have a body-covering of hair, and breathe by means of lungs. There are a few exceptions to these general rules.

The mammals were scarce during Mesozoic time and did not come into their own until the beginning of the Tertiary. During that time many strange and unusual forms evolved, some of them of gigantic size. The development of the mammals culminated in Pleistocene time with the appearance of man-like apes and man himself.

Mammals are not found, nor are they to be expected, in the Paleozoic rocks of Ohio. The Pleistocene mammals of the state include some spectacular forms such as the mammoth and mastodon, the ground sloth, and the giant beaver, all extinct. They also include some forms which are far to the north or south of their present range. Pleistocene mammals are discussed in greater detail in chapter 10.

CHAPTER 4. ORDOVICIAN FOSSILS

Collecting Localities

GENERAL. Ordovician rocks are found at the surface in the southwestern part of the state. Fossils may be found almost anywhere within the triangular area bounded by Miami County on the north, the state line on the west from Preble County southward, and on the south from the Indiana line to Adams County (see map, fig. 8). In parts of this area, Ordovician fossils are so abundant that they cannot fail to attract attention. It is not surprising to find that collectors began work early in the Cincinnati region and that more than 700 species have been described from that area. Some of the particularly good collecting localities are noted here but there are many others too numerous to mention.

In general, fossils from the older formations of the Ordovician may be found in the vicinity of the Ohio River and those from the younger formations along the edges of the Ordovician outcrop area (see map, fig. 8).

CINCINNATI. The city is built on a veritable storehouse of fossils, a storehouse that seems inexhaustible. Sometimes, when building operations are started, a hillside will be stripped of soil, exposing fossiliferous beds from which specimens can be picked up in thousands. In the ravines and gullies, where streams are constantly eroding the bedrock, clean rock surfaces are often exposed. Where soft shales are attacked by frost and water, fossils are washed out and exposed in thousands along the soft clayey slopes. In the stream beds themselves, fossils freed from the rock can often be picked up but many of them are worn and not as fresh as those still on the slopes or in the rock. The Cincinnati area has been a collecting ground for a century or more but it still yields good specimens in satisfying numbers. See Dalvé (1948).

GREENE COUNTY. In streams and railroad cuts in this county are several exposures of the Whitewater and Elkhorn formations with an abundance of bryozoans, brachiopods, and other fossils. The Whitewater has several kinds of corals and the Elkhorn is notable for good specimens of the brachiopods Hebertella and Platystrophia.

PREBLE AND BUTLER COUNTIES. The Whitewater and Elkhorn are extensively exposed in these counties. Good exposures with abundant fossils are found near the campus of Miami University and in river banks and road cuts in many parts of the two counties.

FORT ANCIENT, WARREN COUNTY. This is the type locality of the Fort Ancient member of the Waynesville formation. Exposures in Stony Run contain abundant brachiopods and other fossils.

BLANCHESTER, CLINTON COUNTY. In this vicinity, the Liberty and Waynesville formations, both fossiliferous, crop out and some zones produce an abundance of brachiopods, pelecypods, and some trilobites.

The Commoner Fossils

PLANTS. No undoubted seaweeds have been found in our Ordovician rocks. "Fucoids," which were once thought to be seaweeds, turn out to be a variety of other things.

PROTOZOA. No protozoans have been found in our Ordovician rocks. Foraminifera have been found sparingly in Ordovician rocks elsewhere and may yet turn up in Ohio.

PORIFERA. Sponges are not abundant in our Ordovician rocks and, in fact, the commonest of these, Stromatocerium huronense, may not be a sponge at all. It grows in irregular colonies covered with pimple-like bumps. It is sometimes mistaken for a coral but can easily be distinguished from it because it shows no tubes in cross-section. This doubtful sponge is found in the Richmond.

ANTHOZOA. Both horn corals and colonial corals are found in our Ordovician rocks. The commoner kinds may be recognized by means of the following key.

Key to the Commoner Ordovician Corals of Ohio

(see p. 4 for use of keys)

1. a) Animals in colonies of closely packed tubes 2
   b) Animals solitary: horn corals............................Streptelasma

2. a) Colonies hemispherical.. 3
   b) Colonies in thin, irregular crusts .... Protarea

3. a) Tubes large, numerous.. 4
   b) Tubes small (diameter of an ordinary pin or less).............. Tetradium

4. a) Tube walls without pores .... Columnaria
   b) Tube walls with pores.......................................Calapoecia

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The commonest of the horn corals belong to the genus Streptelasma (fig. 49) and may be recognized by their horn-like shape. Some people still call these fossil cow horns. Broken and worn specimens are not obviously horn-shaped; they may be recognized by cross-sections of the septa or partitions which radiate outward from the center of the cup. The commonest species is Streptelasma rusticum which occurs, often abundantly, throughout the Richmond.


Fig. 49

The colonial corals are found either as hemispherical colonies or as thin, irregular crusts growing on any convenient surface.

The hemispherical colonies with numerous large (1/8 to 3/16 inch) tubes with strong, short septa, are Columnaria alveolata (fig. 50) of the Richmond, especially the upper formations.

Calapoecia cribriformis is like Columnaria but with rather large pores in the walls of the tubes, arranged in rows between two septa. This feature is not visible in entire colonies but can be seen when a colony is broken parallel to the tubes; it also occurs in the Richmond, especially the upper formations. Tetradium approximatum is like Columnaria but has very narrow tubes; it occurs in large hemispherical

colonies, in the Richmond, especially the upper part. Protarea richmondensis is unlike the other colonial corals. It grows in crusts over fossils and pieces of rock, not in hemispherical colonies. The cups have septa which give the edges of each cup a beaded appearance. It is found in the Richmond.

Fig. 50

BRYOZOA. A bewildering abundance of bryozoans is found in the Ordovician rocks of Ohio. The surest way to identify them is to prepare thin slices for microscopic examination. Still, some forms may be recognized more or less certainly by their external characters. They are divided, according to the outer appearance of the colonies, into twig-like forms and fan- or sheet-like masses.

Key to the Commoner Ordovician Bryozoa of Ohio

(see p. 4 for use of keys)

1. a) Colonies twig-like, cylindrical, branching 2
   b) Colonies twig-like, not branching .... Escharopora
   c) Colonies twig-like, flattened or expanded 7
   d) Colonies fan- or sheet-like 8

2. a) With monticules 3
   b) Without monticules 4

3. a) Monticules numerous .... Hallopora (except H. oneilli) and Homotrypa
   b) Monticules few .... Dekayella

4. a) Branches small (diameter about 1/16 inch) .... Hallopora oneilli
   b) Branches large (diameter about 1/4 inch or more) 5

5. a) Tubes of moderate size 6
   b) Tubes very small, making the branches look almost smooth .... Bythopora

6. a) Tubes almost square in cross-section .... Rhombotrypa
   b) Tubes round in cross-section .... Batostoma

7. a) Without monticules .... Dekayia, Chiloporella, and Homotrypa flabellaris
   b) Without monticules but with maculae .... Homotrypa obliqua
   c) With monticules .... Homotrypa dawsoni

8. a) With monticules 9
   b) Without monticules 10

9. a) Monticules star-shaped .... Constellaria
   b) Monticules not star-shaped .... Monticulipora and Heterotrypa

10. a) Colonies disk-like 11
    b) Colonies fan-shaped, with tubes on both surfaces .... Peronopora
    c) Colonies a network of tubes .... Stomatopora

11 a) Colonies low and irregular in outline .... Aspidopora
   b) Colonies hemispherical .... Homotrypella

Fig. 51

Some bryozoans have a relatively flat surface; in others, groups of tubes are higher than others, forming bumps called monticules (see fig. 51) on the surface of the colony, which are useful in separating the genera from each other. Others have groups of tubes smaller than the others which form spot-like marks, called maculae (see fig. 52) on the surface.

One of the most abundant forms of twig-like bryozoans is the genus Hallopora. Some forms possess monticules but one, H. oneilli, has none. H. ramosa (fig. 53) has numerous distinct monticules on colonies about 1/4 inch in diameter; in H. rugosa (fig. 54) the monticules more or less fuse into sharp ridges; both of these species are found in the McMillan formation.

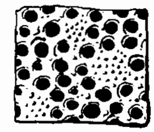
Fig. 52

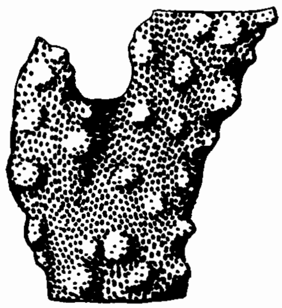
Fig. 53

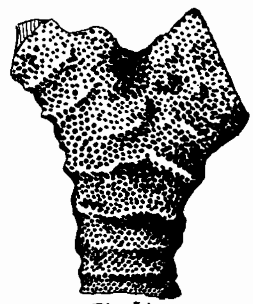
Fig. 54


Fig. 55

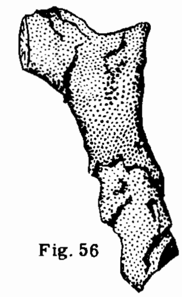
Fig. 56

All of the following species are twig-like but without monticules. Hallopora oneilli (fig. 55) has small (diameter about 1/16 inch) branches with coarse tubes. Rhombotrypa quadrata has branches 1/4 inch or more in diameter which are of approximately the same size throughout; the tubes are almost square in cross-section; it is found in the Richmond. Batostoma jamesi (fig. 56) is like Rhombotrypa quadrata but the tubes are almost round in cross section and the branches thicken irregularly at intervals; it occurs in the Eden. Bythopora gracilis has such small tubes that the surface of the branches (diameter about 3/16 inch) appears smooth; it is found in the McMillan formation. Bythopora meeki is larger (diameter of branches about 5/16 inch) than B. gracilis and has different internal characters; it is found throughout the Richmond.

Escharopora falciformis has unmistakable characteristics that separate it from all others. It is twig-like but not branching, the colony is flattened and pointed at one end. The tube openings are arranged in diagonal rows; it is confined to the Fairview formation.

The following species have twig-like, branching colonies but they are flattened and expanded so that the larger end of the colony often looks more like a fan or leaf than a twig. They have no monticules. Dekayia aspera of the Fairview formation is distinguished from Chiloporella flabellata of the McMillan by internal characters; externally, they look alike except to the most practiced eye.

Homotrypa dawsoni of the Waynesville has twig-like, flat, expanded branches and monticules like Monticulipora mammulata. H. flabellaris has no monticules; its twig-like, flattened, wide branches may be 3/4 inch wide or more; it is found in the Maysville and Richmond. H. obliqua is twig-like to fan-shaped, has no monticules but patches (called maculae) in which the tubes are larger than on the remainder of the surface; it is found in the Fairview.

The following species are sheet-like, occurring in crusts on other objects or rising in fan-like colonies from the original sheet. Constellaria florida (fig. 57) of the Fairview has numerous star-shaped monticules which are characteristic of the genus; C. polystomella (entire Richmond) differs from C. florida by its internal characters. Monticulipora mammulata grows in delicate fan-shaped colonies; its surface has numerous, sharp monticules; it is found in the Fairview. Monticulipora molesta of the McMillan formation is very similar to M. mammulata but differs from it in being coarser and larger. Heterotrypa frondosa of the Fairview has a fan-shaped colony with low, numerous, widely spaced monticules.

The following three genera have no monticules. Aspidopora newberryi has disk-shaped colonies of irregular outline; it is found in the Eden. Homotrypella hospitalis of the entire Richmond is also disk-like but its colonies are hemispherical. Peronopora vera has fan-shaped colonies with tubes on both surfaces; it is found in the entire Cincinnatian.

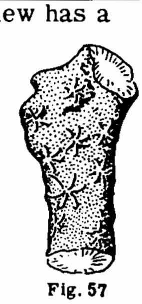
Fig. 57

Stomatopora arachnoidea differs from all the preceding species in that its tubes do not grow parallel to each other; instead, they form a network of tubes irregularly branching from each other and grow on other bryozoans; it is found in the entire Cincinnatian.

BRACHIOPODA. The phylum is represented in our Ordovician rocks by many genera and species and literally millions of individuals. Only the commoner species are included here. As much as possible, they are identified by the outer characters of the shell. If a specimen to be identified has both valves, it is not difficult to compare it with the descriptions, although shells with a concave valve (e.g. Rafinesquina) may give a little trouble at first.

Key to the Commoner Ordovician Brachiopods of Ohio

(see p. 4 for use of keys)

1. a) Beak on margin of shell 3
   b) Beak near center of shell 2

2. a) Concentric ornamentation only .... Crania
   b) Shell with diagonal rows of pits .... Trematis

3. a) Concentric ornamentation stronger than radiating ornamentation 4
   b) Radiating ornamentation stronger than concentric ornamentation 5

4. a) Shell bent downward at margin .... Leptaena
   b) Shell not bent downward at margin .... Sowerbyella

5. a) Shell with less than 40 radiating ribs 6
   b) Shell with more than 40 radiating ribs 8

6. a) Shell with sinus and fold 7
   b) Shell without sinus and fold .... Plectorthis

7. a) Shell round and fat, sinus and fold distinct .... Lepidocyclus
   b) Shell round but thin, sinus and fold indistinct .... Zygospira

8. a) Without sinus and fold 9
   b) With sinus and fold 10

9. a) Ribs unequal, one coarse alternating with several fine ones .... Rafinesquina
   b) Ribs coarse and irregular, not alternating .... Strophomena

10. a) Shell small (3/4 inch or less) and flat .... Resserella
    b) Shell large (more than 3/4 inch) and thick through ..... Dinorthis and Hebertella

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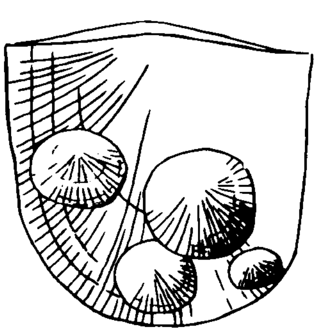

Fig. 58

Two species of brachiopods can be distinguished immediately because the beak is not on one edge of the shell but roughly near the center of it. These are both roughly circular in shape, with nearly central beak. Crania scabiosa (fig. 58) was attached to other objects, such as other brachiopods, and lacks the characteristic ornamentation of Trematis; Crania scabiosa is found in the entire Cincinnatian. Trematis millepunctata is similar to C. scabiosa but has diagonal rows of pits on the shell, which are characteristic; it occurs in the McMillan formation.

In most brachiopods the beak is on the edge of the shell along which the two valves are hinged; hence this edge is called the hinge line. All the remaining species of brachiopods described here have the beak on the hinge line. In some of them grooves and ridges fan out from the beak; these are called radiating ornamentation. They may be crossed by others that follow the curved outline of the shell; these are called concentric ornamentation. We shall first take up the species in which the concentric ornamentation is stronger and then those with stronger radiating ornamentation.

Two genera, *Leptaena* and *Sowerbyella* (*Plectambonites* in older publications) have stronger concentric than radial ornamentation. *Leptaena* is easily distinguished by the downbending of the shell toward the margin; it has strong concentric wrinkles near the beak and weak ones on the downbent part of the shell. Fine radiating ornamentation cuts these wrinkles. *Leptaena richmondensis* (fig. 59) is found in the entire Richmond. In *Sowerbyella rugosa* (fig. 60) the shell is not bent downward, the wrinkles are weaker and near the edge away from the beak; it occurs in the Waynesville and Liberty formations of the Richmond.

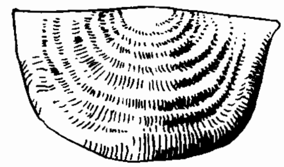

Fig. 59

In all our remaining species, the radiating ornamentation is stronger than the concentric. Some of them have few, strong, radiating ridges and others many weak ones. They may be divided into those with less than 40 such ridges and those with more than 40.

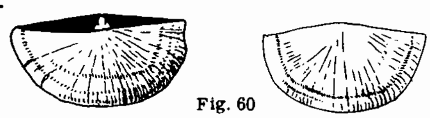

Fig. 60

Two of our genera with less than 40 ridges have a strong ridge, called a fold, down the center of one valve and a corresponding groove, called a sinus, on the other. In the genus *Lepidocyclus* (*Rhynchotrema* in older publications) the shell is round and fat, with a pointed beak. We have two common species, *Lepidocyclus capax* (fig. 61) of the whole Richmond, which is round and fat and and has 3 ridges in the sinus and sharp concentric ridges crossing the radiating ones. *L. dentatum*, also found in the whole Richmond, is smaller than *L. capax*, has only one ridge in the sinus, and lacks the sharp concentric ridges of of that species.

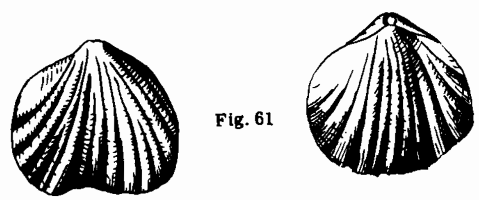

Fig. 61

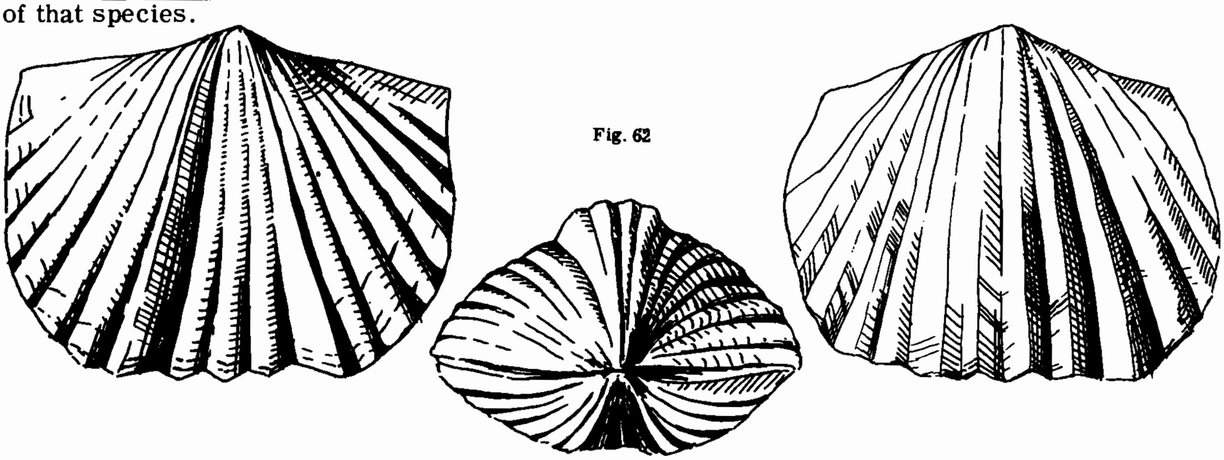

Fig. 62

In the genus *Platystrophia* (fig. 62) also with less than 40 ridges and with a sinus and fold, the shell is straight along the hinge and it has the appearance of two short bird wings. There are many species in our Cincinnatian, each with a particular geologic range. No attempt is made here to distinguish them; the figures in Bucher (1945) will identify the commoner ones.

In *Zygospira* the sinus and fold are weak but distinct, the outline of the shell is rather rounded; the shells are small, about 1/4 inch or less wide. *Z. modesta* (fig. 63) is found throughout the Cincinnatian; it is small even for the genus, less than 1/4 inch wide, has a rounded outline and about 6 plications on each side of the shell.

Fig. 63

Z. cincinnatiensis is larger than Z. modesta and has only 5 plications on each side; it is found in the Fairview formation.

In Plectorthis the hinge is short but almost straight and the sinus and fold are absent. P. plicatella, found in the Fairmount member of the Fairview formation, is characterized by the splitting of the radial ridges.

Among the shells with more than 40 radial ribs and without sinus and fold, the most easily recognized are the large (1. 5 inches or more wide) Strophomenas and Rafinesquinas. The shell has a long straight hinge line, one valve is convex and the other concave in both genera. In Rafinesquina the valve that has the hole for the pedicle (the brachiopod's organ for attaching to a solid surface) is convex and the other (called the brachial valve) is concave. The convexity is reversed in Strophomena.

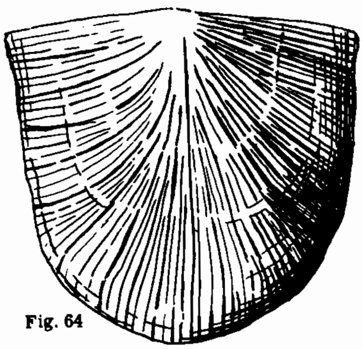

Fig. 64

Rafinesquina alternata (fig. 64) has unequal radial ribs, one coarse alternating with several fine ones. It is found in all Cincinnatian formations and in some beds is the commonest shell to be found. Rafinesquina alternata fracta of the McMillan is thin and almost flat.

In all the species of Strophomena (fig. 65), the striations are irregular but not alternating as in Rafinesquina. The many species are hard to characterize.

Three genera, Resserella, Dinorthis, and Hebertella, have more than 40 radial ribs and a sinus and fold which are rather inconspicuous.

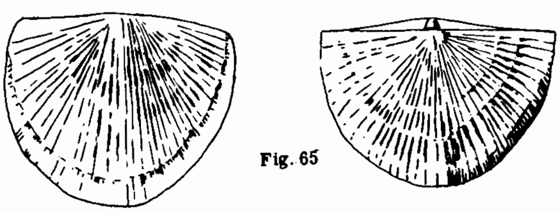

Fig. 65

We have 3 common species of Resserella (Dalmanella of older publications). R. emacerata, found in the Eden, is about 3/4 inch wide, has a rectangular outline, no sinus on the brachial valve; R. multisecta is about 1/2 inch wide, has a rounded outline, and a sinus on the brachial valve; it is also found in the Eden. R. meeki (fig. 66) is like R. multisecta but larger, 3/4 inch wide, and thicker; it is found in the Richmond.

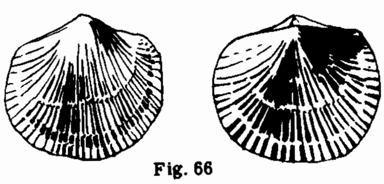

Fig. 66

Dinorthis and Hebertella are externally very similar and are distinguished especially by internal characters. D. carleyi, confined to the Middle Arnheim, has a peculiar distinguishing feature: the area under the beak of the convex valve is slanted forward; it is 1.25 inches or more wide. D. subquadrata has a straight area under the beak, a squarish outline, and its coarse ribs split irregularly; it is about the same size as D. carleyi and is found in the Liberty and Whitewater formations. Hebertella also has coarse, irregularly splitting ribs. Its internal characters distinguish it from Dinorthis. We have 3 common species: Hebertella sinuata is about 1.25 inches wide, has a rectangular outline; it is found in the McMillan formation. H. occidentalis (fig. 67) is about the same size as H. sinuata; it has a characteristic groove on the fold; it occurs in the Maysville and Richmond. H. insculpta is a little smaller (1 inch wide) than the preceding two, has sharp concentric ornamentation cutting the radiating ribs; it is found in the Waynesville and at the base of the Liberty.

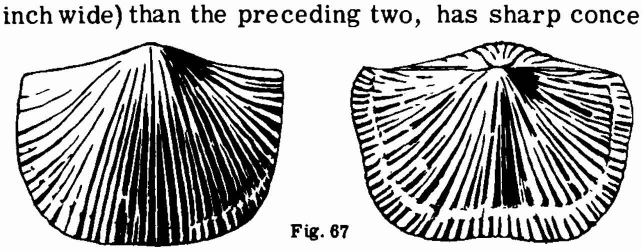

Fig. 67

PELECYPODA. More than 80 species belonging to some 25 genera have been described from the Ordovician rocks of Ohio. Many of these are very rare; in fact, some of them are represented by only a few specimens in our museums. Only the commoner species are discussed here. For the others, see Ulrich (1895, pp. 627-693).

Pelecypods are often preserved as internal molds with closed or open valves. These do not show the external characters but may be quite useful for identification and should be collected. The commoner genera can be recognized by external characters but more certain identification can be made if the interior of the shell is available for study.

Key to the Commoner Ordovician Pelecypods of Ohio

(see p. 4 for use of keys)

1. a) Shell with strong radiating ribs and weak concentric ornamentation 2
   b) Shell without radiating ribs 3

2. a) Beaks terminal, shell winged .... Opisthoptera
   b) Beaks almost terminal, shell not winged ....Byssonychia and Anomalodonta

3. a) Shell winged .... Pterinea
   b) Shell not winged... 4

4. a) Shell longer than high, beak small 5
   b) Shell almost as high as long, beaks large .... Cyrtodontula

5. a) Shell with an internal diagonal ridge .... Ischyrodonta
   b) Shell without internal diagonal ridge .... Modiolopsis

The following genera have strong radiating ribs and weak concentric ornamentation. In the genus Byssonychia the beaks are almost terminal, that is they are near the apex of the triangle formed by the shell. B. radiata (fig. 68) is about 2 inches high and 1.5 inches long; it is found in all Cincinnatian formations. B. grandis is much larger than B. radiata (2 inches long and 2.5 inches high) and is also more convex, i.e. thicker through; it is found from the Waynesville to the Whitewater. Anomalodonta gigantea is like Byssonychia but larger and with broader ribs; it also differs from Byssonychia internally; an average specimen is 3 1/8 inches high and 2 3/4 inches long; it occurs in the Richmond. Opisthoptera differs from the preceding two genera in being longer than wide; is has terminal beaks, strong radiating ribs, and a large wing (that is, a pointed part of the shell on one end of the hinge line) at the end of the shell away from the beak; there are several species, all from the Richmond; an average specimen is 3 inches long and 2 inches high.

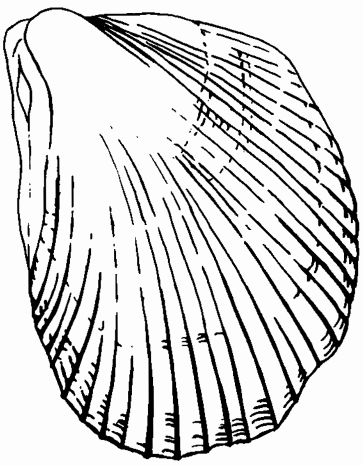

Fig. 68

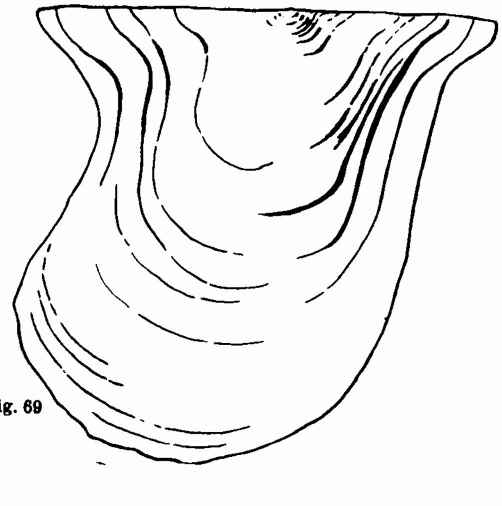

Fig. 69

The remaining genera have no radiating ribs. In Pterinea demissa (fig. 69) the shell has two wings, one on each side of the beak, which is almost in the center of the hinge line;

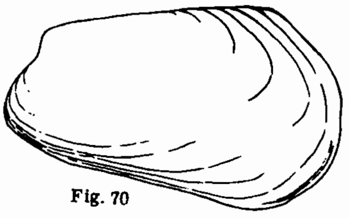

Fig. 70

the species has distinct concentric ornamentation; an average specimen is 2 inches long and 2 inches high; it is found in all Cincinnatian formations. Modiolopsis modiolaris (fig. 70) is longer than high (1.75 inches long, 7/8 inch high) and the shell is narrowest in the region of the beak; it lacks the diagonal ridge of the next genus, Ischyrodonta; the beaks are inconspicuous; it is found in all Cincinnatian formations. Ischyrodonta elongata is like Modiolopsis but with a diagonal ridge running from the beak to the lower margin; specimens are about 2.25 inches long and 1.5 inches high; it occurs in the Whitewater. Cyrtodontula umbonata is large, about 2.25 inches long and 1.75 inches high, has large anterior but not terminal beaks and is thicker through than either Modiolopsis or Ischyrodonta; it is found in the Whitewater formation. This species is called Whitella umbonata in older publications.

GASTROPODA. Several kinds of gastropods are found in our Ordovician. They are never as abundant as the brachiopods and bryozoans. All of them are small (an inch or less long) and their preservation is often poor. Only the commoner species are described here.

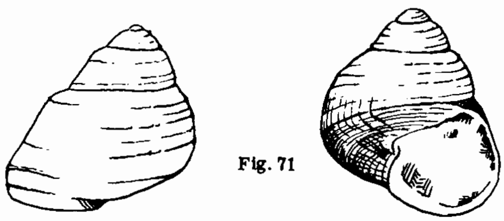

Fig. 71

Cyclonema bilix (fig. 71) looks like a top slightly askew, with many fine thread-like spiral markings and weaker axial ornamentation (i.e. parallel to the long dimension of the shell); the species occurs throughout the Richmond.

Cyclora minuta and C. parvula are like Cyclonema bilix but much smaller; they are abundant in some beds of the Cincinnatian.

Fig. 72

In Lophospira bowdeni (fig. 72) the spire is much longer than in Cyclonema and Cyclora and the whorls have a sharp keel which is characteristic; the species occurs in all Cincinnatian formations.

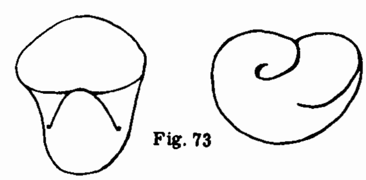

Fig. 73

In Sinuites cancellatus (fig. 73) the earlier whorls of the spire are entirely hidden by the last whorl; the species is found in all Cincinnatian formations.

CEPHALOPODA. Straight-shelled nautiloid cephalopods are common in the Ordovician of Ohio. Some nautiloids with curved shells have also been found. The spirally coiled forms are rather rare. Cephalopods are not readily identifiable from the external characters. Genera are based on the character of the siphuncle and its structure where it goes through the septa. For this reason natural sections, that is specimens in which half the shell has been worn away, showing the siphuncle, should be collected. They are not uncommon in our Ordovician. Only three species of the many found in our rocks are common enough to be mentioned here.

Endoceras proteiforme (fig. 74) has a straight shell with a siphuncle that is very large, as much as half the diameter of the shell; it is found in all Cincinnatian formations. Orthoceras dyeri is like Endoceras proteiforme but has a proportionately smaller siphuncle; it occurs in the Corryville member of the McMillan formation. Other species of Orthoceras and closely allied genera are found throughout the Cincinnatian. Gyroceras baeri (fig. 75) is one of our spirally coiled forms; an average specimen is about 4 inches across; it is found in the Liberty formation.

ANNELIDA. Worm tubes belonging to two genera are found sparingly, attached to brachiopods and other shells. In Cornulites the tube is straight or nearly so, small (up to 1 inch in length), and ornamented with irregular ring-like thickenings. It may be mistaken at first for a crinoid stem, but the fact that it increases rapidly in size and is attached to other objects will set it apart from the crinoids. Several species of Cornulites have been found in the Maysville and a few in the Richmond.

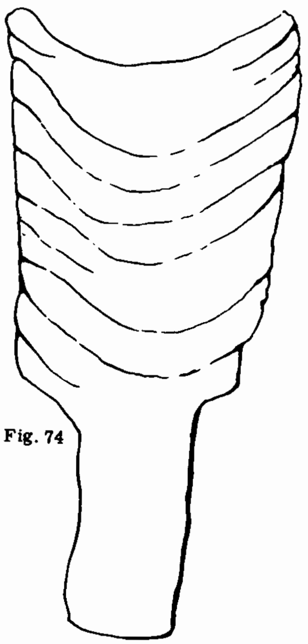
Fig. 74

In Spirorbis (see fig. 43) the shell is coiled like a snail's but is always attached to some other object, often a brachiopod, which snails never are. Spirorbis cincinnatiensis has been described from the Maysville.

OSTRACODA. Shells of these arthropods, which look like tiny pelecypods (see fig. 134), are found, sometimes abundantly, in our Ordovician. They will escape notice unless a special search is made for them, but their beauty and odd ornamentation will repay the trouble involved. Their identification is a job for a specialist.

ARACHNOIDEA. Eurypterids existed in Ohio during Ordovician time but their remains are usually rare. Megalograptus, a spectacular form with abundant spines, scales, and bristles, has been found in the Upper Elkhorn near Manchester, Ohio. An equally rare eurypterid-like animal, Neostrabops martini, has been found in the McMillan formation of Clermont County (see Caster and Macke, 1952).

TRILOBITA. Complete trilobites are rare. In some beds of the Cincinnatian they may be found in fair abundance, generally rolled up with the tail shield fitting snugly against the head. Trilobite fragments are abundant in some beds; the head and tail shields can be identified at least to genus but the thoracic (middle-of-the-body) segments are hopeless except for an expert. The following species are among the least rare.

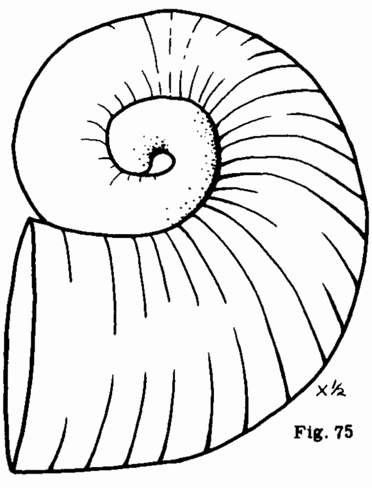

Fig. 75

Key to the Commoner Ordovician Trilobites of Ohio

(see p. 4 for use of keys)

1. a) Tail shield not segmented externally .... Isotelus
   b) Tail shield segmented externally 2

2. a) With cheek spines 3
   b) Without cheek or tail spines .... Calymene

3. a) Head shield with a broad brim, covered with coarse pits .... Cryptolithus
   b) Head shield narrow, not pitted 4

4. a) Tail shield with two long spines .... Ceraurus
   b) Tail shield with three pairs of short, blunt spines .... Ceraurinus

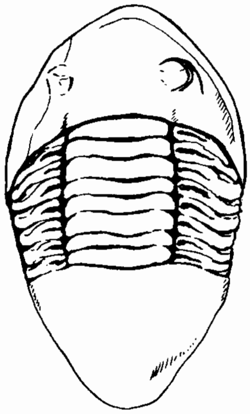

Fig. 76

Species of Isotelus have nearly smooth head and tail shields which are not segmented externally. I. maximus is large, up to more than 2 feet long; I. gigas (fig. 76) is smaller and proportionately wider Both are found in all Cincinnatian formations.

In the following species, the tail shield is segmented and the glabella (central part of the head shield) is distinct. The species can be identified by the presence and position of spines or their absence and the character of the glabella.

Ceraurus pleurexanthemus bears two long spines on the tail shield; the glabella has 4 lobes on each side; there is a prominent cheek spine and each thoracic segment ends in a spine on each side; it is a Trenton species.

Ceraurinus icarus (fig. 77) also has a 4-lobed glabella, short cheek spines close to the body, and a tail shield with 3 pairs of short, blunt spines; it is found in the Richmond.

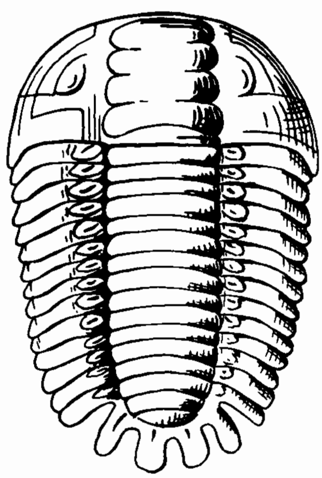

Fig. 77

Cryptolithus tesselatus (fig. 78) of the Eden is distinguished by the broad brim of the head shield which is covered with coarse pits; it has a long cheek spine on each side.

Fig. 78

Calymene meeki (fig. 79) has neither cheek nor tail spines and the brim of its head shield is narrow and not pitted; the glabella is distinct and has 2 deep lateral grooves; it is found in all Cincinnatian formations. Calymene granulosa is smaller than C. meeki and has coarse granules, like pimples, all over the surface of the body.

