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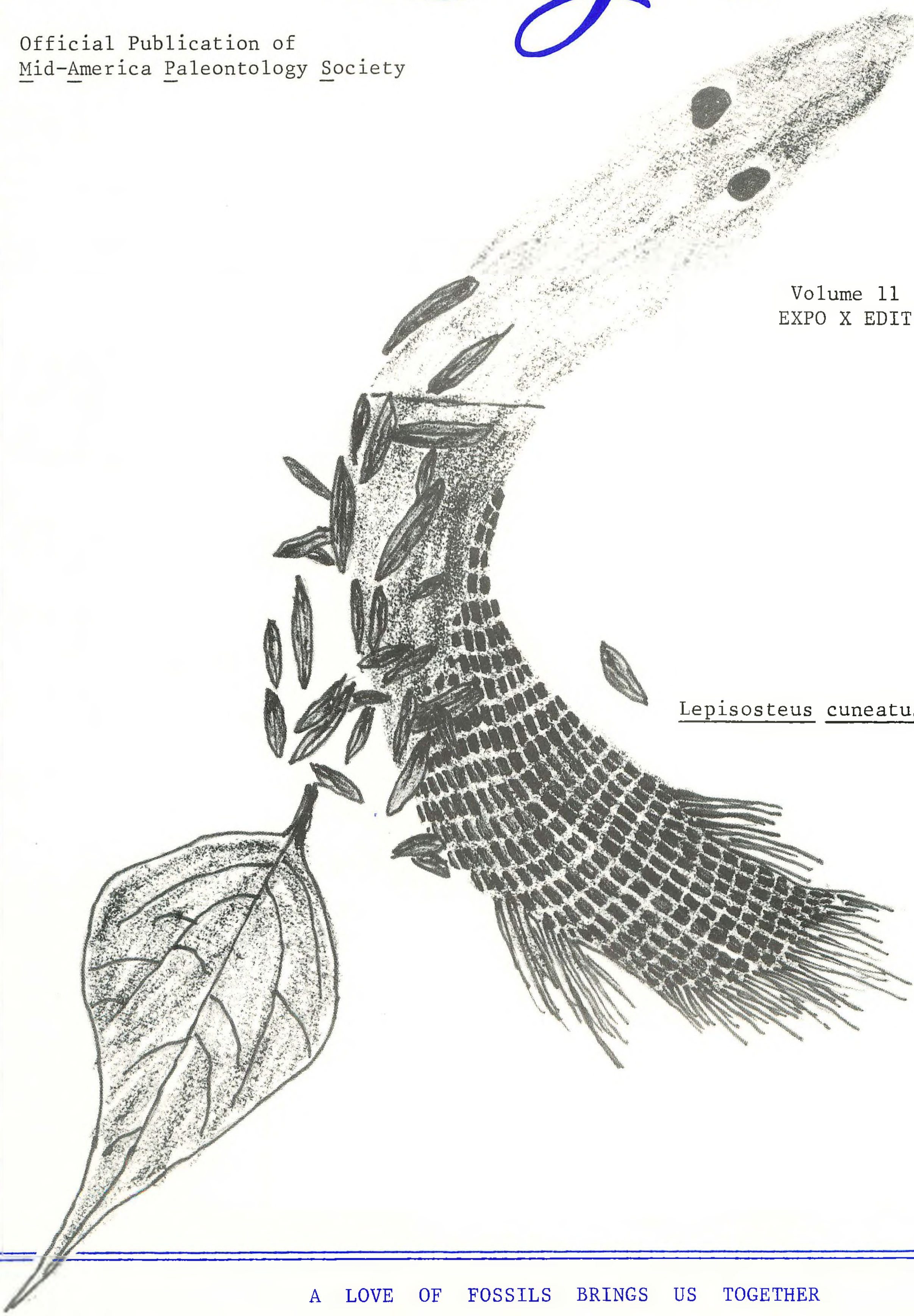

Lepisosteus cuneatus

A LOVE OF FOSSILS BRINGS US TOGETHER

F I S H E S

M A P S   D I G E S T

E X P O   X   E D I T I O N

Mid - America Paleontology Society

A Love Of Fossils Brings Us Together

Western Illinois University

Union Ballroom

Macomb, Illinois 61465

April - 1988

ACKNOWLEDGEMENT

It seems to take at least two years to realize a dream--a vertebrate issue for the EXPO EDITION of MAPS DIGEST, that's what the dream was about.

One year later MAPS member, Dennis Kingery, volunteered to accept the responsibility to organize and make contacts with FISH enthusiasts to contribute to this issue of the DIGEST.

It was different this time. One professor we pursued for weeks before learning he was on sabbatical to South America. The phone just "kept ringing." When follow-up phone calls and correspondence were received comments such as Dr. Lund's, "We can't let Denny down, now can we?", were not uncommon.

We have made new friends. Dr. Rainer Zangerl, Retired, Indiana; Dr. Richard Lund, Adelphi University, New York; Edward M. Lauginiger, Delaware; John Hearty, Scotland; Peter L. Larson, Black Hills Institute of Geological Research, Inc., South Dakota; and preparation specialists Rick Hebdon, Tom Lingren and Ron Mjos; and NASA team member Richard B. Hoover, an old contributor, we caught on the run. Add to these some stalwarts of our special organization and then when the Express Mails and general deliveries came, the issue blossomed.

It is our pleasure to recognize these generous contributors. Enjoy the product of their unique and special gifts--this first Vertebrate EXPO EDITION of MAPS DIGEST.

The Mid - America Paleontology Society (MAPS) was formed to promote popular interest in the subject of paleontology, to encourage the proper collecting, study, preparation, and display of fossil material; and to assist other individuals, groups and institutions interested in the various aspects of paleontology. It is a non-profit society incorporated under the laws of the State of Iowa.

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COVER STORY

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It was a cold morning in November, 1987. We, Dave Tynsky and I, Den Kingery, were digging for leaves near Bonanza, Utah. We were digging in the oil shales of the Parachute Creek Member of the Green River Formation. (Middle Eocene--about 45,000,000 years old). As I had orders for hundreds of fossil leaves, I had hired Dave to help me dig on this very chilly day. We had dug through frozen ground to get to the layered oil shale. The frost had not gone as low as the leaf layers we were digging. That morning we had found a few Platanis wyomingensis (Sycamore) and other nice leaves. Unfortunately, we had not found the quantity I needed, and we were thinking about moving to a new hole. About that time I lifted a large plate of oil shale up on edge to split. Using my masonary hammer, I struck the flat edge of the plate to form a natural, thin line. When this line appeared, I then used a 3 inch chisel to follow the thin line around the plate. It split open with surprising ease. I looked down at the split and saw something I had never seen in that area before. I layed both sides down and asked Dave to "look at this." We immediately realized that I had found the ONLY Gar fish from the Parachute Creek Member that had EVER been found. (As far as I know, or have been able to learn). I have not been able to have a paleoictholist look at it yet, but am hoping to do so soon.

I think, because of the dorsal and anal fins, the shortness of the snout, length of body, and being from Lake Uinta, that it is a Lepisosteus cuneatus. It is preserved differently than other Garfish that I have seen. When you look at it the rear end is a side view so you can see the tail and fins. However, the front end has done a flip-flop, and you are looking at the top of the head. The eyes are showing--looking right up at you.

Also, on the plate are several leaves that are typical for that area. The smaller ones, partially covering the Garfish, are Mimiosites (the most common leaf of the Parachute Member). The larger one is a Populus wilmattae. (Poplar) The way they are laying, you can tell it was the edge of the lake, or in the middle of a small stream.

In the next three days we continued the trench around this hill we were working on. The next day we found a small, embryoutic, turtle, (only the second to be found in this Member, and I found the first, also) and a tadpole head. Here were three very rare fossils, all found in the same trench, in those three days of digging. Unfortunately, we didn't find many more good leaves--but, what the heck, there will be another day.

(NOTE: The Garfish, tadpole head and turtle are on display at the MAPS EXPO X. Look for them.)

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MAPS DIGEST EXPO X EDITION -- FISHES

FAMOUS FOSSIL FISH FAUNAS*

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INTRODUCTION

Fossil fishes have been prized by collectors for hundreds of years. Most paleontological collections contain specimens from one or more of the hundreds of localities which have produced fossil fish. Some localities are so renowned for the fossil fish which are found that the mere mention of a locality name will bring pictures of the fauna to the avid collectors mind. The Green River Formation, Old Red Sandstone, and Monte Bolca are localities whose names conjure up visions of beautiful and even exotic fossil fishes. No comprehensive fossil collections would be complete without a representative from each of these localities.

There are many famous fossil localities which produce exciting fossil fishes but whose fish faunas are eclipsed by other taxa. The names Solnhofen, Lyme Regis, and Niobrara Chalk are famous, but fossil fishes do not necessarily pop in ones mind. Given a little time, however, most collectors would recall the fine specimens of fossil fish found at these localities.

In the following pages we will list, and give information about some of the more famous fossil fish localities and faunas. This list is by no means a complete listing of all of the localities which produce or have produced fossil fishes. If we have, by oversight or design, omitted your favorite locality please accept our apology.

FOSSIL FISHES

The term "fossil fishes" refers to the remains of the aquatic, gill-breathing, cold-blooded, finned and craniate animals which are found incorporated into the Earth's rocks. Fishes are classified as:

Kingdom Animalia
 Phylum Chordata
  Supraclass Pisces
   Class
    Agnatha (Upper Cambrian - present)
    Placodermi (Upper Silurian - Lower Carboniferous)
    Acanthodii (Silurian - Lower Permian)
    Osteichthyes (Lower Devonian - present)
    Chondrichthyes (Middle Devonian - present)

Of the three surviving classes, the Agnathids are by far the most primitive and include the living lamprey, hagfish and slimehags. Chondrichthyes include the sharks, rays, sawfish and chimaeras. Osteichthyes includes all ray-finned, lobe-finned and lungfishes, or most "modern" forms.

LOCALITIES

Fossil fishes have been found on every continent. The following listing of the more famous localities is organized according to age. Information on the formations, lithology of deposits, fish faunas and associated fossils is also given. This report deals with only those localities which have received fame for producing an abundance of display specimens.

PALEOZOIC LOCALITIES

"Bundenbach"

Locality: West Germany; Bundenbach, Rheinland
Age: Early Devonian (Emsian)
Formation: Hunsruck Shale
Lithology: metamorphosed shale (slate)
Type of Deposit: marine
Fish fauna: Agnatha: *Drepanaspis, Pteraspis,*
Placodermi: *Gemundenaspis, Hunsrukia, Lunaspis Machaeracanthus, Sturtzaspis, Tityosteus, Gemundina, Nessariostoma, Paraplesiobatis, Pseudopetalichthys, Stensioella,*
Osteichthyes: *Dipnorhynchus*
Associated fossils: plants, conularid, corals, brachiopods, trilobites mollusks, crustaceans and echinoderms

"Old Red Sandstone"

Locality: Scotland and Wales; especially in Caithness, Scotland
Age: Early to Late Devonian, the fish are found primarily in the Middle Devonian
Formation: Old Red Sandstone
Lithology: marlstones, sandstone and conglomerates, fish are found mostly in the marlstones
Type of Deposit: nearshore (synclinal) marine and fresh water
Fish fauna: Agnatha: *Cephalaspis*
Placodermi.: *Pterichthyodes, Palaeospondylus, Millerosteus, Coccosteus,*
Acanthodii: *Mesacanthus*
Osteichthyes: *Dipterus, Osteolepis, Cheirolepis*
Associated fossils: plants, eurypterids, amphibians

"Cleveland Shale"

Locality: United States; primarily in and around Cleveland, Ohio
Age: Late Devonian (Famennian)
Formation: Ohio Shale (Cleveland Shale Member)
Lithology: limestone concretion bearing black shales
Type of Deposit: marine (probably deep)
Fish fauna: Placodermi: *Mylostoma, Dinichthys, Dunkleosteus, Titanichthys, Gorgonichthys*
Chondrichthyes: *Cladoselache, Cladodus, Cladoselache, Cladodus*
Osteichthyes: *Tegeolepis, Chagrinia*
Associated fossils: plants

"Escuminac Bay"

Locality: Canada; Eastern Quebec, primarily the south side of the Gaspe Peninsula
Age: Late Devonian
Formation: Escuminac Formation
Lithology: limestone concretion bearing shales
Type of Deposit: marine?
Fish Fauna: Placodermi: *Bothriolepis*
Osteichthyes: *Scaumenacea*
Associated fossils: plants

"Bear Gulch"

Locality: United States; central Montana, near Lewiston.
Age: Late Mississippian (Namurian)
Formation: Heath Formation (Bear Gulch Limestone Member)
Lithology: lithographic limestone
Type of Deposit: marine embayment,
Fish fauna: Agnatha: *Hardistiella*
Acanthodii: *(Acanthodes)*
Chondrichthyes: *Harpagofututor, Falcatus, Squatinactis, Stethacanthus, Echinochimaera, Polyrhizodus, Heteropetalus, Damocles, Orestiacanthus*
Osteichthyes: *Polyosteorhyinchus, Lochmocercus, Paratarrosius, Caridosuctor, Allenpterus, Hadronector*
Associated Fossils: plants, crustaceans, mollusks, echinoderms, annelids, conodonts, sponges

"Mazon Creek"

Locality: United States; northeastern Illinois, near Morris
Age: Middle Pennsylvanian (Westphalian)
Formation: Carbondale Formation (Francis Creek Member)
Lithology: carbonaceous shale with ironstone concretions
Type of Deposit: classic coal cyclothems (possibly brackish water)
Fish fauna: Agnatha: *Mayomyzon*
Acanthodii: *Acanthodes*
Chondrichthyes: *Bandringa, Xenacanthus*
Osteichthyes: *Elonichthys, Rhabdoderma, Platysomus*
Associated fossils: plants, mollusks, crustaceans, insects, myriapods, arachnids, eurypterids, xiphosurids, "Tully monster", amphibian, coelenterates

"Kinney Clay Pit"

Location: United States; Central New Mexico, near Albuquerque
Age: Late Pennsylvanian (Virgilian)
Formation: Wild Cow Formation (Pine Shadow Member)
Lithology: thin bedded slabby marls, shales and limestone
Type of Deposit: nearshore, lagoonal deposit
Fish fauna: Acanthodii: *Acanthodes*
Chondrichthyes: *Ctenoptychius, Cladodus, Listracanthus*
Osteichthyes: *Proceratodus, Platysomus, Phanerorhynchus*
Associated fossils: plants, insects

"Odernheim"

Locality: West Germany; Heimkirchen, Pfalz
Age: Permian
Lithology: carbonaceous shales and marls
Type of Deposit: cyclothem?
Fish fauna: Acanthodii: *Acanthodes*
Chondrichthyes: *Oracanthus, Xenacanthus*
Osteichthyes: *Paramblypterus*
Associated Fossils: plants, coelenterates, polychaete worms, insects, crustaceans, reptiles, amphibians

"Red Beds"

Locality: United States; scattered localities in northern Texas and southern Oklahoma; eg. Waurika, Oklahoma
Age: Permian
Formation: Wichita Group, etc.
Lithology: sands and sandy shales
Type of Deposit: red beds, fresh and brackish water
Fish fauna: Chondrichthyes: *Xenacanthus*
Osteichthyes: *Lawnia,* lungfishes
Associated fossils: plants, amphibians, reptiles

MESOZOIC LOCALITIES

"Wapiti Lake"

Location: Canada; westcentral British Columbia, Wapiti Lake, south of Dawson Creek
Age: Early Triassic (Scythian)
Formation: Sulphur Mountain Formation (Vega-Phroso Siltstone Member)
Lithology: laminated siltstone
Type of Deposit: nearshore marine
Fish fauna: Chondrichthyes: *Paleobates*
Osteichthyes: *Pteroniscuius, Birgeria, Boreosomus, Bobastrania, Perleidus, Australosomus, Saurichthys, Albertonia, Whiteia, Coelocanthus*
Associated fossils: plants, mollusks, reptiles

"Monte San Giorgio"

Locality: Switzerland and Italy; the central border between Switzerland and Italy on and near Monte San Giorgio
Age: Mid Triassic (Anisian - Ladinian)
Formation: Grenzbitumenzone
Lithology: bituminous siltstone and limestone
Type of Deposit: lagoonal marine
Fish fauna: Chondrichthyes: *Acrodus*
Osteichthyes: *Pholidopleurus, Belonorhynchus, Perleidus, Colobodus, Meridensia, Platysiagum, Cephaloxenus, Peltopleurus, Placopleurus, Habroichthys, Luganoia, Besania, Aetheodontus, Ptycholepis, Eoeugnathus, Semionotus*
Associated fossils: plants, mollusks, echinoderms, reptiles

"Connecticut Valley"

Locality: United States; valleys in the northeastern states of North Carolina, Virginia, Maryland, Pennsylvania, New Jersey, Connecticut and Massachusetts
Age: Late Triassic to Early Jurassic (Lias)
Formation: Newark Super Group (many formations from many separate basins)
Lithology: pyritic, calcareous siltstone
Type of Deposit: lacustrine (with anerobic bottom)
Fish fauna: Osteichthyes: *Dictyopyge, Redfieldius, Tanaocrossus, Diplurus, Cionichthys, Synorichthys, Semionotus, Turseodus*
Associated fossils: plants, crustaceans, insects, reptiles

"Talbragar Fish Beds"

Locality: Australia; near Gulgong, New South Wales
Age: Jurassic
Formation: Purlawaugh Formation
Lithology: slabby, ferruginous limestone
Type of Deposit: lacustrine
Fish fauna: Osteichthyes: *Leptolepis*
Associated fossils: plants

"Lyme Regis"

Locality: England; exposed sporadically in a NE-SW diagonal line from Lyme Regis, Dorset to Eskdale, North Yorkshire
Age: Early Jurassic (Hettangian - Sinemurian)
Formation: Blue Lias, etc.
Lithology: calcareous shales with calcareous concretions
Type of Deposit: shallow marine
Fish fauna: Chondrichthyes: *Hybodus, Notidanus, Acrodus, Palaeospinax, Agaelus, Squaloraja*
Osteichthyes: *Caturus, Lepidotes, Dapedium, Pholidophorus, Cosmolepis, Chondrosteus, Eomesodon, Proleptolepis*
Associated fossils: plants, mollusks, echinoderms, crustaceans, reptiles

"Holzmaden"

Locality: West Germany; especially near Holzmaden, Wurttemberg
Age: Early Jurassic (Lias)
Formation: Posidon Shale
Lithology: carbonaceous slabby shale - slate
Type of Deposit: marine embayment
Fish fauna: Chondrichthyes: *Hybodus, Acanthorhina, Myriacanthus*
Osteichthyes: *Trachymetopon*
Chondrosteus: Ohmdenia, Acidorhynchus, Ptycholepis, Leptolepis, Dapedius, Lepidotus, Tetragonolepis, Pachycormus, Sauropsis, Caturus, Pholidophorus, Thrissops
Associated fossils: plants, crustaceans, mollusks, echinoderms, reptiles

"Bull Canyon"

Locality: United States; central New Mexico in Guadelupe County
Age: Mid Jurassic (Callovian)
Formation: Bell Ranch Formation (Todilto limestone)
Lithology: silty, slabby limestone
Type of Deposit: nearshore marine or brackish
Fish fauna: Osteichthyes: *Todiltia*
Hulettia, Caturus
Associated fossils: isopods

"Solnhofen"

Locality: West Germany; Bavaria, especially near Eichstatt and Solnhofen
Age: Late Jurassic (Portlandian, Malm-Zeta)
Formation: Solnhofen Limestone
Lithology: lithographic limestone
Type of Deposit: marine lagoon
Fish fauna: Chondrichthyes: *Pseudorhina, Protospina, Ischyodus, Aellopos, Orectolobus, Asterodermus*
Osteichthyes: *Leptolepis, Leptolepides, Lepidotes, Coccoderma, Gyrodus, Hypsocormus, Belonostomus, Aspidorhynchus, Caturus, Mesodon, Ophiopsis, Macrosemius, Propterus, Pholidophorus, Urocles, Anaethalion, Allothrissops, Thrissops, Histionotis, Undina, Holophagus, Pleuropholis, Ionoscopus, Ascalabos*
Associated fossils: plants, insects, crustaceans, mollusks, echinoderms, birds, reptiles

"Santana Formation"

Locality: Brazil; northeastern Brazil in the states of Ceara and Pernambuco
Age: Early Cretaceous (Aptian)
Formation: Santana Formation
Lithology: sandy calcareous concretions from a silty sandstone
Type of Deposit: nearshore marine
Fish fauna: Chondrichthyes: *Rhinobatos*
Osteichthyes: *Lepidotus, Lepidotes, Belonostomus, Tharrhias, Cladocyclus, Anaedopogon, Brannerion, Enneles, Ennelichthys, Notelops, Rhacolepis, Microdon, Ophiopsis, Leptolepis, Aspidorhyncus, Dastilbe, Tharrhias, Paraelops*
Associated fossils: plants, mollusks, crustaceans, reptiles

"Hakel"

Locality: Lebanon; near Hakel
Age: Late Cretaceous (Cenomanian)
Lithology: slabby limestone
Type of Deposit: marine lagoon
Fish fauna: Chondrichthyes: *Rhinobatos, Cyclobatus, Schlerorhynchus, Centrosqualus, Libanopristis, Scyliorhinus*
Osteichthyes: *Petalopteryx, Spathiurus, Coccodus, Palaeobalistum, Xenopholis, Eubiodectes, Diplomystus, Scombroclupea, Pseudoberyx, Holcolepis, Ctenothrissa, Leptotrachelus, Enchodus, Eurypholis, Halec, Prionolepis, Acrognathus, Leptosomus, Microcoelia, Nematonotus, Charitosomus, Exocoetoides, Telepholis, Anguillavus, Urenchelys, Enchelion, Hoplopteryx, Aipichthys*
Associated fossils: plants, crustaceans, echinoderms, mollusks

"Carlile"

Locality: United States; outcrop belt surrounding the Black Hills of South Dakota, particularly near Edgemont, Fall River County
Age: Late Cretaceous (Turonian)
Formation: Carlile Formation (Turner Sandy Member)
Lithology: sandy small pebble conglomerates
Type of Deposit: shoreline marine
Fish fauna: Chondrichthyes: *Synechodus, Ptychodus, Squalicorax, Lamna, Odontaspis, Brachaelurus, Cantioscyllium, Rhinobatos, Ischirhiza, Ptychotrygon*
Osteichthyes: unidentified teeth and vertebrae
Associated fossils: plants, crustaceans, reptiles, mollusks

"Kansas Chalk"

Locality: United States; Western Interior, especially western Kansas.
Age: Late Cretaceous (Santonian)
Formation: Niobrara Formation
Lithology: loosely cemented, slabby limestone
Type of Deposit: shallow seaway, marine
Fish Fauna: Chondrichthyes: *Ptychodus, Squalicorax, Cretalamna, Odontaspis, Scapanorhynchus, Lamna*
Osteichthyes: *Enchodus, Micrcdus, Cimolichthys, Pachyrhizodus, Xiphactinus, Gillicus, Ichthyodectes, Saurodon, Albula, Protosphyraena, Micropycnodon, Hadrodus, Saurocephalus, Ananogmius*
Associated fossils: mollusks, echinoderms, reptiles, birds

CENOZOIC LOCALITIES

"Monte Bolca"

Locality: Italy; northern border near Verona on Monte Bolca and Monte Postale
Age: Early Eocene
Lithology: thinbedded limestone
Type of deposit: marine lagoon
Fish fauna: Chondrichthyes: *Platyrhina, Trygon, Urolophus Carcharias, Rhinobatos, Narcine, Promyliobatis, Lamna, Odontaspis, Carcharodon, Pseudogaleus, Alopiopsis, Mesiteia*
Osteichthyes: *Monopterus, Holosteus, Caranx, Symphodus, Pygaeus, Histionotophorus, Diodon, Exellia, Mene, Eolates, Vomeropsus, Apogon, Eoplatax, Spharnodus, Anguilla, Blochius, Callipteryx, Chanoides, Cyclopoma, Dentex, Ductor, Eomyrus, Ephippus, Platinx, Pristipoma, Rhamphognathus, Semiophorus, Thynnus, Zanclus*
Associated fossils: plants, crustaceans, mollusks, reptiles, birds

"Messel"

Location: West Germany; Messel (near Frankfurt), Hessen
Age: Mid Eocene (Lutetian)
Formation: Messel Shale
Lithology: bituminous claystone
Type of Deposit: lacustrine
Fish fauna: Osteichthyes: *Amia, Lepisosteus, Amphiperca, Palaeoperca, Thaumaturus*
Associated fossils: plants, insects, crustaceans, mollusks, sponges,reptiles, mammals, birds, amphibians

"Green River"

Locality: United States; southwestern Wyoming, northwestern Colorado, and eastcentral Utah, especially in the area around Fossil Butte National Monument, Wyoming
Age: Latest Paleocene (Clarkforkian) to Late Eocene (Uintan), the fish deposits are primarily Mid Eocene (Wasatchian - Bridgerian)
Formation: Green River Formation
Lithology: thin bedded freshwater limestones, silty limestones and siltstones, the fish are found mostly in limestones
Type of Deposit: lacustrine, (3 lake deposits: Fossil Lake, Lake Gosiute, and Lake Uinta)
Fish fauna: Chondrichthyes: *Heliobatis,*
Osteichthyes,*Crossopholis, Lepisosteus, Amia, Eohiodon, Phareodus, Diplomystus, Knightia, Gosiutichthys, Notogoneus, Amyzon, Astephus, Hypsidoris, Erismatopterus, Amphiplaga, Asineops, Mioplosus, Priscacara*
Associated fossils: plants, insects mollusks, crustaceans, arachnids, amphibians, reptiles, birds, mammals

"Smerdis"

Locality: France; Aix en Provence near Cereste
Age: Oligocene (Rupelian)
Lithology: silty, slabby limestone
Type of Deposit: brackish water
Fish fauna: Osteichthyes: *Smerdis, Prolebias, Perca*
Associated fossils: plants, birds, mammals

"River Teeth"

Locality: United States; South Carolina and other coastal states, river beds, notably the Ashapoo River, Cooper River system
Age: Eocene, Miocene and Pliocene
Formation: mixed and reworked
Lithology: loose teeth in modern river beds
Type of Deposits: probably reworked phosphate deposits
Fish fauna: Chondrichthyes: *Procarcharodon, Carcharodon, Hexanchus, Oxrhina, Hemipristis, Isurus, Galeocerdo, Megaprion*
Associated fossils: mammals, mollusks

"Calvert Cliffs"

Locality: United States; Maryland, Massachusetts, New Jersey and Delaware coasts; especially Calvert Cliffs on Chesapeake Bay, Maryland
Age: Miocene
Formation: Calvert Formation
Lithology: loosely cemented sands and shales
Type of Deposit: near shore marine
Fish Fauna: Chondrichthyes: *Squatina, Raja, Myliobatis, Aetobatis, Notidamus, Odontaspis, Oxyrhina, Otodus, Procarcharodon, Carcharias, Galeocerdo, Hemipristis, Sphyrna, Sphyraena*
Associated fossils: plants, mollusks, crustaceans, mammals, birds, reptiles, echinoderms, coelenterates

"Sharktooth Hill"

Locality: United States; near Bakersfield, California
Age: Mid Miocene (Barstovian)
Formation: Temblor Formation (Round Mountain Silt Member)
Lithology: bone bed sandy conglomerate
Type of Deposit: nearshore marine (beach?)
Fish fauna: Chondrichthyes: *Procarcharodon, Isurus, Hexanchus, Galecerdo, Squatina, Myliobatis*
Associated fossils: plants, crustaceans, mammals, reptiles, birds

"Lompoc"

Locality: United States; near Lompoc, San Luis Obispo County, California
Age: Mid Miocene
Formation: Sisquoc Formation
Lithology: diatomite
Type of Deposit: deep water marine
Fish fauna: Chondrichthyes: *Isurus*
Osteichthyes: *Lampanyctus, Empetichthys, Xyne*
Associated fossils: plants, crustaceans, mammals, birds

"Phosphate Pits"

Locality: United States; Florida especially near Mulberry, Polk County
Age: Mid Miocene to Pliocene
Formation: Bone Valley Formation
Lithology: phosphate deposits
Type of Deposit: nearshore, warm, shallow water (perhaps tidal flats, continental shelf)
Fish fauna: Chondrichthyes: *Myliobatis, Odontaspis, Isurus, Raja, Galeocerdo, Carcharhinus, Procarcharodon, Carcharodon, Sphyrna, Negaprion, Ginglyostoma Hemipristis, Hexanchus*
Osteichthyes: *Xiphias, Diodon*
Associated fossils: mollusks, crustaceans, reptiles, birds, mammals

"Marecchia"

Locality: Italy; Rimini, near Marecchia Creek
Age: Early Pliocene (Zanclean)
Lithology: diatomaceous clay
Type of Deposit: shallow, warm water marine
Fish fauna: Osteichthyes: *Amphistyle, Balistes, Bregmaceros, Hippocampus, Syngnathus, Triacanthus*
Associated fossils: ?

"Ottawa"

Locality: Canada; Ontario, Green Creek and others near Ottawa
Age: Pleistocene (Wisconsin or post-glacial)
Lithology: calcareous nodules weathering from glacial and postglacial sediments
Type of Deposit: lake, gravel-beached marine bay and brackish estuaries
Fish fauna: Osteichthyes: *Coregonus, Microgadus, Osmerus, Gasterosteus*
Associated fossils: plants

FOSSIL "FISH"

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When the word fish is mentioned in reference to fossils what usually comes to mind to the average fossil aficionado are the Cenozoic Green River fossil fish from Wyoming. These are relatively recent geologically speaking (40 million years old) and are representatives of the Telosts or bony fish, the most abundant and widespread of living fish today. The common Green River fish Knightia (a herring) and Phareodus (a bass) are really little different from their present day counterparts. This is a pattern seen in most Cenozoic fossils and for many collectors it is part of their appeal. These fossils are easily recognized for what they are in comparison with modern flora and fauna. Paleozoic and some Mesozoic life forms by contrast, are often extinct forms and quite different from animals and plants which live today.

The other fossil fish which fossil enthusiasts treasure are the Cretaceous fish preserved in concretions from Brazil. As fish go these are a bit more exotic than the Wyoming Green River fish, they are older. They are from the Mesozoic era but are still recognizable to any person as being fish. Like the younger Green River fish, living representatives of the most common of these Brazilian fish Aspidorrhincos comptoni Agassiz are still around today, they are the gar pikes. Beside these two occurrences complete, easily recognizable fossil fish are somewhat hard to come by, at least fish which really look like fish.

Perhaps a word on the word "fish". Fish is used in an inconsistant way! In the zoologic sense all fish are vertebrates which inhabit either marine, fresh or brackish water. In common parlance there are starfish, shellfish, and jellyfish; these are echinoderms, mollusks and coelenterates respectively and are not vertebrates. Fish also usually means the bony fish or Teleosts, but sharks, rays and even the jawless lampreys and eels qualify under the heading.