EDRIOASTEROIDEA. Several kinds of seat-stars are found in the Ordovician of Ohio, but most of them are very rare. One of the least rare is Agelacrinites cincinnatiensis of the McMillan formation; it looks like a starfish sitting on a cushion made of scales; the whole thing is really a single animal.

CRINOIDEA. Crinoids are abundant in the Ordovician but perfect specimens are seldom found. On the other hand, there is scarcely a formation in which crinoid stems and joints are not abundant. Crinoids of various types are illustrated elsewhere in this book. Specimens in which the cup and arms are preserved should be referred to a professional for identification. No Ordovician crinoid is common enough in Ohio to deserve description here.

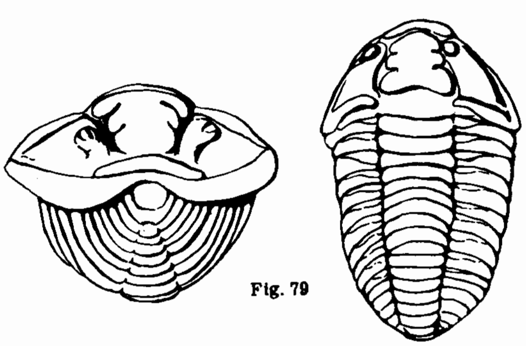

Fig. 79

STELLEROIDEA. Several species of starfish have been described from our Ordovician rocks They are so rare that finding one is a major event in a collector's life. Specimens should be referred to a specialist for identification.

GRAPTOZOA. Graptolites are found, though rarely, in our Ordovician rocks. An example is Climacograptus typicalis of the Eden, which looks like a tiny saw, but with square teeth, and is black in color.

Books for further study

Several works particularly useful in identifying Ordovician fossils are listed in the "References cited" at the end of this book. Bassler's (1915) Index lists all Ordovician and Silurian species known to that date; it is useful in locating descriptions and figures, especially of the rarer forms. Special attention should be called to the illustrations in Bucher (1945) and Cumings (1908). Ulrich (1895) has fine drawings of the pelecypods and Meek (1873) of many kinds of Ordovician fossils.

CHAPTER 5. SILURIAN FOSSILS

Collecting Localities

GENERAL. The Silurian rocks of Ohio are exposed in broken sequence from the outer edges of the Ordovician outcrop area to the Indiana line to the west, the Michigan line and Lake Erie to the north, and the Devonian contact to the east (see map, fig. 8). Many formations, most of them fossiliferous, are represented in this huge expanse of outcrop (see Table of formations, fig. 14). In general, fossils are not as abundant in our Silurian formations as in the Ordovician ones, but they are fully as varied and interesting. They have received less study than the Ordovician forms. Nevertheless, collecting in our Silurian is repaid by a rich harvest of fossils. The possibility of finding in them species unknown to science makes up for the greater difficulties of identification as compared with Ordovician forms. Only a few of the many good collecting localities in the state can be mentioned here.

HIGHLAND COUNTY. Silurian collecting localities too numerous to mention may be found in this county. Many road cuts expose good sections as do several quarries in the county, especially in the neighborhood of Hillsboro. The best collecting is in the Brassfield, Bisher, Lilley (West Union), Peebles, and Greenfield formations. Only the Alger formation is relatively poor for collecting.

CLAY CENTER. This locality in Ottawa County, northwestern Ohio, which is well known to mineral collectors is also a good locality for fossils. The Greenfield, with Whitfieldella, Hindella, and Leperditia, is exposed here as well as the Guelph dolomite with fossils too numerous to count, the commoner ones being Fletcheria, Megalomus, stromatoporoids, Trimerella, Favosites, Halysites, Orthoceras, and gastropods.

CRAWFORD. Just northwest of the town, in Wyandot County, is the type locality of the Tymochtee shaly dolomite from which numerous Leperditia and one specimen of Eurypterus have been collected.

CAREY. At this place, in Wyandot County, the Greenfield dolomite and the Guelph dolomite are exposed. The former has yielded its characteristic fossils, Hindella and Leperditia, and the Guelph a number of gastropods, cephalopods, and brachiopods.

GIBSONBURG. Quarries north of this town, in Sandusky County, have yielded characteristic Guelph fossils, especially the pelecypod Megalomus.

GENOA. The quarries north and southeast of this town in Ottawa County are in the fossiliferous Greenfield and Guelph dolomites, both of which have yielded abundant fossils.

MAPLE GROVE. The quarries around this town, 6 miles northwest of Tiffin, Seneca County, are also working in the Greenfield and Guelph dolomites, both fossiliferous.

YELLOW SPRINGS. Several localities near this town, in Greene County, are good collecting grounds. The abandoned quarry at the southeastern edge of Antioch College campus exposes the Euphemia, Springfield, and Cedarville, the latter two with Pentamerus laevis. The section in Yellow Springs Creek exposes the Osgood, Laurel, Euphemia, Springfield, and Cedarville formations, the last three fossiliferous.

MIAMI COUNTY. The quarry at Piqua exposes the Brassfield and the overlying Dayton limestone. The Brassfield has yielded few fossils but the Dayton affords good collecting. The corals Halysites, Favosites, and others are found here and several species of brachiopods. A few cephalopods and gastropods may also be collected. At the north end of the quarry the surface of the Dayton is marked by good glacial grooves.

The Commoner Fossils

PLANTS. A few poorly preserved impressions presumed to be seaweeds are found from time to time in our Silurian rocks. In a few instances where carbonaceous layers are preserved the evidence of plant origin is satisfactory.

PROTOZOA. Arenaceous Foraminifera, that is Foraminifera which built up their shell with grains of sand, have been found in the Silurian rocks of Ohio. For those interested, the paper by Stewart and Priddy (1941) is recommended.

PORIFERA. Sponges and sponge-allies are not abundant enough in our Silurian rocks to be described here.

STROMATOPOROIDEA. Two genera are common in our Silurian rocks and there may be others which have not yet been listed; the classification and identification of these organisms is difficult. In some beds, hemispherical or globular stromatoporoids are abundant and conspicuous, so much so that they have a common name: cabbage heads. Specimens 8 and 10 inches in diameter are common. Some of them are silicified and weather out of the rock, rolling down slopes or standing out prominently in the rock. The standard reference for this group is Nicholson (1875).

Forms in which there are no round bumps on the surface may be called Clathrodictyon. Only one species, C. vesiculosum, has been recorded for Ohio; it is common in the Niagaran. Forms with numerous round bumps on the surface may be referred to the genus Stromatopora of which two species are common in our Niagaran.

CONULARIDA. The surface ornamentation (fig. 80) of this group is distinctive and can be recognized even in fragments. Entire specimens are very scarce but the group is worth mentioning as fragments are found from time to time. Conularia niagarensis has been recorded from the Brassfield.

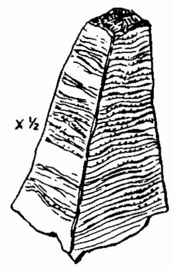

Fig. 80

ANTHOZOA. Corals in great variety and abundance are found in the Silurian rocks of Ohio. In places, erosion has cut through reefs from which corals weather out in great numbers; elsewhere, the corals are closely packed in the beds as if they had lined the sea bottom in a thick mat, as they sometimes do today. The following 18 genera are the commonest ones. Most of them can be separated by external characters but, as the following key will show, some of them must be identified by internal characters. These can often be seen in natural sections. Nicholson (1875) describes and figures most of our species.

Key to the Commoner Silurian Corals of Ohio

(see p. 4 for use of keys)

1. a) Animals in colonies of many individuals 2
   b) Animals solitary, horn-shaped 10

2. a) Tubes arranged in parallel masses 3
   b) Tubes arranged in chain-like series .... Halysites

3. a) Colonies branching or leaf-like .... Coenites
   b) Colonies hemispherical or honeycomb-like 4

4. a) Tubes polygonal in outline 5
   b) Tubes round or elliptical in outline 7

5. a) Tubes large, some as much as 3/8 inch in diameter.......... Arachnophyllum
   b) Tubes smaller than 3/16 inch 6

6. a) Walls of cup thin .... Favosites
   b) Walls of cup thick .... Thecia

7. a) Edges of tubes not touching 8
   b) Edges of tubes touching 9

8. a) Cups joined together by numerous crossbars at right angles .... Syringopora
   b) Cups not joined by crossbars but budding from each other at acute angles. . Fletcheria

9. a) Main, round, cups separated by smaller polygonal cups .... Heliolites
   b) Main cups touching, not separated by smaller, polygonal cups .... Lyellia

10. a) Septa prominent, numerous 11
    b) Septa not prominent; cup with numerous blister-like growths .... Cystiphyllum

11. a) Most of septa reach center of cup 12
    b) None of septa reach center of cup .... Amplexus

12. a) Septa with wavy edges 13
    b) Septa with straight edges 14

13. a) Septa slightly twisted at center .... Heliophyllum
    b) Septa straight throughout.................................. Zaphrentis

14. a) Cup somewhat triangular in outline .... Holophragma
    b) Cup circular in outline 15

15. a) Septa less than 50 .... Streptelasma and Enterolasma
    b) Septa more than 90.................................. Cyathophyllum

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The following descriptions are arranged in the same order as the key. The characters used in the key are not all repeated in the descriptions. The colonial forms are discussed first, then the solitary or horn corals.

Halysites is unique among the colonial forms. It has been well named "chain coral" for its tubes are arranged in rows in a chain-like network which is strikingly apparent in weathered specimens or in natural sections. H. catenularia (fig. 81) and H. labyrinthica are common in some parts of the Niagaran.

Coenites (called Cladopora in older publications) grows in branching colonies (fig. 82) made up of parallel masses of tubes radiating from the center of the branches or covering both sides of a leaf-like colony. Several species are found in our Silurian.

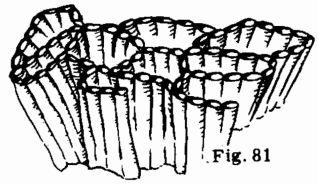
Fig. 81

Arachnophyllum (called Strombodes in older publications) grows in hemispherical colonies and has large, polygonal tubes (fig. 83). A. striatum is common in the Niagaran.

Favosites (fig. 84) is the honeycomb coral (its name is derived from the Latin for honeycomb and of all the colonial corals, it is the one that looks most like a honeycomb). The walls of the cups are thin (they are thick in Thecia). The genus is represented by 6 common species.

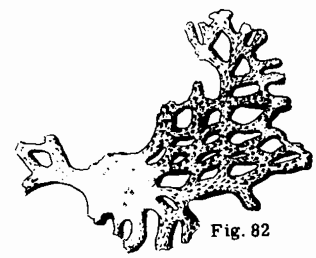
Fig. 82

Thecia minor is somewhat like Favosites but the walls of the cup are thick; it is common in the Upper Niagaran.

Fletcheria (Pycnostylus in older publications) is a colonial coral like Favosites and Thecia, but unlike these two it has cups, better tubes (fig. 85), that are not closely crowded together; the cups are without crossbars, unlike Syringopora, but they bud from each other at intervals. The floor-like diaphragms across the tubes are characteristic. Two common species are abundant in the Upper Niagaran.

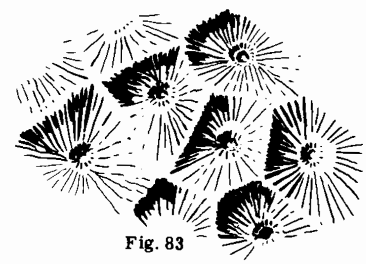
Fig. 83

Syringopora (fig. 86) suggests a mass of spaghetti with crossbars joining the tubes at right angles. The crossbars may be confused with the budding points in Fletcheria at first, but they are numerous and never continue upward to form a new cup; also, they are always at right angles to the tubes whereas the budding individuals in Fletcheria are at an acute angle to the parent tube. Two species of Syringopora are common in the Springfield and Cedarville.

Heliolites (fig. 87) is massive like Favosites but it has a distinctive appearance because the cups are round and do not touch each other. They are separated from each other by smaller, polygonal tubes. We have 3 common species.


Fig. 84

Lyellia is like Favosites but has round cups set close together and without smaller polygonal tubes between them. One species is common in the Dayton.

The remainder of our common corals are solitary or "horn" corals. Cystiphyllum (see fig. 161) is distinguished from all the others because of the blister-like growths which mask the septa in the cup. C. niagarense is common in the Niagaran.

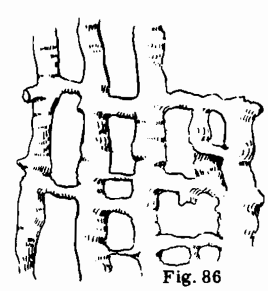
Fig. 86

The remaining horn corals all have distinct septa. Amplexus is unique in that none of the septa reaches the center of the cups; they do so in all the remaining species. A species of Amplexus is common in the Upper Niagaran.

Heliophyllum (see fig. 162) grows quite large; its septa have wavy edges, as in the next genus, and they are slightly twisted at the center of the cup. A species of Heliophyllum is common in the Upper Niagaran.

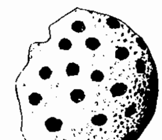
Fig. 87

Zaphrentis (fig. 88) is very similar to Heliophyllum but has straight septa, not twisted at the center of


Fig. 85

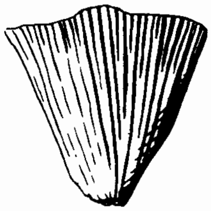
Fig. 88

the cup. Z. digoniata is common in the Niagaran.

Holophragma calceoloides (fig. 89) is the only common Silurian coral with a triangular cross-section. This characteristic is not apparent in all specimens but it is obvious in one out of three. The species is common in the Niagaran of Highland County.

Streptelasma is a common horn coral with septa less than 50 in number. S. radicans (fig. 90) is abundant in the Niagaran.

Enterolasma caliculum (fig. 91) can sometimes be distinguished from the other horn corals because it is extremely thin and long, though small. It is abundant in the Dayton and Euphemia. Enterolasma, like Streptelasma, has less than 50 septa, a character which distinguishes them from the next genus.

Cyathophyllum roadsi (fig. 91a) has more than 90 septa, slightly twisted at the center of the cup. It is common in the Niagaran of Highland County.


Fig. 89

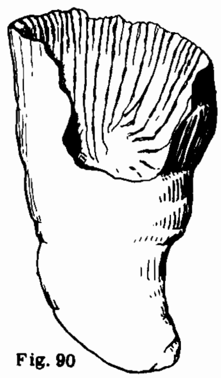
Fig. 90

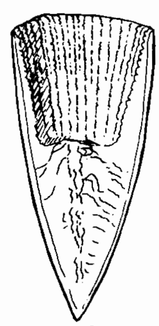
Fig. 91


Fig. 91a

BRYOZOA. In some of the Silurian beds of Ohio, bryozoans are abundant. Ten genera are common enough to be collected frequently. Several rarer ones may also be found. Of these, the first 6 genera have twig-like colonies and the last 4 are leaf-like in appearance. The following key will help identify them. See Nicholson (1875b) for descriptions.

Key to the Commoner Silurian Bryozoa of Ohio

(see p. 4 for use of keys)

1. a) Colonies twig-like, branching 2
   b) Colonies leaf-like 7

2. a) Branches hollow in the middle .... Diamesopora
   b) Branches not hollow in the middle 3

3. a) With monticules .... Trematopora
   b) Without monticules 4

4. a) Apertures close together, polygonal 5
   b) Apertures separated from each other 6

5. a) Walls of apertures thick .... Eridotrypa
   b) Walls of apertures thin .... Monotrypella

6. a) Well preserved apertures with a central ring and radiating ridges . . . Hallopora
   b) No ring or radiating ridges in apertures . . . . Chilotrypa

7. a) Colony without lace-like holes . . . . Fistulipora
   b) Colony with regularly arranged holes giving it a lacy appearance 8

8. a) Holes narrower than the branches . . . . Clathropora
   b) Holes as wide as or wider than the branches 9

9. a) Branches sharply keeled, crossbars short and wide . . . . Semicoscinium
   b) Branches angulated but not keeled, crossbars thin and narrow . . . .Fenestrellina

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Diamesopora (fig. 92) is twig-like and branching. It is unique in having hollow branches, a character which is easily seen on the broken ends of branches. Two species are common in the Niagaran.

The next 5 genera have solid branches, that is, the tubes reach to the center of each branch.

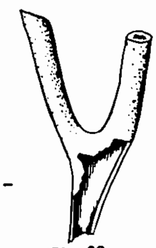
Fig. 92

Trematopora singularis (fig. 93) is distinguished by its monticules which form a series of bumps on the surface of the branches. It is common in the Niagaran.

Eridotrypa echinata (fig. 94) has no monticules and its apertures are close-set and polygonal. The walls of the apertures are noticeably thicker than in the next species. It is common in the Niagaran.


Fig. 93

Monotrypella consimilis also lacks monticules and has polygonal apertures, but their walls are thin. It is common in the Niagaran.

In Hallopora elegantula (fig. 95) the apertures are widely spaced, there are no monticules, unlike some of the Ordovician species, and in well preserved specimens the apertures have a central ring with ridges radiating from it. It is common in the Niagaran.

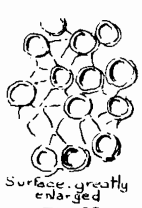

Fig. 95

Chilotrypa varia is like Hallopora but its apertures lack the central ring and ridges. It is common in the Niagaran.

The remaining genera are leaf-like. Fistulipora neglecta is distinct from all the others in that it forms irregular crusts on other objects. It is rare in the Springfield and common in the Cedarville.

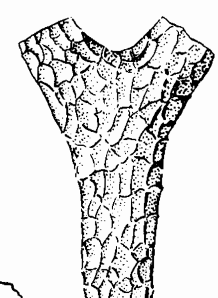
Fig. 94

The last three genera have fan-like or funnel-shaped colonies (figs. 96-98) made up of a series of twig-like branches joined by crossbars. The whole colony seems to be pierced by little windows.

In Clathropora alcicornis (fig. 96) the crossbars are as wide as or wider than the windows and there are many cells across each branch. It is common in the Niagaran.

In Semicoscinium tenuiceps (fig. 97) each branch has a sharp keel down the middle, the apertures are in 2 rows on each branch, and the crossbars are short and wide. It is common in the Cedarville.

Fig. 96

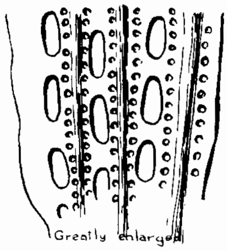

Fig. 97

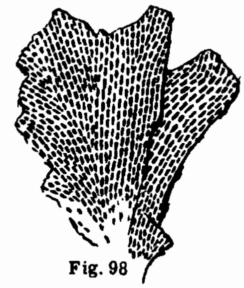
Fig. 98

In Fenestrellina (fig. 98) the branches are angulated but not keeled, and the cross-bars are thin and narrow. F. elegans is abundant in the Cedarville.

BRACHIOPODA. In the Silurian rocks of Ohio, brachiopods are almost as abundant as in the Ordovician. One species, Pentamerus laevis, is especially large, some specimens reaching a length of 5 inches. Some beds are closely packed with fine specimens of Cryptothyrella cylindrica to the exclusion of almost everything else. Still others have a variety of forms which seems almost endless. The following key will help identify the commoner genera.

Key to the Commoner Silurian Brachiopods of Ohio

(see p. 4 for use of keys)

1. a) Shell smooth or with concentric ornamentation only 2
   b) Shell with radiating and concentric ornamentation 6

2. a) Shell longer than wide 3
   b) Shell as wide as long or wider than long 5

3. a) Internal mold with a pair of stout prongs on each side .... Trimerella
   b) Internal mold without prongs 4

4. a) Beaks pointed .... Whitfieldella
   b) Beaks fat and round .... Cryptothyrella

5. a) Surface covered with short spines .... Nucleospira
   b) Surface smooth .... Meristina

6. a) Concentric ornamentation stronger than radial ornamentation 7
   b) Concentric ornamentation weaker than radial 8

7. a) Shell bent downward at margin .... Leptaena
   b) Shell not bent downward at margin .... Plectodonta

8. a) Shell with less than 40 radiating ribs 9
   b) Shell with more than 40 radiating ribs 19

9. a) Shell with sinus and fold 10
   b) Shell without sinus and fold 18

10. a) Hinge line more than half the width of the shell 11
    b) Hinge line less than half the width of the shell 12

11. a) Concentric ornamentation leaf-like and spiny .... Crispella
    b) Concentric ornamentation not leaf-like .... Platystrophia

12. a) Radial ornamentation of only a few (1 to 3) large folds, not ribs 13
    b) Radial ornamentation of more than 3 distinct ribs 14

13. a) Width and height almost equal .... Gypidula
    b) Width much less than height .... Pentamerus

14. a) Outline of shell decidedly triangular .... Rhynchotreta
    b) Outline of shell more or less rounded 15

15. a) Beaks forming a distinct point .... Stegerhynchus
    b) Beaks rounded 16

16. a) Shell wider than long .... Anastrophia
    b) Shell length and height about equal 17

17. a) Shell very fat, globe-shaped .... Uncinulus
    b) Shell not globe-shaped, only moderately thick .... Homoeospira

18. a) Hinge line more than half the width of the shell .... Dolerorthis
    b) Hinge line less than half the width of the shell .... Conchidium

19. a) Hinge line more than half the width of the shell 20
    b) Hinge line less than half the width of the shell 22

20. a) With sinus and fold 21
    b) Without sinus and fold .... Brachyprion, Fardenia, Protomegastrophia and Strophonella

21. a) Sinus and fold inconspicuous .... Parmorthis
    b) Sinus and fold strong .... Eospirifer

22. a) Valves of almost equal thickness .... Rhipidomella
    b) Valves of unequal thickness .... Atrypa

Trimerella (fig. 99) is a rather large brachiopod, generally found as internal molds which are recognizable by the four stout prongs, two on each side of the valve. Two species are common in the Guelph of Ohio.

Whitfieldella can be recognized by its smooth shell which is longer than wide, and its pointed beak. Two species of Whitfieldella are common in the Niagaran. Older publications mention a third common species of Whitfieldella which is now placed in the next genus.

Cryptothyrella cylindrica (Whitfieldella in older publications) is like that genus but the beak is fat and round, not pointed (fig. 100). Some of the shells of this species are almost cylindrical in cross-section. The species is common in the Niagaran.

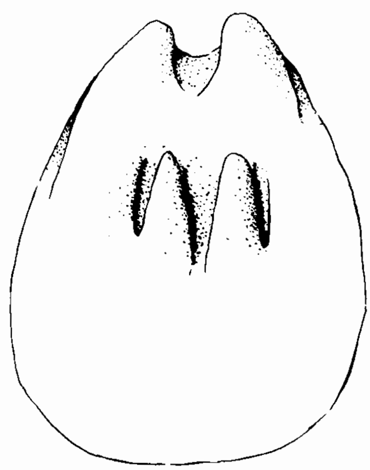

Fig. 99

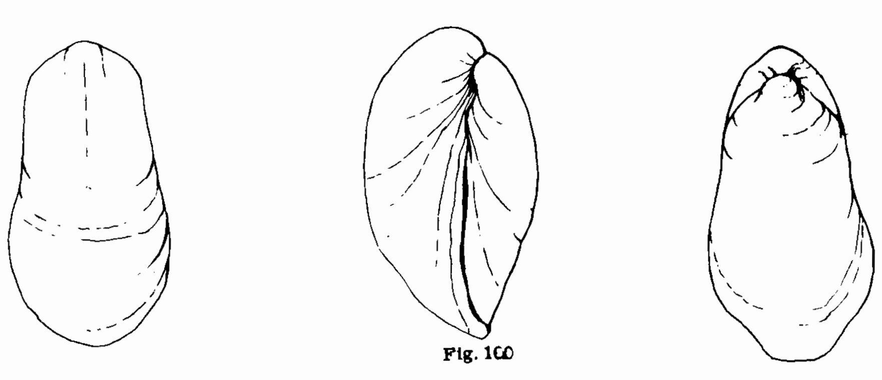

Fig. 100


Fig. 101

Nucleospira (fig. 101) is a wide little shell whose surface is covered with short spines, though they are not always preserved. Two species are common in some parts of the Niagaran.

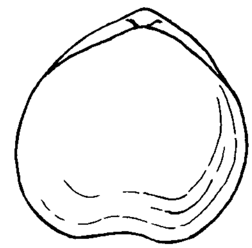
Fig. 102

Meristina maria (fig. 102) is much like Nucleospira but larger and rounder and the margin away from the beak has a small notch in it. It is abundant in the Niagaran.

The genus Leptaena (see fig. 59) is found from the Ordovician to the Mississippian in Ohio. Leptaena rhomboidalis is the Silurian species. It is unmistakable for it is the only Silurian one in which the combination of strong concentric ridges and a sharp downbending of the shell can be found. The latter feature distinguishes it from the next species. It is common in the Niagaran.

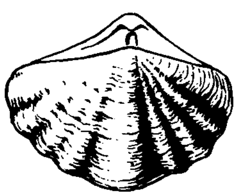
Fig. 103

Plectodonta transversalis (Plectambonites in older publications) is like Leptaena but the shell is not bent downward at the margin (see fig. 60). It is common in the Dayton and Euphemia.

Crispella crispa (Spirifer crispus in older publications) is one of a number of species whose shells suggest butterfly wings. Shells of this type are called spiriferoid, that is, Spirifer-like. They were once all lumped together in one genus, Spirifer, but it was later found that the internal structures were very different in groups of species so they were split up among a dozen or so genera. Crispella crispa (fig. 103) can be distinguished from the other Silurian spiriferoids by its concentric lamellae which bear small spines. It is common in the Niagaran.

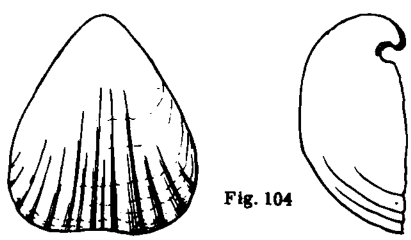
Fig. 104

Another spiriferoid, Platystrophia (see fig. 62) is abundant in the Upper Ordovician and represented by a few Silurian species. It may be distinguished from Crispella by its weaker, not leaf-like concentric ornamentation.

Gypidula galeata (fig. 104) has a short hinge line and its radiating ornamentation consists of only a few folds. The width and height of the shell are almost equal and it is a much smaller species than Pentamerus laevis with which it might possibly be confused. It is common in the Niagaran.

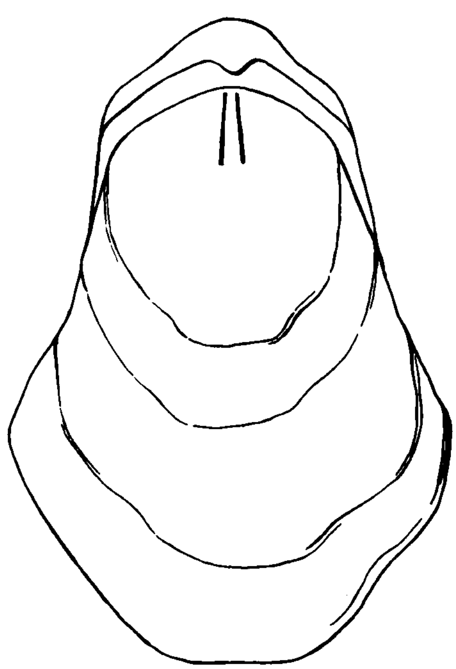
Fig. 105

Pentamerus laevis (P. oblongus in older publications) is the largest of our Silurian brachiopods (fig. 105), up to 5 inches long, and adult specimens are unmistakable. The width is always much less than the height, a feature which helps separate the genus from Gypidula. P. laevis is common in the Niagaran.

Rhynchotreta is one of several genera of small brachiopods with distinct sinus and fold. It has a decidedly triangular outline, the beak forming one point of the triangle and the opposite margin of the shell the other two. Before identifying a specimen with this genus, the figure for Stegerhynchus should be studied also. Rhynchotreta americana (fig. 106) is abundant in the Niagaran.

Stegerhynchus (fig. 107) is similar to Rhynchotreta but has a rounder outline. It differs from Anastrophia, Uncinulus, and Homoeospira in having a decidedly pointed

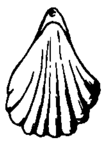

Fig. 106

beak. Two species of Stegerhynchus are common in the Niagaran.

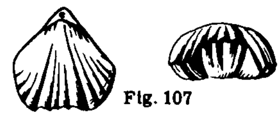

Fig. 107

Anastrophia internascens is like Stegerhynchus but is wider than long and has rounded beaks. It is common in the Upper Niagaran.

Uncinulus stricklandi is like the last 3 genera but has a globose shell which is characteristic. It is common in the Cedarville.

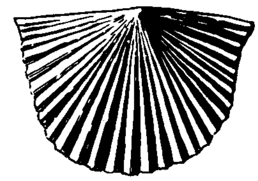

Fig. 108

In Homoeospira, another shell of the same general appearance, the shell is only moderately thick, not globose. It is common in the Cedarville.

Dolerorthis flabellites (called Orthis flabellites in older publications) has no sinus or fold (fig. 108) and is easily recognizable by its wide hinge line, rather flat valves, and strong costae. It is common in the Dayton, rare in the Euphemia and Springfield.

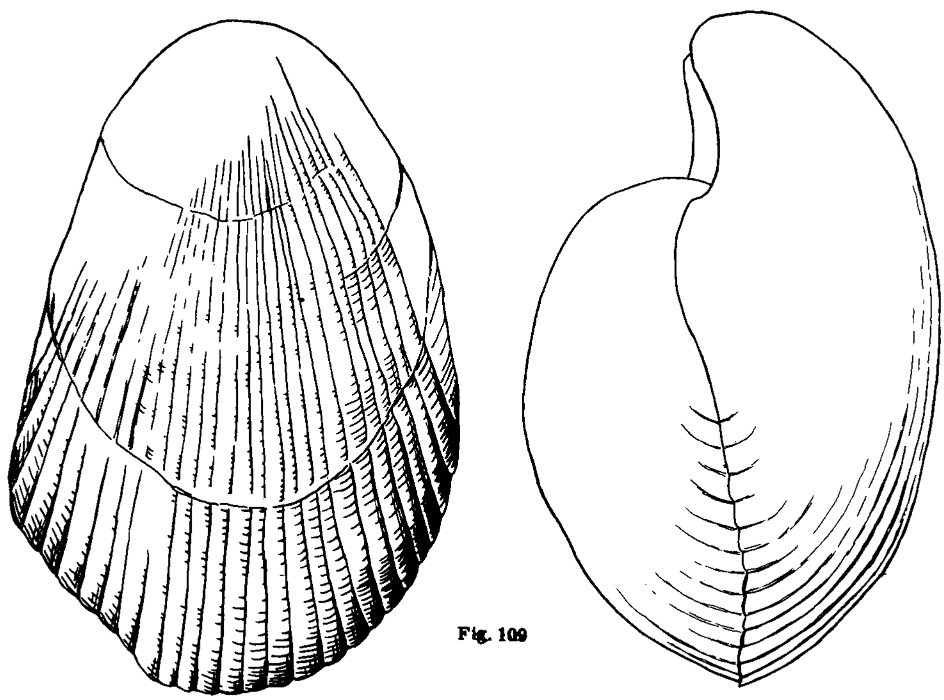

Fig. 109

Conchidium laqueatum (fig. 109) is a large brachiopod, some specimens almost as large as Pentamerus laevis. Its distinct ribs separate it easily from that species. C. laqueatum is abundant in the Upper Niagaran.

The genera Brachyprion, Fardenia (fig. 110), Protomegastrophia and Strophonella have more than 40 ribs on each valve, a wide hinge line, no sinus and fold. In addition, the hinge line has a number of small tooth-like projections, visible on single valves. They can be separated only on the basis of internal characteristics.

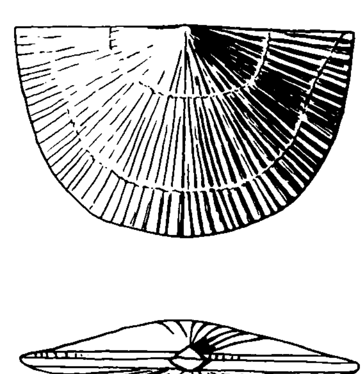

Fig. 110

The remaining genera also have more than 40 radial ribs, but they have a sinus and fold. The sinus and fold may be weak but are always apparent.

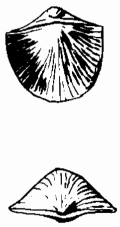
Fig. 111

In Parmorthis (Dalmanella in older publications) the sinus and fold are inconspicuous (fig. 111). Two species are common in the Niagaran.

Eospirifer is another spiriferoid (see Crispella above). It has a strong sinus and fold and its wing-like shell will easily distinguish it from Parmorthis. E. radiatus (fig. 112) is the commonest of four species found in the Niagaran.

In Rhipidomella hybrida (fig. 113) the hinge line is less than half the width of the shell and the valves are almost equal in thickness. It is common in the Niagaran.

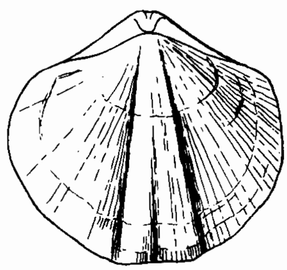
Fig. 112

Atrypa reticularis (see fig. 182) has one thick and one thin valve. It is common in the Niagaran.

PELECYPODA. Only three species are common enough in our Silurian rocks to merit notice here. Since they are very different from each other, they can be distinguished from the descriptions and figures; no key is needed for them.

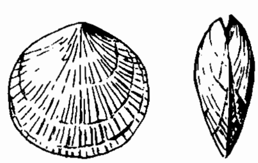
Fig. 113

Megalomus canadensis (fig. 114) is generally found as internal molds, called "beef hearts" by the quarrymen. The name is descriptive and the genus cannot be confused with any other, except possibly Amphicoelia, because of its size. Megalomus has no radial ornamentation, a conspicuous character of Amphicoelia.

Amphicoelia costata (fig. 115) is a large pelecypod (2.75 inches

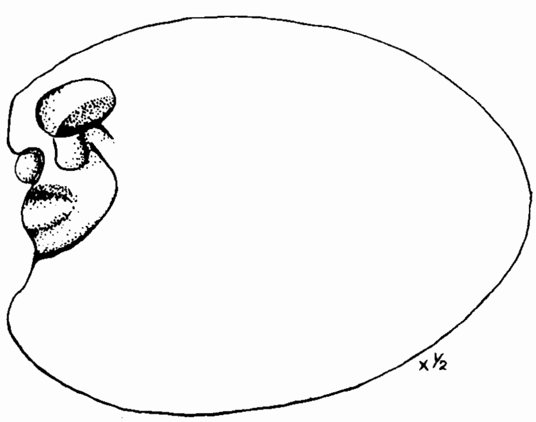

Fig. 114

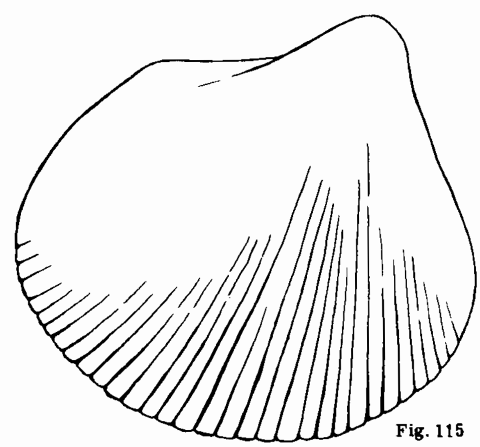
Fig. 115

long) with the beaks near one end of the shell. The surface has prominent but small radiating ribs. It is common in the Cedarville.

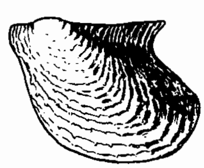
Fig. 116

Pterinea brisa (fig. 116) can be separated from both Megalomus and Amphicoelia by its wings, which these two genera lack entirely. P. brisa is rare in the Springfield and common in the Guelph.

GASTROPODA. Fossil snails are fairly numerous in our Silurian, some of them large enough to attract immediate notice, others so common in some beds that they are frequently collected. Some of the cephalopods are also coiled like snails; large coiled mollusks should be examined for septa before they are keyed out as gastropods. The commoner gastropods may be identified by the following key.

Key to the Commoner Silurian Gastropods of Ohio

(see p. 4 for use of keys)

1. a) Height of shell greater than its width 2
   b) Height and width of shell almost equal 3
   c) Height of shell less than its width 6

2. a) Whorls strongly rounded, giving the spire the appearance of a string of beads .... Hormotoma
   b) Whorls nearly flat-sided .... Coelocaulus

3. a) Aperture longer than the spire 4
   b) Aperture shorter than the spire 5

4. a) Axial ornamentation frill-like .... Phanerotrema
   b) Axial ornamentation thread-like .... Platyostoma

5. a) Whorl with strong upper, middle, and lower angulations or keels... Trochonema
   b) Whorl without keels, angulated on base only .... Cyclonema

6. a) Shell coiled in one plane or almost 7
   b) Shell not coiled in one plane 9

7. a) Inner edge of aperture free from spire .... Platyceras
   b) Inner edge of aperture not free from spire 8

8. a) Whorls angulated above and below .... Poleumita
   b) Whorls rounded, not angulated .... Tremanotus

9. a) Umbilicus wide .... Straparolus
   b) Without umbilicus ....Strophostylus

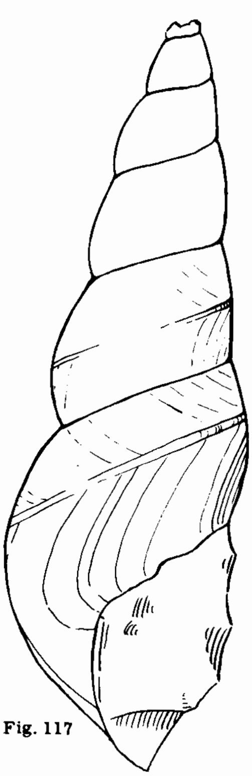

Fig. 117

Of the two long-spired gastropods in our Silurian, Hormotoma is the commoner. It can be distinguished from Coelocaulus by its much more rounded whorls which give specimens the appearance of a group of beads arranged according to size. Even in internal molds, this character is apparent and distinctive. Hormotoma whiteavesi (fig. 117) is common in the Guelph.

Coelocaulus (fig. 118) also has a long spire but its whorls are flat-sided; in internal molds, they are squarish in section, which distinguishes them from Hormotoma. Coelocaulus macrospira is common in the Guelph.

In the following four genera, the height and width of the shell are more or less equal. In the first two, the aperture is longer than the spire and the shell is therefore somewhat globular. Phanerotrema has characteristic axial ornamentation of wavy, frill-like threads. P. occidens (fig. 119) is common in the Springfield and Cedarville.

Platyostoma (Diaphorostoma in some older publications) has axial ornamentation also, but it is straight, not wavy. P. cornutum (fig. 120) is abundant in the Lower Niagaran.

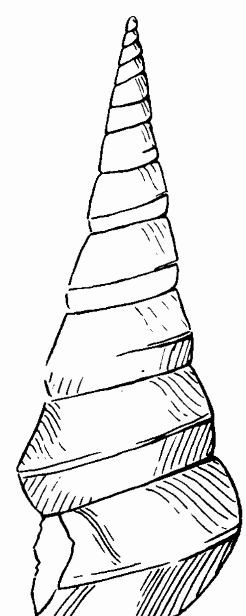

Fig. 118

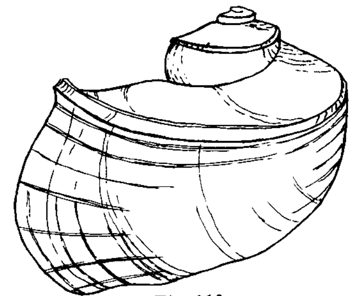

Fig. 119

In the last two genera of this group, the aperture is shorter than the spire and the shell is rather top-like. Trochonema can be recognized immediately by the sharp angulations on the top, middle, and bottom of each whorl. The angulations are so sharp in some species that they can be called keels. T. fatuum (fig. 121) is common in the Cedarville and Guelph.

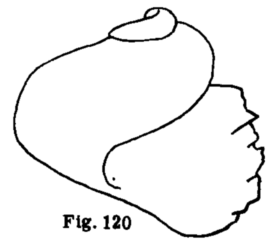

Fig. 120

Cyclonema (see fig. 71) lacks the angulations of Trochonema except for a rather faint one on the base. Its main feature is a series of small but distinct spiral threads cut by fainter axial ones. Cyclonema ohioensis is common in the Springfield.

The remainder of the genera figured are wider than high. The following three genera are coiled in one plane or almost. Platyceras has few whorls which expand rapidly; its most distinctive feature is that the edge of the last whorl is free. Platyceras angulatum (fig. 122) is common in the Niagaran.

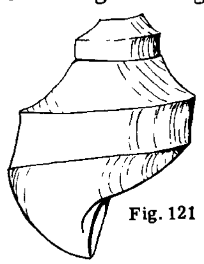

Fig. 121

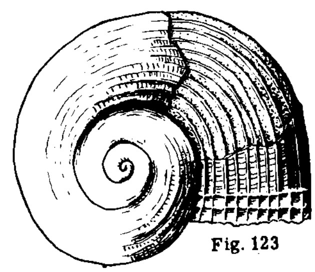

Fig. 123

Poleumita is angulated above and below. The shell surface has 2 kinds of ornamentation; the axial ornamentation is frilled on the upper surface, straight and thread-like below. P. scamnata (fig. 123) is rare in the Cedarville and common in the Guelph.

Tremanotus is one of our spectacular genera. It has a widely flaring aperture like a bugle. Even if the aperture is not preserved, the strong and numerous spiral threads will distinguish this genus from other Silurian ones. Internal molds have small bumps in a line on the outer edge of the whorl; these correspond to a series of holes in the shell like those in the modern abalone. Tremanotus alpheus (fig. 124) is common in the Guelph.

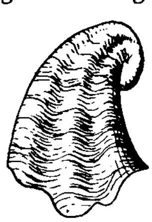

Fig. 122

The last two genera are not coiled in one plane. Straparolus (fig. 125) is shaped like a low cone; the whorls are round in section and the umbilicus is very wide. Straparolus paveyi is common in the Niagaran.

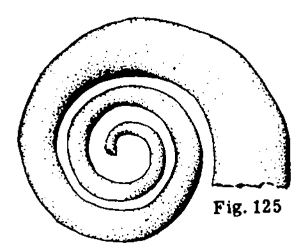

Fig. 125

In Strophostylus the shell is globose and there is no umbilicus. S. cancellatus (fig. 126) is common in the Niagaran.

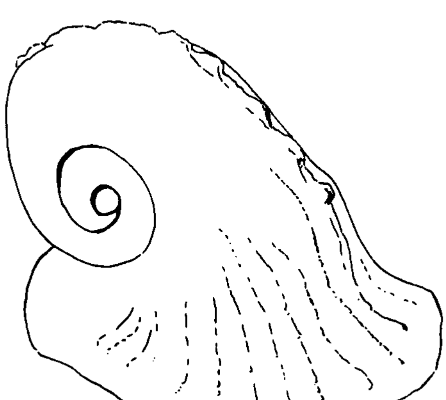

Fig. 124

CEPHALOPODA. Straight, curved, and coiled cephalopods are fairly common in our Silurian. Some of the straight forms reach large size (2 feet long in one incomplete shell in Orton Hall) and some of the curved forms have a narrowed aperture, sometimes a mere slit in the middle of the shell, ending in two lobes on the sides. This gives internal molds the appearance of small sacks of salt or cement. The following key will help distinguish the genera and some species.

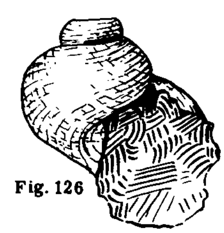

Fig. 126

Key to the Commoner Silurian Cephalopods of Ohio

(see p. 4 for use of keys)

1. a) Shell straight 2
   b) Shell curved 4
   c) Shell coiled 5

2. a) Shell with fine longitudinal striae only .... Orthoceras simulator
   b) Shell with concentric striae only .... Dawsonoceras
   c) Shell with longitudinal and concentric striae 3

3. a) Striae fine and close together .... Protokionoceras
   b) Striae fine but with wider spaces between them .... Kionoceras

4. a) Aperture two-lobed .... Phragmoceras
   b) Aperture with only one lobe .... Amphicyrtoceras

5. a) Whorls touching .... Lechritrochoceras
   b) Whorls not touching .... Discoceras

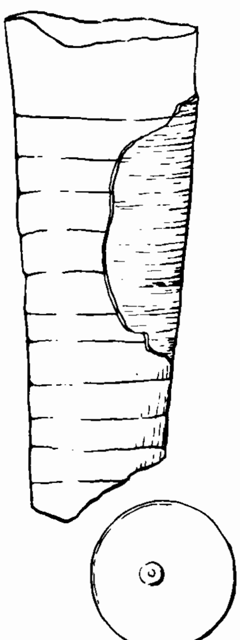

Fig. 127

Orthoceras simulator (fig. 127) has a straight shell with fine longitudinal striae only. Externally it resembles the next genus, Dawsonoceras which has only concentric striae, and Protokionoceras and Kionoceras which have both concentric and longitudinal striae. Identification in these genera will be possible only when the external ornamentation is preserved; internally they look much alike except for the characters of the siphuncle which are visible in sections.

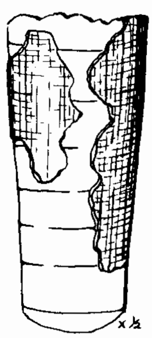

Fig. 129

Dawsonoceras annulatum (fig. 128) is easily recognized by the straight shell with concentric striae only. Even when the exterior is not preserved, the species can be recognized because of the ring-like expansions of the shell. The species is rare in the Dayton, common in the Springfield and Guelph.

Protokionoceras (fig. 129) has a straight shell with fine longitudinal and concentric striae which are close together, a feature which distinguishes it from Kionoceras in which they are farther apart. Both our species are called Orthoceras in older publications. They are common in the Cedarville and rare in the Guelph.

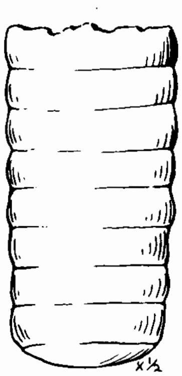

Fig. 128

Kionoceras (fig. 130) is much like Protokionoceras but its longitudinal and concentric striae are fewer and farther apart. Three species are common in the Niagaran.

Phragmoceras has a curved shell, narrowed at the top; the aperture is narrow in the center with two nearly round expansions at the sides. When the aperture is not preserved, it can be mistaken for Amphicyrtoceras. P. parvum (fig. 131) is common in the Cedarville and rare in the Guelph.

Amphicyrtoceras (Oncoceras in older publications) is like Phragmoceras but the narrow aperture has only one

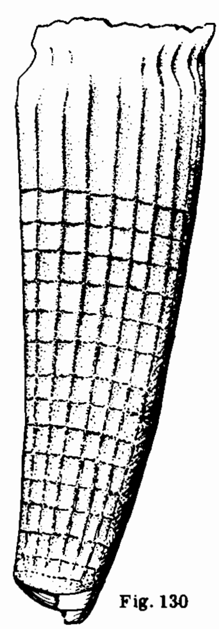

Fig. 130

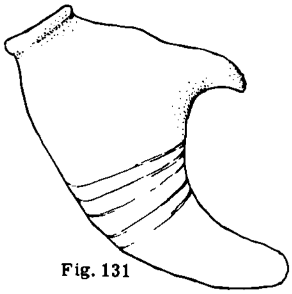

Fig. 131

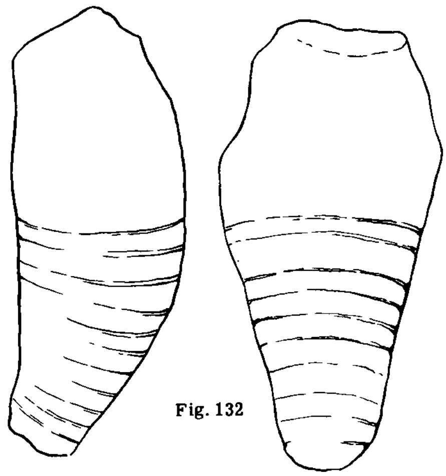

Fig. 132

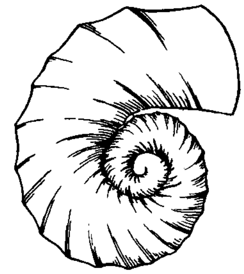

Fig. 133

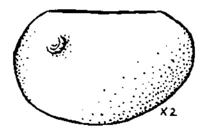

Fig. 134

lobe. A. pettiti (fig. 132) is common in the Niagaran of Highland County.

Lechritrochoceras desplainense (fig. 133) is coiled and each whorl of the shell is in contact with the preceding one. It is common in the Guelph.

Discoceras marshii (Lituites in older publications) is like Lechritrochoceras but the whorls do not touch each other. It is common in the Guelph.

OSTRACODA. Many species of ostracodes have been recorded from the Silurian of Ohio. The one most likely to be collected, because of its size and abundance, is Leperditia angulifera (fig. 134) characteristic of the Greenfield, the basal formation of the Bass Islands group, in which it is abundant. These unusually large ostracodes are bean-shaped with one straight side and on well-preserved specimens the eye-spot is visible.

ARACHNOIDEA. Eurypterids (fig. 18) are scarce in our Silurian rocks but have been reported from the Tymochtee, another formation of the Bass Islands group, near Crawford, Wyandot County. They should be searched for not only for the scientific record but for the spectacular quality of the fossils themselves.

TRILOBITA. Our Silurian trilobites are surprisingly varied. They range in size from tiny specimens to the huge species of Trimerus and in ornamentation from nearly smooth forms to elaborately spiny and pustulose ones. Tail and head shields are the parts most commonly found but an occasional complete specimen may also be expected. The key has been designed to identify both isolated tail and head shields and complete specimens. Only the commoner forms are keyed.

Key to the Commoner Silurian Trilobites of Ohio

(see p. 4 for use of keys)

1. a) Tail shield not segmented externally, head shield smooth except for the eyes .... Bumastus
   b) Tail shield segmented externally, head shield with a distinct glabella 2

2. a) With cheek spines 3
   b) Without cheek spines 5

3. a) Tail shield pointed but not prolonged into a spine .... Encrinurus
   b) Tail shield with one or more spines 4

4. a) Tail shield with a single stout, terminal spine .... Dalmanites
   b) Tail shield with 3 side spines, no terminal spine .... Cheirurus

5. a) Head shield globe shaped, tail with 3 free segments on each side .... Sphaerexochus
   b) Head shield not globe shaped, tail segments fused together.................................... 6

6. a) Center of head shield squarish, tail shield with one short terminal spine ....Trimerus
   b) Center of head shield triangular, 4-lobed; tail shield without spines .... Calymene

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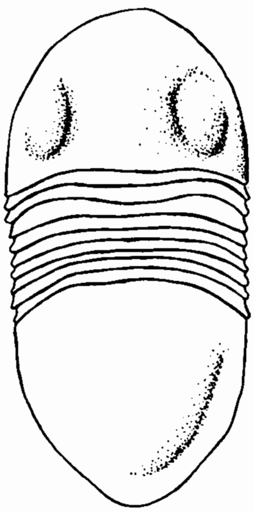

Fig. 135

Fig. 138

Bumastus is the only common Silurian genus with unsegmented tail shield and smooth head shield. B. niagarensis (fig. 135) is the commonest species.

Fig. 139

Encrinurus and all the remaining genera have segmented tail shields; in Encrinurus the tail shield is pointed but not prolonged into a spine. E. ornatus (fig. 136) is common in the Niagaran of Ohio.

Dalmanites has a tail shield with a single stout spine on the end of it. D. vigilans (fig. 137) is the common species of the Niagaran.

Cheirurus niagarensis (fig. 138) has a tail shield with 3 lateral spines, which are characteristic. It is present in the Cedarville and Guelph.

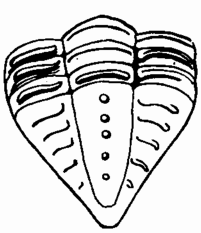

Fig. 136

Sphaerexochus romingeri (fig. 139) has a tail shield with 3 free segments; its head shield is globular and the glabella is widest in the front. It is common in the Cedarville and Guelph.

Trimerus delphinocephalus (Homalonotus in older publications) is a large species (fig. 140); the glabella is squarish, unlobed, and not globe-shaped; there is one short terminal spine on the tail. It is common in the Niagaran of Highland County.

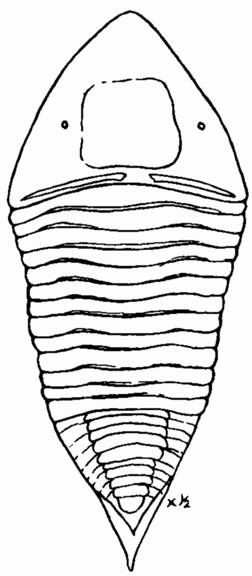

Fig. 140

Fig. 137

Calymene (see fig. 79) is smaller than Trimerus, has no terminal spine on the tail shield. The glabella is narrowest in front and 4-lobed. C. niagarensis is is common in the Niagaran.

ECHINODERMA. Cystoids and crinoids are common enough in some of our Silurian beds to require notice here. Entire specimens are rare and the arms are generally not preserved. In this state, cystoids and crinoids are not easy to separate; therefore, both groups have been keyed together here and treated separately afterwards. See Busch (1943) for a more extensive discussion.

Key to the Commoner Silurian Echinoderma of Ohio

(see p. 4 for use of keys)

1. a) Cup longer than wide... 2
   b) Cup more or less globular, about as long as wide 5

2. a) Outline of cup regularly oval .... Megacystites
   b) Outline rounded-triangular 3

3. a) Plates few (13 only) .... Stephanocrinus
   b) Plates more than 13 4

4. a) Top of cup flat.. .... Periechocrinites
   b) Top of cup tapering to a point .... Calliocrinus

5. a) Arm bases projecting sideways from edge of cup 6
   b) Arm bases not projecting sideways from edge of cup 9

6. a) Larger plates convex .... Habrocrinus
   b) Large plates nearly flat 7

7. a) Plates striated or with rows of tubercles 8
   b) Plates not ornamented .... Periechocrinites

8. a) Plates striated .... Marsupiocrinus
   b) Plates with 5 radial and many concentric rows of tubercles ...... Caryocrinites

9. a) Plates convex, with ridges radiating from the center......... Stribalocystites
   b) Plates flat and plain 10

10. a) Cup conical ....Eucalyptocrinites
    b) Cup globe-shaped 11

11. a) Cup more than 3/4 inch in diameter .... Lecanocrinus
    b) Cup less than 3/4 inch in diameter .... Pisocrinus

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CYSTOIDEA. The following descriptions include one genus of the subclass Blastoidea, treated in some books as a separate class.

Megacystites greenvillensis (Holocystites in older publications) is regularly oval and has rows of wart-like bumps along the edges of the plates (fig. 141). It is found in the Guelph.

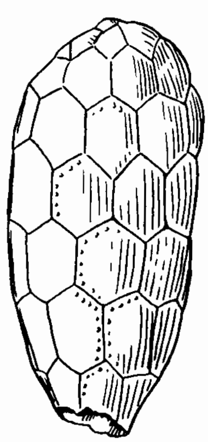


Fig. 141

Stephanocrinus elongatus (fig. 142) belongs to the subclass Blastoidea. It has only 13 plates on the cup and the upper ones are forked. The cup is flat or pointed on top. It is found in the Niagaran.

Caryocrinites ornatus (Caryocrinus in older publications) has conspicuous arm bases; (fig. 143) the plates are flat, each with 5 radiating and many concentric rows of tubercles on each plate. It is fairly common in the Cedarville and less so in the Guelph.

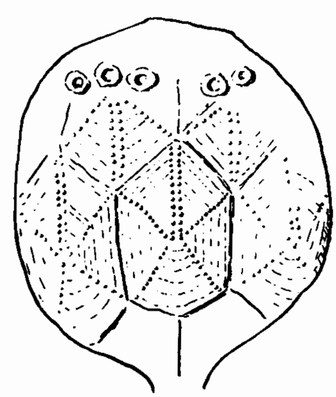


Fig. 143

Stribalocystites gorbyi (fig. 144) is characterized by its convex plates. It occurs in the Cedarville.

Fig. 142

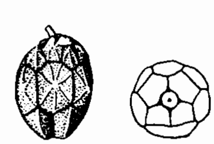


Fig. 144

CRINOIDEA. A key to both crinoids and cystoids has been given at the beginning of this section. The commoner genera and species of crinoids follow.

Calliocrinus has a cup that tapers to a point on top. It has more than 13 plates and a rounded triangular outline. It occurs in the Cedarville ville.

Habrocrinus benedicti (fig. 145) has conspicuous arm bases that project sideways. The plates are convex but have a depression in the center of each one. It is found in the Cedarville and Guelph.

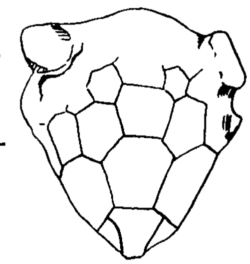


Fig. 145

Marsupiocrinus praematurus (Marsipocrinus in older publications) has conspicuous arm bases (fig. 146). The plates are flat and striated from the center outward. It occurs in the Cedarville and Guelph.

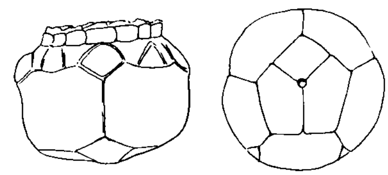


Fig. 146

In Periechocrinites (fig. 147) the shape of the cup may be elongated or globular, hence it is keyed under both groups. The cup is flat on top, the arm bases are prominent, and the plates are flat and plain. P. tennesseensis occurs in the Cedarville.

Eucalyptocrinites (Eucalyptocrinus in older publications) has arm bases but they do not project sideways. The plates are flat or slightly convex, the body conical, not globe-shaped as in the next two genera. Eucalyptocrinus crassus (fig. 148) is found in the Niagaran.

Lecanocrinus has inconspicuous arm bases, a globe-shaped cup, and flat plates. It is larger than Pisocrinus, being always more than 3/4 inch in diameter. Lecanocrinus waukoma (fig. 149) is found in the Cedarville and Guelph.

Pisocrinus is like Lecanocrinus but smaller - always less than 3/4 inch in diameter. P. gemmiformis occurs in the Lower Niagaran.

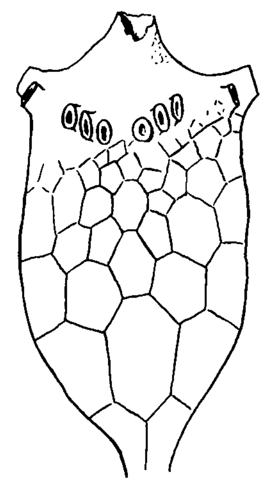


Fig. 147

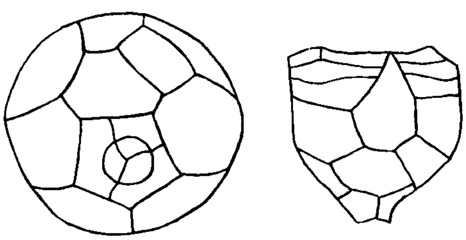


Fig. 149

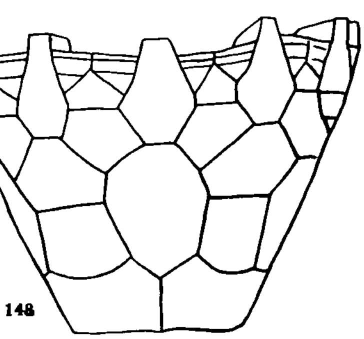


Fig. 148

Books for further study

Bassler's (1915) index lists all Ordovician and Silurian species known to that date; it is useful in locating descriptions and figures, especially of the rarer species. Meek (1873) and Hall and Whitfield (1875) describe and figure many of our Silurian species. Several Indiana Geological Survey reports (see especially Kindle and Breger, 1904) have descriptions and figures of Silurian species which are found in Ohio as well as in Indiana. Many of our Silurian species were first described in Canada. The works of Billings (1865) and of Whiteaves (1906) are particularly helpful but they are rare and have long been out of print.

CHAPTER 6. DEVONIAN FOSSILS

Collecting Localities

In the curving band of Devonian exposures that runs from south-central to northeastern Ohio (see map, fig. 8), collecting localities are so numerous that specific discussion of them is not necessary. Numerous quarries have been opened in this area and many of them are still good collecting grounds. The same is true of the creeks and runs that flow into the Scioto and Olentangy Rivers.

Over most of the state the Devonian rocks comprise four formations; the Columbus and Delaware limestones below, and the Olentangy and Ohio shales above. Several thin "Bone Beds" (Wells, 1944) occur in the limestones. These interesting layers are packed with tiny scales, spines, and teeth of fish. They also contain abundant foraminifera, scolecodonts, ostracodes, and plant spores. Such concentrations of fossil material have been explained as marking times of pause in deposition and a slight erosion of the sea bottom, washing away the mud by gentle wave action and leaving the fossils behind. Although bone beds are more or less local phenomena, the stratigraphic positions of several of the major ones are well established and they have been mapped over considerable areas. One of the best known bone beds is that at the top of the Columbus limestone in central Ohio. Another is about 25 feet above the base of the Delaware limestone in a layer containing abundant specimens of the "button coral," Hadrophyllum d'orbignyi." Another bone bed is exposed in the quarries at East Liberty, Logan County, in the top of the Columbus limestone where this formation is overlain disconformably by the Ohio shale.

Devonian rocks are exposed in several northwestern Ohio counties. The Dundee limestone throughout this area yields abundant fossils; an example is the Whitehouse quarry, near Whitehouse, Lucas County, and there are several others.

The most attractive locality, from the paleontologist's standpoint, is Silica, Sylvania Township, Lucas County, where the Silica formation (named for the village) crops out. The quarries are north of the village of Silica and have yielded beautifully preserved and abundant fossils for many years. Permission of the quarry owners MUST be obtained before entering them. Some of the best collecting is to be found in the older parts of the quarry, where the rock has been weathering for a long time and loose specimens can be picked up. The fauna of the Silica formation has been described by Stewart (1927, 1930, 1940) and her works should be consulted for further details. The lower part of the Silica formation is called the "Blue limestone" in older publications. Detailed descriptions of the localities in this area will be found in Ehlers, Stumm, and Kesling (1951).

The Commoner Fossils

PLANTS. Plant remains are extremely rare in our Devonian marine limestone and limy shales. They are found occasionally but are too poorly preserved for identification.

In the Devonian black shales, tree trunks, branches, twigs and spore-like fossils are abundant in places. The tree trunks usually can be identified with the genus Callixylon and specimens 2 to 3 feet in diameter have been found. Branches and twigs of smaller size, 3 to 4 inches in diameter, squashed flat but still recognizable, are common in parts of the Ohio shale. The numerous ridges across the branches are characteristic. See Berry (1932); Hoskins and Blickle (1940).

On some bedding planes of the Ohio shale innumerable tiny, yellowish, disk-shaped objects may be found. These have been called Tasmanites (Sporangites in older publications) and are probably the spore coats of a plant otherwise unknown. Large spore cases of different shape (fig. 150) from the same beds may be called Foerstia. These probably represent remains of a type of marine alga.

Fig. 150

PROTOZOA. Foraminifera have been recorded from the bone beds of the Columbus and Delaware limestones by Stewart and Lampe (1947). The bone bed species are arenaceous forms, that is, forms built up of sand grains. They are all microscopic in size.

PORIFERA. Sponge spicules are fairly common in our Devonian limestones, especially in the bone beds, but they are inconspicuous and not likely to attract attention. Whole sponges are very rare.

STROMATOPOROIDEA. Three genera of stromatoporoids are common in our Devonian limestones, especially in the coral-bearing beds. The generic and specific characters are internal but some genera can be recognized in natural sections. If you have the side of a specimen, wet it, and the structure will show up better. Nicholson (1875) has descriptions and figures of most of our species.

Stylodictyon can be identified because of the rather regular pillar-like structure of the cross-section which is caused by the upbending of successive layers. The pillars are continuous throughout most of the thickness of the colony. S. columnare is found in the Columbus limestone.

Syringostroma has larger pillars than Stylodictyon but they are less persistent. Syringostroma densa is recorded from the Columbus limestone.

Stromatopora has parallel layers, without the pillars of the first two genera. Star-shaped groups of radiating grooves can often be seen on the surfaces, as well as low, rounded bumps. Three species are found in the Columbus limestone.

CONULARIDA. This small group of animals, probably Hydrozoans, has been discussed and figured in the Silurian chapter (fig. 80). They are rare in our Devonian rocks.

ANTHOZOA. The Middle Devonian of Ohio has long been famous for its abundant and well preserved corals. They have been described and figured by Stewart (1938) whose work should be consulted for identification of species. Nicholson (1875) gave descriptions and figures of most of our species also.

Coral reefs have been cut through, either by erosion or quarrying, in many localities in central and northern Ohio; many of them afford good collecting for corals. Both colonial and horn corals, some of them of large size, are included in our fauna, as well as the unique "button coral" (Hadrophyllum), really a horn coral with a very rudimentary cup. Only the commoner genera are listed here. They are keyed according to external characters but, as for all fossil corals, they are distinguished mainly on internal features. See Stumm (1949) for revision of genera and families.

Key to the Commoner Devonian Corals of Ohio

(see p. 4 for use of keys)

1. a) Animals in colonies of many individuals 2
   b) Animals solitary 10

2. a) Tubes arranged in parallel masses 3
   b) Tubes arranged serially .... Aulopora, Ceratopora, Romingeria

3. a) Colonies branching or leaf-like.. 4
   b) Colonies hemispherical or honeycomb-like 5

4. a) Intervals between the cups wider than the cups themselves.......Trachypora
   b) Intervals between the cups narrower than the cups themselves ..... Coenites

5. a) Tubes polygonal in outline 6
   b) Tubes round or elliptical in outline..................................... 7

6. a) Tubes large (some as much as 3/8 inch in diameter)...........Hexagonaria
   b) Tubes all smaller than 3/16 inch ....Favosites, Emmonsia

7. a) Edges of cups not joined together...................................., 8
   b) Edges of cups joined together by ring-like expansions ....Eridophyllum

8. a) Tubes free except where one branches off from another.....Cylindrophyllum
   b) Tubes free, joined by distinct crossbars.............................. 9

9. a) Diameter of tubes less than 1/8 inch ....Syringopora
   b) Diameter of tubes more than 1/8 inch....................Synaptophyllum

10. a) Coral button-shaped....................................... Hadrophyllum
    b) Coral horn or tube-shaped ....,11

11. a) Cup horn-shaped..., 12
    b) Cup tube-shaped, much longer than wide.......... Siphonophrentis gigantea

12. a) Septa prominent, numerous 13
    b) Septa not prominent, cup with numerous blister-like growths.............................. Cystiphyllum

13. a) Septa with wavy edges 14
    b) Septa with straight edges.. 15

14. a) Septa slightly twisted at center............................. Heliophyllum
    b) Septa straight to center.................................... Zaphrentis

15. a) Only half of the septa reach to the center of the cup.........Siphonophrentis
    b) Most of the septa reach to the center of the cup....................... 16

16. a) Septa less than 90 in number............................. Heterophrentis
    b) Septa more than 90 in number .... Aulacophyllum, Cyathophyllum

---

The following common genera are arranged in the same order as the key. The first twelve are colonial forms and the last eight are solitary or horn corals. Siphonophrentis gigantea appears twice in the key because the full-grown specimens are very different from young ones and from other species of the genus.

Species of Aulopora, Ceratopora, and Romingeria are very similar. They are colonial but do not grow in colonies of parallel tubes. Instead, the tubes branch out from each other in a network of cells (see fig. 151). A. expatiata (fig. 151) is found in the Columbus limestone and three other species in the Delaware.

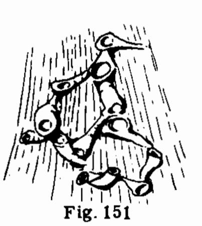


Fig. 151

The next two genera have stick-like, branching colonies. In Trachypora the cups are fewer and farther apart than in Coenites. The cups are separated by an interval wider than the cups themselves in Trachypora (fig. 152) and narrower than the cups in Coenites. Trachypora elegantula is found in the Tenmile Creek dolomite.

In Coenites (Cladopora in older publications) the cups are close together (see Trachypora above). Some of the species have stick-like, branching colonies, others are leaf-like and flat. Several species of Coenites are found in our Devonian rocks.

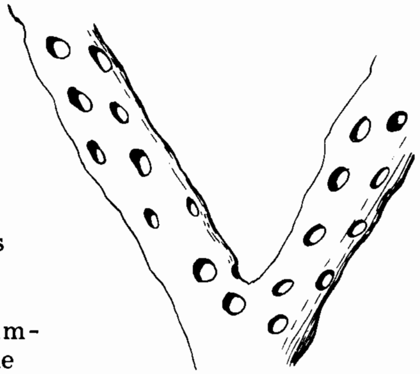


Fig. 152

Hexagonaria (Prismatophyllum and Stylastraea in older publications) is a large coral whose surface suggests a honeycomb (fig. 153) with very large cells (as much as 3/8 inch in diameter). H. prisma is the common species of the Columbus limestone.

The Devonian species of Favosites (fig. 154) are very similar to the Silurian forms (fig. 84). In Devonian collections the genus can be distinguished from Hexagonaria and its relatives by the smaller size of the tubes in Favosites. See also the next genus, Emmonsia, for forms very similar to Favosites. The genus is represented by several species in our Devonian rocks.

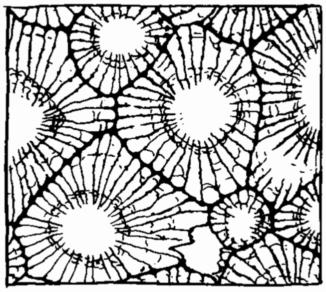


Fig. 153

In Emmonsia the tubes are usually more irregular in size than in Favosites. This character is not constant enough to be reliable in all cases but it is helpful in separating the genera. Five species have been recorded from the Columbus limestone and one from the Silica formation.

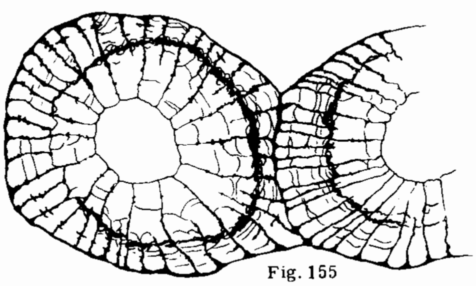


Fig. 155

The next four genera are generally similar but can be separated by the characters given in the key (nos. 7-9). Eridophyllum (fig. 155) is found in the Columbus limestone.

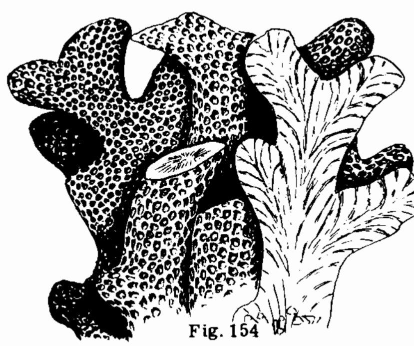


Fig. 154

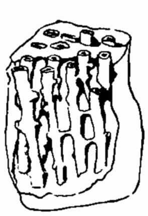


Fig. 157

Cylindrophyllum is much like Eridophyllum but the edges of the cups are not joined together. C. propinquum (fig. 156) is found in the Columbus limestone and C. panicum in the Tenmile Creek dolomite.

Syringopora (fig. 157) and Synaptophyllum are very similar except for size; Syringopora looks like a miniature of Synaptophyllum. Several species of Syringopora have been found in the Columbus limestone, the Olentangy shale, the Prout limestone, and the Silica formation.