A number of years ago, as an enthusiastic mid-teen fossil collector browsing the geologic literature I found "fish" listed in the faunal lists of mid-western geological literature. E. B. Branson's "Geology of Missouri" comes to mind where an exhaustive (as of 1944) listing of all fossils known from within the confines of Missouri are tabulated in faunal lists; and in these faunal lists are found many "fish". Many fossil "fish" are not in most cases, recognizeable to the casual observer as are those from Wyoming and Brazil, but rather are of representatives of extinct and by modern standards bizaare forms. To make matters more difficult many of these are usually not found complete as is the case with the "fish" in faunal lists from Missouri. The Green River fish fossils, like the fish which made them are quite attractive. Many of these Paleozoic fish fossils by comparison, look strange and to some are down right ugly, and in many cases the animals which were responsible for the fossils also would not have won any beauty contests.

What were some of these Paleozoic "ugly ducklings"? Some were sharks or shark-like forms, others were lobe finned fish.

In the late Paleozoic strata of the midwest are found the teeth and spines of these sharks. Sharks in vertebrate classification occupy the same level as do the reptiles, amphibians, mammals, and birds. That is, they represent a class of the vertebrates, the Chondrichthyes. Modern sharks are really living fossils, in fact the Paleozoic shark Cladodus, usually found in the form of long, mean looking tearing and puncturing teeth must have been every bit as nasty as some of its modern relatives. Other fossil shark teeth found in Paleozoic rocks are the flat and smooth "pavement tooth" variety. The name "pavement tooth" has reference to the teeth looking like paving blacks used on city streets of the 19th Century. A shell crushing shark of today, the Port Jackson shark has similar teeth to accommodate its shell crushing diet. When, however, the tooth structure of the modern shell crusher and the Paleozoic forms are compared there is a substantial difference. Some paleontologists say that the structural differences between Paleozoic pavement tooth "sharks" and the modern Port Jackson shark are sufficiently different to place the Paleozoic forms in a category other than the Chondrichthyes. There are no "shark-like" animal groups living today other than the Chondrichthyes. So in terms of modern taxonomy there is no place to put the Paleozoic "pavement tooths". Could it be that a vertebrate group, that is a class, equal in rank to the mammals, reptiles or bony fish existed in the distant past and left no living relatives? Some paleontologists think so and these teeth are placed by some in the extinct Class Bradyodonti.

Spines of Elasmobranch and Chimæroid Fishes.
a, *Acanthias* (recent); *b*, *Callorhynchus* (recent); *c*, *Machæracanthus* (Devonian); *d*, *Hybodus* (Jurassic); *e*, *Asteracanthus* (Jurassic); *f*, *Squaloraja* (Lias); *g*, *Gyracanthus* (Carboniferous); *h*, *Elestes* (Carboniferous); *i*, *Pleuracanthus* (Carboniferous).

Dorsal spines of shark-like late Paleozoic fishes.

Jawless Fishes

The earliest and most primitive "fish" belong to a class of jawless vertebrates called the Class Agnatha. Three groups belonging to the Agnatha live today--the lampreys, the hagfishes, and the slime eels. Like all members of the Agnathids these animals have no jaws nor do they have a skeleton or other hard parts capable of leaving much of a fossil record. All living forms are parasitic and the question has arisen as to whether these modern jawless vertebrates are truly primitive or whether they may have evolved in a "negative" way from some higher group of vertebrates and their primitiveness is a consequence of their parasitic existence.

The earliest vertebrates known from the fossil record are a group of jawless bony armored "fish" called Ostracoderms. These had part or all of their body covered with bony plates, they lacked jaws and a true mouth; they are one of the "bizaare fish" of the Paleozoic. Fossil ostracoderms don't really look like fish. The calcium fluro-apatite dorsal shield, without its appendages resembles some sort of arthropod. Complete specimens with appendages are spectacular and quite rare. Ostracoderms were probably bottom dwellers which injested bits of organic matter, probably algae and other organic debris, by means of a suction device at the anterior (front) part of the animal, a sort of animated vacuum cleaner. Image forming eyes were not present, however, a light sensative spot, (a "photocell" like organ) called the pineal eye was located just above the anterior opening. The body of the animal was covered by either small or more massive bony plates making the animal more invertebrate looking than vertebrate. These plates, like the bony tissue in all of the vertebrates were composed of calcium-fluro-phosphate or calcium phosphate, a skeletal composition characteristic of the vertebrates. The ostracoderms became extinct in the late Paleozoic.

The parasitic lampreys, hagfish, and slime eels are the only living jawless fishes. The oldest ostracoderms may go back to the Cambrian for small phosphatic plate fragments have been found in both middle and upper Cambrian strata. However, the material is poor so that actual affinities and identification is unclear. Ostracoderms are known with certainty from the Ordovician, in fact red sandstone of the Middle Ordovician Hardin Formation near Morrison, Colorado, is packed full of fragments of these dorsal shields. It is significant that Ostracoderm remains are not found in the marine limestones so common in the Ordovician but are rather associated with localized sandstones like those at Morrison, Colorado, which apparently had a brackish or fresh water origin. Some Ostracoderms had a fusiform or fish like shape, however, many were very unfish-like in appearance, possessing a large bony head shield in which a single pineal eye was anteriorally located. In more advanced types a pair of lateral, presumably image forming eyes were also present. The pineal foramin or site of the pineal eye is often conspicuous on fossil specimens of this group of early and primitive vertebrates.

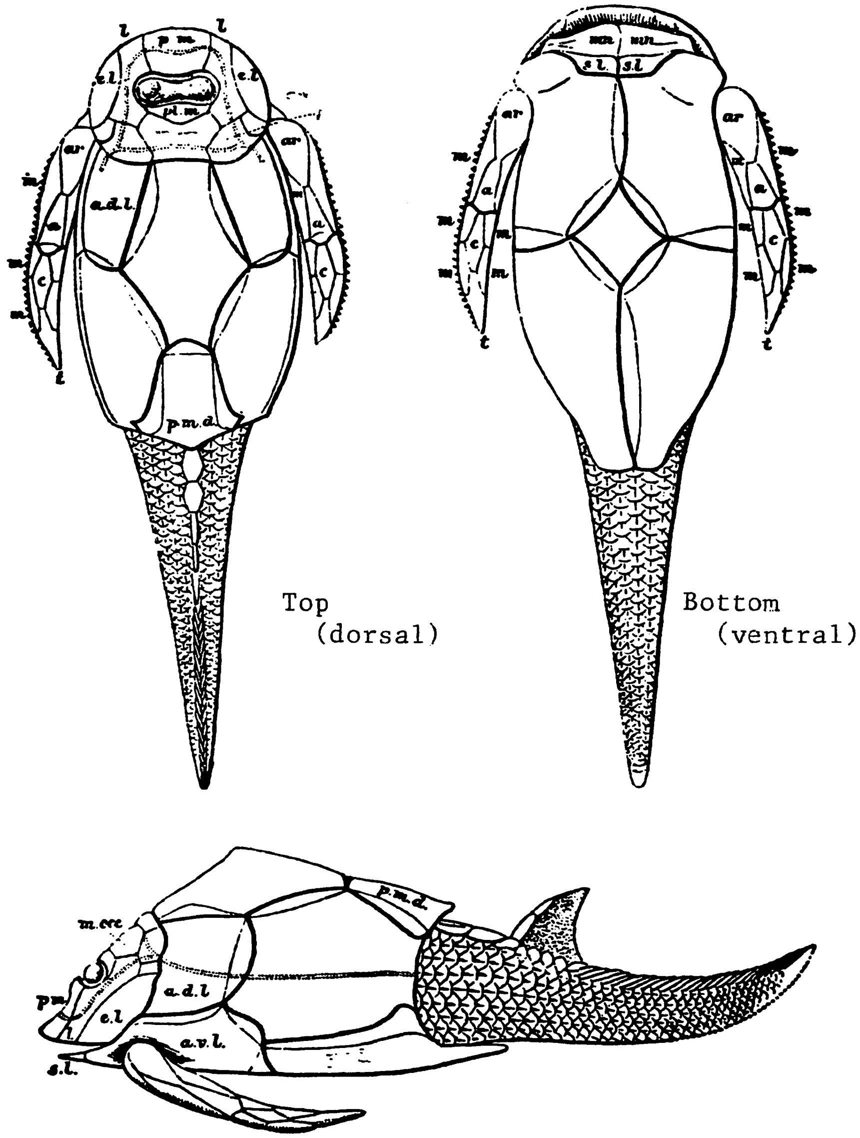
Placoderms

The Placoderms are an extinct group of vertebrates which, like the Ostracoderms were usually well endowed with a covering of bony armor plate. The Placoderms were however, jawed fishes, some of which became particularly abundant during the Devonian period. Like the Ostracoderms, most Placoderms by comparison with today's fishes, were really peculiar looking. The development of the jaw in the vertebrates was a major event in the evolution of that phylum. Jawless vertebrates at best are resigned to an existance of mud grubbing to filter out what organic material is present or to strain water in quest of algae or other small organisms as a food source. A predacious life style would be nearly impossible for such an animal, the only other possible lifestyle being that of a parasite--the path taken by the modern jawless fishes.

An animal with a set of jaws has the potential to make his neighbor his dinner, and could, take on an aggressive and predacious life style. If, however, you are going to eat your neighbor, you had better be either physically stronger or most importantly, smarter and more agile than he or else he might eat you first. A predacious mode of existence for that organism, with a more sophisticated nervous system, and with the appearance of the jaw in the Placoderms, the superiority of the vertebrates was established.

The evolution of the jaw can be traced as an adaptation of the gill arches in non=jawed Placoderm ancestors, possibly the Ostracoderms. The gill arches were originally non-mineralized cartilage which when replaced by bone, became an effective means of food procurement and both an offensive and defensive weapon. The teeth of Placoderms and all vertebrates for that matter, are composed of calcium-fluro-apatite ($CaFPO_4$), the same chemical compound which composes the bony armor plate. The evolutionary pathway which led to the development of teeth may have been the one by which bony plate surrounding the gill arches served as a rigid margin which increased the variety of food sources available to a Placoderm ancestor. This invagination of the bony armor plate into the mouth had survival advantage, and was favorably selected. Modification of the shape of the bony armor plate and the gill arches gave rise to teeth and bone of the jaw. The presence of teeth in modern vertebrates is the only vestigal remnant of armor plate in the vertebrates except for the bony denticles embedded in the skin of sharks.

Some of the more primitive Placoderms had heavy armor plate covering most of their bodies. These forms, called the antiarchs, were locally abundant life forms, particularly during the Devonian Period. Some of these primitive Placoderms resemble the general appearance of an Ostracoderm and suggest a cross between a fish and a turtle. Other Placoderms were more fish-like in appearance such as the arthrodires. These were one of the largest and most formitable vertebrates of the Paleozoic Era. Forms like Dunkleosteus are widely distributed in eastern North America but like other Devonian fishes their remains usually are not associated with true marine sediments. The Arthrodires had a massive head covered with bony armor plate and a large mouth ringed by scempter-like teeth; they were all formidable predators. Some Arthrodires, like Titanichthys were huge animals. Titanichthys apparently reached a total length of over 80 feet (25 meters). Some Placoderms had rows of flat crushing teeth with which they crushed and ate many marine invertebrates on which they lived. The teeth of some of these marine Placoderms, like Ptyctodus, are quite common in some Devonian sediments along with fragments of their tuberculated bony armor plate which attests to the abundance of these animals in shallow epicontinental seas of the Devonian Period.



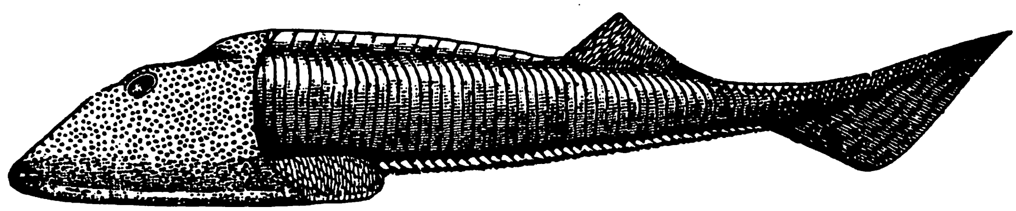
Placoderm -- Bothriolepis sp.

In discussing fossil fish, particularly Paleozoic ones, the Devonian Period is particularly significant. The Devonian Period is often referred to as the "age of fishes", and for good reason. It was during this period of geologic time that the sharks, bradyodonts, lobe and ray finned fishes not only first appeared but also achieved a startling diversity compared with the fish of earlier geologic periods. It has long been observed that Paleozoic vertebrates, particularly fishes, are characteristically associated with certain sediment types, which in turn reflect a unique and specific environment. The particular environment often represented by Devonian sediments is that of brackish water (mixed salt and fresh water) rather than the marine environment usually represented by older strata. In strata older than the Devonian, when fossil fish are found, they are associated with these brackish water sediments or with fresh water sediments. So frequent is this association that it is believed by some paleontologists that the early vertebrates may have originated in either fresh or brackish water. This origin of the vertebrates is supported by physiological functions in the vertebrates as well, such as the physiology of the vertebrate kidney. The kidney to function as it does in land vertebrates would have had to have evolved in fresh water. Devonian sedimentary environments were certainly favorable for fish and one sequence of fresh water deposits occurring on both sides of the Atlantic but best known in Scotland is particularly noteworthy. This is the Old Red Sandstone of Scotland which has been famous for over 150 years for its incredible variety of fossil fish. (See figures page

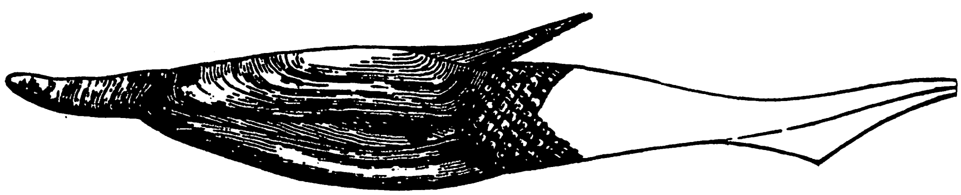
First made famous by the writings of Hugh Miller in the early 1800's, the Old Red Sandstone yielded the first known lobe-finned fish, Placoderms, and ray-finned fish. These fish were so different from those of today that early paleontologists were uncertain that they were really fish. Old Red Sandstone fish were also the "hard" data which strengthened the idea and concept as to the existence of wholly extinct life forms which once flourished in the geologic past, but which today have no living representatives. Baron Georges Cuvier, a French paleontologist of the late 18th Century, first proposed that such life forms once existed but which today are extinct, a concept which in its time was radical and met with considerable religious opposition on the basis that extinction would have implied imperfection in creation, an impossibility in a divinely created world. Cuvier was a proponant of creationism, the concept that all life forms were created "as is" by a Supreme being, but, of course, this was way before the writings of Charles Darwin and his concept of natural selection. Darwin's concept of evolution, first published in 1859 in the book Origin of Species was long after the work of Cuvier. Strange fossil fish found in the Old Red Sandstone were also used by Hugh Miller in his writings to support a curious combination of liberal theology and geology at a time when the immensity of geologic time was just becoming understood.