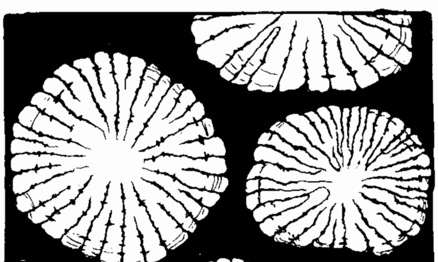


Fig. 156

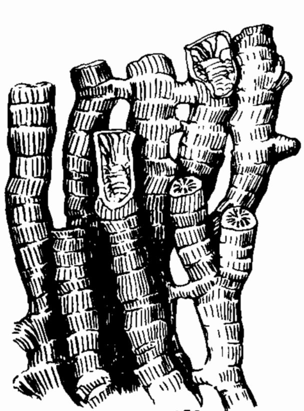


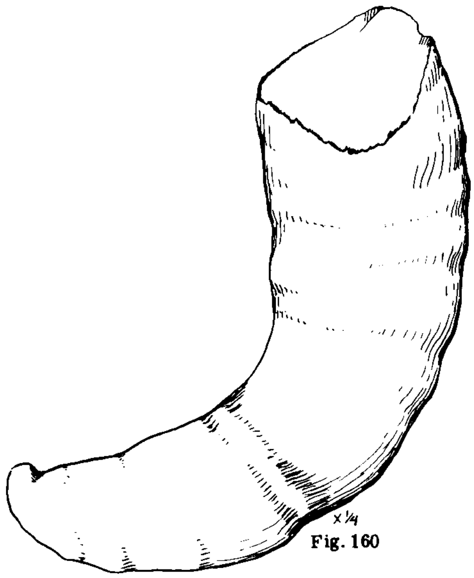
Fig. 158

Synaptophyllum (see under Syringopora for characteristics) is represented by one species, S. simcoense (fig. 158) of the Columbus limestone.


Fig. 159

Hadrophyllum d'orbignyi, the button coral (fig. 159) cannot be mistaken for any other coral. In fact, it looks so unlike other corals that its nature may be in doubt when it is first collected. The distinct septa on the upper surface will reveal its true relationships. It is rarely found in the Columbus and is abundant in some beds of the Delaware.

Full grown specimens of Siphonophrentis gigantea (fig. 160) are not hard to identify because of their huge size and tube-like cup, but young specimens and the other species of the genus are harder to separate from the more usual cup corals.


x 1/4
Fig. 160

Cystiphyllum (fig. 161) seems to have no septa at all and the cup seems to have started growing all over again several times. This is a rough description for a process called rejuvenation which occurs in many corals. Several species are found in the Columbus limestone.

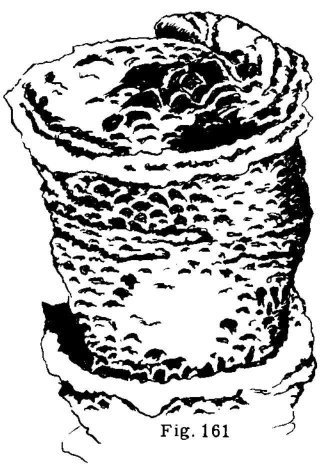


Fig. 161

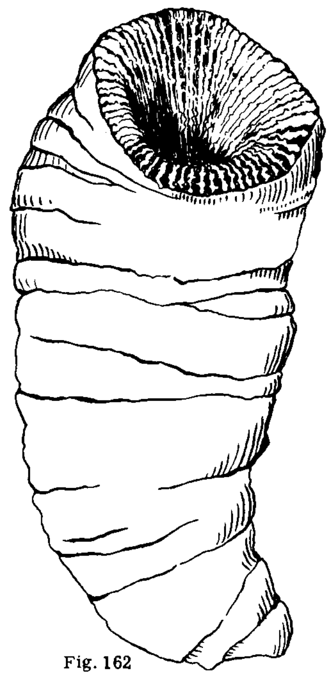


Fig. 162

Heliophyllum halli (fig. 162) is a fine coral with deep, regular cup and many septa. It is the commonest of four species in the Columbus limestone. H. proliferum is found in the Tenmile Creek dolomite.

Zaphrentis is much like Heliophyllum but has straight septa. Silicified specimens, weathered out of the rock, are particularly striking. Z. corniculum (fig. 163) is the commonest of three species in the Columbus limestone.

Heterophrentis resembles Zaphrentis but the septa have straight, not wavy, edges. Seven species have been recorded from our Middle Devonian, H. prolifica is the commonest of these.

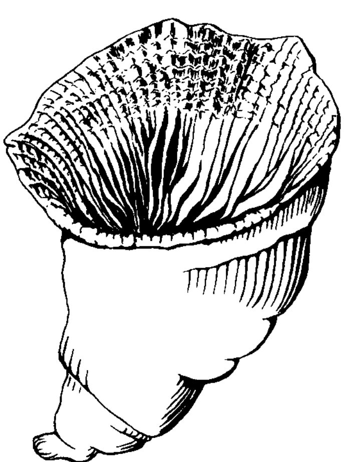


Fig. 163

In Aulacophyllum (fig. 164) and Cyathophyllum, the septa are numerous (more than 90) and reach the center of the cup. Further separation requires thin sections. Several species of these genera are recorded.

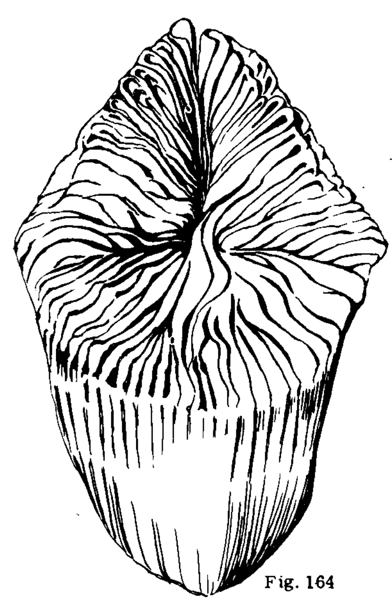


Fig. 164

BRYOZOA. The Devonian forms are rather inconspicuous because of their small size but are well worth looking for. They are abundant in some beds, notably in the shales of the upper part of the Silica formation and in the coral reefs of the Columbus limestone. Nine genera are common enough to be collected frequently but there are several rarer ones not included in the following key.

Key to the Commoner Devonian Bryozoa of Ohio

(see p. 4 for use of keys)

1. a) Colonies twig-like, branching 2
   b) Colonies leaf-like 6

2. a) Branches almost cylindrical 3
   b) Branches flattened 5

3. a) Branches of almost the same diameter throughout 4
   b) Branches made up of short joints, the joints thickened at each end .... Helopora

4. a) Branches about as thick as sewing thread (3/160 inch) ...... Acanthoclema
   b) Branches twice as thick as sewing thread (3/80 inch) .... Streblotrypa

5. a) Branching many times (like a twig with many leaves, see fig. 165).. Hederella
   b) Branching, but not as many times as Hederella (see fig. 166). Sulcoretepora

6. a) Colony with regularly arranged holes, giving it a lacy appearance 7
   b) Colony without lace-like holes .... Fistulipora

7. a) Colony made up of long rods joined by shorter cross-bars .... Fenestrellina, Semicoscinium
   b) Colony leaf-like, with widely spaced round holes .... Coscinium

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Helopora has a distinctly "jointed" appearance; the ends of the "joints" are thickened and pointed at one end which fits into a socket in the next joint. *H. inexspectata* is abundant in the upper part of the Silica formation.

Acanthoclema is stick-like, branching, but not jointed. It resembles Streblotrypa but is smaller (3/160 inch in diameter) or about the size of stout sewing thread. *A. ohioensis* is abundant in the upper beds of the Silica formation.

Streblotrypa is like Acanthoclema but larger (3/80 inch in diameter) or about the size of very fine twine. *S. anomala* is abundant in the upper beds of the Silica formation.

Hederella (fig. 165) is also stick-like but it forms a branching crust on other objects. Figures 165 and 166 will distinguish this genus from Sulcoretepora. *H. canadensis* is found in the Olentangy shale and the Silica formation.

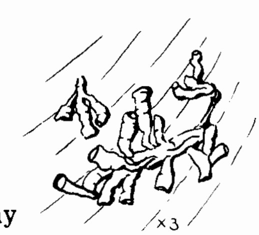

Fig. 165

Sulcoretepora (Cystodictya of older publications) is like Hederella but has a very different method of growth (fig. 166). There are not as many branches as in Hederella but the branches are stouter. See figures 165 and 166.

Fistulipora is leaf-like and forms crusts on other objects. It lacks the the lace-like openings of the next two genera. Two species are recorded for our Devonian.

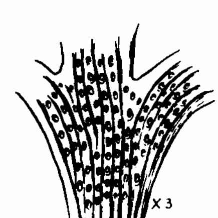

Fig. 166

Fenestrellina (Fenestella of older publications) has already been described in the Silurian chapter (fig. 98). Several species are found in our Devonian rocks.

Semicoscinium has also been described in the Silurian chapter (fig. 97).

It is similar to Fenestrellina but has sharp keels on the branches. Two species are recorded for the Columbus limestone.

Coscinium is a lace-like bryozoan also but it has no cross-bars like Fenestrellina and Semicoscinium. Instead, the leaf-like colony is pierced by rounded holes. C. striatum occurs in the Columbus limestone.

BRACHIOPODA. Our Devonian brachiopods are both varied and abundant. Several genera survive from the Silurian into the Devonian but the general aspect of Devonian and Silurian assemblages is distinct enough for easy recognition. The following key will identify the commoner genera.

Key to the Commoner Devonian Brachiopods of Ohio

(see p. 4 for use of keys)

1.	a)	Shell smooth or with concentric markings only	2
	b)	Shell with radiating and concentric markings	6
2.	a)	Beak on margin of shell	3
	b)	Beak near center of shell	5
3.	a)	With sinus and fold	4
	b)	Without sinus and fold	Lingula
4.	a)	Height greater than width	Meristella
	b)	Height and width nearly equal	Athyris
5.	a)	Beaks near (less than 1/3 of shell) the margin	Craniops
	b)	Beaks far (more than 1/3 of shell) from the margin	Orbiculoidea
6.	a)	Beaks near center of shell	Philhedra
	b)	Beaks on margin of shell	7
7.	a)	Concentric markings stronger than radial markings	Leptaena
	b)	Concentric markings weaker than radial markings	8
8.	a)	With sinus and fold	9
	b)	Without sinus and fold	14
9.	a)	Hinge line narrow (less than 1/3 of width)	10
	b)	Hinge line wide (more than 1/3 of width)	11
10.	a)	Ribs of almost equal size throughout	Camarotoechia
	b)	Ribs on fold and sinus larger than those on sides	Leiorhynchus
11.	a)	Fold and sinus weak, inconspicuous	Schizophoria
	b)	Fold and sinus strong	12
12.	a)	Ribs covered with fine radiating markings (really numerous spines)	Elytha
	b)	Ribs without fine radiating markings	13
13.	a)	One beak very large, with a triangular area as high as half the width of the shell or more under it	Cyrtina
	b)	Beaks with low triangular area under them	Spirifer
14.	a)	Hinge line short (less than 1/2 width of shell)	15
	b)	Hinge line wide (more than 1/2 width of shell)	16

15. a) Radiating markings very fine (more than 100 on one shell)....... Rhipidomella
    b) Radiating markings coarse (less than 100 on one shell).............. Atrypa

16. a) Adult shell less than one inch wide............................ Chonetes
    b) Adult shell more than one inch wide.................................... 17

17. a) Hinge line with fine tooth-like projections............................. 18
    b) Hinge line smooth .... Schuchertella

18. a) Tooth-like projections on part of hinge only ....Strophonella
    b) Tooth-like projections on entire hinge 19

19. a) Riblets of more or less equal size ....Stropheodonta
    b) Riblets of 2 sizes, one large alternating with many smaller ones.. Megastrophia

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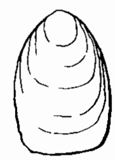


Fig. 167

Lingula (fig. 167) is a small, tongue-shaped brachiopod with a pointed beak and concentric ornamentation only. It is usually light brown in color and some of the shells weather to a light gray blue. It is one of the most interesting of all fossils, not because of its size and ornamentation but for its tremendous geologic range, Ordovician to present. It is first mentioned in the Devonian because it is not abundant in our Ordovician and Silurian rocks. Several species occur in our Devonian.

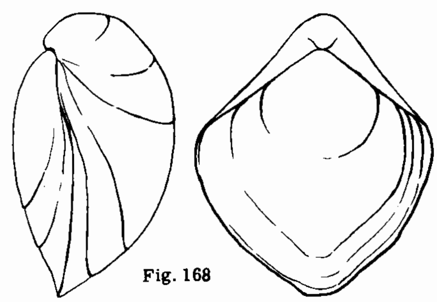


Fig. 168

Athyris (see fig. 241) and Meristella (fig. 168) are similar on the outside but have very different internal structures. Meristella is a rather plain brachiopod with a conspicuous sinus and fold. It may be separated, in most specimens, from Athyris by its proportionally greater height. Both genera are represented by several species in our Devonian.


Fig. 169

Craniops (Pholidops of older publications) (fig. 169) belongs to the same group as Lingula but is placed her to follow the same order as the key. It looks more like a limpet than a brachiopod but its internal structures reveal its true nature. It lived attached to other shells and should be looked for on other fossils. C. patina is found in the Columbus limestone.

Orbiculoidea is like Craniops but the beaks are closer to the center of the shell (fig. 170). Three species are abundant in the Delaware limestone, generally in the same beds as Lingula.


Fig. 170

Philhedra (Crania in older publications) is like Orbiculoidea and Craniops (see fig. 58) but has distinct radiating ornamentation. P. crenistriata is found in the Columbus limestone.

Leptaena has already been described in the Silurian chapter (see fig. 59) and it is possible that the Devonian species is the same as the Silurian one, L. rhomboidalis, which is recorded as common in the Columbus and Delaware limestones.

Camarotoechia is similar to Rhynchotreta and other genera of the Silurian. It can be distinguished from Leiorhynchus of the Devonian by the characters given in the key (No. 10). Several species are found throughout our Devonian.


Fig. 171

Leiorhynchus (fig. 171) is similar to Camarotoechia but the central ribs, those on the fold and sinus, are larger than the side ones which may be lacking. Several species occur in our Devonian.

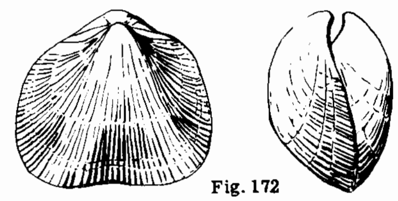


Fig. 172

Schizophoria is a neat shell of medium size with a weak fold and sinus, practically absent in some specimens. S. propinqua (fig. 172) is found in the Columbus limestone and similar species in the Olentangy and Plum Brook shales, the Silica formation, and the Prout limestone.

Elytha (Reticularia, Delthyris, and Spirifer fimbriata of older publications) is distinguished by its fine spines which may look more like fine radiating markings in poorly preserved specimens. E. fimbriata (fig. 173) occurs in the Columbus and Prout limestones.

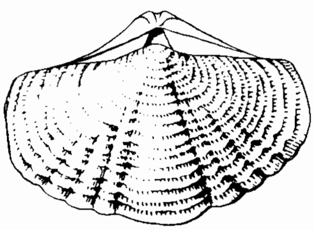


Fig. 173

Cyrtina has the general appearance of Spirifer but is characterized by having one large beak and a correspondingly large triangular area under it. Most of the Spirifers also have a triangular area under the beak but it is smaller than that of Cyrtina. C. hamiltonensis (fig. 174) is found in our Devonian.

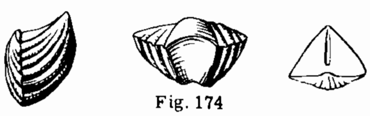


Fig. 174

Spirifer is distinguished by its characteristic form: in side view each valve suggests a butterfly with pointed outspread wings. The genus contains a great many species (figs. 175-181) which have been split up among several comparatively new genera. Strictly speaking, there are no true Spirifers in the Devonian; all our species have been transferred to other genera. We have kept the group together here since it is more easily understood than the finer genera. About 10 species are common in our Devonian rocks.

Rhipidomella has already been described in the Silurian chapter (fig. 113). Comparison of figure 113 with that for Atrypa (fig. 182) will easily separate the two genera. R. vanuxemi occurs in the Columbus, Delaware, and Silica.

Atrypa (fig. 182) is another genus found in both the Silurian and Devonian. Some older records lump most Atrypas as A. reticularis, a Silurian species, but recent workers separate the Devonian forms as distinct species.

Chonetes (fig. 183) is a small brachiopod, often abundant on slabs of Devonian limestone and shale. Its small size is distinctive. Many species are found in our Devonian.

Schuchertella (see fig. 253) is very similar to the next three genera but has a smooth hinge line whereas the next three have tooth-like projections on the hinge. Three species are common in our Devonian.

Stropheodonta (fig. 184) has teeth on the entire hinge and its riblets are of more or less equal size. Several species are common in our Devonian.

Megastrophia (fig. 185) is like Stropheodonta but its riblets are arranged in a characteristic pattern, two large ones with many smaller ones between them. M. hemisphaerica occurs in the Columbus and Delaware.

PELECYPODA. Fossil clams and scallops are scarce in our Devonian rocks as compared with the brachiopods. Only Conocardium can be called fairly common and it may not be a pelecypod at all. It appears twice in the key because some species fit both choices given in a

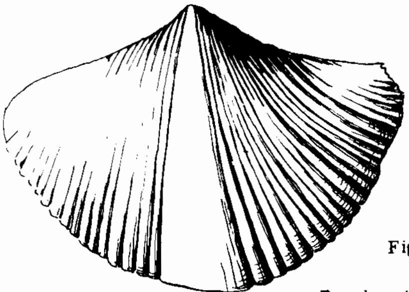
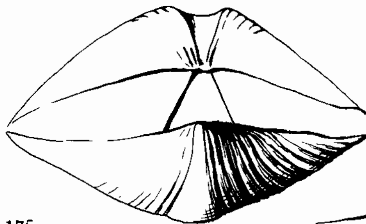



Fig. 175

Brachyspirifer audaculus

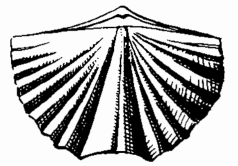



Fig. 178

Mucrospirifer consobrinus

Fig. 176

Brevispirifer gregarius

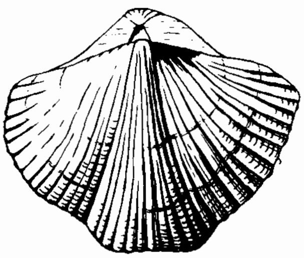


Fig. 177

Fimbrispirifer divaricata

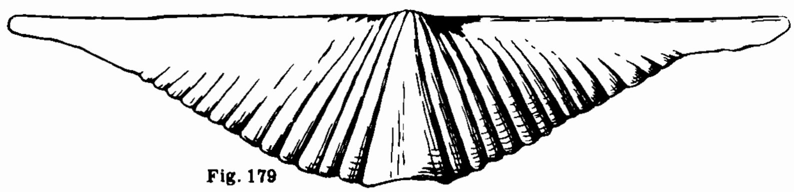


Fig. 179

Mucrospirifer mucronatus

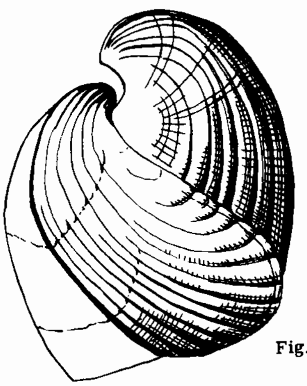
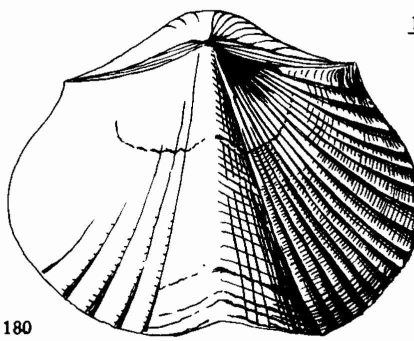



Fig. 180

Paraspirifer acuminatus

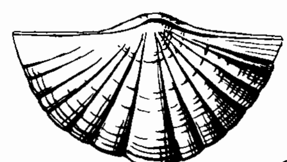
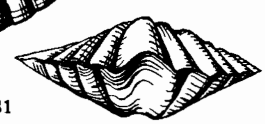



Fig. 181

"Spirifer" duodenarius

Fig. 183

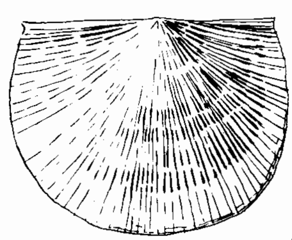


Fig. 184

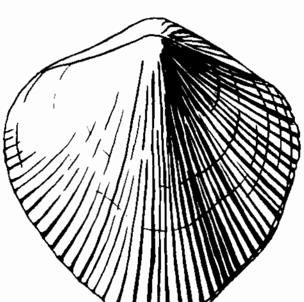
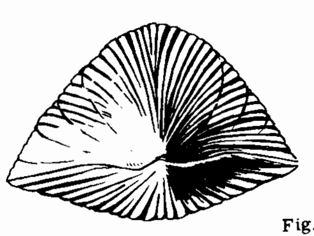



Fig. 182

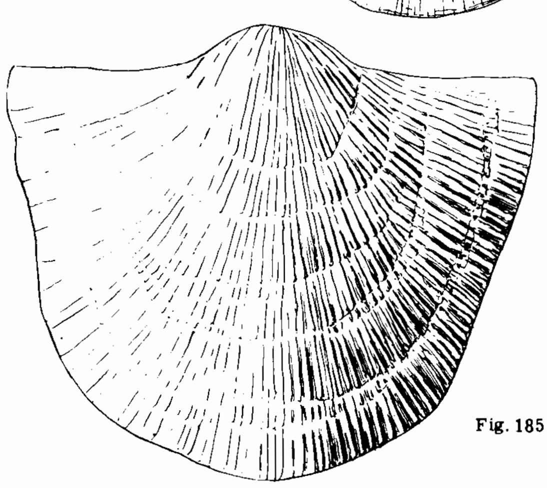
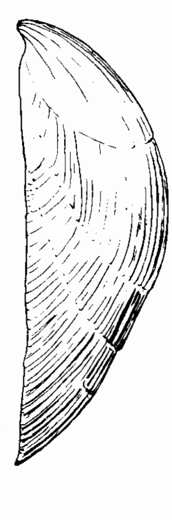



Fig. 185

section of the key. The Devonian pelecypods of Ohio have not received as much attention as the brachiopods, so do not be surprised if you find specimens that do not fit the key - you may have a new record for the state. In collecting pelecypods, both the internal and external molds should be collected when available. Also, open valves, which may show internal characters, should be watched for. The best source for Devonian pelecypod illustrations is Hall (1884, 1885).

Key to the Commoner Devonian Pelecypods of Ohio

(see p. 4 for use of keys)

1. a) Height and length of shell approximately equal (length less than 1.5 times the height) 2
   b) Length of shell 1.5 times or more than 1.5 times the height 8

2. a) Surface with concentric and radiating ornamentation 3
   b) Surface smooth or with concentric ornamentation only 6

3. a) Shell with two well developed wings 4
   b) Shell without wings 5

4. a) Ribs numerous and subequal .... Aviculopecten
   b) Ribs few and strong, with smaller ribs between them .... Cornellites

5. a) Strong ribs on entire surface of shell .... Conocardium
   b) Strong ribs on central third of shell only .... Grammysia

6. a) Shell almost round in outline .... Paracyclas
   b) Shell elongate in outline 7

7. a) Shell with an internal ridge from beak to margin (forms a groove in internal molds) .... Nuculites
   b) Shell without internal ridge .... Schizodus

8. a) Surface with strong radiating ribs .... Conocardium
   b) Surface with concentric ornamentation only 9

9. a) Shell swollen at one end .... Modiomorpha
   b) Shell not swollen at one end .... Sanguinolites

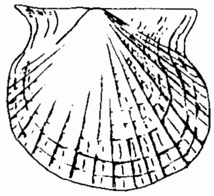


Fig. 186

In Aviculopecten (fig. 186) the shell is not oblique; it is the closest thing we have to a scallop in the Devonian of Ohio. It has both concentric and radiating ornamentation and the ribs, in the commoner Devonian forms at least, are fine and numerous. Several species occur in our Devonian rocks.

Cornellites (Pterinea in older publications) is similar to Aviculopecten but it has widely spaced, strong radial ribs. C. flabella (fig. 187) is the common Devonian species.

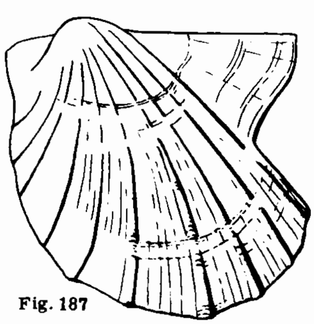


Fig. 187

Conocardium, as we have already noted, may not be a pelecypod at all, but since it looks like one and nobody is quite sure just what it is, we have included it here. The hood (fig. 188) is often preserved in our specimens and should be looked for; nobody

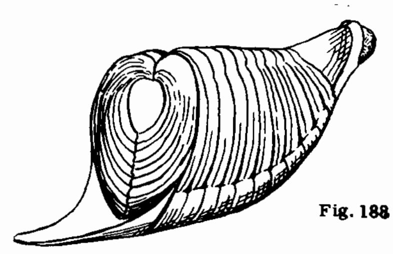


Fig. 188

knows what its function was in the living animal. Conocardium is found from the Ordovician to the Permian but in Ohio it is commonest in the Devonian. C. cuneus occurs in the Columbus and Delaware.

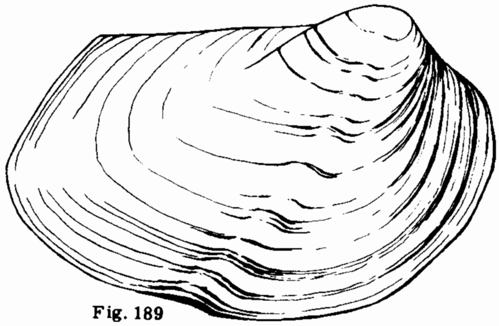


Fig. 189

Grammysia (fig. 189) seems to be cut off at one end. It is easily recognized by the ribs, of which there are only a few in the central part of the shell. Several species are found in our Devonian rocks.

Modiomorpha is very like some of our present-day river clams in appearance. The shell is swollen at the end away from the beak and it lacks the internal ridge of Nuculites. M. concentrica (fig. 190) is our common species.

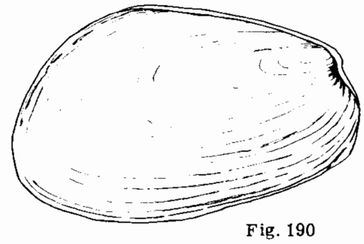


Fig. 190

The most characteristic feature of Nuculites is the internal ridge which shows as a groove in internal molds. Nuculites triqueter (fig. 191) is found in the Olentangy and Plum Brook.

Sanguinolites has closely spaced concentric ridges. It is larger and more elongate than Nuculites. S. sanduskiensis (fig. 192) is found in the Columbus.

Schizodus can be recognized by its squarish outline, evenly convex shell, thicker in the region of the beak. S. appressus (fig. 193) occurs in the Columbus, Olentangy, and Plum Brook.


Fig. 191

Paracyclas might well be called the "round clam." It is almost round in outline and has sharp, closely spaced concentric ridges. Some of the less-rounded species may belong in the genus Phenacocyclas of which one species,

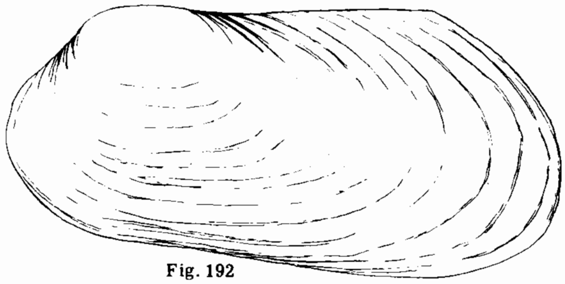


Fig. 192


Fig. 193

formerly called Paracyclas, occurs in the Dundee. Paracyclas elliptica (fig. 194) occurs in the Columbus, Delaware, and Prout.

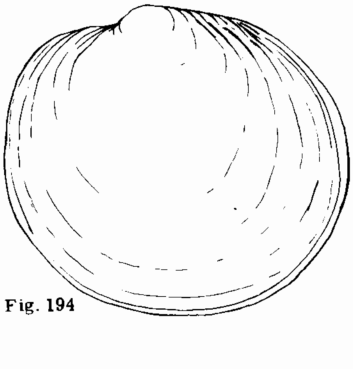


Fig. 194

GASTROPODA. Fossil snails large and small are fairly common in our Devonian rocks. As for the Silurian, the long-spired forms are described first, then the shorter-spired ones. The first six genera are higher than wide, the next five are about as high as wide, and the last seven are wider than high.

Key to the Commoner Devonian Gastropods of Ohio

(see p. 4 for use of keys)

1. a) Height of shell greater than its width 2
   b) Height and width of shell almost equal 6
   c) Height of shell less than its width 10
   d) Shell cylindrical or conical, small .... Pteropoda

2. a) Aperture more than 1/3 of the height 3
   b) Aperture less than 1/3 of the height 5

3. a) Shell keeled 4
   b) Shell not keeled, spindle-shaped .... Soleniscus

4. a) Underside of shell almost flat .... Palaeotrochus
   b) Underside of shell rounded .... Acanthonema

5. a) Whorls strongly rounded, giving the spire the appearance of a of a string of beads .... Loxonema
   b) Whorls nearly flat .... Coelocaulus
   c) Whorls keeled or angled .... Murchisonia

6. a) Whorls keeled 7
   b) Whorls not keeled 8

7. a) Strongest keel at middle of whorls .... Bembexia
   b) Strongest keel near top of whorl .... Trepospira

8. a) Aperture more than 1/2 the height of the shell 9
   b) Aperture less than 1/2 the height of the shell .... Elasmonema

9. a) Spire very low, growth lines fine .... Naticopsis
   b) Spire high, growth lines coarse .... Ptychospirina

10. a) Whorls keeled 11
    b) Whorls not keeled 15

11. a) Lip free from previous whorl; shell loosely coiled .... Platyceras
    b) Lip touching previous whorl; shell tightly coiled 12

12. a) Spire sunken below level of whorl 13
    b) Spire elevated above level of whorl 14

13. a) Keels small, numerous, and regular, beaded, the upper and lower ones scalloped .... Porcellia
    b) Two strong keels only, one basal, one upper; the surface not beaded .... Pleuronotus

14. a) Base rounded .... Mourlonia
    b) Base flattened .... Turbonopsis

15. a) Umbilicus open .... Isonema
    b) Umbilicus closed .... Naticonema

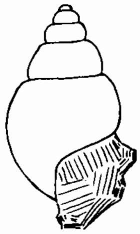


Fig. 195

Soleniscus (Macrocheilus of older publications) is higher than wide, with a spindle-shaped shell. The aperture is very narrow at the top. S. hebe (fig. 195) is found in the Columbus limestone.

Palaeotrochus is higher than wide, but not much; its top-shaped shell with a strong basal keel and coarse growth lines is characteristic. P. kearneyi (fig. 196) occurs in the Columbus limestone.

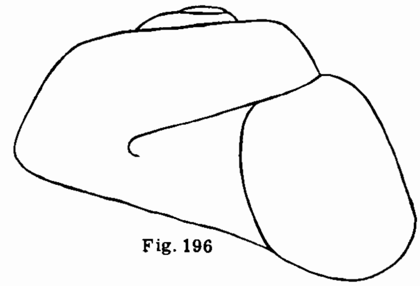


Fig. 196

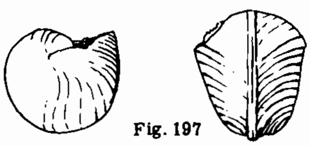


Fig. 197

Acanthonema (Bellerophon and Orthonema in older publications) is small, with keeled whorls and a rounded base; A. newberryi (fig. 197) is found in the Columbus limestone.

Loxonema and the next three genera are much higher than wide. Loxonema (fig. 198) has strongly rounded whorls that give the shell the appearance of a short string of beads. Several species have been recorded for the Columbus limestone.

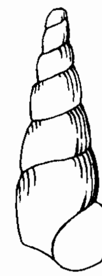


Fig. 198

Coelocaulus (see fig. 118) has a long, thin shell also but unlike Loxonema, it has flat-sided whorls. C. strebloceras is found in the Columbus limestone.

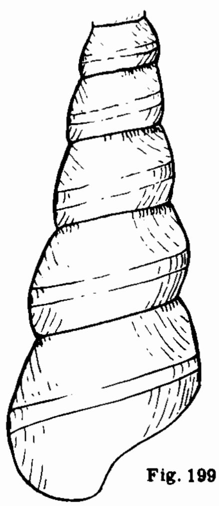


Fig. 199

Murchisonia (fig. 199) is like the last two but has keeled whorls. Several species have been recorded from the Columbus limestone.

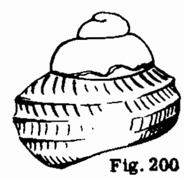


Fig. 200

Bembexia (Pleurotomaria in older publications) and the next four genera are about as high as wide. Bembexia is distinguished by its strong middle keel and the finer ones above and below it. B. adjutor (fig. 200) is found in the Columbus limestone.

Trepospira has a strong keel on top of the whorl (not in the middle, as in Bembexia) and in addition, the keel is broken up into a series of wart-like bumps. T. rotalia (Pleurotomaria in older publications) occurs in the Olentangy and Plum Brook (fig. 201).

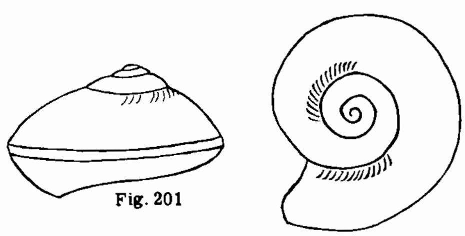


Fig. 201

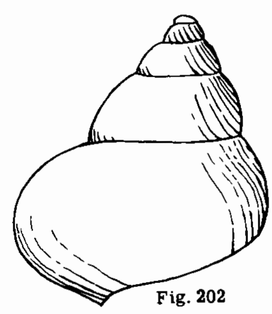


Fig. 202

In Elasmonema (Callonema of older publications) the whorls are not keeled and the aperture is less than half the height of the shell. E. bellatulum (fig. 202) is found in the Columbus limestone.

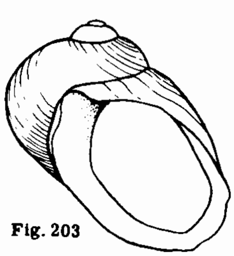


Fig. 203

Ptychospirina (Strophostylus in older publications) has a large aperture, more than half the height of the shell, and coarse growth lines. The figures for Elasmonema, Ptychospirina, and Naticopsis should be carefully compared before a specimen is referred to one of these genera. The most obvious feature is the size of the aperture which is large in all three but larger in Ptychospirina than in Elasmonema and largest of all in Naticopsis. Ptychospirina varians (fig. 203) occurs in the Columbus.

Fig. 204

In Naticopsis (fig. 204) the aperture is larger than in

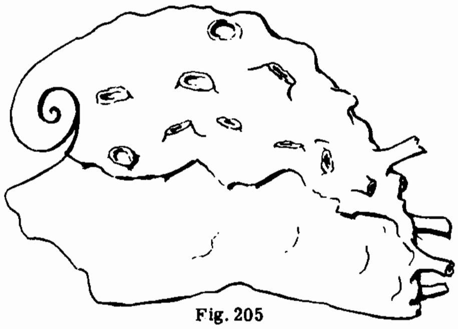


Fig. 205

the last two genera; see under Ptychospirina for distinction between these three similar genera. In addition, the growth lines in Naticopsis, when they are preserved, are very fine and the shell is very thick. Three species have been recorded from the Columbus limestone.

Platyceras has a distinctive shape which is mainly due to the rapid increase in size of the whorls (fig. 205). The external ornamentation varies all the way from nearly smooth shells, with a single low keel on the body whorl only, to forms with knobs and spines which may be as long as half the diameter of the shell or more. The lip is detached from the last whorl in most specimens. A large number of species have been recorded from our Devonian. P. dumosum (fig. 205) of the Columbus and Delaware is the commonest one.

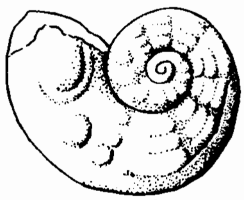


Fig. 206

Porcellia and Pleuronotus are easily separated from the other genera in our Devonian because the spire is sunken below the level of the whorls; they are coiled in one plane. Porcellia has a row of wart-like bumps on the top and bottom of the whorl and the entire whorl is covered with fine, crowded axial and spiral ridges which give the surface the appearance of bead work. Porcellia sciota is found in the Columbus and P. hertzeri (fig. 206) in the Delaware.

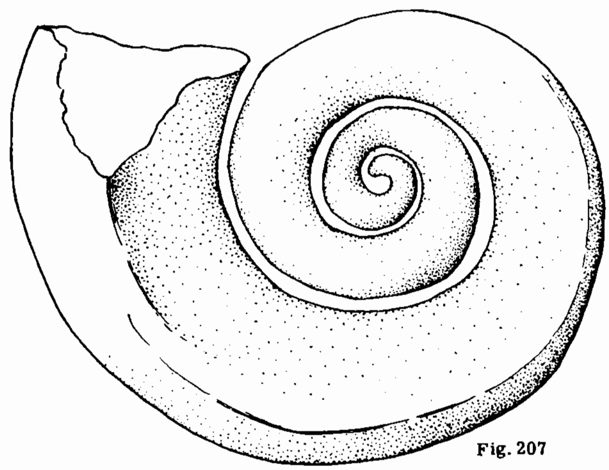


Fig. 207

Pleuronotus is like Porcellia but its ornamentation is different. The whorls are squarish in cross section, even in internal molds, and the surface has no bead-like ornamentation; instead, there are two strong ridges on the upper and lower edges of the whorl and strong, distant axial ridges. P. decewi (Euomphalus of older publications) is found in the Columbus and Delaware (fig. 207).

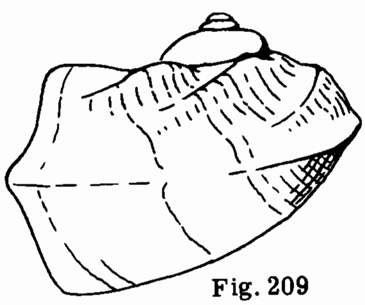


Fig. 209

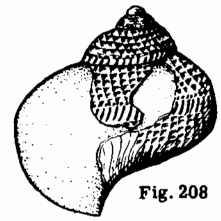


Fig. 208

In Mourlonia (Pleurotomaria in older publications) the spire is not sunken below the last whorl and the base of the shell is rounded. M. lucina (fig. 208) is found in the Columbus.

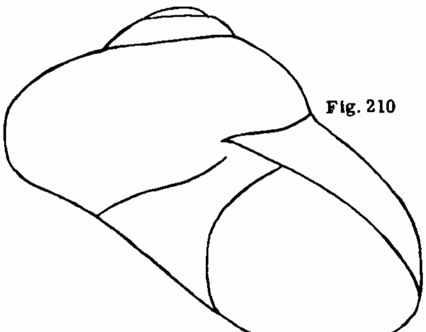


Fig. 210

Turbonopsis (Turbo in older publications) resembles Palaeotrochus but its base is not flattened, the keel is higher on the whorl, and the upper part of the whorl has a row of wrinkle-like bumps. Turbonopsis shumardi (fig. 209) occurs in the Columbus.

Isonema has unkeeled whorls and its base is flat ana sunken. I. humile (fig. 210) is found in the Columbus.

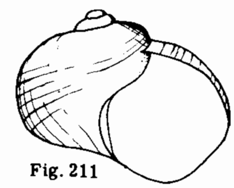


Fig. 211

Naticonema (Platyostoma of older publications is like Isonema but has a rounded base and different ornamentation. N. lineata (fig. 211) is found in the Columbus and Prout.

PTEROPODA. The next two genera have been placed in the Pteropoda, a subclass of the Gastropoda. They look more like small cephalopods than snails but they lack septa. They are sometimes found in great abundance on slabs of Devonian limestones and shales in Ohio and elsewhere.

Fig. 212

Styliolina is small, conical, and has growth lines but no longitudinal striations. A glance at the figures will separate it from Tentaculites. Styliolina fissurella (fig. 212) occurs in the Olentangy, Plum Brook, and Silica.


Fig. 213

Tentaculites is about the size of Styliolina but has distinctive rings on the shell. It looks like a small wood screw but the markings on it are not spiral but circular. T. scalariformis (fig. 213) is found in the Dundee, Columbus, and Delaware; T. bellulus in the Silica.

CEPHALOPODA. Because of their large size, some cephalopods are bound to attract your attention. They are not as common as corals and brachiopods or even gastropods, so it was difficult to decide which ones to include here and which to leave out. We hope the following key will identify the commoner kinds.

Key to the Commoner Devonian Cephalopods of Ohio

(see p. 4 for the use of keys)

1. a) Shell straight 2
   b) Shell curved .... Acleistoceras
   c) Shell coiled 5

2. a) Shell straight and smooth 3
   b) Shell with tubercles or rings 4

3. a) Septa with wavy edges; shell small, about 1/4 inch in diameter..... Bactrites
   b) Septa with straight edges; shell large, more than 1/2 inch in diameter......... Ormoceras

4. a) Ornamentation of ring-like expansions and contractions of the shell.............. Spyroceras
   b) Shell smooth except for one row of tubercles lengthwise along the shell .... Tylorthoceras

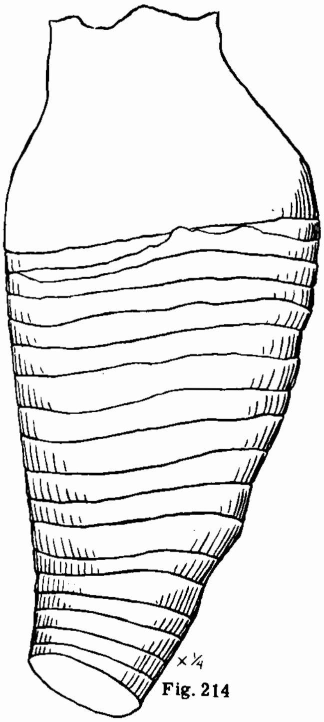
5. a) Whorls touching 6
   b) Whorls not touching 9

6. a) Umbilicus very narrow, almost closed .... Tornoceras
   b) Umbilicus wide 7

7. a) Outer edge of whorl with a row of small tubercles .... Centroceras
   b) Outer edge of whorl smooth 8

8. a) Top of whorl with a row of tubercles .... Nassauoceras
   b) Entire whorl smooth .... Gigantoceras

9. a) Whorls expanding slowly .... Ryticeras
   b) Whorls expanding quickly .... Nephriticerina


x¼
Fig. 214

Acleistoceras (Gomphoceras in older publications) has a curved shell which is widest about the middle of the living chamber and is narrower again at the aperture (fig. 214). Several species have been recorded for the Columbus and one for the Delaware.

Bactrites is one of the earliest ammonoids. It is small and straight, looking very much like a small orthoceroid but its septa have wavy edges. B. arkonensis (fig. 215) occurs in the Columbus and Plum Brook.

Ormoceras is also straight and has straight septal edges; it is a nautiloid and much larger than Bactrites. O. winchelli (fig. 216) is found in the Columbus.

Spyroceras (fig. 217) is another straight nautiloid; its distinctive feature is a series of ring-like expansions and contractions of the shell. Two species occur in the Columbus.

Tylorthoceras is straight and smooth except for a row of tubercles on one side of the shell. T. ohioense (fig. 218) is found in the Columbus.

Tornoceras (fig. 219) is a coiled ammonoid with narrow,


Fig. 215

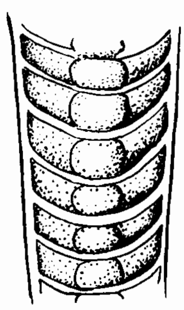


Fig. 216

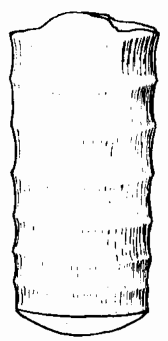


Fig. 217

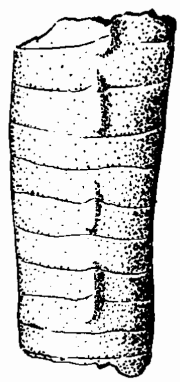


Fig. 218

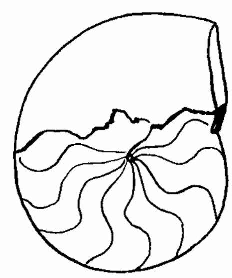
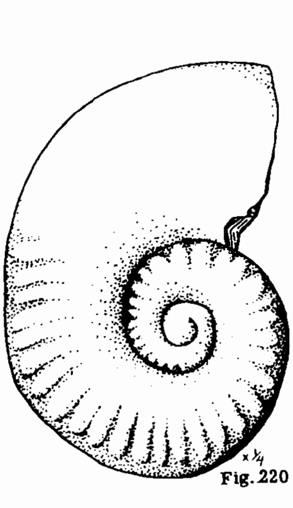


Fig. 219

almost closed umbilicus, very different from all our other coiled cephalopods which are nautiloids. Two species occur in the Columbus and one in the Plum Brook.


x¼
Fig. 220

Centroceras (fig. 220) is distinguished by the row of bumps (tubercles) on the outer edge of the whorl. Nassauoceras also has a row of bumps but they are on top of the whorl. C. ohioense occurs in the Columbus and Delaware.

Nassauoceras (Gyroceras in older publications) has a row of tubercles on top of the whorl (fig. 221); see Centroceras, above, for another genus with tubercles dif-

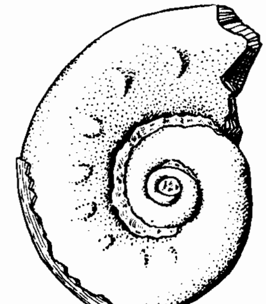
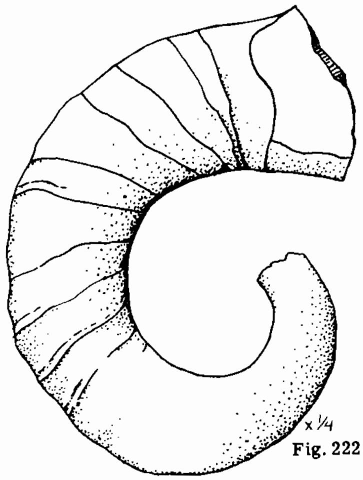


Fig. 221

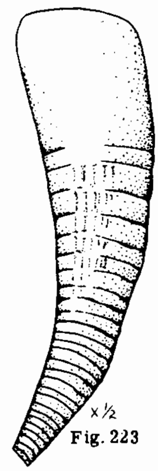


x 1/4
Fig. 222

ferently placed. N. seminodosus is found in the Columbus.

Gigantoceras is coiled and has smooth whorls, without tubercles, which distinguishes it from Centroceras and Nassauoceras. G. inelegans occurs in the Columbus and Delaware.

Ryticeras (fig. 222) has a loosely coiled shell whose whorls do not touch. One of our species has a series of frill-like expansions of the shell which are very striking. When the shell is cut through in quarrying blocks, the frills look like spines; one specimen of this kind is in the outer wall of the State House in Columbus, to the right of the front door. R. cyclops is the commoner species of the Columbus limestone.



x 1/2
Fig. 223

Nephriticerina has a shell of few whorls, not touching as in Ryticeras, but the whorls expand very quickly. Comparison of the figures will distinguish it from Ryticeras. N. metula (fig. 223) occurs in the Columbus.

ANNELIDA. Worm tubes are found sparingly in our Devonian rocks. They belong to the genus Spirorbis, described in Chapter 4 (see fig. 43).

OSTRACODA. These tiny arthropods are abundant in some beds of the Ohio Devonian but they are not easy to identify, even under the microscope. Many species occur in the Silica, Olentangy, and Plum Brook shales and in the bone beds of the Columbus limestone. See Stewart (1936), Stewart and Hendrix (1945), and Stewart (1950).

TRILOBITA. Heads and tails of trilobites are not too rare in our Devonian. Finding a complete specimen, like Phacops rana milleri (frontispiece) is quite an event. Enrolled specimens of this species with the tail touching the head are more frequent than those lying flat. The Silica formation of northwestern Ohio has long been known as a good collecting ground for trilobites and that is where the one figured in our frontispiece came from. The following key will serve both for isolated heads and tails or complete specimens.

Key to the Commoner Devonian Trilobites of Ohio

(see p. 4 for use of keys)

1.	a) Specimen with only the head preserved	2
	b) Specimen with only the tail preserved	7
2.	a) Head with spines	3
	b) Head without spines	Phacops
3.	a) Head with a central spine on the neck	Anchiopsis
	b) Head without a central spine on the neck	4
4.	a) Central part of head wider at front	5
	b) Central part of head wider at the back	Proetus
5.	a) Central part of head divided into lobes	6
	b) Central part of head not divided into lobes	Trypaulites

6. a) Front margin of head fluted .... Odontocephalus
   b) Front margin of head not fluted .... Coronura

7. a) Tail without spines 8
   b) Tail with spines 10

8. a) Tail with a distinct border .... Proetus
   b) Tail without border 9

9. a) Tail with a tubercle on the center of each segment .... Trypaulites
   b) Tail segments without central tubercle .... Phacops

10. a) Tail with a long terminal spine .... Anchiopsis
    b) Tail without terminal spine but with 2 or more side spines 11

11. a) Two short side spines only .... Odontocephalus
    b) Many short side spines, two on almost every segment .... Coronura

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Phacops (fig. 224) is the only genus which has neither cheek nor tail spines. The central part of the head bulges out in front and the tail lacks the border of Proetus. A complete specimen of P. rana milleri from the Silica formation is shown, much enlarged, on the frontispiece of this book.

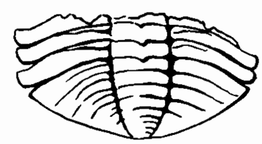


Fig. 224

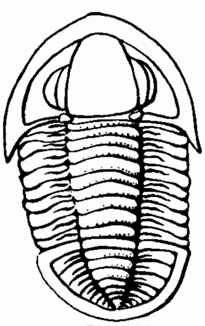


Fig. 225

Proetus has cheek spines but no tail spines. The central part of the head bulges out in the back. The tail has a distinct border. P. rowii (fig. 225) is found in the Columbus, Delaware and Prout.

Trypaulites (Chasmops in older publications) has cheek spines but no tail spines. The central part of the head bulges out in front but is not lobed, and there is no central neck spine on the head. The tail is without border or spines but has a tubercle in the central part of each segment. T. calypso (fig. 226) occurs in the Columbus.

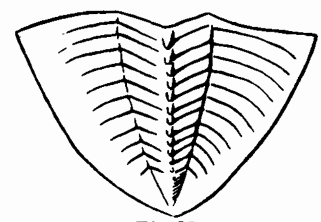
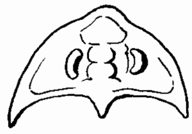


Fig. 226



Anchiopsis has cheek spines, a central neck spine, and a terminal tail spine. Some specimens are quite large, but not as large as Coronura. A. anchiops (fig. 227) is found in the Columbus.

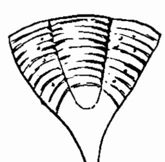


Fig. 227

Odontocephalus (fig. 228) has cheek spines but no central neck spine. The two tail spines are on the sides, not terminal. The central part of the head is lobed and bulges out in front. The flutings on the front of the head are distinctive. Two species occur in the Columbus.

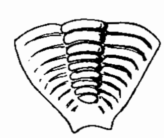


Fig. 228

Coronura (fig. 229) grows very large; it is the largest of our Devonian trilobites. It has cheek spines but no central neck spine. The central part of the head is lobed and bulges out in front. The tail has many spines, two on each end of most of the segments, none terminal. Three species are found in the Columbus.

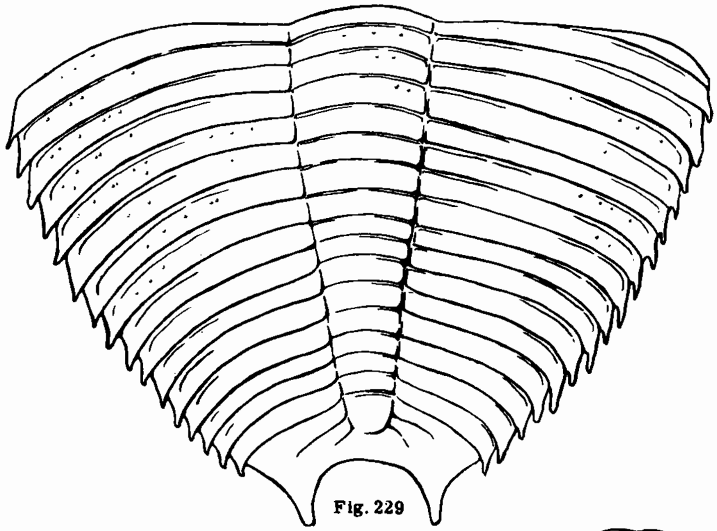


Fig. 229

BLASTOIDEA. Two genera of blastoids are common enough in our Devonian rocks to deserve notice. This does not mean that they will be found easily for they are not common everywhere. They are found in numbers only in certain beds of the Columbus and Delaware, usually silicified.

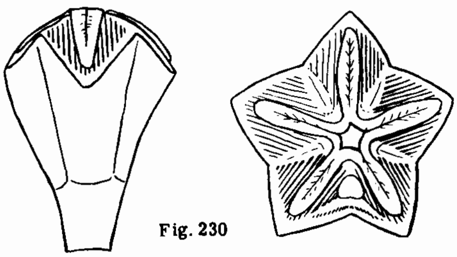


Fig. 230

Codaster has a cup with decidedly pointed ends and five indentations in the top half of the cup, whereas Nucleocrinus is melon-shaped and has rounded ends. C. pyramidatus (fig. 230) is found in the Columbus limestone.

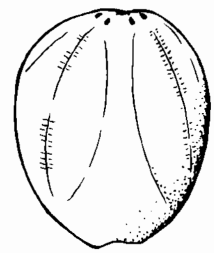


Fig. 231

Nucleocrinus is large, as blastoids go, and lacks the strong indentations of Codaster. The best specimens are the ones that have been silicified and weathered out of the rock. N. verneuilli (fig. 231) has been recorded from the Columbus limestone.

CRINOIDEA. Specimens of this group cannot be called common in the Devonian of Ohio. Still, six genera are collected often enough to justify inclusion here. The following key will separate reasonably well-preserved cups but the majority of specimens collected are disappointingly fragmentary.

Key to the Commoner Devonian Crinoids of Ohio

(see p. 4 for use of keys)

1. a) Height and width of cup about equal 2
   b) Width of cup greater than its height 4

2. a) Plates of cup convex .... Melocrinites
   b) Plates of cup not convex 3

3. a) Surface of plates granular ("warty") .... Arthroacantha
   b) Surface of plates smooth .... Hexacrinites

4. a) Surface of plates smooth 5
   b) Surface of plates with radiating ridges .... Dolatocrinus

5. a) Base of cup conical .... Euryocrinus
   b) Base of cup flattened 6

6. a) Plates very convex, some ending in a point .... Gilbertsocrinus
   b) Plates moderately convex, not pointed .... Megistocrinus

In Melocrinites the width of the cup is about equal to the height; the smooth, convex plates of the cup will distinguish this from Arthroacantha. M. onondaga is found in the Columbus.

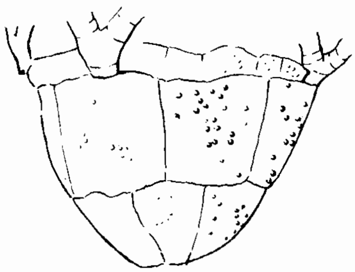


Fig. 232

Arthroacantha is also about as wide as high; the plates of the cup are not convex; they are beautifully ornamented with wart-like granules. A. carpenteri (fig. 232) occurs in the Silica.

Hexacrinites is like the first two in having about equal height and width; the plates of the cup are not convex and they bear no granules. H. leai is found in the Silica.

Dolatocrinus (fig. 233) has a bowl-shaped cup, wider than high; the plates are convex, and each is ornamented with radiating ridges. Several species are found in our Devonian.

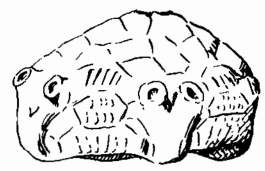


Fig. 233

Euryocrinus has a deeper and smaller cup than Dolatocrinus but it is still wider than high; the arms are large and branching; the plates are slightly convex, smooth, and the base is conical. E. laddi occurs in the Silica.

Gilbertsocrinus has a large cup, wider than high, and bowl or vase shaped, with straight sides. The plates are very convex and smooth; the base is flattened. G. ohioensis (fig. 234) is found in the Silica.

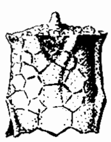


Fig. 234

Megistocrinus is also wider than high. Its plates are smooth and convex, but less so than those of Gilbertsocrinus. Several species are found in our Devonian.

GRAPTOZOA. The only graptolite recorded for the Devonian of Ohio is Dictyonema leroyense, found in the Columbus. It is fan shaped, branching, and has cross-bars. The colony suggests the bryozoan Fenestrellina but the black color in well preserved specimens indicates that it is a graptolite.

FISHES. The Devonian of Ohio has long been famous for its fossil fishes. A few nearly complete skeletons are found now and then in the Middle Devonian limestones but by far the most interesting and spectacular finds have come from the Upper Devonian black shales of northern Ohio. Newberry (1873, 1875, 1889) has described most of the genera and species and his monographs are still usable for identification. More recent papers are by Dunkle and Bungart (1939--1946).

We wish that we could pick out a few genera common enough to be worth illustrating here, but it simply can't be done. In the middle Devonian bone beds fish plates, teeth, and fragments are abundant enough but they are not easily identifiable. Good material has been found in the Cleveland shale, in pockets that were soon worked out. If you should be fortunate enough to uncover such a pocket, report your find to the nearest museum. You might be able to work out your specimens yourself but it would be far better to entrust them to a specialist who will be able to get full scientific value from them. See chapter 2, p. 19 for discussion of some Devonian fishes.

Books for further study

Books on particular groups have already been noted in the text. Collectors in northwestern Ohio should get a copy of Stewart's (1927) bulletin on the Silica shale and Ehlers, Stumm, and Kesling's (1951) for descriptions of the outcrops and sections. Both of these have illustrations of fossils.

In the Cleveland area, the pocket guide by Williams (1940) will be very useful. It is available at 50 cents from the Cleveland Museum of Natural History.

Many of our Devonian species are described and figured by Meek (1873). The Columbus region is covered by Survey Bulletin 14 (Stauffer, Hubbard, and Bownocker, 1911) and the Central Ohio region by Stauffer (1909) although this book is rather technical and has few fossil illustrations. The sections and lists of species will be useful for detailed collecting. We have already called attention to Stewart's (1938) work on corals and other papers on special groups. Kindle's (1901) Indiana report has some excellent pen and ink drawings but it has long been out of print and is hard to find in second-hand book stores.

CHAPTER 7. MISSISSIPPIAN FOSSILS

Collecting Localities

GENERAL. The Mississippian rocks of Ohio are exposed in a wide belt from the Ohio River in the south to the vicinity of Lake Erie in the north where the outcrops continue eastward to the Pennsylvania line (see map, fig. 8). In the extreme northwestern part of the state, in Defiance, Williams, and Fulton counties, is a smaller area of Mississippian rocks separated from the larger area to the east.

In the Lower Missippian Waverly group we find the oldest large body of sandstones and shales cropping out in Ohio. The lower part of the Waverly consists of shales, in some places hard to distinguish from the Devonian shales. Silt and sandstone layers increase as we go upward in the column until they make up most of the rock of the Upper Waverly. Siltstones, sandstones, and shales all contain abundant fossils from place to place.

The Maxville limestone is found only in patches as it was deposited on an irregular surface and much of it was eroded before the later sediments were laid down. The Maxville carries a fauna small in number of species but abundant in individuals of remarkably good preservation. See Morse (1911) for description of the species.

NORTHEASTERN OHIO. The lower part of the Mississippian section in this area yields brachiopods sparingly throughout but there are large concentrations of fossils in some beds. The Cuyahoga formation contains a varied fauna which includes well preserved brachiopods, pelecypods, gastropods, and a few trilobites.

EAST-CENTRAL OHIO. In the area centering around Licking County, the Cuyahoga and Logan formations have proved particularly prolific in fossils: Both the silty and shaly beds of these formations yield fossils in abundance but the better preserved ones are those from the shales. The area around Granville and Newark was intensively explored by many workers, especially C. L. Herrick (1887) who published extensive lists of fossils from that area. In some beds in Licking County, the whole surface of a bed may be covered with brachiopod shells (Rhipidomellas and productids). In the shales, pelecypods are commonly found, along with rarer cephalopods and conularids. Some of the best preserved specimens are from iron concretions which abound in some of the shales.

SOUTH-CENTRAL OHIO. In this area, the formations mentioned for northern and east-central Ohio are also present and yield fossils in about the same numbers, but here they are overlain, in some localities, by patches of Maxville limestone which is abundantly fossiliferous; see Lamborn (1945). Thirty-six species have been listed from the Maxville.

A famous collecting locality of former days was the ledge of Byer sandstone in the Ohio River, called the Sciotoville bar. It has yielded thousands of brachiopods, pelecypods, gastropods, and other fossils. Many of these are filled with the mineral sphalerite (zinc sulphide) or sometimes with galena (lead sulphide) or with calcite (calcium carbonate) in which delicate structures of the interior of the shell are preserved. The bar is now covered by deep water behind one of the dams which provide water for navigation.

The Commoner Fossils

PLANTS. Poorly preserved plant remains occur throughout the Mississippian. Their identification, when it can be achieved at all, is a matter for a specialist. The logs, tree-trunks, and twigs of our Mississippian beds are in general so similar to those of the Pennsylvanian that the discussion of Pennsylvanian plants (chapter 8) may be used for both.

Tiny spore coats of unknown plants, already mentioned in chapter 6, are also found in the Mississippian.

PROTOZOA. Foraminifera undoubtedly existed in our Mississippian seas but as yet we have no record of them.

PORIFERA. Sponges were present in the Mississippian seas of Ohio. The only ones for which we have a record are those which burrowed into the shell of other organisms, making holes and tubes. These may be simple or branching. In some specimens the shell may be dissolved away, leaving only the mud fillings of the sponge burrows.

ANTHOZOA. Corals are generally rare in our Mississippian rocks and we know of no coral reefs of this age in Ohio. Several species of Zaphrentis (see fig. 163) are present in the Waverly and Maxville. All are smaller and more delicate than the Devonian species. Honeycomb corals (see fig. 154) are very rare.

CONULARIDA. Some of the finest specimens of conularids have been collected from Ohio Mississippian rocks. The two common species, C. micronema (fig. 235) and C. newberryi (fig. 236) can be distinguished by the features shown in the figures.

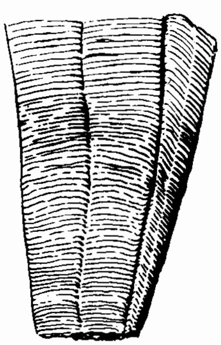


Fig. 235

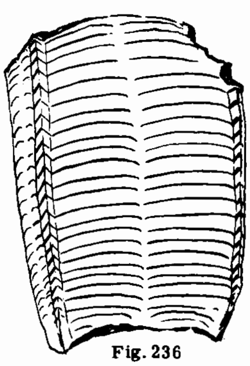


Fig. 236

BRYOZOA. A few bryozoans occur in our Mississippian rocks but their identification is difficult because of poor preservation. Species of Fenestrellina (see fig. 98) or a related genus occur in the Cuyahoga, Logan, and Maxville formations.

BRACHIOPODA. The most abundant individual fossils in our Mississippian rocks are the brachiopods. They are remarkably varied in size and appearance but only 19 genera may be considered common. They may be identified from the following key. For further information on Brachiopoda, see Hyde (1953).

Key to the Commoner Mississippian Brachiopods of Ohio

(see p. 4 for use of keys)

1. a) Shell smooth or with concentric markings only 2
   b) Shell with radiating and concentric markings 6

2. a) Beak on margin of shell 3
   b) Beak near center of shell .... Orbiculoidea

3. a) Height greater than width 4

b) Width greater than height 5

4. a) Beaks large, projecting over margin of shell .... Girtyella
b) Beaks small, not projecting over margin of shell .... Lingula

5. a) Hinge line wide, shell spiny .... Strophalosia
b) Hinge line narrow, shell without spines .... Athyris

6. a) Concentric ornamentation stronger than radial ornamentation ..... Leptaena
b) Radiating ornamentation stronger than concentric ornamentation 7

7. a) Radiating ornamentation of less than 20 folds or striations 8
b) Radiating ornamentation of more than 20 folds or striations 10

8. a) Hinge line more than half as wide as the shell .... Avonia
b) Hinge line less than half as wide as the shell 9

9. a) Shell with 10 or less radial ridges .... Ptychospira
b) Shell with 12 or more radial ridges .... Camarotoechia, Rhynchopora

10. a) Shell with spines 11
b) Shell without spines 13

11. a) Spines small, numerous, aligned in concentric rows .... Torynifer
b) Spines large, few, irregularly distributed on the shell 12

12. a) Radiating ridges continuous .... Dictyoclostus
b) Radiating ridges interrupted .... Buxtonia

13. a) With sinus and fold 14
b) Without sinus and fold 16

14. a) Hinge line as long as width of shell 15
b) Hinge line less than width of shell .... Rhipidomella

15. a) Cardinal area very high .... Syringothyris
b) Cardinal area low .... Spirifer

16. a) Shell small, with spines on cardinal margin .... Chonetes
b) Shell large, no spines on cardinal margin 17

17. a) Both valves convex .... Schuchertella
b) One valve flat .... Derbyia, Schellwienella

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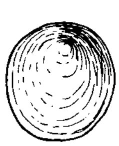


Fig. 237

Orbiculoidea (Lingulodiscina in older publications) is a survivor from the Devonian (see fig. 237); its nearly central beak is distinctive. O. newberryi is abundant near the base of the Sunbury and very rare in the Logan.

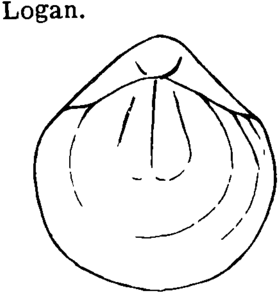


Fig. 238

Girtyella has a large beak on one valve which curls over the beak of the other valve. It has a characteristic outline which separates it from our other Mississippian brachiopods. G. flora (fig. 238) is common in the lower part of the Logan.

Fig. 239

Lingula has already been described in the Devonian chapter (see p. 81). L. melie (fig. 239) is common near the base of the Sunbury and in some parts of the Cuyahoga and Logan.

Strophalosia is a small brachiopod with concentric wrinkles and scattered spines. The spines are seldom preserved entire but their position is indicated by the broken bases. The surface also has low wart-like bumps. The genus is related to *Avonia*, *Buxtonia*, and *Dictyoclostus* but these three genera always have some radial ornamentation. *Strophalosia beecheri* (fig. 240) is common in parts of the Logan.

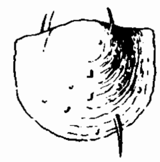


Fig. 240

Athyris is somewhat like *Girtyella* but is wider than high and usually larger than species of *Girtyella*. *A. lamellosa* (fig. 241) is common in parts of the Cuyahoga and Logan.

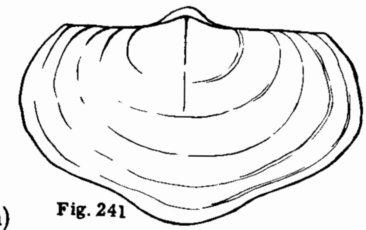


Fig. 241

Leptaena is a long-lived genus (Ordovician to Mississippian) easily distinguished by its shape (see Fig. 59) and the strong concentric ridges which are larger than the fine radiating ones. *L. analoga* is common in parts of the Cuyahoga.

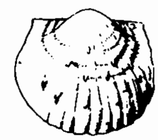


Fig. 242

Avonia (fig. 242) is a spiny brachiopod, distinguished from *Strophalosia* by the presence of radiating ornamentation. From *Dictyoclostus* and *Buxtonia* it differs in having only a few radiating ridges whereas these genera have abundant ridges on the entire shell. Three species of *Avonia* are locally abundant in the Cuyahoga formation.

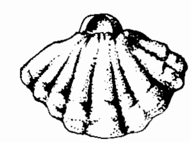


Fig. 243

Ptychospira is one of several genera (*Camarotoechia* and *Rhynchopora* are the other common ones) in which the shell has much the same character. *Ptychospira* can be separated from the others by the small number of ridges, ten or less, radiating from the beak. *P. magna* (fig. 243) is common in some parts of the Logan.

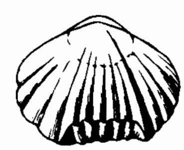


Fig. 244

Camarotoechia and *Rhynchopora* (fig. 244) are lumped together here as they cannot be distinguished by the outside of the shell. They have very characteristic internal structures which are seldom preserved in our Mississippian specimens. Several species of *Camarotoechia* are common in the Cuyahoga and a few species of *Rhynchopora* occur in the Cuyahoga and Logan.

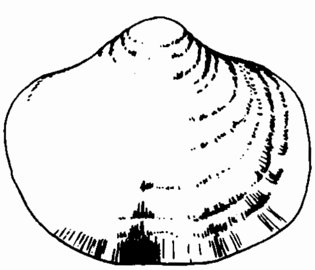


Fig. 245

The shell of *Torynifer* resembles that of *Athyris* but is more regularly oval. The ornamentation is unmistakable; it consists of concentric rows of fine, closely-crowded, short spines over the whole surface of the shell. *T. pseudolineata* (fig. 245) is common in places in the lower part of the Logan.

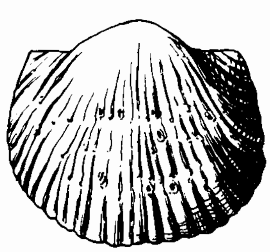


Fig. 246

Buxtonia is another spiny shell, a productid (compare with *Strophalosia*, *Avonia*, and the next genus). It has one very convex and one almost flat valve. Both the concentric and radiating ridges are strong in *Buxtonia* but the radiating ridges are interrupted whereas they are continuous in *Dictyoclostus*. *Buxtonia scabricula* (fig. 246) is common in parts of the Logan formation of east-central Ohio.

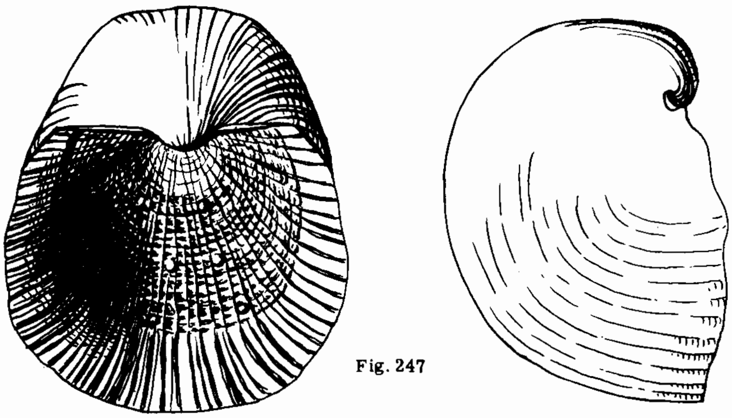


Fig. 247

Dictyoclostus, another productid, also has one convex and one nearly flat valve. It is separated externally from Buxtonia by its continuous radiating ridges which are interrupted in Buxtonia. Several species of Dictyoclostus are common in the Cuyahoga and Logan. Very large forms from the Logan are likely to be D. bovis (fig. 247).

Rhipidomella (fig. 248) has a thin shell with one slightly convex and one almost flat valve. The radiating ornamentation is distinct but fine and thread-like. Rhipidomella resembles Schuchertella and Schellwienella but has a shorter hinge line. Two species of Rhipidomella are common in some beds of the Cuyahoga and Logan.