The Old Red Sandstone had its fish fauna first recognized in Scotland during the early 1800's. However, during the late 1800's sedimentary rocks similar to those of the Old Red Sandstone were found cropping out in Eastern Quebec, New Brunswick, Newfoundland, and Maine and these were found to yield almost identical fossil fish as the Scottish Old Red. The fact that these fresh and brackish water deposits were separated by the Atlantic ocean was a problem which puzzled geologists and that these beds on both sides of the Atlantic contained the same fossil fish just added to the puzzle. Just after the turn of the Century an extensive piece of work on continental drift was published by the German meteorologist and explorer, Alfred Wegener. Wegener's solution--many geologic dilemmas like the Old Red Sandstone dilemma was that North America and Europe were once part of a single continent which later split along a "crack" not called a rift zone, and the two pieces drifted away. Geologists and most paleontologists of the time were not too keen on

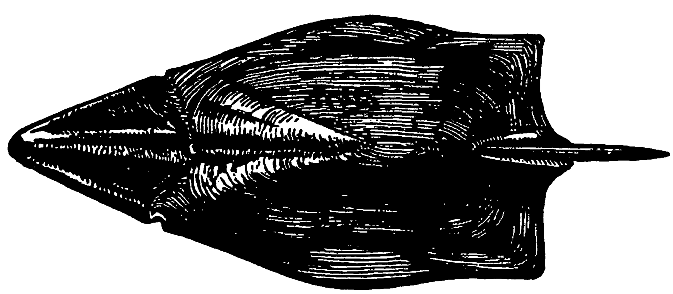
Wegener's hypothesis; however, during the 1960's study of the geology of the ocean floor and data from geophysics essentially proved Wegener correct. These Devonian deposits as well as others of different ages on both sides of the Atlantic were explained as being, at one time, on the same continent which later "split" with the opening of the rift zone which later opened to form the basin of the Atlantic Ocean, carrying North America and its share of the Devonian deposits westward and Europe with its part of the Old Red Sandstone eastward. During the 1960's and '70's geophysics and ocean floor geology verified continental drift which has now become part of a unified concept on Earth movements called Plate Tectonics.



-*Cephalaspis Murchisoni*, Egert.; L. Old Red Sandstone (Passage Beds), Ledbury, Herefordshire.



Restoration of *Pteraspis rostrata*, Ag.—Lower Old Red Sandstone;



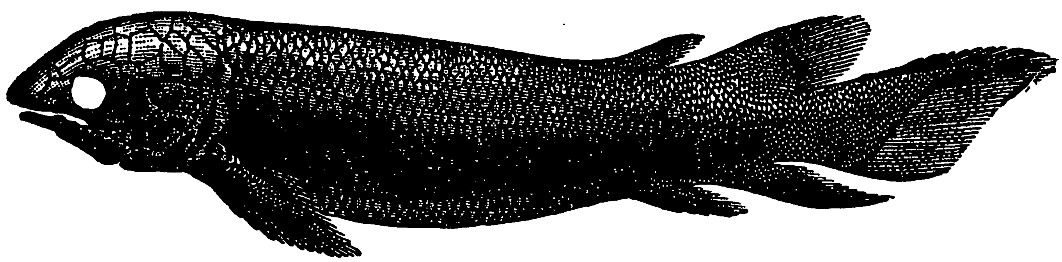
Restoration of shield of *Pteraspis rostrata*, Ag.,upper aspect (after Lankester).—Lower Old Red Sandstone; Herefordshire.

Fossil Jawless Fishes

Lobe Finned Fish

These fish are some of the most spectacular of fossil fishes, but complete specimens are rare. They are the Sarcopterygii or fleshy finned fishes made up of generally less well known fish such as the lobe finned fish and the lung fish. The lobe finned fish or as they are technically called, the Crossopterygians, possess a distinctively shaped homocercal tail, a head region well endowed with bony plates (cranial skeleton) and fins with fleshy lobes at their ends, hence the name lobe finned fish. The fins of the Crossopterygians unlike the fins of other fish have a series of small bones in them which effectively increase their rigidity. We use the present tense here for although the lobe fins were once thought to have become extinct, and were at first known only from fossils, in 1938, a living lobe fin fish was discovered off the Island of Madagascar and since then it has become known that a population of these living fossils survives in part of the Indian Ocean. All of the fleshy finned fishes and some of the ray finned fish have a swim bladder which assists in swimming and which may have been inherited from bony armor ancestors which particularly would have needed it to counteract the mass of bony armor plate.

The lobed finned fish with their framework of small bones, could at times utilize these fins to crawl over mudflats from bodies of water which had desiccated; the fins being strong enough to support the weight of the animal. In making a trip across a mudflat or other land the swim bladder may have been used to gasp enough oxygen to survive the trip. Lob finned fish in the Devonian did exactly this and over a period of a few millions of years forms were selected which had a swim bladder full of blood vessels so that the swim bladder could begin to function as a type of primitive lung.



Dipterus Valenciennesi, **Sedgw. and Murch. (restored by C. H. Pander); Lower Old Red Sandstone, Scotland.**

This scenario of fish walking across land is being enacted again today with the walking catfish introduced a few decades ago into Florida. These animals find that if a particular body of water isn't to their liking they can use their fins to make a trip across land, sometimes eating small animals in the process, and find a more suitable body of water. The walking catfishes swim bladder functions as a primitive lung in the same manner as did the Coelacanths of the Devonian Period. The only problem here is that the catfish are doing this 380 million years too late!

Some small but excellent lobe finned fishes have come from the Pennsylvanian iron stone nodules from Pit 11 near Essex, Illinois. Some of these have been exhibited at EXPO in the past. The Old Red Sandstone of Scotland also has produced a number of lobe finned fish fossils. Specimens of these also have shown up at EXPO from time to time.

Lungfish

Another group of fleshy finned fish are the lungfish or Dipnoans. These animals get their name from the fact that they use their modified swim bladder as a primitive lung when they bury themselves in the mud of evaporated lakes during the dry season. Lung fish use their gills as any other fish would when the lake is full, but when it starts to desiccate (dry out) they burrow into the mud, using their "lungs" to obtain sufficient oxygen to survive until the lake again fills with water. Lungfish like the Crossopterygians lived in the intermittant lakes of the Devonian Period and found the possession of a swim bladder a key element to their survival. They, like the Crossopterygians, have survived until the present.

***Phaneropleuron Andersoni*, Huxl. (restored by Dr. R. H. Traquair); Upper Old Red Sandstone, Dura Den, Fife.**

Bony Fishes

These are the types of fish which have fins, a tail and an ossified skeleton. They consist of two major subdivisions (subclasses). The Actinopterygii or ray finned fishes and the Sarcopterygii or fleshy finned fishes. Both of these two groups first appeared as with so many other "fish" groups in the Devonian. The earliest members were generally small forms possessing thick bony scales, often referred to as "ganoid" type fish after a type of thick scale like that of a gar. These early ray finned fish were the Paleoniscids, a group which continued into the Triassic then became extinct. Other related fish also with thick scales appeared in the Mesozoic. These were groups which include the sturgeons and the paddlefish, primative looking fish which are still living today. The gars also appeared in the Mesozoic and with their thick, bony scales and head composed of interlocking bony plates, suggest a link with bony armor fish of the Mid-Paleozoic.

The major living group of ray finned fishes living today are the Teleosts or the true bony fish. These appeared in the Jurassic and specimens of these small fish, Leptolepis sprattiformis are quite common fossils at Solenhofen Germany.

Once established the Teleosts spread throughout both marine and fresh waters. The Teleosts are characterized by a well ossified skeleton in which vertebrae have a characteristic "hour glass" shape. The tail is homocercal, the body covered with small scales and the sense of hearing well developed, partially as a consequence of small, oval shaped bones called otoliths or ear stones which are common microfossils from the Cretaceous to the present. During the Cretaceous, large, predaceous Teleosts appeared, some of them the largest bony fish ever to have ixisted. In the early Cenozoic appeared the ancestors of the fish so common in fresh and marine waters of today, such as bass, herrings, catfish and flatfish; the latter along with the flounders, soles, and swordfish are analogous to the skates and rays which evolved from the sharks during the Mesozoic Era. These are generally the most common and frequently seen of fossil fish.

THE ICHTHYOLITES OF SCOTLAND

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Special thanks to Brenda Cook, a smashing wee lass, who did the typing!

No Scotsman would attempt to write anything on the fossil fish of his country without first mentioning Hugh Miller the 19th century Theologian and Geologist born in Cromarty in tye year 1802. And so a few paragraphs on Hugh Miller.

The midwife who delivered Hugh predicted from the odd configuration and size of his skull that the baby was destined to become the local idiot. Undeterred by this less than heartening start to life Hugh set out to prove the midwife wrong, he commenced his career as a stone-mason, later worked in a bank and then progressed to the editorship of an Edinburgh newspaper, the "Witness." So the midwife got it wrong, but then again we all make mistakes! Ghe "Cromarty Stonemason" as Miller is often referred to is non-the-less best remembered for his work on Scottish Devonian fish, for it was his collaboration with Louis Agassiz that caused many of these fish to be names and then represented in the latter's magnificent work "Poisson Fossils." Up until the discovery of these Ichthyolites (GK "fish stones") by Miller it was largely considered that the old red sandstone was "remarkably barren of fossils."

Here is a small extract from Miller's most famous book "The Old Red Sandstone" where he describes finding that curious antiarch Pterichthyodes ... "I fain wish I could communicate to the reader the feeling with which I contemplated my first found specimen. It opened with a single blow of the hammer; and there, on a ground of light-coloured limestone lay the effigy of a creature-fashioned apparently out of jet, with a body covered with plates, two powerful-looking arms articulated at the shoulders, a head as entirely lost in the trunk as that of the ray or the sun fish, and a long angular tail. My first-formed idea regarding it was, that I had discovered a connecting link between the tortoise and the fish ...".

The Devonian Fish

The fossil fish in the North of Scotland are predominantly of Middle Devonian (Eifelian-Givetian) age, but some Upper Devonian fish also occur. Middle Devonian fish include the crosspterygians Osteolepis macrolepidotus (Agassiz), Gyroptychius agassizi (Trail) and Dipterus valenciennesi (Sedgewick and Murchison), the acanthodian Cheirolepis trailli (Agassiz), the antiarchs Asterolepis orcadensis (Traquair) and Pterichthyodes milleri (Agassiz), and the placoderms Coccosteus cuspidatur (Miller), Dickosteus threiplandi (Miles and Westoll) and Millerosteus minor (Miller). Agnathan (jawless) fish represented in the middle "Old Red" are Cephalaspis magnifica and Achanarella sp., the latter being a small anaspid similar to Jamoytius kerwoodi (cf Silurian Fish). A small fish Palaeospondylus gunni (trail) is of problematical affinities, if indeed any at all! Its small size, seldom exceeding 50 mm, has caused it to be thought of as a larval stage of almost every conceivable fish. The larval theory is attractive though unfortunately not altogether probable because even the tiniest specimens of Palaeospondylus only a few millimetres in length are fully ossified.

Many of the Devonian fish brom the North of Scotland occur only as isolated plates and bones or loose associations of scales, but good complete fish can be found, especially around Nairn, near Hallkirk in Caithness, and on Orkney Mainland. Many fine examples of Scottish Devonian fish can be seen on display in the Royal Scottish Museum (Edinburgh), the Hunterian Museum (University of Glasgow) and of course in the British Museum of Natural History (London). If in Edinburgh I would certainly recommend a visit to the "Royal Scottish" followed by a tour of the antiquarian bookshops where you may still be lucky enough to pick up a copy of your own favourite Hugh Miller book. (Any MAPS member who wishes may call on me and we can arrange the same).

The Silurian Fish

I will not argue, you're quite right, denticles and scales of Ordovician fish have been found in various parts of the world, but who can boast of some of the earliest complete fossil fish. Aye, in my best Scottish accent I modestly have to admit, you're right again, Scotland.

The Lesmahagow inlier in Scotland's midland valley produces very sparingly such strange early agnathan fish as the earliest cephalaspid Ateleaspis tessellata (Traquair), the thelodonts Lanarkia spinosa and Logania (Thelodus) scotia, the armoured anaspid Birkenia elegans (named after the Birkenhead burn, Lanarkshire), the unarmoured anaspid Lasanius problematicus (Traquair), and last but certainly not least the earliest anaspid Jamoytius kerwoodi (named after the famous ichthyologist J. S. Moy-Thomas). All these fish are of Lower Silurian (Llandovery) age.

Birkenia elegans (Traquair) is a most curious individual. It is an anaspid (laterally compressed) with a decidedly strange arrangement of dorsal spines, the anterior dorsal spines being rudimentary, the posterior dorsal spines projecting posteriorly and the median dorsal spine bifurcating anteriorly and posteriorly. This elaborate arrangement of dorsal spines together with the heavy armour plating is commonly held to have been necessary to dissuade the gastronomic attentions of those contemporary invertebrate predators the eurypterids. Eurypterids were around, their remains include the fearful Lanarkopterus (Mixopterus) dolichoschelus, the gigantic Slimonia acuminata and that aquatic eating-machine romantically referred to as Erettopterus (Pterygotus) bilobus by we few enthusiasts who can pronounce its name! Thus, although the "heavy armour" theory neatly explains why Birkenia was in fact heavily armoured it sadly does not do anything to explain why Lasanius was naked, devoid of scales and armour, possessing only the standard row of dorsal spines. I find it hard to believe that even a naked anaspid such as Lasanius could outpace such strong and capable swimmers as the eurypterids, so where then did the advantage lie in shedding that heavy armour almost obligatory to all other contemporary vertebrates. It seems curious that the only "protective" devices represented in the genus Lasanius are the dorsal spines which being non-retractable would have caused turbulence in their watery medium and so hindered any attempt at swift retreat from potential predators. Lasanius is an interesting though visually uninspiring fish for they are almost impossible to see on the matrix, poorer specimens being nothing but a gill basket and a row of dorsal spines.

If I may I would like to digress for a minute and introduce to you another faunal element commonly encountered in the Lesmahagow inlier. The problematical fossil Dictyocaris has I fear been most unfairly accused of many and diverse affinities but I would suggest that a feeling is growing amongst palaeontologists that Dictyocaris represents a kelp-like plant, rather than for instance the exuviae of some crustacean. The suffix "carris" (GK. "shrimp") is singularly unfortunate from my point of view for I think I will never see a shrimp in a Dictyocaris no matter how hard I try. Possibly this will not be a bad thing with regard to my sanity! Dictyocaris almost always exhibits grazing voids (?), small circular holes in its integument of some s-5 mm in diameter held by some research workers to represent the nibblings of Jamoytius. These grazing voids (if that they are) may however represent the work of industrious ostracods (waterfleas) rather than the nibblings of Jamoytius. Ostracods of the genus Beyrichia are extremely common faunal elements that, like Dictyocaris range throughout the inliers strata. In contrast Jamoytius is restricted to a narrow "fish bed" at one particular locality in the inlier, and therefore I feel it must be admitted by even the most ardent proponents of our fine fishes nibblings that this fact mitigates heavily against Jamoytius being responsible for the poor complexion of Dictyocaris.

Although I know that certain modern ostracods graze on algae, I have no specific knowledge of the damage that they cause to aquatic plants. If any modern ostracod workers should chance to read these few lines I would certainly welcome any communications on the subject of ostracod damage to recent algae.

The Carboniferous Fish

Carboniferous rocks outcrop widely in the midland valley of Scotland and fish occur in both lower and upper parts of the system from Ayrshire in the West to Edinburgh and the Lothians in the East. Lower Carboniferous (Mississippian) fish from Edinburgh include the acanthodian Gyracanthus formosus (Agassiz), the elasmobranchs Cladodus hibberti (Agassiz) and Diplodoselache woodi (Dick), the palaeoniscids Amblypterus striatus (Agassiz) and Cosmoptychius striatus (Agassiz), and the crossopterygians Rhizodus hibberti (McCoy) and Megalichthys hibberti (Agassiz).

The first discovery of a major vertebrate and crustacean marine fauna in the British Carboniferous was not however made in the midland valley of Scotland but in the lower Carboniferous (Upper Dinantian, Asbian) rocks at Glencartholm, Eskdale in Dumfriesshire, southern Scotland, by Macconochie of the Scottish Geological survey in 1879. Mississippian palaeoniscid fish from this locality include Cycloptychius concentricus (Traquair), Rhadinichthys canoblensis (Traquair), Canobius elegantulus (Traquair), Mesopoma macrocephalum (Traquair) and Elonichthys serratur (Traquair). The elasmobranchs Onychoselache traquairi (Dick) and Deltoptychius, and the acanthodian Acanthodes nitidus are also recorded from this locality.