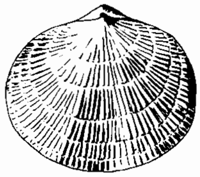


Fig. 248

Syringothyris is distinguished from Spirifer, which it resembles in general outline, by its very high cardinal area. Species of this genus are among the largest of our Mississippian brachiopods. Several species

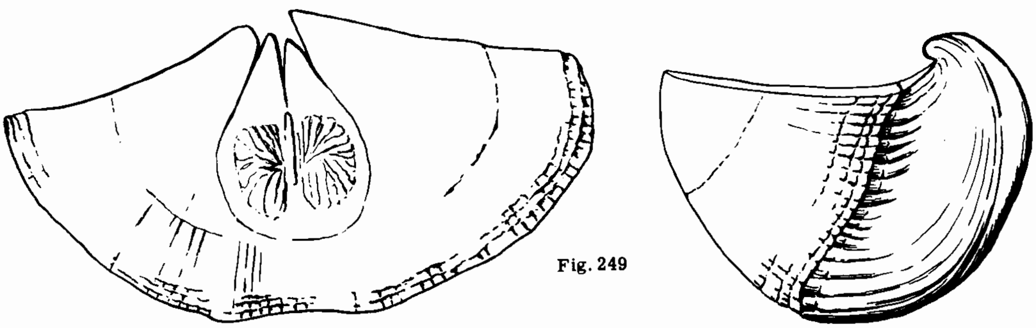


Fig. 249

have been recorded from Ohio. S. typus (fig. 249) is common in the Logan.

Spirifer has a strong sinus and fold, as in Syringothyris, but a lower cardinal area which is characteristic. Two species are found in our Mississippian rocks; the commoner one is S. centronatus (fig. 250) of the Logan. S. striatiformis (fig. 251) is common in the Cuyahoga.

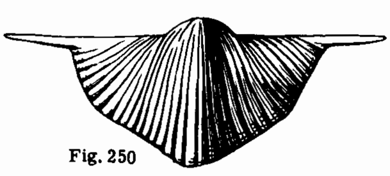


Fig. 250

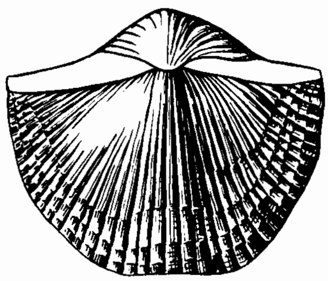


Fig. 251

Our Mississippian species of Chonetes are less than half an inch wide. The spines of the cardinal margin are distinctive but not always preserved. C. glenparkensis (fig. 252) is abundant in places in the Logan.


Fig. 252

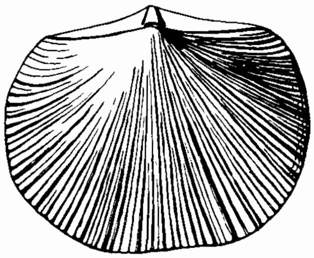


Fig. 252a

Derbyia crassa (Orthothetes in older publications) has one flat and one convex valve that bulges prominently at the beak (fig. 252a). The surface of both valves is marked by fine, sharp ridges radiating from the beak. It is found in the Maxville and ranges upward into the Pennsylvanian.

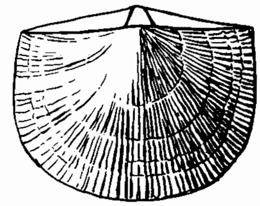


Fig. 253

Schuchertella (fig. 253) and Schellwienella both have a semicircular outline, prolonged into wing-like expansions on the hinge line in some species. If both valves are preserved, they may be separated by the convexity of the valves, but unfortunately only separate valves are usually found in our Mississippian. Schuchertella is represented by one species in the Cuyahoga and two in the Logan; two species of Schellwienella occur in the Logan.

PELECYPODA. Many genera of pelecypoda are represented in our Mississippian rocks but the majority of them are rare. Only the commoner genera are listed in the following key. For more detailed information, see Hyde (1953).

Key to the Commoner Mississippian Pelecypods of Ohio

(see p. 4 for use of keys)

1. a) Shell scallop-like, with 2 distinct "wings"; height and length approximately equal .... Aviculopecten
   b) Shell without "wings" 2

2. a) Height and length nearly equal 3
   b) Height distinctly less than length 4

3. a) Beaks large .... Grammysia
   b) Beaks small .... Palaeoneilo

4. a) Exterior of shell with concentric ridges 5
   b) Exterior of shell without concentric ridges 7

5. a) Shell with a ridge or angulation from the beak to the margin .... Grammysia
   b) Shell without such ridge or angulation 6

6. a) One end of shell pointed .... Palaeoneilo
   b) Ends of shell not pointed .... Allorisma

7. a) One end of shell pointed .... Nuculana
   b) Ends of shell not pointed 8

8. a) Shell with ridge or angulation from the beak to the margin 9
   b) Shell without such ridge or angulation .... Parallelodon

9. a) Beaks wide and low .... Sanguinolites
   b) Beaks narrow and high .... Sphenotus

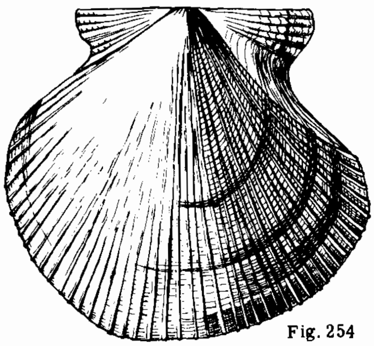


Fig. 254

The only common scallop-like pelecypod in our Mississippian is Aviculopecten which can be recognized by the "wings" on the margin of the shell. A. winchelli (fig. 254) is common in parts of the Logan.

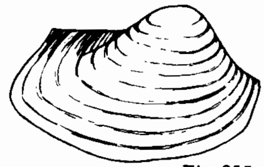


Fig. 255

The outline of the shell in Grammysia (fig. 255) is variable, hence the genus appears twice in the key. Whether the shell is short or long, the large beaks, the concentric ridges, and the strong angulation from the beak to the margin will identify these shells. One species is common in both the Cuyahoga and the Logan; three others are rare in the Logan.


Fig. 256

Palaeoneilo has a characteristic outline (fig. 256) which will help identify it. In addition, internal molds show numerous small teeth perpendicular to the hinge. Three species of Palaeoneilo are common in the Logan. Others are found rarely in other formations of the Mississippian.

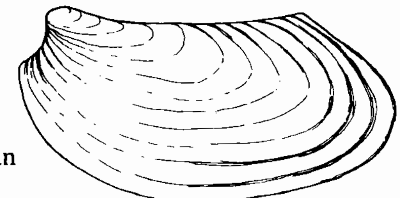


Fig. 257

Allorisma (fig. 257) is a large clam with large beaks which can be recognized by the characters given in the key. It is abundant in some beds of the Logan but specimens are usually crushed and broken.

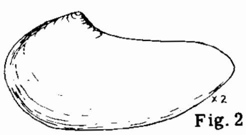


Fig. 258

The external surface in Nuculana (fig. 258) is covered with closely crowded concentric grooves; internal molds show teeth of the same character as those of Palaeoneilo but the shape of the shell is sufficient to distinguish them. A few species are common in parts of the Logan.


Fig. 259

The shell of Parallelodon (fig. 259) is about the same size as that of Allorisma but the proportions are different and Parallelodon lacks the distinct concentric ridges of Allorisma. Parallelodon depressus is abundant in the Logan.

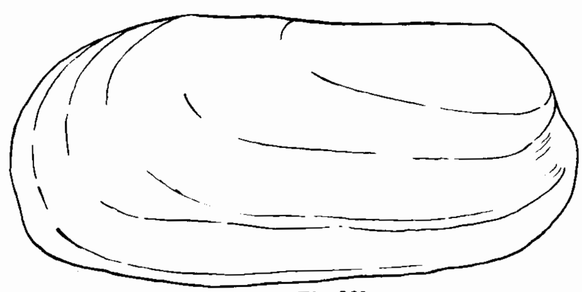


Fig. 260

In Sanguinolites the beak is very near one end of the shell and the greatest height is not in the region of the beaks. S. websterensis (fig. 260) is abundant in some beds of the Logan and is also found in the Cuyahoga.

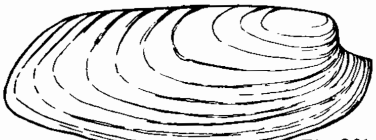


Fig. 261

The common species of Sphenotus, S. aeolus (fig. 261) is an elongate clam. It has a well-marked ridge from the beak to the margin. It is abundant in some beds of the Logan.

GASTROPODA. Only six genera of Mississippian gastropods are common enough in Ohio to be noted here. No key is necessary as the figures and text will guide the reader to their identification.

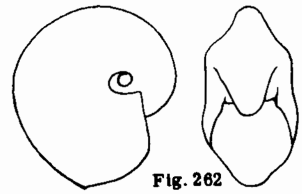


Fig. 262

Tropidodiscus is flat-spired, with a characteristic sharp keel on the edge of the whorl which distinguishes it from Euphemites, another flat-spired genus. T. cyrtolites (fig. 262) is common in some beds of the Logan.

Euphemites resembles Tropidodiscus in having a flat spire but it lacks the sharp keel present in that genus. Euphemites nautiloidea (fig. 263) is abundant in the Cuyahoga and another species is rare in the Logan.

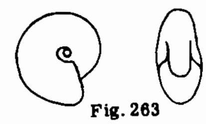


Fig. 263

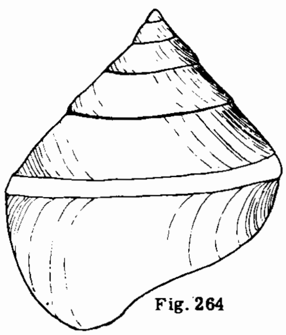


Fig. 264

Pleurotomaria textiligera (fig. 264) has a conical shell of four or five whorls flattened exactly on the line of the slope. The surface is marked by fine axial and spiral ornamentation. Height of a large specimen is a little less than 1 1/2 inches. The species is quite common in the Waverly of northern Ohio.

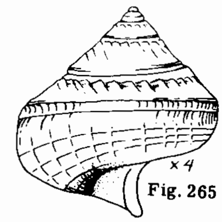


Fig. 265

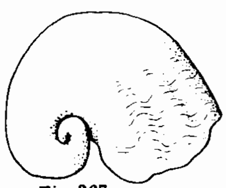


Fig. 267


Fig. 268

Mourlonia has a moderately high spire with strong spiral and axial ornamentation. M. stellaeformis (fig. 265) is common in the Logan, along with 2 other species of the same genus.

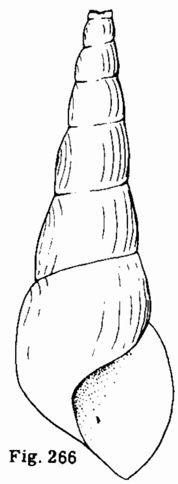


Fig. 266

Loxonema is distinguished from the preceding genera by its very high spire and spindle-like outline. L. pikensis (fig. 266) is rare in the Logan except for local concentrations which may contain dozens of specimens closely crowded together.

The name Platyceras is used here in the wide sense to include loosely coiled shells which vary from almost straight cones to shells in which only the first two whorls are in contact. The cone-shaped forms may be high and almost cylindrical a little distance from the apex or they may be low, flat, and limpet-like. The only common form is P. hertzeri (fig. 267) of the Logan which has a clearly coiled apex. P. lodiense (fig. 268) is common in northern Ohio.

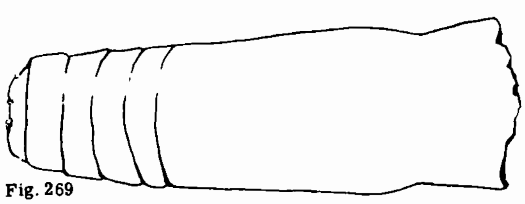


Fig. 269

CEPHALOPODA. Cephalopods are not common in our Mississippian rocks. Both nautiloids and ammonoids occur but the latter are very scarce. Hyde (1953, pp. 336-344) describes and figures 12 species.

The least rare of these is the straight nautiloid Michelinoceras icarus (fig. 269) of the Logan. It is an elongate-conic shell about one inch or less in diameter.

Prolecanites (fig. 270) is not quite as common as Michelinoceras icarus. It is a coiled ammonoid with a wide umbilicus. Average specimens are about an inch in diameter. Two species occur in the Waverly.

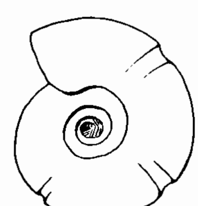


Fig. 270

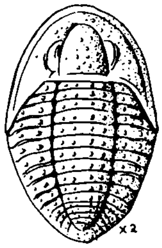


Fig. 271

TRILOBITA. These are rare in our Mississippian rocks. Brachymetopus rusticus (fig. 271) is a small species in which both the head and tail are ornamented with numerous bumps and short spines. Heads are very rare but tails in fair numbers have been found in some beds of the Logan.

Griffithides marginatus (fig. 272) has only low bumps instead of bumps and spines. The tail is proportionally narrower than that of Brachymetopus rusticus. Tails of G. marginatus are found sparingly in parts of the Logan.

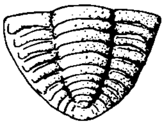


Fig. 272

ECHINODERMA. Crinoid stems are common in some of the Mississippian beds in northern Ohio. Crinoid heads are extremely rare. Hall and Whitfield (1875) have described the Ohio species. The other classes of echinoderms occur too rarely for mention.

FISHES. Scales and plates of fishes turn up fairly frequently in our Mississippian formations, especially in the black shales, but few identifiable remains may be expected. For discussion of some Mississippian fishes, see chapter 2, p. 22 . Newberry (1873, 1875, 1889) has described most of our species.

Books for further study

Hyde's work (1953) is the most useful source book for the Mississippian invertebrates of southern Ohio. It contains descriptions and figures of most of the common forms and it is recent enough to be still available. Many Mississippian species are described in Hall and Whitfield's (1875) report on the Waverly fossils of northern Ohio. That volume is now out of print but is available in libraries. Morse's (1910) work on the Maxville limestone, Bulletin 13 of the Geological Survey of Ohio, and his (1911) paper on the fauna of the same formation are also useful.

CHAPTER 8. PENNSYLVANIAN FOSSILS

Collecting Localities

The Pennsylvanian rocks of Ohio are exposed in an irregular crescent extending from the Ohio River in Lawrence County to Geauga County in the north and Trumbull County in the northeast. Throughout this area, fossiliferous beds are exposed although they yield fossils in variable abundance. It would be pointless to attempt to list all good collecting localities in the area, for the catalog would occupy many pages and involve tedious repetition. For those who seek details on localities within a particular county, the following references will provide specific information.

Athens: Condit (1912, p. 104); Belmont: Condit (1912, p. 181); Carroll: Condit (1912, p. 209), Lamborn (1942); Columbiana: Condit (1912, p. 217), Morningstar (1922, p. 13), Stout and Lamborn (1924); Coshocton: Morningstar (1922, pp. 78, 107), Lamborn (1954); Gallia: Condit (1912, p. 74), Stout (1916); Guernsey: Condit (1912, p. 165); Harrison: Condit (1912, p. 185); Hocking: Condit (1912, p. 122), Morningstar (1922, p. 126); Holmes: Morningstar (1922, p. 79), White and Lamborn (1948); Jackson: Morningstar (1922, pp. 26-27, 145), Stout (1916); Jefferson: Condit (1912, p. 197), Lamborn (1930); Lawrence: Condit (1912, p. 61), Morningstar (1922, p. 49), Stout (1916); Licking: Mark (1911), Morningstar (1922, pp. 44, 70); Mahoning: Morningstar (1922, pp. 35, 82, 83-85, 111), Lamborn (1942); Meigs: Condit (1912, p. 90); Monroe: Condit (1912, p. 164); Morgan: Condit (1912, p. 129); Muskingum: Mark (1911), Condit (1912, p. 142), Morningstar (1922, pp. 39-44, 146), Stout (1918); Noble: Condit (1912, p. 155); Perry: Condit (1912, p. 122), Morningstar (1922, pp. 55, 97-99), Flint (1951); Pike: Stout (1916); Portage: Morningstar (1922, p. 81); Scioto: Morningstar (1922, pp. 18, 22, 37-38, 49-50, 96), Stout (1916); Stark: Morningstar (1922, pp. 81, 110); Summit: Morningstar (1922, pp. 25, 81, 145); Trumbull: Morningstar (1922, p. 20); Tuscarawas: Condit (1912, p. 178), Morningstar (1922, pp. 44, 78); Vinton: Stout (1927); Washington: Condit (1912, p. 154); Wayne: Conrey (1921).

The Commoner Fossils

PLANTS. The Pennsylvanian rocks of Ohio contain many coal seams which were produced by accumulation of plant remains. Plant fossils are particularly abundant in the shales and sandstones associated with the coals of Ohio. All phyla of the plant kingdom except the Angiosperms and possibly Cycadophytes are represented. The Mississippian and Permian plant fossils are very similar to those of the Pennsylvanian but are not as abundant. For that reason, the account of Late Paleozoic plants given here applies to all three systems. More extensive treatment may be found in Arnold (1947), Crookall (1929), and Walton (1953). Many of the species have been described by Newberry (1873) and Andrews (1875).

The plant material which can be collected from the Upper Paleozoic rocks of Ohio consists of roots, logs, twigs, leaves, cones, spore-bearing organs, and isolated spore coats of a variety of plants. A simplified classification of fossil plants has been given in chapter 3. Some of the commoner forms are noted below.

The first five genera may be true ferns (Pteridophyta) or seed ferns (Pteridospermophyta). The first four are fern-like fronds beautifully and abundantly preserved in Pennsylvanian black shales; the last two are trunks and twigs thought to be true ferns.

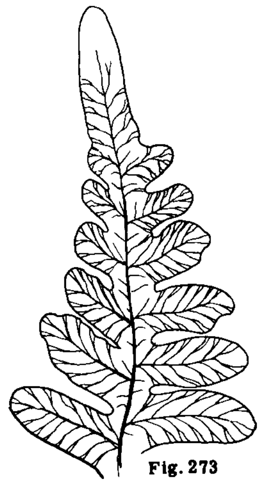


Fig. 273

Alethopteris (fig. 273) has long fronds with a row of leaves (pinnules) on each side. It has a distinct midrib which reaches the edge of the leaf. The leaves are long, with many secondary veins, and are attached by the whole width of the base. We have several species.

Pecopteris (fig. 274) is very similar to Alethopteris but it has short leaves with few secondary veins. The genus is a common one.

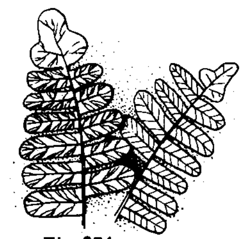


Fig. 274

Sphenopteris (fig. 275) has leaves contracted at the base, as in the next genus, but it has lobed or toothed leaves whereas Neuropteris has entire leaves. Sphenopteris is also represented by common species.

Neuropteris (fig. 276) has entire, oval or tongue-shaped leaves which are seldom lobed. Several species are common.

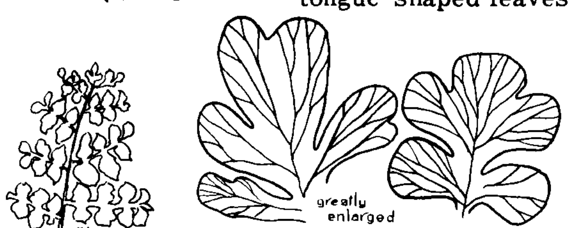


Fig. 275

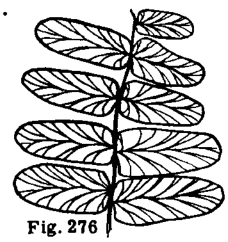


Fig. 276

The name Psaronius (fig. 277) has been given to stems of tree-ferns reaching a length of about 30 feet and with a diameter of nearly two feet. In cross-section, the true stem is seen to be only a few inches thick and surrounded by a thick coating of smaller "stems" which are called "adventitious" roots, because they originate above ground. Partial cross-sections of the adventitious roots, visible on the exterior of fossil logs and trunks, are characteristic of this genus.

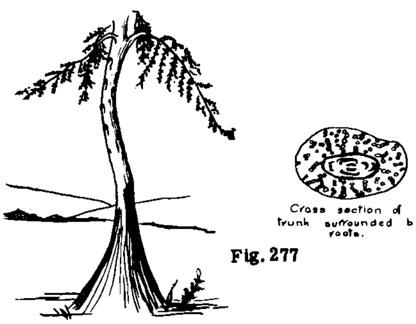


Fig. 277

The parts of Psaronius that show leaf-scars are given another name, Megaphyton. In it, the arrangement of leaf-scars is characteristic. The larger scars are oval and alternate in two rows on opposite sides of the stem. Psaronius and Megaphyton are common in places in our Pennsylvanian.

Calamites (fig. 278) resembles the modern horsetail or scouring rush. The Pennsylvanian forms of Calamites were trees 50 or more feet high, with a trunk several feet in diameter (see fig. 28). Whorls of leaves grew on nodes of the younger branches. Well-preserved trunks and sections of branches and twigs are common in some of our Pennsylvanian beds.

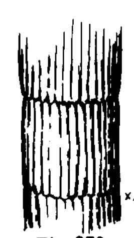


Fig. 278

Fig. 279

Sphenophyllum (fig. 279) is small, with swollen nodes bearing whorls of triangular leaves with one toothed or rounded border. It is common in some of the Pennsylvanian beds of Ohio.

Lepidodendron (fig. 280) was a giant relative of the modern club-mosses, a tree 100 feet high and 2 or more feet in diameter (see fig. 6b). The genus flourished in the Pennsylvanian and died out in the Permian. The needle-shaped or strap-like leaves were borne on leaf-cushions or scars which are diamond-shaped and spirally arranged. Stalked cones grew on the ends of smaller branches. Isolated cones, whose specific relationship is uncertain though the general alliance with Lepidodendron is well supported, are referred to the genus Lepidostrobus. Trunks and branches of

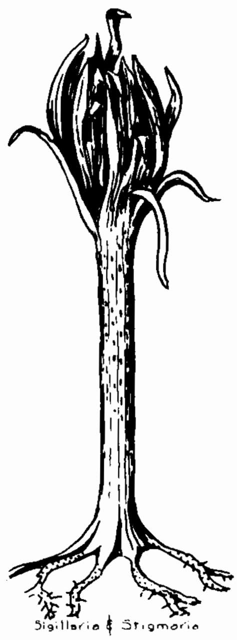
Fig. 280

Lepidodendron, often squashed flat, are common in parts of our Pennsylvanian.


Fig. 281

Lepidocarpon (fig. 281) has cones composed of seed-like structures, is probably related to Lepidodendron or allied genera, and is found in the same rocks.

Sigillaria (fig. 282) is similar to Lepidodendron but the leaf-scars are in longitudinal rows. Cones, generally regarded as related to Sigillaria, are identified as Sigillariostrobus. Some of the trunks of Sigillaria were large trees about 100 feet high. It is a common genus in the Pennsylvanian of Ohio.



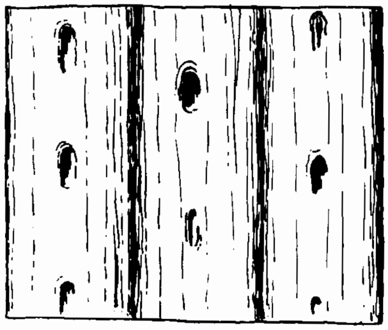


Fig. 282

Stigmaria (fig. 283) is the name applied to the roots of scale trees. The surface has circular scars in regular spirals; they mark the point of attachment of rootlets. Stigmaria is a very common type of fossil in the clays under some of our Pennsylvanian beds.

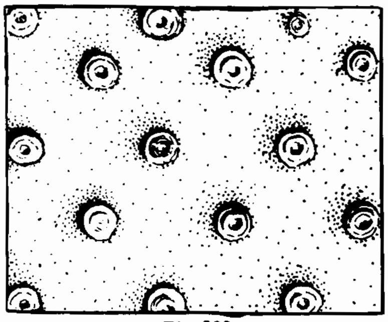


Fig. 283

Cordaites (fig. 284) is distantly related to modern conifers. It belongs in the phylum Coniferophyta. The Cordaites were large trees 100 feet or more high, with a diameter of about 2 feet. The surface bore numerous spirals of sessile leaves up to 2 and 3 feet long, sword-like in shape. Cordaites is well represented by large leaves in the Pennsylvanian of Ohio.


Fig. 284

PROTOZOA. The most conspicuous protozoans of the Pennsylvanian are the fusulinid Foraminifera. They are small, 1/4 inch or less long, and shaped like a wheat grain (fig. 285). They occur in our marine limestones, sometimes in great abundance. Specimens must be sectioned for even generic identification, so it seems pointless to differentiate them here. Several genera and species have been recorded from Ohio. See Thompson (1936) and Smyth (1951).


Fig. 285

ANTHOZOA. Corals are scarce in our Pennsylvanian rocks. The only form which is common enough to be noted here is a small cup coral, Lophophyllidium profundum (fig. 286), abundant in places.

BRYOZOA. Leafy and twig-like bryozoans are common in some of the limestones and shales of our Pennsylvanian. In addition, a curious parasitic form, Bascomella, has been described from Ohio. It bored into the shell of brachiopods and pelecypods. The commoner genera may be identified by means of the following key. The species are figured by Meek (1875), Foerste (1887, pp. 71-88), Mark (1912), and Morningstar (1922).

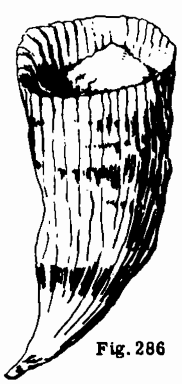


Fig. 286

Key to the Commoner Pennsylvanian Bryozoa of Ohio

(see p. 4 for use of keys)

1.	a)	Colonies twig-like, branching	2
	b)	Colonies leaf-like	6
2.	a)	Branches almost cylindrical	3
	b)	Branches flattened	5
3.	a)	Branches longitudinally ridged	Pinnatopora
	b)	Branches not longitudinally ridged	4
4.	a)	Branches about 1/8 inch in diameter	Rhombopora
	b)	Branches about 1/4 inch in diameter	Tabulipora
5.	a)	Branches with wavy edges	Prismopora
	b)	Branches with straight edges	Cystodictya
6.	a)	Parasitic in the shell of brachiopods and pelecypods; branching irregularly, with sac-like appendages attached to the branches	Bascomella
	b)	Branching regularly, colony made up of rods joined together by cross-bars	7
7.	a)	Cross-bars curved or angulated	Septopora
	b)	Cross-bars straight	8
8.	a)	Rods with wavy ridges between the rows of cells	Polypora
	b)	Rods without such wavy ridges	Fenestrellina

Fig. 287

Pinnatopora colonies look like miniature fir twigs. The branches are nearly cylindrical, they fork many times, and are ribbed longitudinally. The tiny cups alternate in two rows between the ribs on the branches. P. whitii (fig. 287) is common in some beds.


Fig. 288

Rhombopora is also twig-like but the branches fork very little; fragments more than 1 inch long show no signs of forking. The branches are very slender, about 1/8 inch in diameter and about half the size of the branches of Tabulipora. The cells are small, about 20 rows of them around the branches. R. lepidodendroides (fig. 288) is common in some beds.

Tabulipora is like Rhombopora but the branches are twice as thick, about 1/4 inch in diameter. The branches also fork more frequently in Tabulipora. T. ohioensis is common in places.


Fig. 289

Two genera of twig-like bryozoans with flattened branches are easily recognized. In Prismopora the branches have wavy edges and a strong ridge runs down the middle of the branch. P. sereata (fig. 289) is the common species.


Fig. 290

Cystodictya lacks the median ridge of Prismopora and the flattened branches have straight, not wavy edges. The opening of each cell is at the top of a little mound and there are several rows of cells across each branch. C. carbonaria (fig. 290) is common.


Fig. 290a

Bascomella should be looked for on internal molds of brachiopods and pelecypods or on specimens that show the interior. This bryozoan actually bored into the shells of bivalves and it is preserved as a network of branches with sac-like appendages. It is unlike any of the other common Pennsylvanian bryozoans and the figure will identify it from all others. B. gigantea (fig. 290a) is common in parts of the Pottsville of Ohio in which it was originally discovered.

The more normal leaf-like bryozoans - as compared with Bascomella - appear as a regular network of rods and shorter connecting cross-bars. In Septopora the cross-bars are curved or angulated; they are straight in the other genera. Septopora biserialis (fig. 291) is common in some beds.


Fig. 291


Fig. 292

Fenestrellina (fig. 292) has straight rods and cross-bars forming rectangular, window-like openings which have given the genus its name. The cells are generally arranged in one or two rows and are not bordered by ridges. Several species are common.


Fig. 293

Polypora is similar to Fenestrellina but the Pennsylvanian species may be distinguished by the wavy ridges which separate the rows of cells, by the greater number of cell rows (4 in Polypora, 1 or 2 in Fenestrellina), and by the thickening of the cross-bars near the rods, producing oval "windows" instead of the rectangular ones of Fenestrellina. Polypora fastuosa (fig. 293) is a common species.

BRACHIOPODA. The Pennsylvanian of Ohio yields an amazing wealth and variety of brachiopods, fully equal to those of the Devonian and far superior to those of the Mississippian. Only the commoner forms have been included in the following key.

Key to the Commoner Pennsylvanian Brachiopods of Ohio

(see p. 4 for use of keys)

1. a) Shell smooth or with concentric markings only 2
   b) Shell with radiating or concentric markings 7

2. a) Beak on margin of shell 4
   b) Beak near center of shell 3

3. a) Outline and concentric markings nearly round . . . . Orbiculoidea
   b) Outline and concentric markings irregular . . . . Petrocrania

4. a) With sinus and fold . . . . Composita
   b) Without sinus and fold 5

5. a) Beaks small, not incurved . . . . Lingula
   b) Beaks large, incurved 6

6. a) One valve nearly flat, the other convex . . . . Crurithyris
   b) Valves almost equally convex . . . . Phricodithyris

7. a) With sinus and fold 8
   b) Without sinus and fold 12

8. a) Hinge line as wide as the width of the shell 9
   b) Hinge line narrower than the width of the shell 11

9. a) Sinus and fold simple 10
   b) Sinus with a median ridge, fold with a median groove . . . . . . Mesolobus

10. a) Fold and sinus without ridges . . . . Punctospirifer
    b) Fold and sinus with several ridges . . . . Neospirifer

11. a) Radiating ridges strong, extending from beak to margin . . . . Hustedia
    b) Radiating ridges weak near the beak, strong near the margin . . . Wellerella

12. a) Beaks large and coiled; one valve larger than the other 15
    b) Beaks small, not coiled; valves almost equal in size 13

13. a) Hinge line as great as or greater than the width of the shell; with spines . . . . Chonetes
    b) Hinge line narrower than the width of the shell; without spines 14

14. a) Beaks scarcely projecting over the hinge line . . . . Derbyia
    b) Beaks clearly projecting over the hinge line . . . . Rhipidomella

15. a) Length greater than width; large . . . . Echinoconchus
    b) Length less than the width 16

16. a) Concentric and radial ornamentation equally strong 17
    b) Radial ornamentation stronger than the concentric ornamentation . . . . Linoproductus

17. a) Concentric and radial ornamentation forming wart-like bumps . . . Juresania
    b) Concentric and radial ornamentation forming a network of square pits . . . . Dictyoclostus

---

Orbiculoidea has already been described (see fig. 237). Its regular outline distinguishes it from Petrocrania whose outline is irregular. Three species have been recorded.

Petrocrania resembles Orbiculoidea (see fig. 237) but has a characteristic irregular outline. P. modesta is common in some beds.

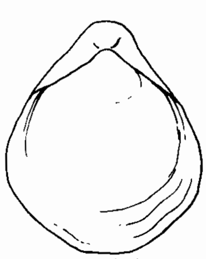


Fig. 294

Composita is a neat little shell without radiating ornamentation. Its strong concentric striae and well-marked sinus and fold are distinctive. C. subtilita (fig. 294) is common to abundant.

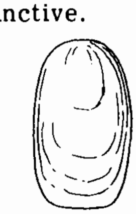


Fig. 295

Lingula is distinguished from other Pennsylvanian genera by its small beaks, the lack of a sinus and fold, and the fine but distinct concentric striae. L. carbonaria (fig. 295) is common.

Crurithyris (Ambocoelia of older publications) can be identified by its prominent beaks and very unequal valves. C. planoconvexa (fig. 296) is common.

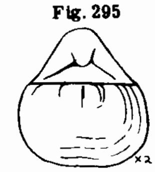


Fig. 296

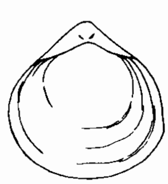


Fig. 297

Phricodithyris (Squamularia in older publications) is characterized by concentric rows of small spines on each valve. The spines are seldom preserved and without them the genus might be confused with Crurithyris except that Phricodithyris has almost equally convex valves whereas Crurithyris has one almost flat valve. P. perplexa (fig. 297) is abundant in some beds.


Fig. 298

Mesolobus (some species of Chonetes of older publications) is characterized by its double fold and sinus. It has some of the characteristics of Chonetes including the spines on the hinge and the fine radiating ornamentation. M. mesolobus (fig. 298) is the common species.

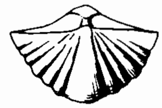


Fig. 299

Punctospirifer (Spiriferina in older publications) is one of the many genera of Paleozoic spiriferoid shells. It can be distinguished from the next genus by the fact that there are no ridges on the sinus and fold. P. kentuckyensis (fig. 299) is common.

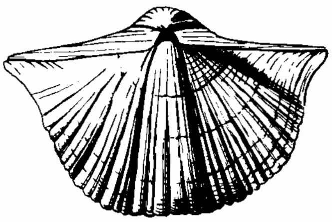


Fig. 300

Neospirifer (Spirifer in older publications) is also a spiriferoid distinguished from Punctospirifer by the numerous ridges on the sinus and fold. N. cameratus (fig. 300) is abundant.

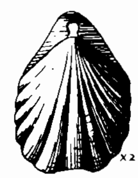


Fig. 301

The next two genera are small shells and resemble Camarotoechia and Rhynchopora of the Mississippian. Hustedia has strong radial ridges, extending from beak to margin, which distinguish it from the next genus. H. mormoni (fig. 301) is common.

Wellerella (Pugnax of older publications) resembles Hustedia but has ridges only on the margin of the shell. A species of Wellerella (fig. 302) probably W. osagensis (Pugnax utah of older publications) is common in some beds.

Fig. 302

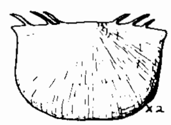


Fig. 303

Chonetes (fig. 303) is related to Mesolobus (see above) but has neither sinus nor fold. Three species are common.

Derbyia is a large, flat shell with numerous fine radiating ridges, some of which are irregular and wavy. It resembles Schuchertella and Schellwienella of the Mississippian (see fig. 250). Derbyia crassa (see fig. 252a) is the commonest of 3 species.

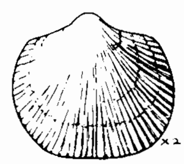


Fig. 304

The genus Rhipidomella, already noted for the Silurian, Devonian, and Mississippian, is also present in the Pennsylvanian. It may be distinguished from Derbyia by its more rounded outline, shorter hinge line, and larger beaks which project distinctly over the hinge line. Rhipidomella pecosi (fig. 304) is common.

The remaining genera of brachiopods are productids, a group which is particularly common from the Mississippian to the Permian. All of these genera are lumped together as Productus in older publications. The genera can be identified from the key if well-preserved material is available; otherwise, it is safer to label shells of this group "productids" and not to attempt even generic identification until better material is at hand.

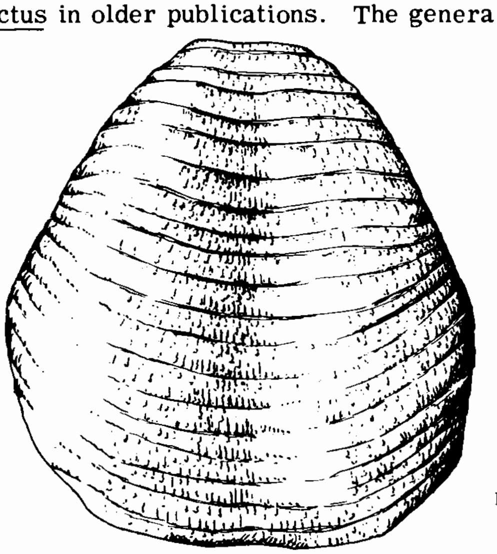
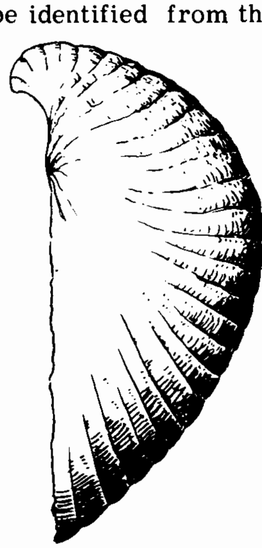



Fig. 305

Echinoconchus is one of our largest productids; the shell is usually longer than wide. Both valves bear spines and the beaks are strongly incurved. E. punctatus (fig. 305) is common in places.

Fig. 306

The shell in Marginifera (fig. 306) is comparatively small. The length is about 2/3 of the width and one valve is strongly convex, the other almost flat. Two species are common.

Linoproductus has fine, numerous radiating ridges which appear to be free of spines. Close examination will show the broken bases of a few scattered, slender spines on their surface. Our species of Linoproductus can be distinguished from the other productids by the near absence of concentric ornamentation of the shell. L. cora (fig. 307) is the abundant species.

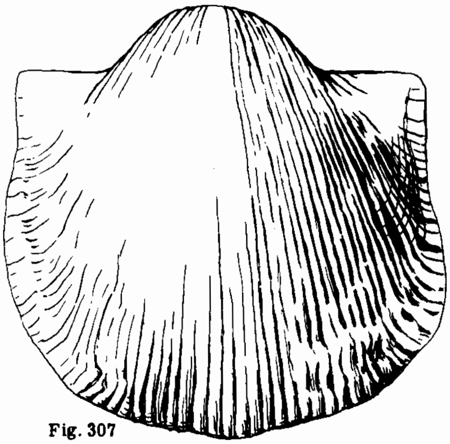


Fig. 307

In the next two genera, the concentric and radial ornamentation are about equally developed. In Juresania (fig. 308) they form wart-like bumps regularly arranged on the surface of the shell. Three species, two of them common, are found in our Pennsylvanian.

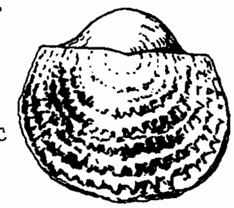


Fig. 308

Dictyoclostus resembles Juresania but its radial and concentric ornamentations are continuous instead of separated into bumps. This gives the surface of the shell the appearance of a network of square pits, most distinct in the beak region, less so away from the beak. D. semireticulatus (fig. 309) is common.

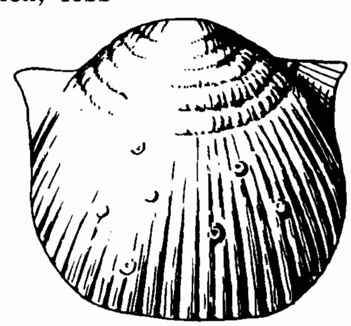


Fig. 309

PELECYPODA. The marine limestones and shales of the Pennsylvanian contain an abundance of pelecypods. Twenty-two genera are common enough to be noted here. The brackish or fresh-water shales interbedded with the coals of Ohio contain, in places, great numbers of pelecypods of peculiar character. They belong to the genus Naiadites and may be the first truly nonmarine pelecypods. The following key will help identify the commoner forms.

Key to the Commoner Pennsylvanian Pelecypods of Ohio

(see p. 4 for use of keys)

1. a) Shell with one or two distinct "wings" on the hinge 2
   b) Shell without "wings" 12

2. a) Shell with one wing only 3
   b) Shell with 2 distinct wings 4

3. a) Length more than twice the height . . . . Aviculopinna
   b) Length and height nearly equal . . . . Posidonia

4. a) Beaks at or near one end of the shell 5
   b) Beaks near the center of the shell 6

5. a) Shell higher than long, beaks at one end of the hinge . . . . Myalina
   b) Shell longer than high, beaks near but not quite at the end of the hinge . . . . Naiadites

6. a) Hinge line straight 7
   b) Hinge line V-shaped, the wings prolonged over the beak . . . . . Entolium

7. a) Wings decidedly unequal in size 8
   b) Wings almost equal in size 9

8. a) Length much greater than the height . . . . Pteria
   b) Height greater than the length . . . . Aviculopecten

9. a) Outline of one wing concave (fig. 317) 10
   b) Outline of both wings straight or convex 11

10. a) Radial ridges with wart-like bumps . . . . Euchondria
    b) Radial ridges smooth or nearly so . . . . Deltopecten

11. a) Radial ridges grouped in pairs . . . . Lima
    b) Radial ridges almost equally spaced . . . . Acanthopecten

12. a) Shell longer than high 14
    b) Shell higher than long or height and length equal 13

13. a) Surface with widely spaced concentric ridges . . . . Astartella
    b) Surface with small, crowded concentric ridges . . . . Nucula

14. a) Beaks nearly central 15
    b) Beaks nearer one end of the shell than the center 17

15. a) Surface with widely spaced concentric ridges . . . . Edmondia
    b) Surface without widely spaced concentric ridges 16

16. a) Shell with a distinct ridge from beak to margin . . . . Schizodus
    b) Shell without such a ridge . . . . Nucula

17. a) Length 4 times the height . . . . Solenomorpha
    b) Length less 4 times the height 18

18. a) Shell with one or more distinct ridges from beak to margin 19
    b) Shell without such a ridge 20

19. a) One radiating ridge only from beak to margin . . . . Parallelodon
    b) Three radiating ridges from beak to margin . . . . Pleurophorella
    c) Four to six radiating ridges from beak to margin . . . . . . Pleurophorus

20. a) One end of shell ending in a sharp point . . . . Nuculana
    b) Both ends of shell gently rounded 21

21. a) Beaks at one end of the hinge . . . . Allorisma
    b) Beaks near, but not at one end of the hinge . . . . Cypricardinia

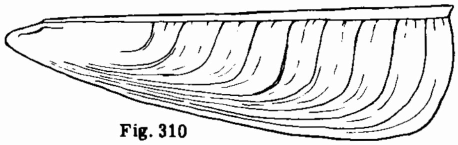


Fig. 310

Of all the winged shells of the Pennsylvanian, Aviculopinna is the most elongate; the length is more than twice the height. The beak is very near one end of the shell. A. americana (fig. 310) is a common form.

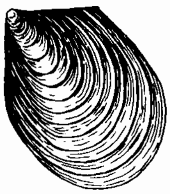


Fig. 311

Posidonia (fig. 311) has a rounded outline, very different from that of Aviculopinna and the surface is marked by widely spaced concentric ridges. Two species are common.

In Myalina (fig. 312) the beak end of the shell is sharply pointed. In some species the wing is distinct, in others it is a mere flattening of the shell behind the beaks. Several species are common.

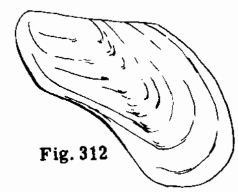


Fig. 312

Naiadites (fig. 313) is a genus of brackish or freshwater pelecypods. The specimens from shales are squashed flat and therefore look much broader than they really were. Uncrushed specimens from iron concretions show the true proportions of the shell. It has two wings, a small one next to the beak, a larger one at the other end of the shell. It lacks the pointed beak region of Myalina. Two species of Naiadites are common.

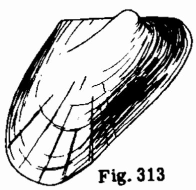


Fig. 313

The outline of Entolium (fig. 314) is quite distinct. The ears are prolonged above the hinge line, forming a V with the point at the beaks. We have two common species.

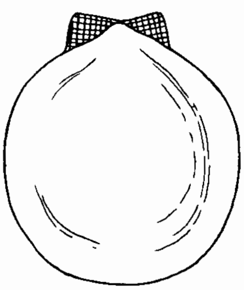


Fig. 314

The following features are characteristic of Pteria (fig. 315): the unequal wings, beak near one end of the shell, elongate outline, and strongly notched larger wing. P. ohioense is common in some beds.

Aviculopecten (fig. 316) also has unequal wings but the shell differs from that of Pteria in being as high or higher than wide, not elongate. Several other genera (see below) have about the same kind of outline but the wings are almost equal in size and they have other distinctive features. Four species of Aviculopecten occur in our Pennsylvanian.

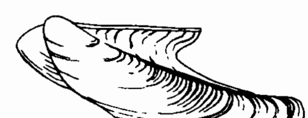


Fig. 315


Fig. 316

Euchondria and the next 3 genera have wings of almost equal size but their outline is different. In Euchondria the outline of one wing is concave and the radial ridges have wart-like bumps on them. E. neglecta (fig. 317) is common in places.

Deltopecten (fig. 318) resembles Euchondria but the radial ridges are smooth or nearly so. Two species of Deltopecten are common.

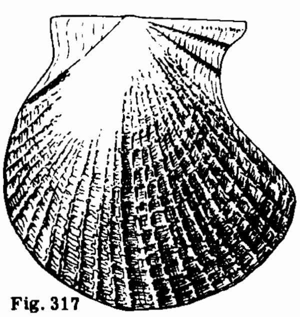


Fig. 317

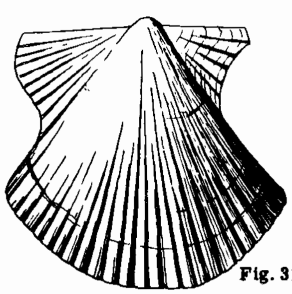


Fig. 318

In Lima and the next genus, the wings are straight or convex, not concave. Lima has radial ridges grouped in pairs; they are evenly spaced in Acanthopecten. Lima retifera (fig. 319) is common in the Pottsville; it persists into the Conemaugh which also contains another common species of Lima.

Acanthopecten (fig. 320) may be separated from Lima by the features mentioned under that genus. Two species are common.

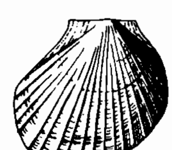


Fig. 319

Fig. 320

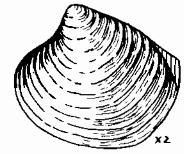


Fig. 321

Astartella (fig. 321) and the remaining genera are wingless. Astartella has a rounded shell with prominent beaks and numerous concentric ridges; the latter feature distinguishes it from Nucula. Six species of Astartella have been recorded from Ohio.

Fig. 322

Nucula (fig. 322) is mentioned twice in the key as some species are longer than high, others higher than long. The nature of the concentric ornamentation will distinguish this genus from Astartella and the absence of a ridge from beak to margin separates it from Schizodus. Six species are recorded as common from Ohio.

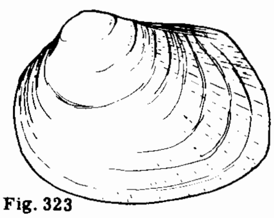


Fig. 323

Edmondia (fig. 323) is one of several genera with nearly central beaks and a rounded outline. The widely spaced concentric ridges separate it from Schizodus and Nucula. Six species of Edmondia are recorded, several of them common.

Fig. 324

Schizodus (fig. 324) has large beaks and a strong ridge running from the beak to the margin of the shell. The outline varies from almost round to elongate. Seven species, of which 3 are common, are recorded.

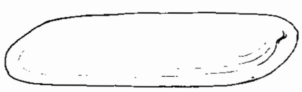


Fig. 325

Solenomorpha is a distant relative of the living razor clams. The elongate shell is distinctive. One species, S. lamborni (fig. 325) is common.

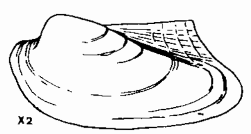


Fig. 326

Parallelodon (fig. 326) is similar to the next two genera in having an elongate shell with a strong ridge from beak to margin. It differs from them in that the ridge is rounded and not keeled and in having low but distinct radiating ridges on the entire shell or part of it. Four species of Parallelodon are common in Ohio.

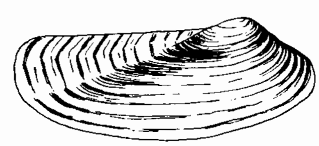


Fig. 327

Pleurophorella (fig. 327) is like Parallelodon but has 3 distinct radiating ridges and an otherwise unridged shell. Three species are common.

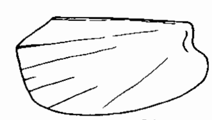


Fig. 328

Pleurophorus (fig. 328) has 4 to 6 widely spaced radiating ridges on an otherwise almost smooth shell. Three species are common.

The shell of Nuculana (fig. 329) is pointed at one end; the concentric ornamentation of fine, sharp concentric ridges is like that of Nucula. Four species are common.

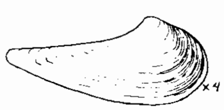


Fig. 329

Allorisma terminale (fig. 330) can be recognized by the position of the beaks which are almost at the end of the hinge. It is common in some beds.

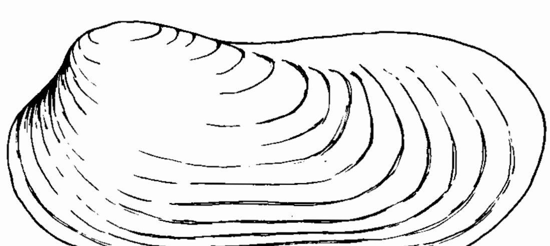


Fig. 330

Cypricardinia has much the same shape as Allorisma but the beaks are not at the end of the hinge. C. carbonaria (fig. 331) is a common species.

Fig. 331

GASTROPODA. Our Pennsylvanian rocks contain an abundance of gastropods belonging to many genera. We have chosen only the commoner forms for discussion here. The generic names used are those in the most recent works we have been able to find and we have used them although we strongly suspect that some of them should be changed. Work in progress, but not as yet published, will bring these names up to date. The commoner forms may be identified by means of the following key.

Key to the Commoner Pennsylvanian Gastropods of Ohio

(see p. 4 for use of keys)

1.	a)	Spire longer than the body whorl	6
	b)	Spire shorter than the body whorl	2
2.	a)	Spire sunken below level of last whorl	3
	b)	Spire low but above level of last whorl	Worthenia
3.	a)	Umbilicus closed, spire entirely hidden by last whorl	4
	b)	Umbilicus open, spire visible	Schizostoma
4.	a)	Axial ornamentation stronger than spiral ornamentation	Pharkidonotus
	b)	Spiral ornamentation stronger than axial ornamentation	5
5.	a)	Axial ridges almost equal in size	Euphemites
	b)	Axial ridges of 2 sizes, one large separated by 3 to 5 smaller ones	Patellostium
6.	a)	Height more than 3 times the width	7
	b)	Height less than 3 times the width	10
7.	a)	Ornamentation of axial ridges only	Loxonema
	b)	Ornamentation of spiral ridges only	8
	c)	Ornamentation of axial and spiral ridges	9
8.	a)	Three widely spaced spiral ridges only	Orthonema
	b)	Four or more closely spaced spiral ridges	Aclisina
9.	a)	Spiral ridges numerous, covering entire whorl	Aclisina
	b)	Two spiral ridges only, near the top of the whorl	Orthonema bilineatum
10.	a)	Spire shorter than the aperture	11
	b)	Spire and aperture almost equal in length	13
11.	a)	Spire sharply pointed	Sphaerodoma
	b)	Spire bluntly pointed	12
12.	a)	Axial ridges fine, crinkled	Phanerotrema
	b)	Axial ridges fine, straight	Bulimorpha
13.	a)	Shell with strong spiral ridges	Pleurotomaria
	b)	Shell without spiral ridges	Soleniscus

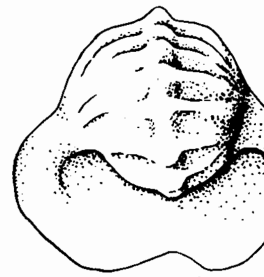

Fig. 332

Worthenia is a low-spired, highly ornamented snail with both axial and spiral ridges whose intersection forms strong nodes. W. beedei (fig. 332) is the common species.

Schizostoma (Euomphalus in older publications) is coiled in one plane and the spire is sunken below the level of the body whorl. S. catilloides (fig. 333) is common in some beds.


Fig. 333

Pharkidonotus (Bellerophon in older publications) is one of 3 genera of bellerophontids in which the spire is entirely hidden inside the body whorl (fig. 334)). It is distinguished from Euphemites and Patellostium by its strong axial ridges and the lack of spiral ridges. Several species are common.


x2
Fig. 334

Euphemites (Euphemus in older publications) is similar to Pharkidonotus in form but it has spiral ornamentation that is stronger than the axial. E. carbonarius has 16 or more spiral ridges. E. nodocarinatus (fig. 335) has a single spiral ridge on the middle of the whorl and the ridge bears a series of nodes.

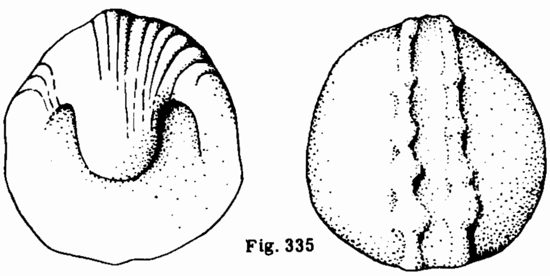
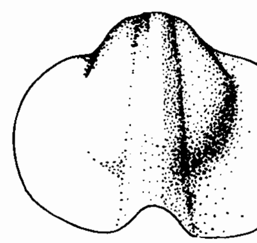


Fig. 335

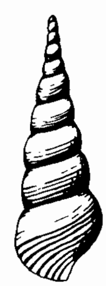
Patellostium is like the last 2 genera in form but it seems to combine the ornamentation of both. The spiral ridges are of two sizes, two large ones separated by three to five smaller ones, and it also has strong axial folds. P. montfortianum (fig. 336) is common; most specimens are crushed but recognizable by their ornamentation.

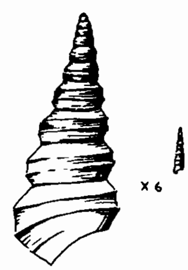

x2
Fig. 336

Loxonema and the remainder of our Pennsylvanian genera all have a spire that projects above the body whorl. In fact, in Loxonema and several of the following genera, the spire is high and the length much greater than the width. The only common species is L. scitulum (fig. 337) of the Conemaugh. It probably belongs in some other genus but for the present can still be called Loxonema.

Aclisina (fig. 338) resembles Loxonema. One group of species has only spiral ridges, the other has both spiral and axial ones. The species with spiral ridges only can be distinguished from Orthonema by the greater number of spiral ridges (only three in Orthonema). Those with axial and spiral ornamentation can be distinguished from Loxonema by the presence of the latter. Several species of Aclisina are common.


x7
Fig. 337


x7
Fig. 338


x6
Fig. 339

The species of Orthonema can be distinguished from Loxonema and Aclisina by the character of the ornamentation. O. subtaeniatum (fig. 339) has only 3 spiral ridges on the whorl; O. bilineatum resembles some species of Aclisina but it has fine axial ridges and only 2 spiral ridges near the top of the whorl. Both species are common in some beds.

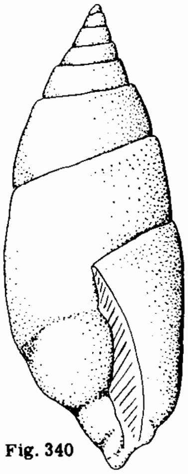


Fig. 340

Sphaerodoma (fig. 340) has a large body whorl, as compared with the last 3 genera. The spire is sharply pointed as compared with the next 2 genera. Several species of Sphaerodoma are common.

The most conspicuous character of Phanerotrema is the crinkled appearance of the axial ornamentation. The shell is wide and the aperture large. P. grayvillensis (fig. 341) is common in some beds.

Fig. 341

Bulimorpha minuta (fig. 342) of the Conemaugh is a very small shell with fine, straight axial ornamentation. The body whorl is large, as in Phanerotrema grayvillensis but size alone is sufficient to separate the two.

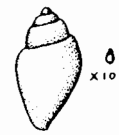


Fig. 342

Several Pennsylvanian species are placed in the genus Pleurotomaria (see fig. 264) which may not be a Paleozoic genus at all. For lack of a better generic assignment, we are leaving these species in Pleurotomaria. They are small forms with rather low spire and strong spiral ridges. One species is common and several others are rare.

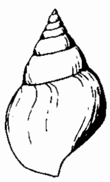


Fig. 343

In Soleniscus (fig. 343) the aperture and spire are almost equal in length. The genus is distinguished from Pleurotomaria by the absence of spiral ridges. Several species are common in some beds.

CEPHALOPODA. This class of the Mollusca is represented sparingly in the Pennsylvanian of Ohio. Only a few species can be called common. The existing fossil remains represent only a small fraction of the forms that lived in our Pennsylvanian seas for they belong to a large number of species, almost all represented by rare individuals.

Unklesbay (1954) has summarized the distribution of American Pennsylvanian cephalopods. His paper contains several lists for Ohio formations. Miller and Sturgeon revised the ammonoids and nautiloids in several papers which are noted under these groups.

Our nautiloid cephalopods include both straight and coiled forms. Two straight forms are recorded as common: "Orthoceras" rushense (fig. 344) of the Conemaugh, almost certainly belongs in some other genus, not as yet determined; and Pseudorthoceras knoxense (fig. 345) of the Pottsville.

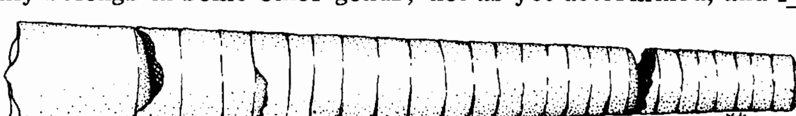


Fig. 344

Fig. 345

Fragments of coiled cephalopods (fig. 346) are not uncommon in our Pennsylvanian but their identification requires more detailed description than could be given here. The nautiloids have been revised by Sturgeon (1946) and Sturgeon and Miller (1948). The ammonoid cephalopods of the Ohio Pennsylvanian are likewise rare and varied. The species have been revised by Miller and Sturgeon (1946).

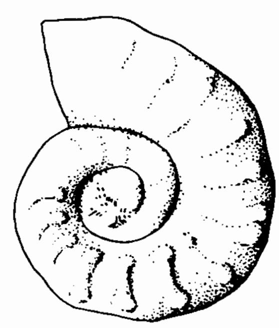


Fig. 346

OSTRACODA. Ostracodes occur abundantly in some of the Pennsylvanian beds of the state. One of us (Marple, 1952) has described in detail the species of the Pottsville series in Ohio. The other series of the Pennsylvanian rocks also contain ostracodes but the references to them are few and scattered.

Some of the non-marine Pennsylvanian beds of Ohio contain abundant ostracodes in places; their identification is difficult and should be left to the specialists. Ostracode material should be collected, even if it cannot be identified easily, as it has considerable scientific value.

TRILOBITA. Pennsylvanian trilobites are even rarer than Mississippian ones. Only one genus, Phillipsia (fig. 347) has been recorded as common. It has a plain, rather long tail with many segments. Two species are common.

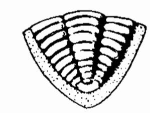


Fig. 347

INSECTA. Fossil cockroaches are found in our Pennsylvanian but they can scarcely be called common. Two localities have produced 49 species, summarized by Handlirsch (1906). Both of these localities are in the Birmingham shale (Conemaugh), one near Steubenville, the other near Richmond, Ohio (Scudder, 1888).

CRINOIDEA. Crinoids are scarce in the Pennsylvanian of Ohio although crinoid stems are abundant enough in many beds. Only one species, Eupachycrinus mooresi (fig. 348) is common enough to include here. Complete specimens are rare but the spiny plates are common in some parts of the Pottsville. They look like small cup corals but of course have no septa.

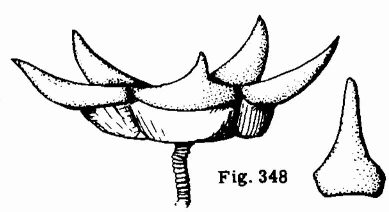


Fig. 348

ECHINOIDEA. This group must be mentioned here although no complete specimens have yet turned up in Ohio. Recognizable echinoid spines are abundant in some of our Pennsylvanian beds.

CONODONTS. These microscopic structures are found in many of the formations of our Pennsylvanian. Sturgeon and Youngquist (1949) have published on the Allegheny conodonts of Ohio.

VERTEBRATES. The Pennsylvanian of Ohio has yielded a variety of vertebrate remains. Fish scales and spines are fairly common in some beds but complete fish skeletons are rare. See Romer and Smith (1934) and Wells (1944a). A few amphibian skeletons of great scientific interest have been found at Linton, Ohio (Case, 1917; Moodie, 1916) but their remains are generally rare. The basic reference on the subject is Cope's (1875) paper. These forms have been revised by Romer (1930) and Steen (1931). Large footprints of amphibians or reptiles have been found in our Pennsylvanian. They have been described by Carman (1927a) and Mitchell (1931, 1933).

Books for further study

The two main reference works for Pennsylvanian fossils in Ohio are bulletins 17 and 25 of the Geological Survey of Ohio. Bulletin 25 is by Morningstar (1922) and describes the Pottsville and some Allegheny faunas. Bulletin 17 by Condit (1912) is on the Conemaugh formation, with paleontological descriptions by Mark (1912). A summary of Pennsylvanian stratigraphy with references to paleontological papers is given by Schuchert (1943). Earlier papers by Meek (1875) and Whitfield (1893) contain descriptions of many of our species. Papers dealing with individual groups have been cited in the text.

CHAPTER 9. PERMIAN FOSSILS

Collecting Localities

The Permian area of outcrop in Ohio is smaller than that of any other Paleozoic system. It forms a narrow crescent bounded by the Pennsylvanian outcrop areas on the west and north and the Ohio River in the southeast. Few of our Permian beds contain fossils. Fossil plants are found in some abundance above and below the coals. The most abundant animal remains are those of the Washington formation but they are much scarcer than in the underlying Pennsylvanian.

The best plant collections have been obtained at Cameron and Clarington in Monroe County and at Beckett Station, Crabapple, and Vallonia in Belmont County. The localities for animal remains are the ones mentioned above for Belmont County and Little Short Creek, Shadyside, Pleasant Grove, and Raven Rocks in the same county; Clarington, in Monroe County; and the following localities in Washington County: one mile east of Elba and Marietta.

The Commoner Fossils

PLANTS. Ferns and sections of tree trunks are found especially in the Washington formation in Monroe and Belmont counties. The genera are the same as some of the Pennsylvanian genera. They are: Pecopteris, several species; Neuropteris, Alethopteris, one species, Sphenophyllum, one species; Sigillaria, Annularia, and Cordaites, one species each.

BRACHIOPODA. A single species of Lingula (see fig. 295), L. permiana, is recorded. Some specimens are nearly half an inch long but the majority of them are smaller. The species is common in black shales near the top of the Washington formation.

PELECYPODA. Three genera of pelecypods occur in our Permian but their generic assignment is doubtful in each case. The genera may be recognized from the descriptions that follow.

Pleurophorus (?) ohioensis (fig. 349) is longer than high, with beaks near one end of the shell. The ornamentation of fine concentric ridges is inconspicuous. The species is found in the Elm Grove limestone, near the base of the Washington formation.

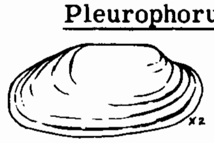


Fig. 349

Glossites (?) belmontensis (fig. 350) is similar to the preceding species and differs from it only in the following respects. The shell is more elongate, the beaks nearer one end of the shell, and less prominent. It occurs with Pleurophorus (?) ohioensis at the same locality.

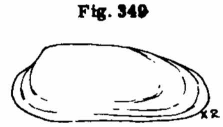


Fig. 350

Two species referred doubtfully to Edmondia (fig. 351) are proportionally higher and shorter than the last two species and much smaller, i.e. about 1/4 inch long. These two species are from the lower half of the Washington formation.

Fig. 351

GASTROPODA. Three species from our Permian have been referred doubtfully to 3 different genera. If the generic assignments are correct, one of them is a land snail and the other two are marine. Stauffer and Schroyer (1920), who described them, thought it quite probable that they were brackish or even freshwater forms belonging to undescribed genera.

Anthracopupa (?) dunkardana (fig. 352) is spindle-shaped, about 1/4 inch long, with a large body whorl and a tooth on the upper lip of the aperture. These features certainly suggest relationship with some of the land snails, but there are freshwater and marine snails which also possess these features. The shell has fine axial and spiral ornamentation. The species is from the lower part of the Washington formation.

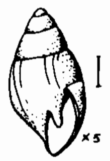


Fig. 352

Loxonema (?) parva (fig. 353) is high-spired, with a small body whorl and a pointed apex. The shell is about 1/4 inch long. It occurs in the lower part of the Washington formation.

Fig. 353

Naticopsis (?) diminuta (fig. 354) is only about 1/8 inch long and almost as wide. Its shell is proportionally wider than that of the 2 preceding species. It is found in the lower part of the Washington formation at the same locality as Loxonema (?) parva.

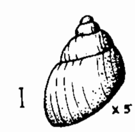


Fig. 354

ANNELIDA. Small, spiral worm tubes of the genus Spirorbis (see fig. 43) are abundant in the limestones and calcareous shales of our Permian. They have not been identified specifically. They are often mistaken for small gastropods but may be distinguished from them by the flatness of the "spire," i. e. the side of the shell by which it was attached.

OSTRACODA. Representatives of this group are common in parts of our Permian. They have been referred to the genus Cythere but the variety of forms found suggests that other genera may be represented also.

FISHES. A variety of fish material is found in the Permian of Ohio, but none of it consists of complete skeletons. Coprolites, probably from fishes, are common near the base of the Washington formation. A large spine, one foot long, has been found in the same formation and fragments of the same nature may be expected elsewhere. Small, conical fish teeth are common in the same formation. A shark tooth, with two large and one small cusps, has been called Diplodus washingtonensis. It is from the middle of the Washington formation.

AMPHIBIANS. The only amphibian remains so far recorded for the Permian of Ohio are coprolites, larger than the fish coprolites already mentioned. They are common in the middle of the Washington formation.

REPTILES. The finding of a single fragment of a spine of Edaphosaurus from the middle part of the Washington formation indicates that this group of animals was represented in Ohio during Permian time. No other specimens have so far been collected.

Books for further study

The standard reference for Permian fossils in Ohio is Stauffer and Schroyer (1920). They describe and illustrate the species just mentioned. There is a short discussion of the Permian of Ohio in Schuchert (1943, p. 574). The catalogue compiled by Branson (1948) lists all species recorded from Permian beds; it is an invaluable guide for the advanced worker. For a more extensive treatment of vertebrates, see Burke (1935).

CHAPTER 10. PLEISTOCENE FOSSILS

Collecting Localities

There is scarcely a county in Ohio where Pleistocene fossils may not be found. The old beaches of Lake Erie in the northern part of the state have yielded some interesting fossil plants, invertebrates, and vertebrates; extinct lakes, long since drained or choked up with sediments, have formed marl and clay beds which contain abundant gastropods, pelecypods, and ostracodes. One such deposit, in Madison County, has recently yielded the skeleton of a mastodon associated with an abundant freshwater fauna. Abandoned river channels in several places in the state have beds of gravel and dried mud which also contain fossils.

The Commoner Fossils

PLANTS. The plants of the Pleistocene, in most cases, are identical with living plants. Fossil wood, leaves, and seeds from Pleistocene deposits are best identified from botany manuals. Some of the lake beds contain great quantities of fossil pollen which, with the help of a microscope, can be identified to genus, if not to species. It provides an indication of the vegetation surrounding a particular lake or pond during Pleistocene time.

The age of fossil wood from Pleistocene beds in Ohio has been determined by the carbon 14 method (see chapter 2). See Libby (1952) for carbon 14 determinations of Ohio fossil wood.

INVERTEBRATES. The fossil invertebrates found in Ohio Pleistocene deposits nearly all belong to species still living in the state. There is no better way to learn the genera and species of these deposits than collecting the living invertebrates of the state and studying them. This method has the advantage of applying to the fossil forms the rich store of information derived from living animals studied in their natural environment. The Pleistocene fauna seems less rich than the present one for only those animals with hard parts, for example a shell or carapace, have been preserved. No record of freshwater sponges, jellyfish, bryozoans, or soft-bodied arthropods exists for the Ohio Pleistocene. The record for the spiders and insects is exceedingly scanty although these groups must have been as abundant then as they are now. The most abundant record is that of clams, snails, and ostracodes.

MOLLUSCA. The two classes represented in our Pleistocene deposits are the Pelecypoda (clams) and the Gastropoda (snails). The standard text for freshwater clams and snails is Baker (1928); most of our freshwater genera and species are described in this text. A more elementary guide is Goodrich (1932) which is as suitable for Ohio as for Michigan. The best reference for land snails is Pilsbry's two-volume work (1939, 1940, 1946, and 1948) which covers the subject thoroughly. One of us (La Rocque, 1953) has published a catalogue which gives references for all species likely to occur in the Ohio Pleistocene.

PELECYPODA. The Pleistocene freshwater pelecypods of Ohio belong to two families, the Unionidae (freshwater mussels) and the Sphaeriidae (fingernail clams). They may be distinguished by the following characters and the key to the commoner genera of Unionidae which follows.

Sphaeriidae: beaks almost in the center of the hinge, their sculpture like that of the remainder of the shell; cardinal teeth almost directly under the beaks; two groups of lateral teeth, one at each end of the hinge; adults less than one inch long.

Unionidae: Beaks near one end of the hinge, their sculpture different from that of the remainder of the shell; one group of teeth (called pseudocardinals, but usually referred to as cardinals) under the beaks and another (laterals) parallel to the hinge and behind the beaks; one or both of these groups of teeth may be lacking; adults more than one inch long.

Key to the Commoner Pleistocene Unionidae of Ohio

(see p. 4 for use of keys)

1. a) Hinge without teeth . . . . Anodonta
   b) Hinge with one or more teeth 2

2. a) Length 1.5 times or more the height 3
   b) Length and height almost equal 7

3. a) Teeth consisting of indistinct swellings . . . . Strophitus
   b) Teeth distinct and prominent 4

4. a) Shell with flutings at one end . . . . Lasmigona
   b) Shell without flutings 5

5. a) Shell much thicker at one end . . . . Elliptio
   b) Shell not noticeably thicker at one end 6

6. a) Shell convex, almost cylindrical . . . . Ligumia
   b) Shell compressed . . . . Lampsilis

7. a) Shell winged 8
   b) Shell not winged 9

8. a) Teeth under beaks poorly developed; shell solid . . . . Proptera
   b) Teeth under beaks well developed; shell thin and fragile . . . . . . Leptodea

9. a) Shell almost round in outline; beaks low; teeth large and solid . . . . Obovaria
   b) Shell oval in outline; beaks swollen; teeth small . . . . Lampsilis

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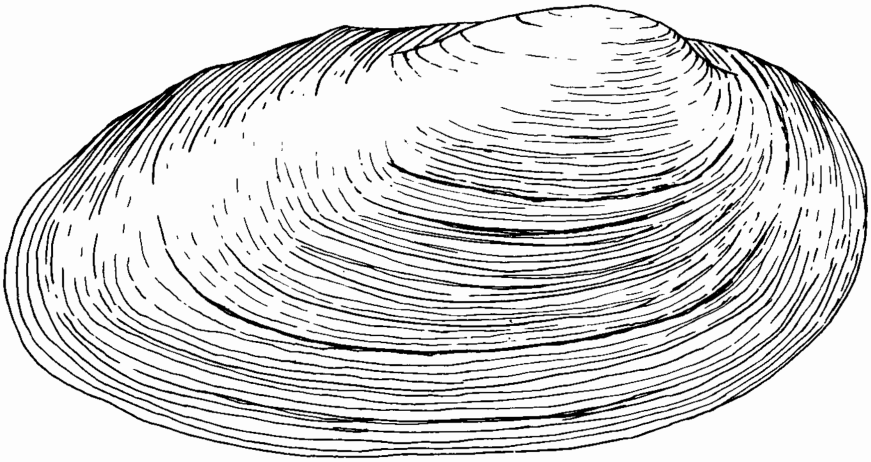

Fig. 355

The genus Anodonta (fig. 355) is easily recognized; no other freshwater mussel has such a thin shell; besides, the hinge is completely without teeth. Several species live in Ohio lakes and rivers at present. Fragments have been found in Pleistocene deposits, usually too poorly preserved for specific identification.