The most famous upper Carboniferous fish locality in Scotland and probably the world is the Manse Burn, Bearsden, Glasgow, of basal Namurian age. This site was excavated during the summer of 1981 by Mr. Stan Wood, he also having discovered the site. This discovery by Stan Wood being the only other instance of its type found in Britain since Macconochies original discovery more than 100 years previously of Glencartholm. From this site at Bearsden comes the most complete (and best-preserved) Carboniferous shark known from anywhere in the world. The acanthodian Stethacanthus (the "Bearsden Shark") has helped illuminate the previously known but fragmentary material collected from the upper Mississippian (Lower Namurian) of Montana. The completeness of the "Bearsden Shark" could ultimately prove that Cladodus neilsoni (Traquair) from East Kilbride in Scotland and Stethacanthus altonensis (St John and Worthen) from Bear Gulch, Montana, are one and the same organism; Stethacanthus being the first named and therefore claiming seniority.

Two complete specimens of Stethacanthus with all soft parts preserved were recovered at Bearsden but unfortunately both were males and because of this it is impossible to say whether the spinous frill attached to the animal's back (just to the rear of the head) is diagnostic of the species or simply a case of sexual dimorphism.

Fish associated with Stethacanthus at Bearsden included the palaeoniscids Rhadinichthys, Elonichthys, Mesopoma and Chirodus and the acanthodian Acanthodes sulcatus (Agassiz). An extensive crustacean fauna was found associated with these fish, including the large shrimp Anthracophausia dunsiana (Peach).

I would like to finish if I may with another quotation from Hugh Miller's "Old Red Santstone". ..."My curiosity, once fully awakened, remained awake, and my opportunities of gratifying it have been tolerably ample. I have been explorer of caves and ravines, a loiterer along sea-shores, a climber among rocks, a labourer in quarries. My profession was a wandering one."

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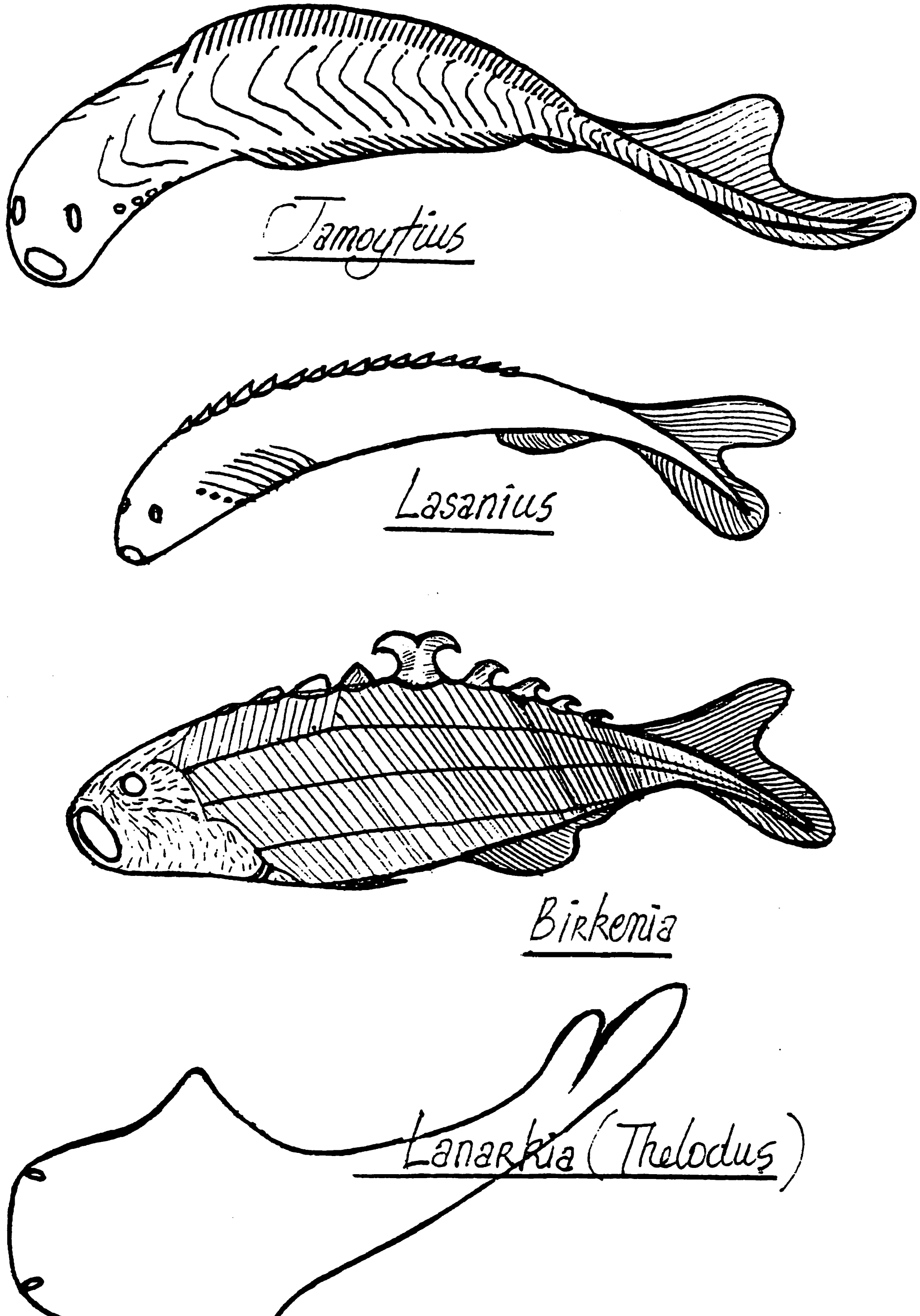
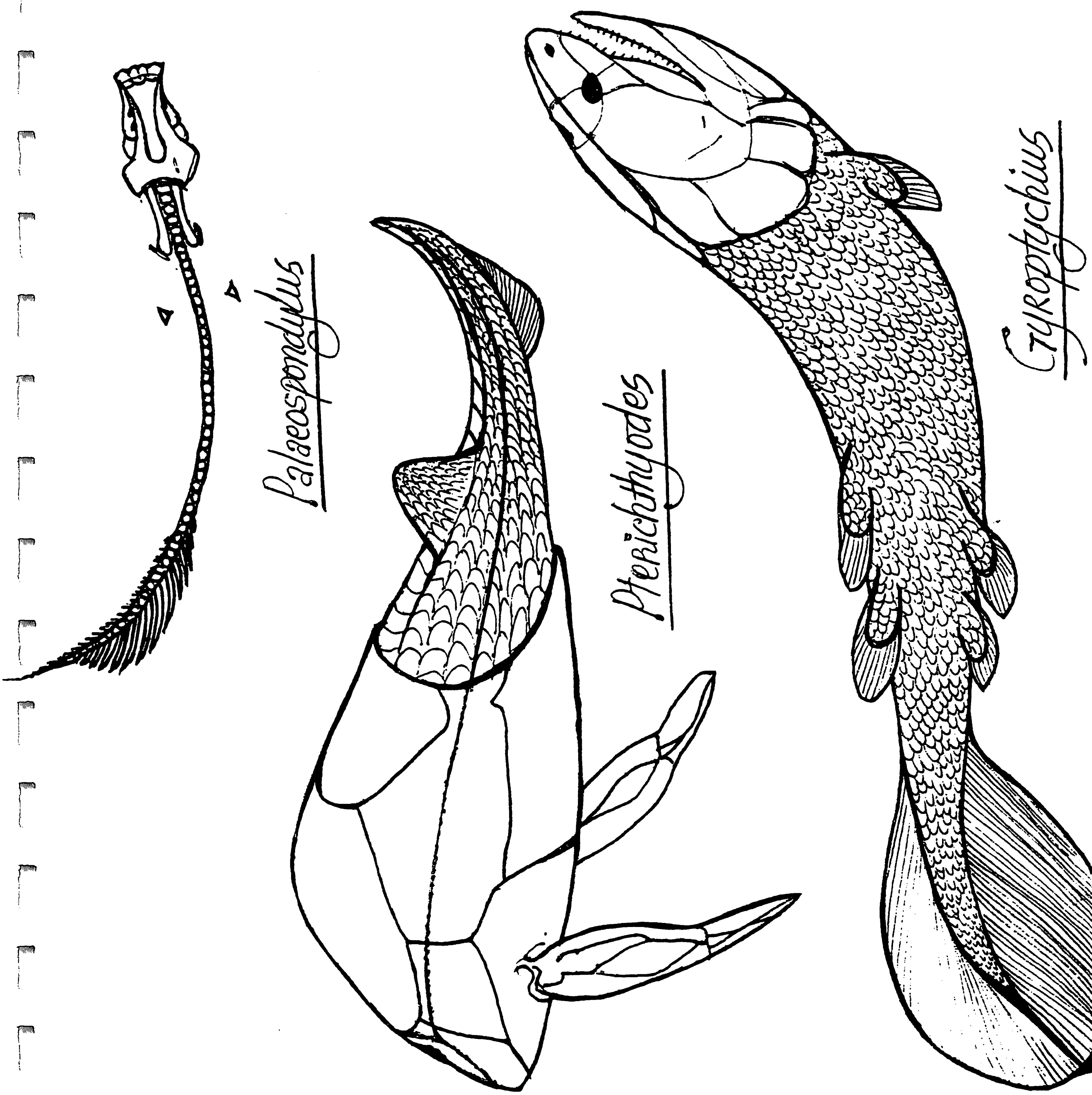
THE SILURIAN FISH



NOT TO SCALE

THE DEVONIAN FISH



NOT TO SCALE

THE BEARSDEN SHARK *Stethacanthus*

OHIO FOSSIL ARMORED FISH SKULL

Bob Guenther
149 E. Main St.
Shelby, Ohio 44857

I found a postcard of a huge fish skull, that I have admired for many years, and I made an enlarged sketch of it, along with some information pertaining to this monster of the fish family.

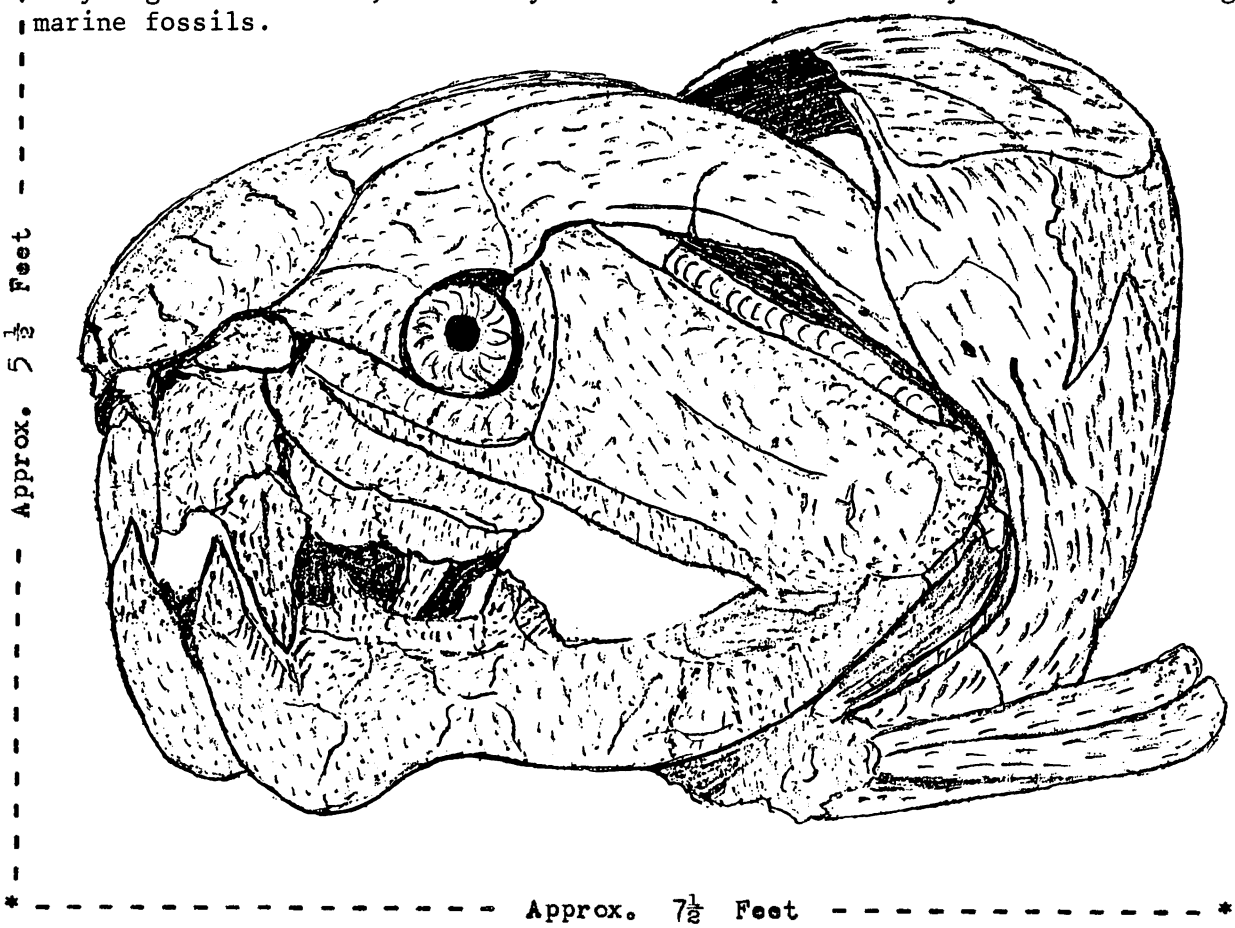
This huge Ohio Armored Fish Skull of the Devonian Period, 350 million years ago, was found in the Rocky River Valley, in the Cleveland Shale.

Named Dunkleosteus terrelli, of the Class Placodermi, (Greek plax, plakos, a flat round plate + derma, skin) is one of the extinct arthrodires, jaw bearing, heavily armored fishes that had large powerful jaws and jointed necks. Fish of this variety sometimes reached a length of 50 feet and were believed to have been the dominant vertebratae of the Devonian Period.

These ferocious fishes, probably caused as much terror in the Devonian Seas as the carniverous Dinosaurs caused in the much later Cretaceous on land.

This very rare, and well preserved museum specimen is on display at Natural Science Museum in Cleveland, Ohio.

Several years ago, when the Ohio State Highway Department was finishing the Interstate Highways through the Cleveland Shales, they uncovered and preserved many huge concretions, that they believe will provide many more interesting marine fossils.



HUNTING SHARKS, IN MONTANA?

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It was hot, very hot. The five of us concentrated on checking lifting and splitting pieces of the layer of light-colored limestone, searching for traces of fish, invertebrate, or other fossils that could appear, while trying to avoid slipping down the 40^{o} slope. Each of us was making little rocks out of big ones, a task traditionally associated with committing a heinous crime in some places, and each had their own pattern of comments, pounding and chopping noises. The sounds had stopped several minutes ago brom Bob Carr's corner, and I wondered whether the heat had started to affect him. Finally, he rose and handed me the rock that had puzzled him. Nothing was obvious on it except a very small white blob, a piece of a thumbnail brachiopod, and some stains, butthere was a form to the stains.

Licking the rock to moisten it brought out the faintest of radiating lines along two edges, but was this thing fossil junk or more? As Bob had stared, so did I, until the hand-lens revealed first one tooth and then more, in the white blob. This 2-inch thing had a mouth full of teeth, a truly strange body shape, and faint traces of calcified cartilage fin rays. The rays of calcified cartilage related it to the cartilaginous fish, sharks and their relatives, and the petal-shaped teeth still clenched together as at the time of death, identified it further as a petalodont shark. We had found one other petalodont a few years before, a beautiful, large fish with very big fins and a few jagged teeth; it was nicknamed Madame DeFarge (from Dickens' Tale of Two Cities) because it was found on Bastille Day and the teeth looked deadly. Madame DeFarge was only the second species of petalodont ever found as anything but as isolated tooth, and had no close resemblance to the first one or to any other fish ever found. This small one was somewhat different, so it was promptly nicknamed Ernest. Weeks of delicate work in the laboratory would be needed before all the teeth were exposed, and months before this tale of Two Fish could be written, but once again the Bear Gulch limestone had produced another dramatically new Mississippian fish. We celebrated the strange new arrival in the nearby town of Grass Range, Montana, that night!

After 20 summers of breaking rock in the summer sun, the Bear Gulch limestone has yielded 90 species of fish as well as many other rare fossils. The continuous stream of new knowledge has made this deposit the most species-rich fossil fish deposit in the world, and we are still digging, and still finding an average of one new fish for every 100 fish uncovered.

It all started as a two-person, 1-prybar stone quarry, so small you wouldn't even notice it along the little gully. The stone came out in nice crisp, even layers of any thickness your wall or fireplace needed, and in various shades of yellow to buff to gray. Very pretty stuff, and used ornamentally all over central Fergus County, Montana.

The U. S. Geological Survey missed this rock unit completely the first time around, when the Big Snowy group was named in the 1930's--it was off the main roads, on private ranch land. When someone geological finally found it, he named it the Bear Gulch limestone, and called it barren, Pennsylvanian and a part of the Tyler Formation. He was vaguely right--there is not much of interest in Bear Gulch itself. It would take several years for Jack Horner, then a student at the University of Montana, to establish that the Bear Gulch limestone was Mississippian and a part of the Heath Formation. But the quarry operators knew it wasn't barren, because an occasional pretty, and obvious, fish would be found during quarrying. One especially lovely coelacanth (pronounced see-la-canth), so the story goes, was saved to be the centerpiece over a fireplace. When the stonemason laid up the wall, however, the stone didn't fit quite right, so he turned it fish inwards and cemented it! Another fish had a better fate, being given to a newphew of one of the quarrymen. It was carried to Missoula in 1968 where Bill Melton, curator in the Geology Department, realized that this fish was new to Montana. Bill, with Jack Horner investigated the site amid the snows of autumn, found a few more fossils, and resolved to come back the next summer. His goal seemed simple, to collect enough fish to describe in print.

My family and I arrived for a visit early in the summer of 1969. With few specimens both the preservation and the fossils themselves were startling. Worms, fine algae, a completely unknown soft-bodied animal, and several lovely but strange fish were accompanied by a variety of shrimp. The fish were not common, were frequently excellently preserved, and moreover, were being uncovered in an increasing variety of body forms. Plans were made to continue to dig the following summer.

The unknown invertebrate had conodonts in it, causing a tremendous sensation at paleontological meetings in the fall: the long-sought conodont animal had apparently been found. Apparently because even now, with many specimens, there is disagreement about the cigar-shaped beast with the net-like tail, and whether it grew condonts or ate them. One thing is obvious about it, it is unknown except from the Bear Gulch limestone; a statement that would become more and more common through the years.

Quarrying was slow and difficult at the first few sites, and we exhausted one little outcrop after another, slowly sampling up and down this valley. Some spots yielded just enough material to tantalize us, to keep our waning interest from dying out and of course, rather than just increasing the number of individuals of any fish species to a level at which we could understand it for publication, for every few specimens we found we added new species, and therefore compounded our problems.

It was with the finding of two sharks in particular that the Bear Gulch started to take on a dimensionality above and beyond just any other fossil deposit. Since sharks lack bones, hard articulated objects which fossilize well, they are rarely fossilized as whole individuals. The Paleozoic era in particular had an appalling poor representation of them. So when a three foot male, missing only its tail was found stretched out as if it had been dissected, and the dorsal-fin and spine of this matched pieces named Stethacanthus altonensis in the 1890's, there was a thrill of excitement. But another shark was even more exciting: only 3.5 inches long, with delicate skin and eye pigments, skin outlines, and thick dental plates, it tapered to a knife-like point and seemed to fade from view like a ghost as the rock dried.

The ghostfish, as we nicknamed it, proved to be an introduction to a virtually unknown world, not only because many of this kind were found, not only because the preservation was breathtaking, but also because we found a great range of sizes and stages of maturity. It was when male ghostfish were found, with long, complex, crab-like appendages projecting from their rostrums while females showed no such structure at all, that we started to realize just how little we knew of the world of Carboniferous sharks.

The word shark brings to mind today's sleek apex predators, highly evolved hunter-killers with batteries of cutting replacement teeth and a variety of sensory systems unmatched in any other vertebrates. In fact, some of today's sharks have a brain-to-body volume equal to that of some mammals and birds, a number are warm blooded, and a majority of them give birth to living young after long and complex gestation periods. Skates and rays are also closely related to sharks, having similar morphologies and sensory systems although differing in body forms and dietary (feeding) adaptations. Sharks, skates and rays are grouped together in the class Chondrichthyes (cartilage fish) subclass Elasmobranchii (strap gills). Chimaeras (known as elephant-, rat- and rabbit-fish), unlike elasmobranchs, have evergrowing tooth plates rather than teeth and their upper jaws are fused to the braincase, but they are also cartilage fish. They share with the other cartilage fish the specific structure of the reproductive system and the fact that fertilization is internal with males having claspers for copulation and sperm transmission. Chimaeras are placed in a second subclass, Holocephali, but until the Bear Gulch fishes and those of Dr. Rainer Zangerl were discovered, there was no scientific agreement whether the two subclasses were related. There is now little reason to doubt that they are descended from a common ancestor.

Holocephalans are very rare among recent cartilage fishes, and sharks, skates and rays are only 3% of living fish species. In the Bear Gulch bay, however, 50 of the 90 species of known fish are shark-like and over 20 of these are known to be or inferred to be, holocephalan or close to holocephalan. One of our most common, Echinochimaera, is an offshoot of the lineage leading to chimaeras, and the males of this species are adorned with paired sets of throns over the eyes and down the top of the tail, as well as an elaborately enlarged first dorsal fin and spine. The largest males are also twice the size of the females, although at six inches they are tiny compared to most modern shark-like fish. I have found major differences in body shape and size between sexes, known as sex dimorphism, not only in the ghostfish and Echinochimaera but in many Bear Gulch sharks. Thus, a family of at least 7 species all have males with crowns of large scales and strange first dorsal fins and spines. The fins don't look like fins, the spines are radically different from those of any other fish, and females either don't have any traces of any of these male ornaments or look obviously different. Sex dimorphism among the Carboniferous sharks undoubtedly served the same functions it does today among deer, elk, peacocks, and many other animals: for the male, it pays to advertise how male you are; for the female, choosing the most macho male could guarantee stronger and thus more successful off-spring. For the Bear Gulch expeditions, of course, this has lead to many problems in figuring out what males go with which female. This has also added a refreshing tone to discussions of fossil fish evolution, as the fossil record is notoriously deficient in information about the sexual aspects of life.

Among the many Bear Gulch sharks are those with almost every conceivable body form: a long, ribbon-like one; the skate-like Squatinactis; and one with a profile so strange it got its nickname, El Wierdo, from my then 6-year old daughter. Some looked like they could fly through the water on huge fins; others probably could fly out of the water like today's flying fish. There was one we called baby meanteeth, an obvious fetus with a full gut and jagged slashing teeth.

Ultimately we come down to those fish we have only pieces of, and someday hope to get more of. Among these is a head with very large eyes attached to a tiny down-turned mouth, and in the mouth are a clump of very small teeth that look a bit like miniature beans with wrinkles along them. This google-eyed thing may also have been eel-like. My wife, Wendy, who is also my illustrator, curator, and chief cook and bottle-washer in the field, normally turns my pencil drawings into final inked illustrations in a process she calls the sow's ear to silk purse department, but she refuses to even sign her name to the final rendition of this creature we all know as Nessie. It just doesn't look plausible!

The sharks are diverse, and obviously had evolved during the Mississippian into a bewildering assortment of highly specialized forms. Most of the bony fish are far less dramatic, but for sheer glamour few fish, living or fossil, can match coelacanths. These fleshy-finned near relatives of the amphibians flourished in the Paleozoic and Mesozoic eras and were thought to have died out with the dinosaurs until one was caught off the east coast of Africa in 1939. The one living species, Latimeria chalumnae, has only recently been caught on video underwater and has never been kept alive in captivity, so little is known about its habits. There are 5 species in the Bear Gulch, however, each a slightly different shape for a slightly different mode of feeding and swimming. We know the long-bodied one swallowed large shrimp, so it was named Caridosuctor, or shrimp sucher. Wendy, a student and myself suggested on the basis of Bear Gulch coelacanth anatomy and mouth measurements that all the coelacanths vacuumed up their food. We did have, as you can imagine, a problem with measuring the mouths of squashed fossils without a soft-bodied example around for comparison, but we did our best with what we could find in the literature on Latimeria. Early this year, I participated in dissections of two fresh-frozen Latimeria and found that we had been too about our fossil mouths. They were far more powerful suction feeders than we guessed. I have handled hundreds of fossil coelacanths, but few events could match the thrill of examining a fresh one, in the flesh, let alone finding out that we had been correct.

There are a few thrills greater, and every time a rock is split or turned over on the outcrop in Montana, my sense of anticipation climbs. I still never know what new fish will come into the sunlight after 320 million years--and whether it is greeted by a whoop of excitement, a muttered "what the blazes is this," or an awe-struck silence, each new or well preserved fish is more exciting than the previous one. The fishes of the Bear Gulch Limestone just get more amazing with time.

FIGURE CAPTIONS

Figure 1. Madame DeFarge, drawn from the type specimen. The scale bar is in centimeters. The abbreviations are: L, liver; P, palate; and S, shoulder girdle. Teeth of this petalodont closely resemble teeth found in southern Indiana.

Figure 2. Teeth of *Polyrhizodus digitatus* from a jaw found in the Bear Gulch Limestone. *Polyrhizodus* teeth are common in Mississippian limestones both in North America and Europe. The scale bar is one centimeter.

Figure 3. Ghostfish (*Harpagofututor volsellorhinus*): male above and female below. Tooth plates similar to those of the ghostfish have been found in the St. Louis, Missouri area. The scale bar is one centimeter.

Figure 4. *Echinochimaera meltoni*, the male above and the female below. The placoid scales covering these fish have been omitted for clarity. The scale bars are in centimeters.