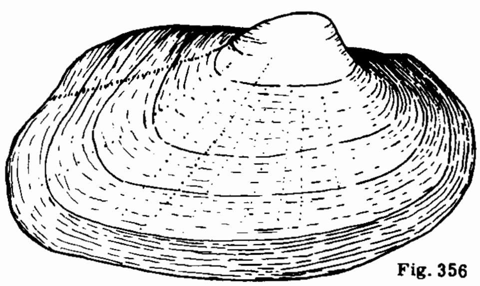

Fig. 356

Strophitus (fig. 356) is similar to Anodonta in having a thin shell and lacking lateral teeth, but it differs in having one or two rudimentary cardinal teeth in each valve.

In Lasmigona (fig. 357) the hinge of the right valve bears one cardinal tooth, that of the left valve two; the lateral teeth are poorly developed. In one group of species of this genus, the shell is strongly fluted at one end; in another group, it is smooth or nearly so. Species of the genus have not so far been identified from Ohio Pleistocene deposits, but they will be found in them sooner or later. Several species of Lasmigona are still living in Ohio waters.

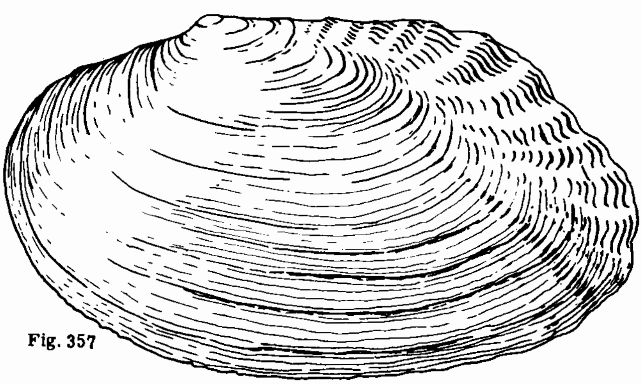

Fig. 357

The shell of Elliptio (fig. 358) is solid and the interior is purple. The hinge has two cardinal and two lateral teeth in the left valve; one cardinal and one lateral in the right valve. This is a river mussel, usually poorly preserved in Pleistocene river deposits, but still living in the rivers of the state.

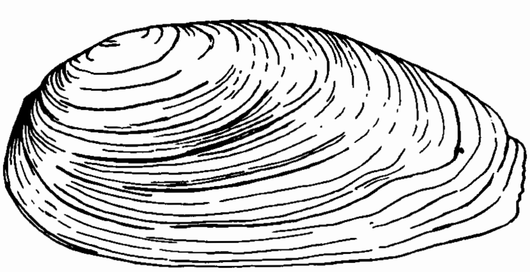

Fig. 358

The shell of Ligumia (fig. 359) is thick, solid, much longer than wide. Two cardinals in the left valve, one in the right. Two laterals in the left valve, one in the right. The laterals are wide, long, and have rough edges. One species still lives in Lake Erie and other waters of the state.

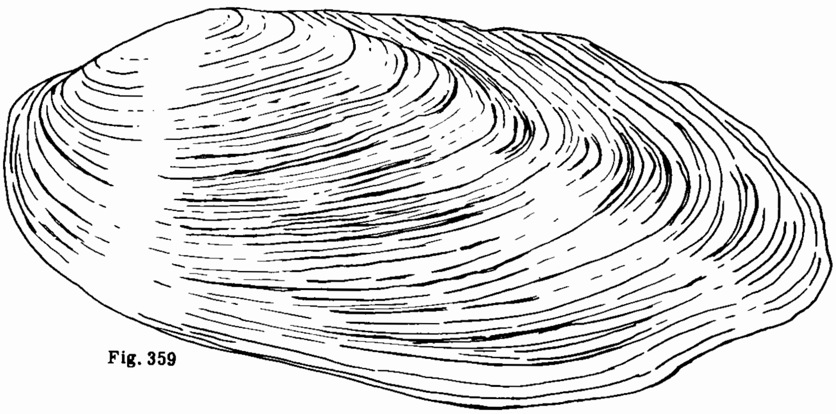

Fig. 359

Lampsilis (fig. 360) appears twice in the key as some of the species are elongated and others are almost circular in outline. The shell may be as much as 6 inches or more long; it has one or two cardinals and one lateral in the right valve; two cardinals and two laterals in the left valve; female shells are strongly swollen behind. The genus contains many species, some of which are still living in the rivers and lakes of Ohio. They are often numerous in Pleistocene deposits.

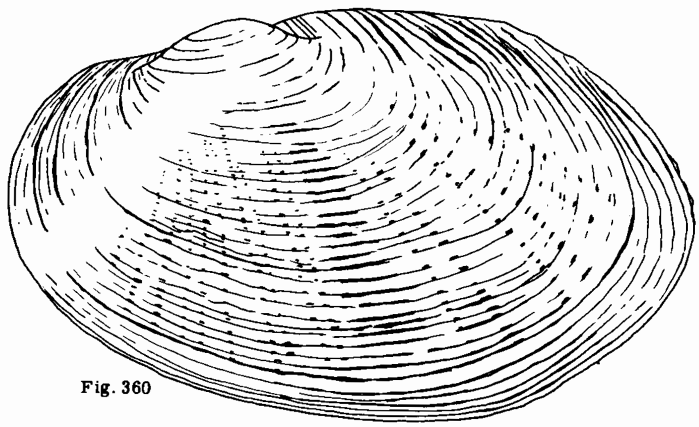

Fig. 360

In Leptodea (fig. 361) the shell is very thin and fragile, straw-yellow, prolonged into a wing posteriorly. Two cardinals in the left valve, one in the right. Two laterals in each valve. It may be distinguished from the next genus by the greater development of the cardinal teeth and the thinness of the shell.

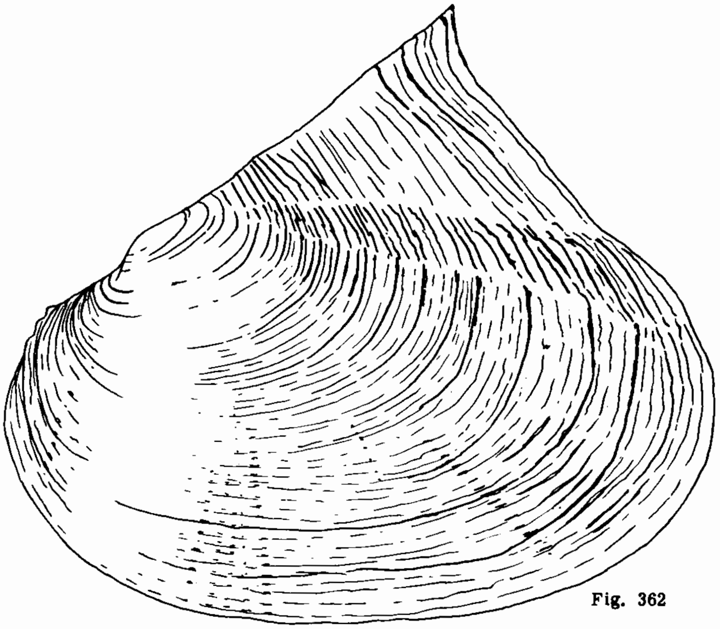

Fig. 362

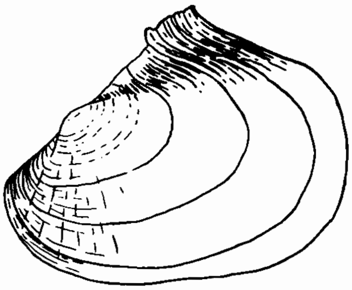

Fig. 361

Proptera (fig. 362) has a large shell with a wing which is similar to that of Leptodea. It is distinguished from that genus by the imperfectly developed cardinal teeth. Living shells are dark brown on the outside of the shell, various shades of purple inside, and the color is often preserved in fossil shells.

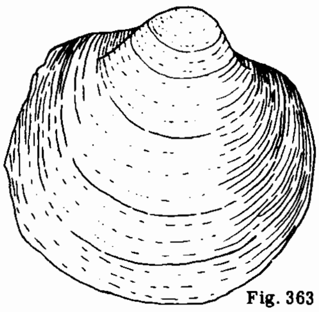

Fig. 363

The shell in Obovaria (fig. 363) is small, almost round, with solid teeth, both laterals and cardinals. The species are easily recognized by the thick shell, which is thickest in the region of the beak.

In the family Sphaeriidae, there are cardinal teeth under the beak and one set of laterals on each side of the hinge. Identification of the species is a job for a specialist. For descriptions, see Baker (1928a). The genera may be distinguished by the following characters.

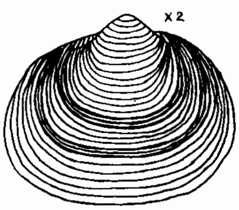

Fig. 364

In Sphaerium (fig. 364) the beaks are almost central, not inflated; the shell is regularly ovoid. Individuals of several species are common in Ohio Pleistocene lake and river deposits.

Musculium (fig. 365) is similar to Sphaerium; in fact, some specialists consider the two genera identical. Species of Musculium can be recognized by the swollen beaks, which are separated from the body of the shell by a distinct groove. A few species have been recorded in lake and pond deposits; where they occur, they are often very common.

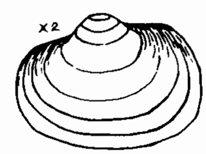

Fig. 365

In Pisidium (fig. 366) the shell is small and the beaks are nearer one end of the shell than the other. The valves are thick, so much so that some specimens at first sight look like a garden pea. It is very abundant in lake and river deposits.

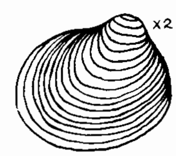

Fig. 366

GASTROPODA. The Pleistocene gastropods of Ohio belong to several families but the characteristics on which they are based are not available in the fossil shells. They can be identified to genus by shell characters which have been used exclusively in this book.

Both land and freshwater snails are found in our Pleistocene deposits. No general rules can be given to distinguish freshwater snails from land snails and they occur together in lake and river deposits, the freshwater snails preserved in their natural habitat, the land forms washed into the lakes and rivers by rains and floods. The following key will identify the commoner genera. In the text, the genera are grouped according to their habitat.

Key to the Commoner Pleistocene Gastropods of Ohio

(see p. 4 for use of keys)

1. a) Shell saucer-shaped, not coiled . . . . Ferrissia
   b) Shell coiled 2

2. a) Shell coiled in one plane 3
   b) Shell not coiled in one plane 7

3. a) With axial ornamentation only 4
   b) With both axial and spiral ornamentation . . . . Helicodiscus

4. a) Shell keeled on outer margin . . . . Promenetus
b) Shell not keeled on outer margin 5

5. a) Shell funnel-shaped on top and bottom 6
b) Shell funnel-shaped on bottom only . . . . Gyraulus

6. a) Shell with internal teeth . . . . Planorbula
b) Shell without internal teeth . . . . Helisoma

7. a) Shell coiled to the left 8
b) Shell coiled to the right 9

8. a) Spire longer than aperture . . . . Aplexa
b) Spire shorter than aperture . . . . Physa

9. a) Edge of aperture sharp, not reflected 10
b) Edge of aperture thick, reflected 36

10. a) Shell longer than wide 11
b) Shell wider than long 25

11. a) Spire sharply pointed 12
b) Spire bluntly pointed 17

12. a) Aperture more than 1/4 of the length 13
b) Aperture less than 1/4 of the length 16

13. a) Aperture more than 1/2 the length 14
b) Aperture less than 1/2 the length 15

14. a) Whorls nearly flat-sided . . . . Lymnaea
b) Whorls rounded . . . . Bulimnea

15. a) Length of adult more than 3/4 inch . . . . Stagnicola
b) Length of adult less than 3/4 inch . . . . Fossaria

16. a) Aperture prolonged below into a short canal . . . . Pleurocera
b) Aperture rounded below . . . . Goniobasis

17. a) Aperture longer than spire 18
b) Aperture shorter than spire 19

18. a) Surface with both axial and spiral striae . . . . Pseudosuccinea
b) Surface with axial striae only . . . . Succinea

19. a) Aperture not reflected over umbilicus 20
b) Aperture reflected over umbilicus 22

20. a) Adult more than 1 inch high . . . . Campeloma
b) Adult less than 1 inch high 21

21. a) First two whorls coiled in same plane . . . . Cincinnatia
b) First two whorls not coiled in same plane . . . . Amnicola

22. a) Length and width almost equal . . . . Zoögenetes
b) Length greater than the width 23

23. a) Shell very smooth and shining . . . . Cionella
    b) Shell with distinct axial striae 24

24. a) Shell almost cylindrical . . . . Columella
    b) Shell spindle-shaped . . . . Pupilla

25. a) Shell angulated or keeled 26
    b) Shell with rounded whorls 28

26. a) Shell with 3 angulations which may also be keeled . . . . Valvata
    b) Shell with one angulation only 27

27. a) Surface with irregular brown markings; adult more than 3/4 inch wide . . . . Anguispira
    b) Surface without irregular brown markings; adult less than 5/8 inch wide . . . . Discus

28. a) Adult more than 3/4 inch wide 29
    b) Adult less than 3/4 inch wide 30

29. a) Whorls increasing rapidly in size . . . . Mesomphix
    b) Whorls increasing slowly in size . . . . Haplotrema

30. a) Aperture more than 1/2 the length . . . . Vitrina
    b) Aperture less than 1/2 the length 31

31. a) Shell globular, with flattened base . . . . Euconulus
    b) Shell like a thick lens 32

32. a) Shell with 3 rows of internal lamellae . . . . Paravitrea
    b) Shell without internal lamellae 33

33. a) Adult shell less than 1/8 inch wide 34
    b) Adult shell more than 1/8 inch wide 36

34. a) Surface with both axial and spiral ridges 35
    b) Surface with axial ridges only . . . . Hawaiia

35. a) Surface with axial and spiral ridges . . . . Striatura
    b) Surface with axial ridges only . . . . Punctum

36. a) Shell smooth, shining, with only a few, widely spaced ridges . . . . Retinella
    b) Shell with numerous, closely spaced ridges . . . . Zonitoides

37. a) Shell higher than wide 38
    b) Shell wider than high 41

38. a) Spire bluntly pointed . . . . Carychium
    b) Spire cylindrical, flat-topped 39

39. a) Aperture widely reflected . . . . Gastrocopta
    b) Aperture narrowly reflected 40

40. a) Last whorl not constricted just behind the aperture . . . . Vertigo
    b) Last whorl constricted just behind the aperture . . . . Pupilla

41. a) Adult more than 1/2 inch wide . . . . Mesodon and related genera
b) Adult less than 1/2 inch wide 42

42. a) Shell globular 43
b) Shell like a thick lens 44

43. a) With internal lamellae . . . . Strobilops
b) Without internal lamellae . . . . Euconulus

44. a) Shell only a little wider than high . . . . Vallonia
b) Shell much wider than high . . . . Planogyra

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a) Freshwater Genera

In Campeloma (fig. 367) the shell is large (1.25 to 1.5 inches or more long), green, the spire often eroded. The aperture is rounded and not reflected over the umbilicus. This group of snails lives in shallow, quiet water, on mud and sand. Several species live in Ohio; a few have been found as fossils.

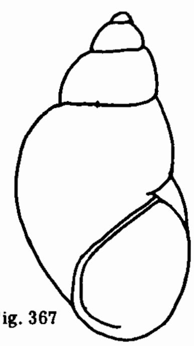
Fig. 367

The shell in the genus Valvata is small; the umbilicus is large and deep; in one Ohio species, V. tricarinata (fig. 368) the shell has three keels, one on the shoulder of the whorl, one in the middle, and one at the base. In two other Ohio species, V. lewisi and V. sincera, there are no keels but the shape is the same as in V. tricarinata. V. lewisi has a wide umbilicus and low spire; V. sincera has a narrow umbilicus and high spire.

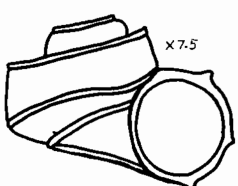

Fig. 368

Amnicola (fig. 369) has a small shell (1/8 to 1/4 inch high), the spire is moderately high, the umbilicus narrow, the aperture entire and not reflected over the umbilicus. Several species have been recorded from the Pleistocene of Ohio.


Fig. 369


Fig. 370

Cincinnatia (fig. 370) is similar to Amnicola, but with the first 2 whorls coiled in the same plane; it is about the same size as Amnicola. A few species are abundant in our Pleistocene.

Goniobasis (fig. 371) is the commoner of two very long-spired genera; it is of medium size, 1 to 1.5 inches long, and is distinguished from Pleurocera by its rounded lip which is not prolonged into a short canal below. Species of this genus are particularly abundant in river deposits.

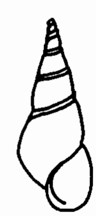
Fig. 371

Pleurocera (fig. 372) is similar to Goniobasis but has an even higher spire. The lower lip is prolonged into a short canal and the shell seems therefore to be slightly pointed below. It is also found in river deposits, but not as commonly as Goniobasis.

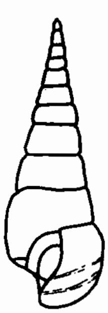
Fig. 372

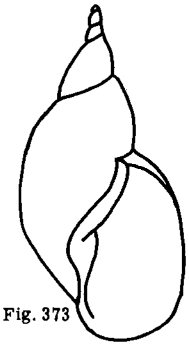
Fig. 373

The shell of Lymnaea is large, up to 2.5 inches long, thin, with a sharply pointed spire and a large aperture. The inner edge of the aperture is widely reflected over the umbilicus which it closes almost entirely. L. stagnalis (fig. 373) is common in lake deposits.

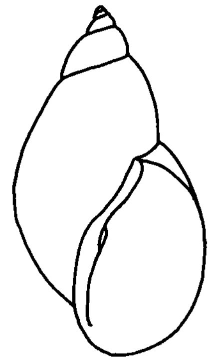
Fig. 374

Bulimnea has almost as large a shell as Lymnaea but its spire is shorter and stouter, with more swollen whorls. The color of the fresh shell is purplish brown and some of the color is preserved in fossil shells. B. megasoma (fig. 374) is common in some lake deposits.

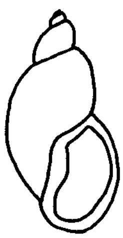
Fig. 375

In Stagnicola (fig. 375) the shell is of much the same shape as in Bulimnea but with a longer spire and smaller aperture. Shells of this genus are smaller than the preceding two genera, seldom attaining more than 1.5 inches. Several species are common in lake and river deposits in our Pleistocene.


Fig. 376

Pseudosuccinea has a shell of medium size, 5/8 to 3/4 inch long; the aperture is longer than the spire, wide and flaring; the surface has minute spiral and vertical ridges, a feature which distinguishes Pseudosuccinea from Succinea and Oxyloma which have only axial ridges. P. columella (fig. 376) is common in small-lake deposits in Ohio.

Fig. 377

Fossaria (fig. 377) has a shell much like that of the preceding two genera but much smaller. The differences between the three genera are anatomical and it is not always possible to distinguish Fossaria from them. A shell having this general aspect and less than 1/2 inch long can be safely referred to Fossaria. Several species of the genus are common in all freshwater beds.

Shells of the following four genera are commonly called "ramshorn snails" because of their shape. Those of the genus Helisoma are the largest of the group. The three commoner species may be separated by means of the following key:

a) Spire sunken, in the shape of a funnel; umbilicus deep . . . . H. anceps (fig. 378)
b) Spire flat, sometimes rising a little above the body whorl; umbilicus deep; aperture bell-shaped . . . . H. campanulatum (fig. 379)
c) Spire flat, almost always lower than the body whorl, aperture not bell-shaped . . . . H. trivolvis (fig. 380)

These three species are common in both river and lake deposits in Ohio.

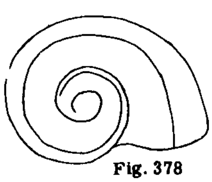
Fig. 378

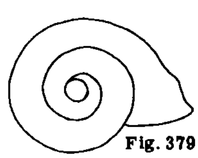
Fig. 379

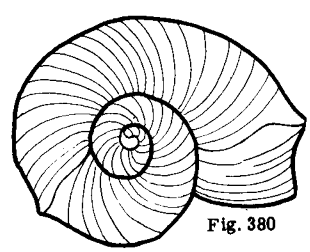
Fig. 380

Planorbula is similar to Helisoma but smaller, flattened, and the last whorl has several lamellae within the whorl. P. armigera (fig. 381) is common in stream deposits in Ohio.


Fig. 381

Promenetus (fig. 382) is small (1/4 to 3/8 inch), like Planorbula but much flatter, and without internal lamellae. The outer edge of the whorl is pinched in to form a low keel. Several species are common in the Pleistocene of Ohio.


Fig. 382

Gyraulus (fig. 383) is similar to Promenetus in size and shape but it lacks the keel on the outer edge of the whorl. Several species are common in our Pleistocene.

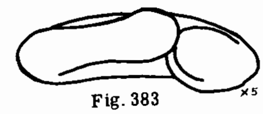
Fig. 383

The shells of Ferrissia (fig. 384) are unique among freshwater gastropods. They are not coiled, but saucer-shaped or cap-shaped. Several species are common in the Pleistocene of Ohio.

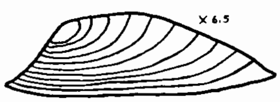
Fig. 384

The shell of Physa (fig. 385) is similar to that of Lymnaea but coils in the opposite direction. Compare figures of the two genera and note the position of the aperture. Physa can be confused only with Aplexa which is the only other shell that coils in the same direction. Several species of Physa are found in both lake and river deposits.


Fig. 385

Aplexa (fig. 386) is similar to Physa but the spire is narrower and more slender. Moreover, the shell of Aplexa has a metallic sheen which is preserved in fossil shells. A. hypnorum is common in pond deposits.


Fig. 386

b) Land Genera

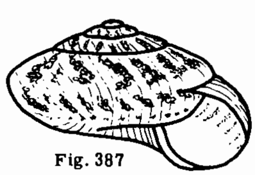
Fig. 387

Anguispira (fig. 387) has a depressed shell, wider than high, and a wide umbilicus. The surface is covered with irregular brown markings, sometimes preserved in fossil shells. The aperture is not reflected. A. alternata is one of the commonest land snails of the Ohio Pleistocene and its shells are found commonly in lake and river deposits.

Mesodon (fig. 388) has a large shell, with a moderately high spire; the body whorl is large, evenly rounded; lip reflected all round, the inner margin covering the umbilicus. In some species the aperture has internal lamellae which may be so large as to fill the aperture almost completely. Several genera (Allogona, Triodopsis, Stenotrema) resemble Mesodon so closely that they are not separated from it here. These land snails are common in lake deposits into which they were washed from the surrounding land areas. They are called Polygyra or Helix in older publications.


Fig. 388


Fig. 389

The shell of Succinea (fig. 389) resembles that of Pseudosuccinea very closely, but it may be distinguished from it by the presence of axial striations only on the surface; Pseudosuccinea has both axial and spiral striations. Three species of Succinea and the closely related genus Oxyloma are common in lake deposits.

The shell of Haplotrema (fig. 390) is similar to that of Anguispira; it has the same wide umbilicus and simple lip, but it lacks the color markings of Anguispira. The whorls increase in size more slowly than in Anguispira. H. concavum is abundant in some of our lake deposits.


Fig. 390

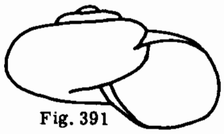

Fig. 391

Mesomphix (fig. 391) is similar to Haplotrema but has whorls that increase rapidly in size; the shell is very thin and fragile and therefore is often represented only by fragments in our lake deposits. Two or three species are common in the Pleistocene of Ohio.

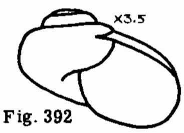

Fig. 392

Vitrina has a shell of only 3 whorls, enlarging rapidly, the last whorl much larger than the other two; the shell is thin, the aperture simple, the lip sharp. V. limpida (fig. 392) is the common species in the Pleistocene of Ohio.

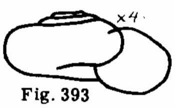

Fig. 393

In Zonitoides (fig. 393) the shell is small or of medium size, with a slightly elevated spire. The umbilicus is moderately wide, the lip simple, sharp. Ornamentation of faint, crowded axial striae only. Two species are common in our Pleistocene.

Discus is similar to Zonitoides but has a much wider umbilicus. The ornamentation is of coarse, widely spaced axial striae. The shoulder is angulated to rounded. Discus cronkhitei (fig. 394) is common in the Ohio Pleistocene.

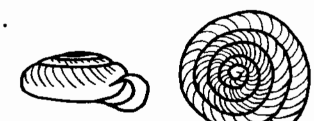

Fig. 394

In Vallonia (fig. 395) the shell is small, a little wider than high; the most conspicuous feature is the reflected lip which is of the same width all round. Common in lake deposits.

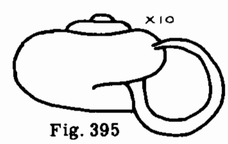

Fig. 395

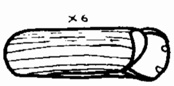

Fig. 396

Helicodiscus is so like the smaller ramshorn shells that it was first described under the genus Planorbis, by mistake. It is now known to be a land snail. The shell is small (1/8 inch wide), the spire very low. The surface has both axial and spiral ridges. Helicodiscus parallelus (fig. 396) is common in pond and lake deposits.

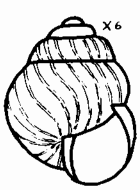

Fig. 397

Zoögenetes is also small (3/16 inch high) but the spire is higher than that of Helicodiscus. The surface has strong axial ridges; the aperture is oval, the lip sharp. Z. harpa (fig. 397) is common in some pond deposits in Ohio.

In Cionella the shell is longer than wide, small (1/4 inch high), very smooth and shining, the aperture narrowed below. It has no internal lamellae. C. lubrica (fig. 398) is common in pond and small lake deposits in Ohio.

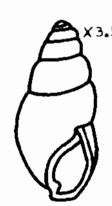

Fig. 398

Fig. 399

Carychium (fig. 399) resembles Cionella but is much smaller (about 1/16 inch long) and it has a reflected lip and elongated aperture. There is one internal lamella. The surface bears weak axial ridges. Two or more species are represented in the Pleistocene of Ohio.

Pupilla is one of 4 genera with a barrel-shaped shell. It is small (length 3/8 inch), the aperture is thickened and bears one or two lamellae or none at all. The lip is less reflected than that of Gastrocopta and the last whorl is not constricted as in Vertigo. Pupilla muscorum (fig. 400) is abundant in some pond beds in Ohio.

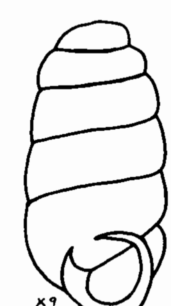

Fig. 400

Gastrocopta (fig. 401) resembles Pupilla but has a more strongly reflected lip. From Vertigo it differs in that the last whorl is not constricted. Most of the species have strong internal lamellae but they are weak and inconspicuous in some of them. Several species have been collected in the Pleistocene of Ohio.


Fig. 401


Fig. 402

Vertigo (fig. 402) is the smallest (less than 1/16 inch) of the barrel-shaped land shells. It is recognized by its constricted body whorl, the lamellae, which are strong in most species, and its small size. Several species occur in our Pleistocene.

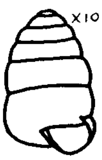
Fig. 403

Columella is also very small (1/16 inch high) and almost cylindrical; it is recognized by its high spire, small aperture, and the absence of internal lamellae. C. edentula (fig. 403) is a common species in the Pleistocene of Ohio.

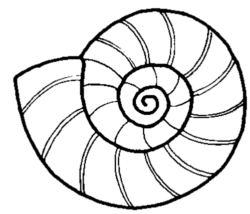
Fig. 404

Retinella (fig. 404) has a low-spired shell; the surface is shining, even in fossil specimens, and has very weak axial ridges. The umbilicus is narrow or moderately wide. The lip is thin and sharp. Two or three species are common in our Pleistocene.

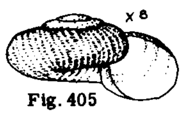
Fig. 405

Striatura (fig. 405) is small (1/8 inch or less) with a low spire; the strong ornamentation of axial and spiral ridges, the simple lip, and the absence of internal lamellae are characteristic. Three species are common in pond and lake deposits.


Fig. 406

In Planogyra the shell is small, the spire low. It is distinguished from Striatura by the strong axial ridges which are parallel to the growth lines; in Striatura the axial ridges are oblique. P. asteriscus (fig. 406) is commonly found in pond and lake deposits.


Fig. 407

Punctum resembles Striatura but is even smaller (a little more than 1/16 inch wide); the aperture is simple, sharp. It is distinguished from Striatura by the lack of spiral ridges; the axial ridges are strong and distinct. P. pygmaeum (fig. 407) is the common species of our Pleistocene.

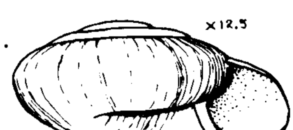
Fig. 408

Hawaiia is a little larger than Punctum which it closely resembles. It has microscopic vertical ridges, the aperture is nearly round, and the umbilicus is wide. H. minuscula (fig. 408) is common in pond and lake deposits.


Fig. 409


Fig. 410

The shell of Strobilops is small (1/8 inch wide, globular but with a flattened base; its shape suggests a beehive. It has strong vertical ridges; the several internal lamellae are spiral, extend far back into the shell, and bear microscopic spines. S. labyrinthica (fig. 409) is the common species.

Euconulus resembles Strobilops but lacks internal lamellae. The surface has only faint axial ridges. E. fulvus (fig. 410) is common in lake deposits.

c) Slugs

Living slugs seem to have no shell at all; it is hidden inside the mantle which covers the front part of the body. The slug shell is a flat or slightly curved plate, oval in shape; in some genera it is reduced to a few calcareous granules. It is difficult to identify slug shells even to genus, but they are mentioned here as they have been found in some numbers in our Pleistocene deposits.

OSTRACODA. Fossil ostracodes in great numbers are found in Pleistocene deposits of Ohio. Their identification is difficult for a non-specialist. Many genera and species have been recorded for Ohio.

INSECTA. Fossil insects are rare in Ohio Pleistocene deposits. No doubt insects existed in large numbers during Pleistocene time here, but the sediments were such that the delicate bodies of insects were seldom preserved. Stout beetle wing-cases are found from time to time; their identification is a task for an entomologist.

AMPHIBIA AND REPTILIA. The Pleistocene amphibians of Ohio, unlike those of the Pennsylvanian, are neither large nor extinct. They are the familiar living salamanders, toads, and frogs, as well as the "mud-puppy" Necturus maculosus which looks like a catfish but can be distinguished from one by its legs and external, red gills.

The reptiles include lizards, snakes, and turtles of the same species as those now living in Ohio.

BIRDS. Bird bones are sometimes found in Pleistocene deposits but complete skeletons have not yet been recorded. No especially curious forms have been noted.

MAMMALS. The mammals are the most important and interesting of the fossil vertebrates of the state. During times of glaciation northern forms, such as the mastodon, mammoth, giant beaver, and many others, inhabited the state and their remains are found from time to time in gravel pits and dried swamps. During the periods when glaciers were absent from the state and the climate was even milder than now, southern forms invaded Ohio; of these the ground sloth, the peccaries, and horses are the most interesting.

Pleistocene mammals are found in Ohio as rare complete skeletons, occasional skulls, and more often as isolated bones and teeth. Identification of complete skeletons and skulls is relatively easy, at least to genus; some types of teeth (e.g. mammoth, mastodon) are easily recognizable but others call for a specialist.

Pleistocene mammal finds may have considerable scientific interest, but digging them out should be left to a specialist. If you find indications of such a specimen, for example a tusk or part of a skull sticking out of a river bank, the best thing to do is to leave it alone and report the find to the closest specialist - there is usually one at the nearest university or college - who can decide whether it has scientific value. If it has, he can make careful notes on the position of the skeleton with respect to the beds in which it lies and dig it out carefully so that it will have maximum scientific value. By the way, don't expect to make a fortune out of your find; the geologist who digs it out will have to spend both time and money to get it to a museum. Don't be surprised either if your find turns out to be a horse or cow that somebody buried ten or thirty years ago.

The mastodons and mammoths are the largest of our Pleistocene mammals. Their long bones, ribs, and vertebrae look very much alike but if the skull or even just the teeth are found, they can be identified. They have large teeth, some nearly a foot long, which set them apart from anything else. In the mastodons the teeth (fig. 411) have two rows of large cone-shaped bumps, called cusps; in the mammoths (fig. 412) the teeth have a series of transverse ridges instead. For a recent find of a mastodon skeleton in Madison County, see papers by Goldthwait, LaRocque, Sears and Clisby, Thomas and Wood, all (1952).

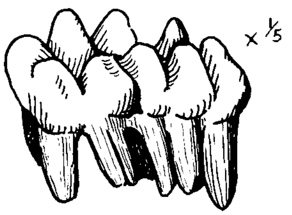

Fig. 411

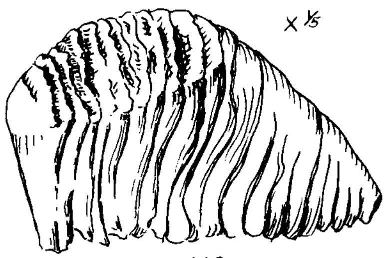

Fig. 412

Giant beaver skulls are easily recognizable because of their size and the long, chisel-shaped front teeth, called incisors; smaller skulls, with the same kind of teeth, may belong to a variety of mammals, such as beaver, muskrat, woodchuck, squirrels, chipmunks, rats, and mice.

Antlers of moose and deer turn up occasionally in Pleistocene deposits as well as horn-cores of bison and musk-ox. Their skulls can easily be mistaken for cow skulls and vice versa. Bear skeletons have also been found, but rarely.

Ground sloths (fig. 413) ranged into Ohio during the warmer intervals of the Pleistocene. One complete skeleton from Holmes County is mounted in the Geological Museum of the Ohio State University in Columbus (Claypole, 1891). The ground sloths were much like the South American tree sloths of the present day but they were much larger and lived on the ground, rather than in trees. They were slow-moving animals, almost without teeth, feeding on ground plants and the leaves of trees and bushes. They were clumsy looking animals, walking on the sides of their feet. The skull is large, recognizable by the near absence of teeth. The foot bones may also be recognized by their peculiar shape and long claws.

Fig. 413

Peccaries are pig-like animals, more like wild pigs than the domestic animals, and about the same size. Skulls are easily recognizable by the short tusks but the remainder of the skeleton, except for the hooves, would be hard to identify.

Horse skulls are easy enough to recognize, but identification as true Pleistocene horses is another matter. One of the difficulties is that horses of the same species as the present-day horse lived in Ohio during the Pleistocene, along with other species now extinct. Radiocarbon dating helps to determine the age of a particular skeleton but many "fossil" finds turn out to be very modern and as such of no particular scientific interest.

Remains of Pleistocene man have not so far turned up in Ohio but they may eventually do so. Anyone so fortunate as to find them should exercise special care not to disturb them and report the find to the Curator of Archaeology, Ohio State Museum, Columbus. Pleistocene human remains are so scarce and so precious that their excavation deserves all the care and skill that a team of geologists, paleontologists, and archaeologists can lavish on them. They will want to be sure that the remains are Pleistocene and not merely later burials in Pleistocene deposits. They will try to recover every scrap of bone available and note its position, and any implements or weapons that may have been buried with them. This is serious, painstaking work, best left to the specialist. The greatest service that you can render to science is to report the find and leave it strictly alone for the experts to work on, much as you should report a suspected murder and leave the solution to the police.

Books for further study

The identification of Pleistocene plants and most groups of invertebrates is best done by using manuals on living plants and invertebrates. Since the Mollusca are among the most abundant of Pleistocene invertebrates, some references to key texts have been given for them. For vertebrates in general, Romer's (1941) "Man and the Vertebrates" is a good introductory text; the same author (Romer, 1945) has written an advanced text on vertebrate paleontology. See also Colbert (1955) for the evolution of the vertebrates. These may be supplemented with books on living fishes, amphibians, reptiles, birds, and mammals, which your local librarian will recommend.

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