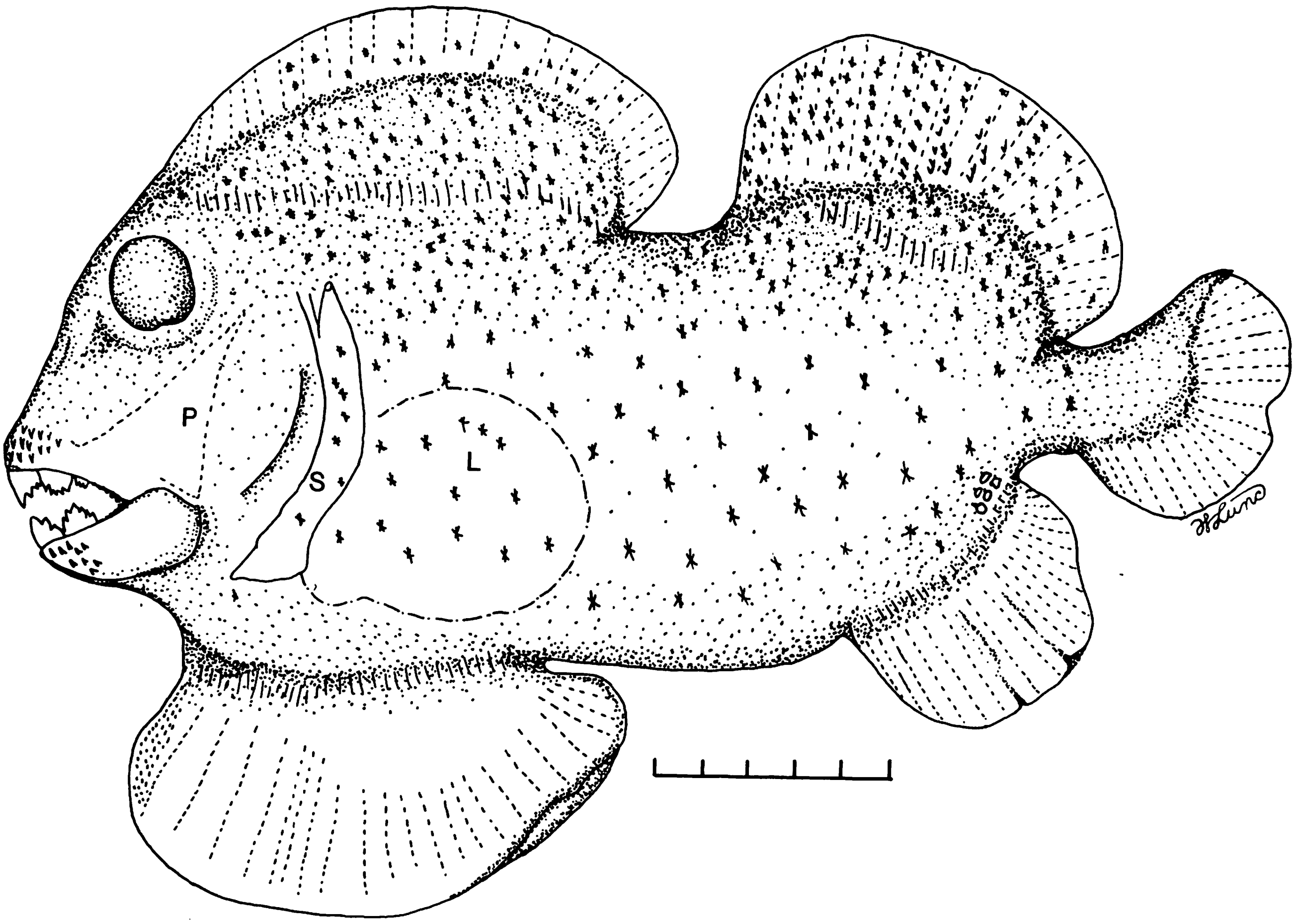

Figure 1

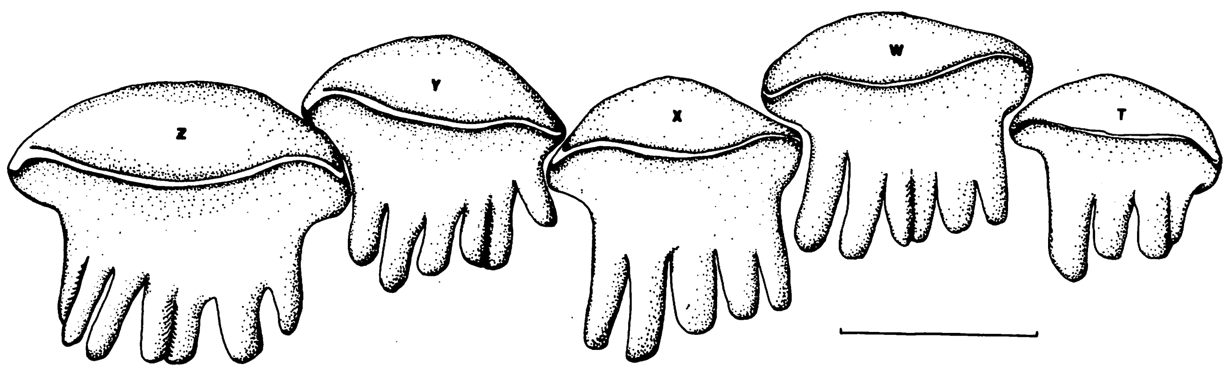

Figure 2

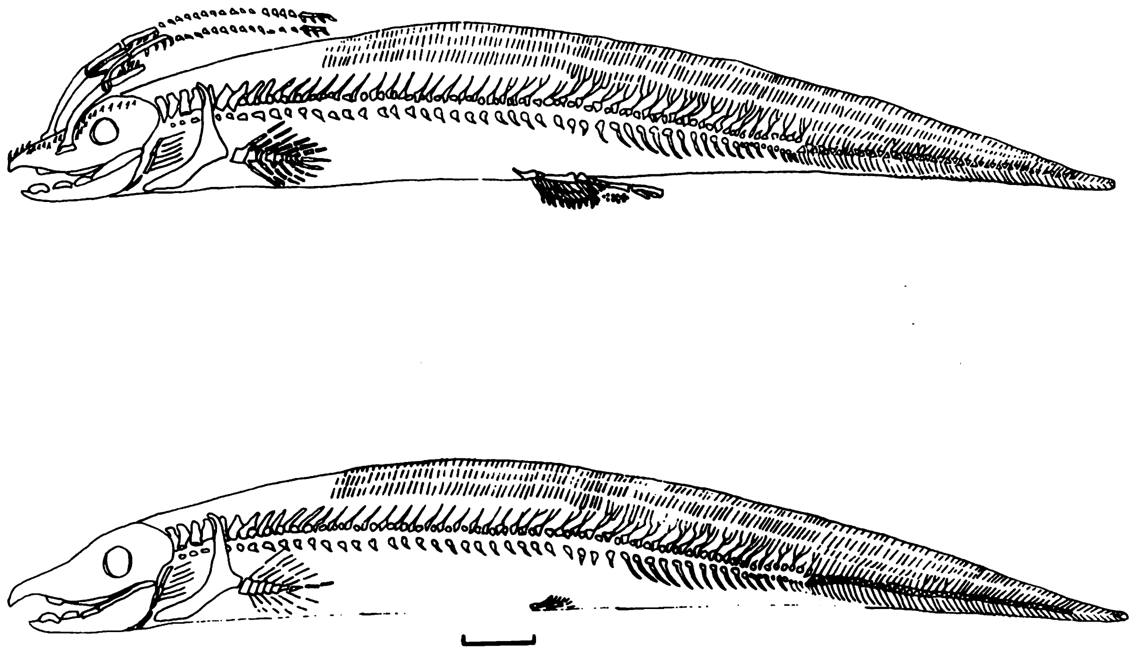

Figure 3

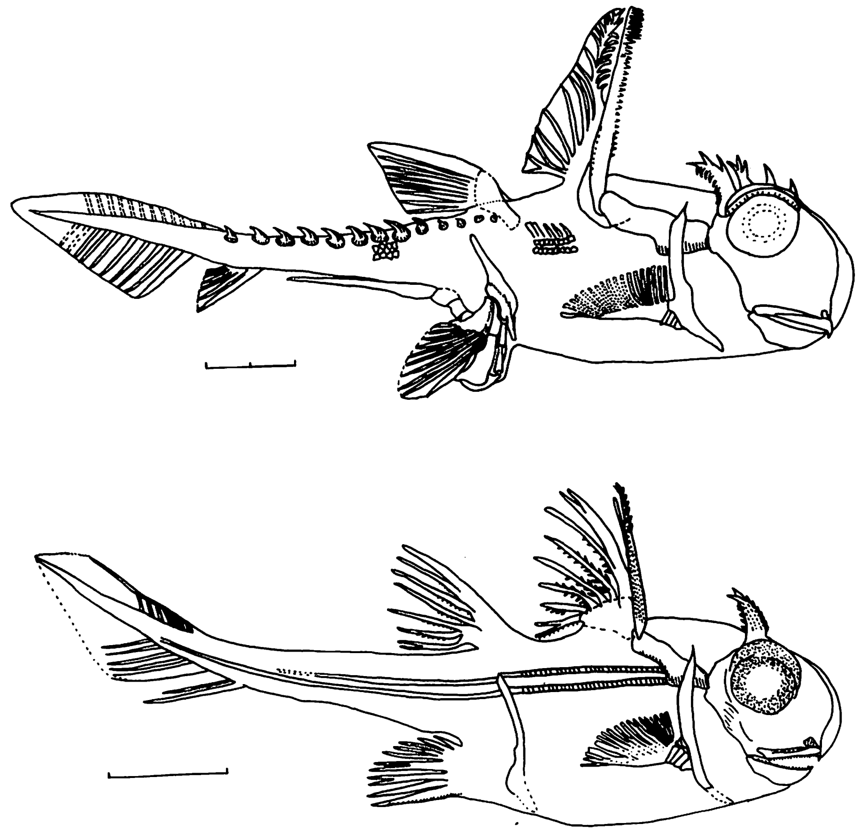

Figure 4

Below is an Abstract from FIELDIANA GEOLOGY MEMOIRS, Published by Field Museum of Natural History. Volume 6

Iniopterygia, a New Order Of Chondrichthyan Fishes From The Pennsylvanian of North America

--Rainer Zangerl
Gerard R. Case
June 29, 1973, Publication 1167

ABSTRACT

An entirely new group of Pennsylvanian fishes, belonging to the class Chondrichthyes, is described and their comparative anatomical and phylogenetic relations are discussed. Seven species belonging to five genera are distinguished and placed within the subclass Holocephali as a separate order, Iniopterygia. The iniopterygians are structural, but not phyletic, intermediates between the chimaeroids (as here defined) and the elasmobranchs. Present analysis permits the notion that the holocephalians and the elasmobranchs are sister groups sharing a common ancestor that never possessed a bony dermal armor but an even spread of lepidormorial denticles over the entire skin and the stomodaeum. Iniopterygians and chimaeroids, in turn, appear to be sister groups having evolved from a common ancester that combined an autostylic jaw suspension with a generalized shark-like dentition.

Iniopterygians are presently known only from carbonaceous, sheety shales of the Pennsylvanian basin complex of central North America.

A most sincere thank you to Dr. Rainer Zangerl who supplied the above information. For more information please contact Dr. Rainer Zangerl, R.R. , Box 252A Rockville, IN 42872, or Field Museum of Natural History, Chicago, IL

RAIDERS OF THE LOST SHARKS

Edward M. Lauginiger
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Wilmington, Delaware 19809

There are thousands of people who daily travel the interstate highway system through Delaware and into the state of new Jersey. Little do these people realize that they are crossing sediments which were deposited over seventy million years ago when these two states were at the bottom of an ancient sea. These shallow seas were the home for many types of plants and animals. Clams, oysters, snails, ammonites, corals, crabs, lobsters and numerous other invertebrates lived, died and are preserved as fossils in these sediments. My interest, however, deals with those animals who had skeletons of cartilage and who only left behind their teeth and occasional spines and vertebrae to prove that they were there. It is for the purpose of collecting shark and fish remains that I annually take groups of students into the field to visit these Cretaceous age sediments.

In Delaware, the teeth are found in three of the four Upper Cretaceous formations which outcrop along the banks of the Chesapeake and Delaware Canal. At one time specimens could be collected in place from the formations but today they must be found in the numerous spoil piles put down by the United States Army Corps of Engineers as they dredge to keep the canal open to shipping. Collecting is done by crawling or walking slowly along the spoil piles or by dry-screening the material. As recently as 1982 a micro-vertebrate rich deposit was laid down on the north bank near the town of St. Georges. This material contained many large shark teeth, some over an inch long, as well as fish, reptile, and even a few dinosaur teeth. With additional dredging due in the near future and the possible construction of a new bridge and highway system this area should soon produce many new additional specimens.

Collecting Cretaceous shark material in New Jersey is a little easier and can be a lot more rewarding. Most of the collecting is done by wet-screening gravel from one of the many streams which cut through the sediments. One can also collect and screen directly from the formation itself if the bone-bearing bed can be identified and located. One of the best streams to collect at is located in Monmouth County, New Jersey, just outside of the town of Freehold. This stream, known as Big Brook, has been producing shark material since the turn of the century and it is where I take my students to collect. A group of four students with a single screen can recover well over a hundred teeth in a single five hour collecting day. The more dedicated collectors can find at least this many by themselves. In addition to teeth, the stream also contains coprolites, vertebrae, and other vertebrate and invertebrate material.

The main Upper Cretaceous formations which contain shark material in Delaware and New Jersey include the following:

Merchantville Formation: This formation locally contains numerous large goblin shark teeth.

Marshalltown Formation: This formation contains lenses with a rich and varied vertebrate fauna.

Wenonah Formation:	This formation has been reported in the literature as containing few fossils but in the area near Big Brook there is an eighteen inch bone bed which contains a rich micro-vertebrate assemblage.
Mount Laurel Formation:	This formation contains a less varied fauna than the previous formations yet still produces many excellent specimens.
Navesink Formation:	This formation pinches out and is not found in Delaware. It produces the same type of teeth as are found in the Mount Laurel.

The fish fauna in these formations is varied but material from seventeen genera of sharks and their relatives and four genera of bony fish can be found by experienced collectors who are willing to take the time and effort.

Partial jaw sections of the chimaera or rabbitfish Ischyodus can be found in the gravel beds but the broken and rootless teeth of the hybodont sharks Hybodus and Lonchidion are very small and can only be recovered by the screening of formation material through one-eighth inch mesh.

The teeth of the guitarfish Rhinobatos, the oral teeth of the primitive sawfish Ischyrhiza, and the rostral spines and oral teeth of the sawfish-like Ptychotrygon are also specimens which can only be recovered by the fine-screening of formation sediments. The large rostral spines of Ischyrhiza, however, are occasionally found in the stream deposits.

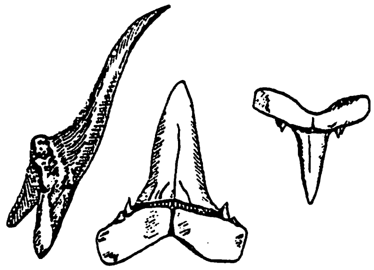
The isolated chevrons or pavement teeth of the primitive cownose ray Brachyrhizodus are common stream and gravel finds but the teeth of the skates Rhombodus and Pseudohypolophus are small and can only be found in the formations.

The anterior and lateral teeth of the goblin shark Scaphanorhynchus and the teeth of the two species of crow sharks Squalicorax are the most common shark teeth found in the Cretaceous deposits of Delaware and New Jersey. In addition, teeth of the angel shark Squatina; the sand shark Odontaspis; and the primitive makeral sharks Plicatolamna and Cretolamna are also easy to collect. Rarer shark teeth include those from the nurse shark Ginglymostoma and the primitive thresher shark Paranomotodon

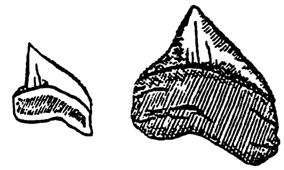
The bony fish are represented by the abundant isolated teeth and jaw sections of the pike-like Enchodus; single teeth from the battery of the coral nibbler Anomoeodus; single teeth and partial plate pieces of the ancestral ladyfish Paralbula; and isolated lateral teeth from the giant tarpon-like Xiphactinus.

In addition to the Cretaceous, teeth from the Paleocene, Eocene, and Miocene deposits can also be found in New Jersey. All that is needed is a geological map to locate the streams which cut through the fossil rich deposits and the willingness to spend the time to do some exploring. Any of the numerous streams found in New Jersey is a potential fossil shark tooth gold mine. For more detailed information and a bibliography please feel free to contact the author.

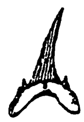
CHONDRICHTHYES



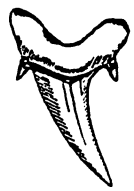
Scapanorhynchus texanus (Roemer)



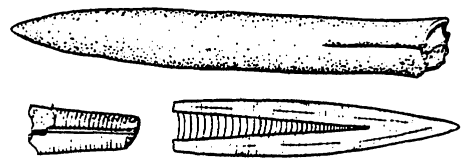
Squalicorax sp.



Odontaspis sp.

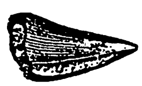


Plicatolamna arcuata (Woodward)



Belemnitella americana **(Morton)**

Shark coprolite

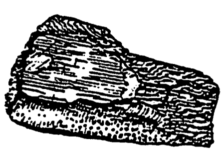


Mosasaur sp.

Hybodus sp.

Enchodus sp.

Cretolamna appendiculata (Agassiz)



Ischyodus bifurcatus Case

Ischyrhiza mira **Leidy**

Brachyrhizodus wichitaensis **Roemer**

CRETACEOUS FISHES OF LEBANON

Dennis Kingery
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Rock Springs, Wyoming 82901

Summary

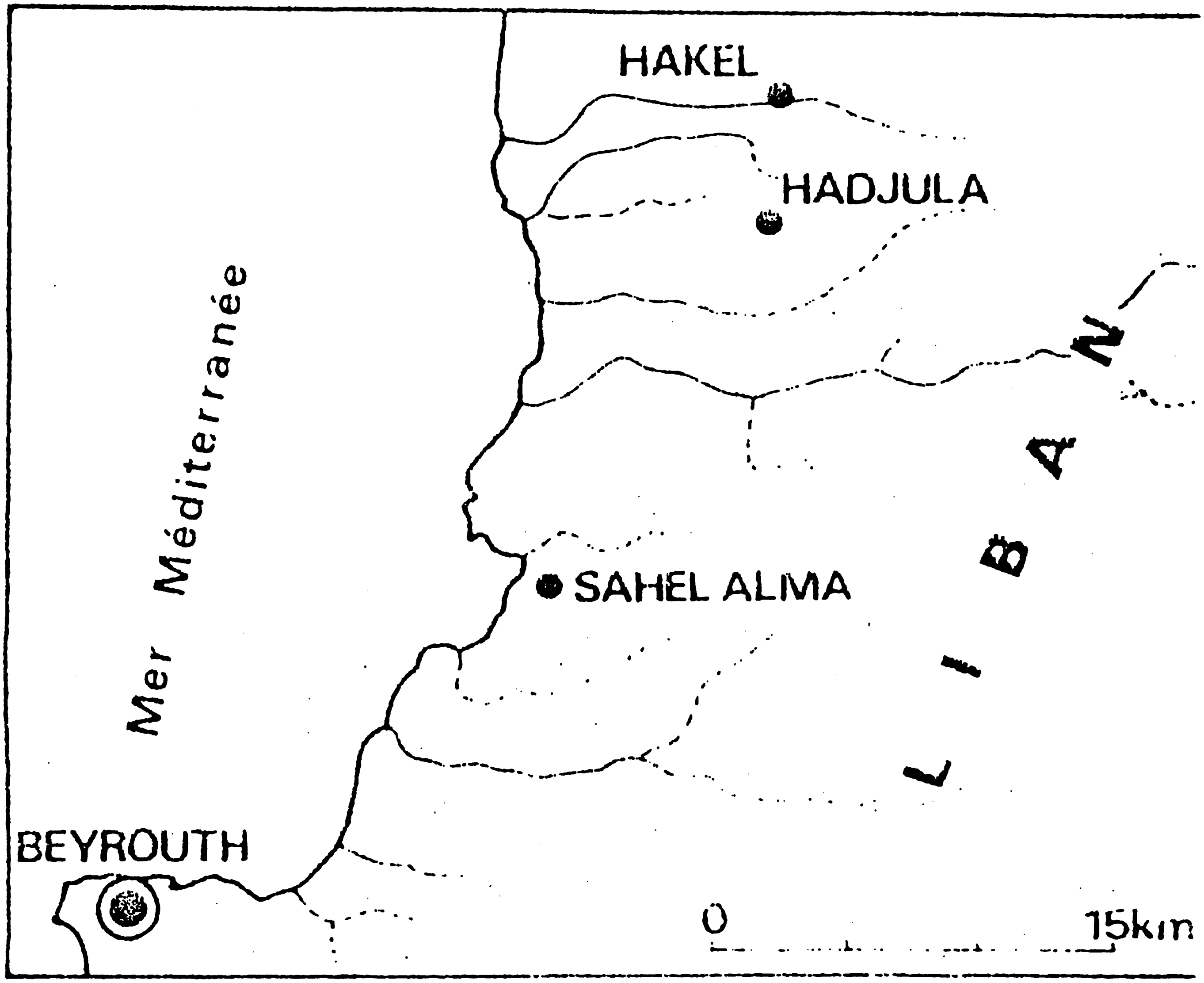
The sublithographic limestones of the Lebanon, famous through their fish and other well preserved fossils, are situated within an area of thick Cretaceous shelf sediments containing Nerineids, Rudists, and Orbitolinids indicative of a warm and shallow sea. They were deposited in small basins of only a few hundred meters across, but now up to 270 m. deep relative to the surrounding surface. The fish deposits are always accompanied by breccia-like deposits. These rest unconformably on the basin slops and represent the initial phase of the basin filling.

The fish beds in contrast, indicate slow deposition in a subsequent stagnant stage, though they may have become re-deposited by occasional small-scale suspension currents. Locally they interfinger with the beds of the surrounding sea floor. Some basins seem to have collapsed intermittently, with new slide masses and fish deposits cutting through the earlier ones. As there is no indication of salt deposits, karst or contemporary volcanic activity, a tectonic origin of the basins at the intersection of block fault systems is suggested. These conclusions refer primarily to the basins of Haqel and Hjoula (see map), which have been mapped and studied in more detail. They, as well as some other basins in their neighborhood were formed and filled during the later part of the early Cenomanian. (97.5 to 91 million years ago) The above text was taken from: J. jb. Geol. Palaont. Abh. 135 2 113-149 Stuttgart, Juni-1970 Fossil-Lagerstatten, Nr. 7 "Die Fischschiefer von Haqel und Hjoula in der Oberkreide des Libanon", Von Ulrich Huckel, Tubingen . Mit 17 Abbildungen und 5 Tabellen in Text.

All the above and the following illustrations were from surveys from the British Museum, sent to me by Tony Jones of California Rocks and Minerals. (THANKS TONY)

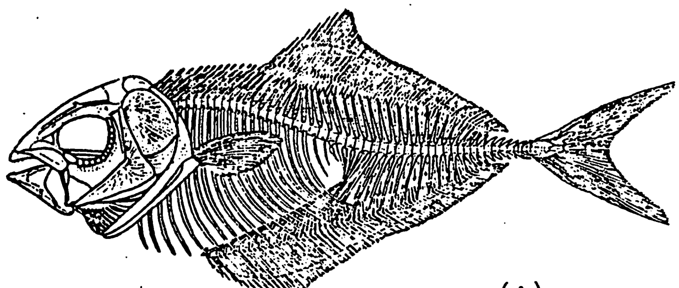
It is fun to compare the skeletons of these salt water fish with the fresh water fish of the Green River Formation. I personally have a few of these Lebanese fish, love them, and would like to acquire more. (Due to the unrest in that area, the fish are rather difficult to hunt at this time).

LOCATION OF CRETACEOUS FISHES OF LEBANON



LEBANESE FOSSIL FISH

A) Protobrama avus Smith Woodward
B) Tselfatia formosa Arambourg
C) Ichthyotringa furcata Agassiz
D) Apateopholis laniatus Davis
E) Phylacyocephalus microlepis Davis
F) Sardinioides minimus Agassiz
G) Palaeolycus dreginensis von der Marck
H) Hemisaurida hakelensis sp.nov.
I) Pattersonichthys delicatus gen. et sp. nov.
J) Aulopus flamentosus
K) Nematonotus bottae Davis
L) Sardinius cordieri von der Marck
M) Volcichthys dainellii d'Erasmo
N) Dercetis triqueter Pictet
O) Dercetis armatus von der Marck
P) Dercetis gracilis Davis
Q) Enchodus marchesettii Kramberger
R) Rhynchodercetis hakelensis Pictet and Humbert
S) Eurypholis boissieri Pictet
T) Saurorhamphus freyeri Heckel
U) Prionolepis cataphractus Pictet & Humbert
V) Halec haueri Bassani
W) Pharmacichthys venifer Woodward
X) Dercetis rostralis Signeux
Y) Rhynchodercetis yovanovitchi Arambourg
Z) Clenothrissa protodorsalis nov. sp.
AA) Ctenothrissa enigmatica nov. sp.
BB) Lissoberyx dayi Woodward
CC) Stichocentrus elegans Gaudant
DD) Stichopteryx lewisi Davis
EE) Pharmucichthys numismalis nov.sp.
FF) Aipichthys velifer Woodward
GG) Stichocentrus spinulosus nov. sp.
HH) Lissoberyx arambourgi Gaudant
II) Pycnosteroides levispinosus Hay
JJ) Pattersonichthys delicatus Goody
KK) Ctenothrissa vexillifer Pictet
LL) Cryptoberyx minimus nov. gen. nov. sp.
MM) Libanoberyx spinosus nov.gen. nov. sp.
NN) Humilichthys omentalis nov. gen. nov. sp.
OO) Macristium chavesi Regan
PP) Heterothrissa signeuxae nov,gen. nov. sp.
QQ) Phoenicolepis arcuatus nov. gen. nov. sp.



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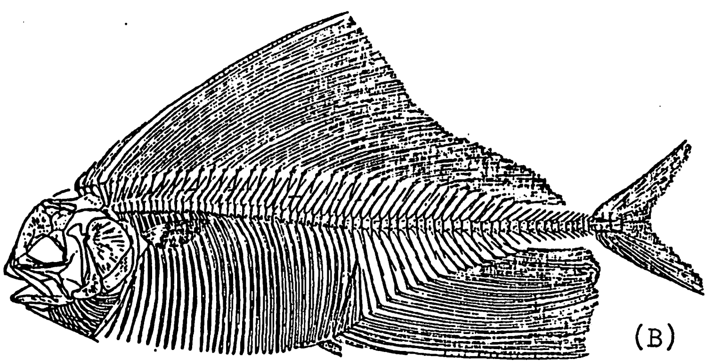

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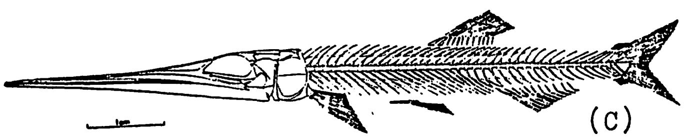

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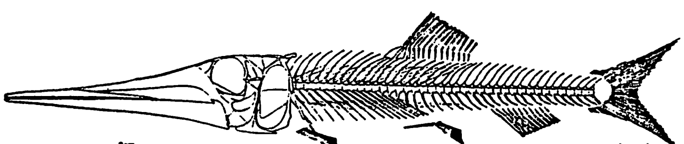

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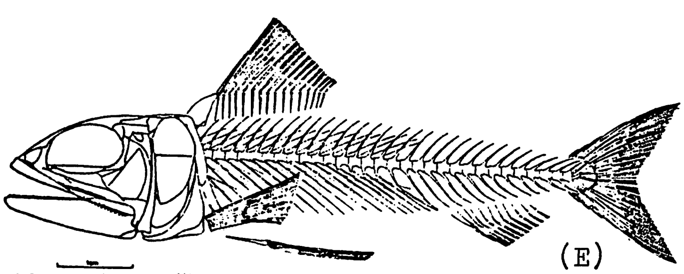

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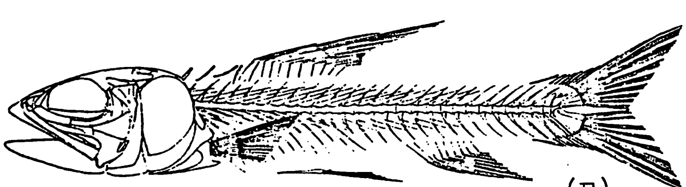

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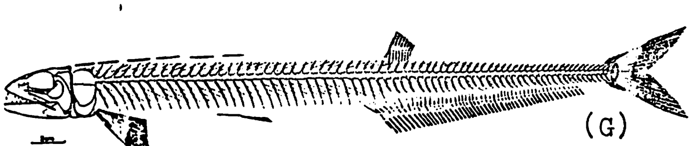

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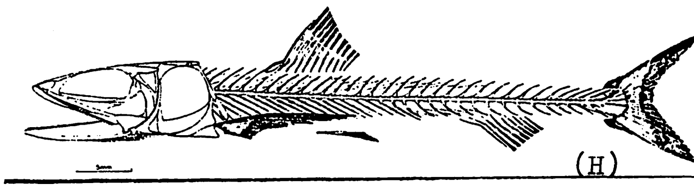

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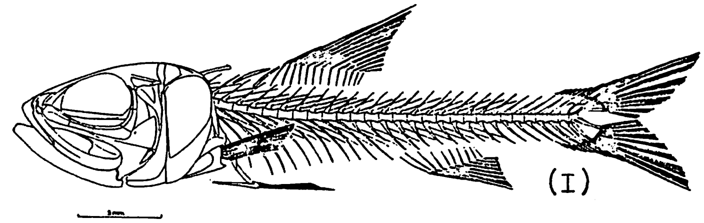

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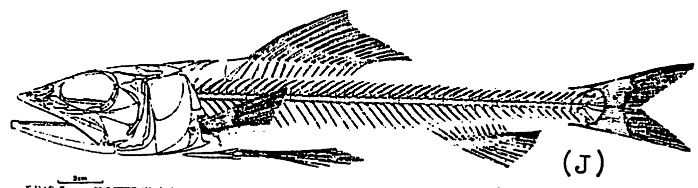

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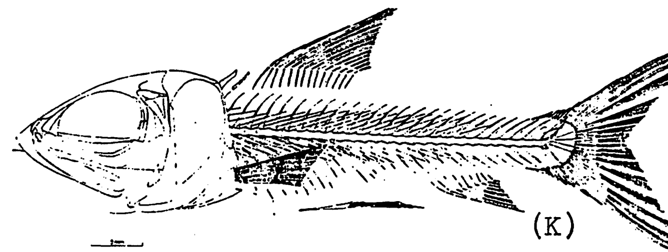

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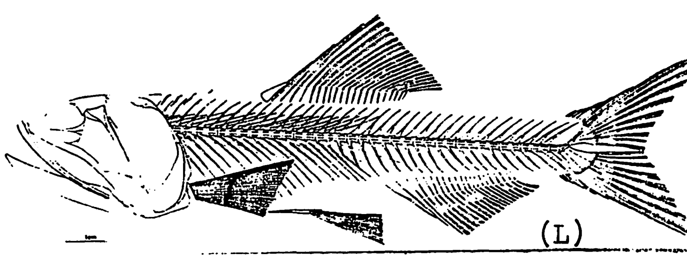

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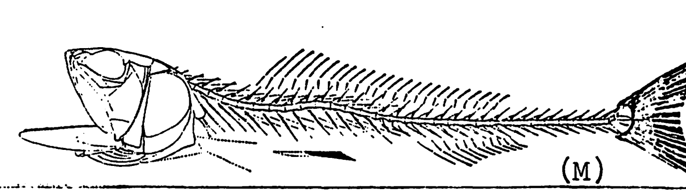

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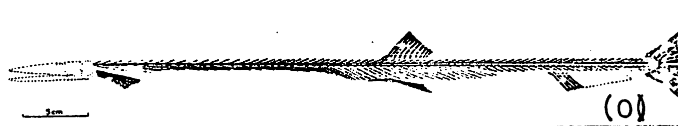

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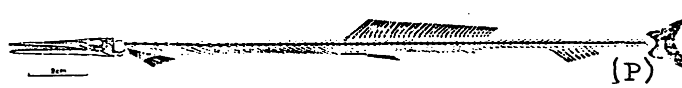

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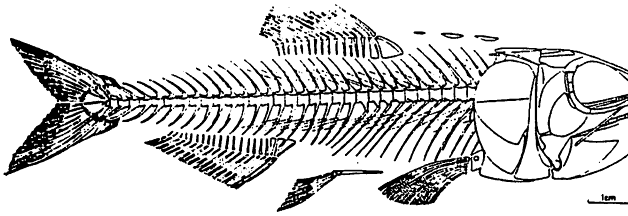
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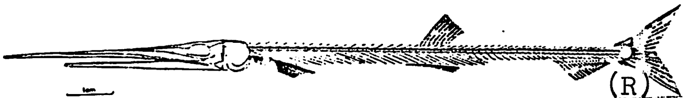
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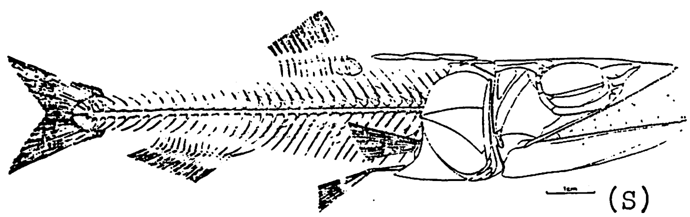
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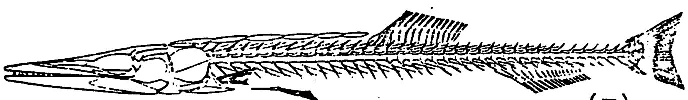
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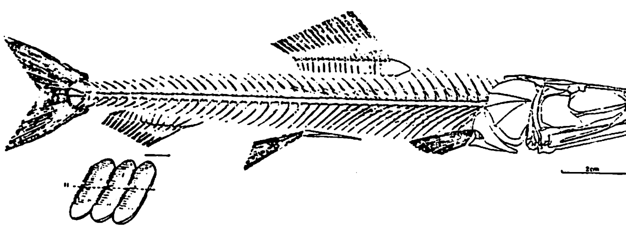
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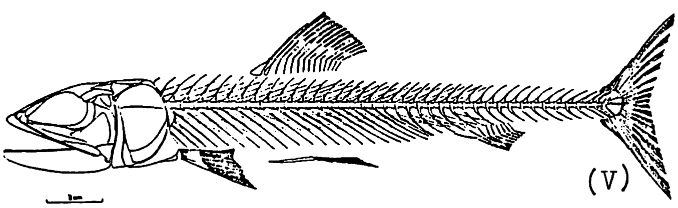
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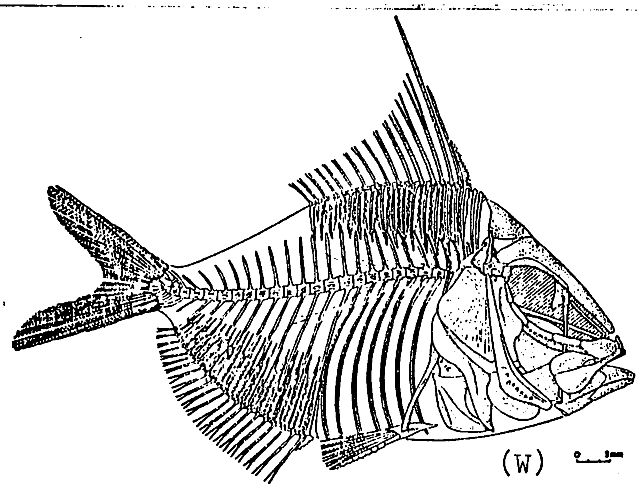
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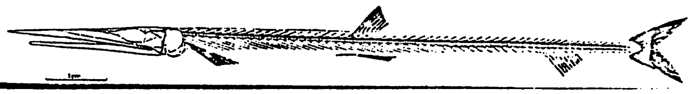
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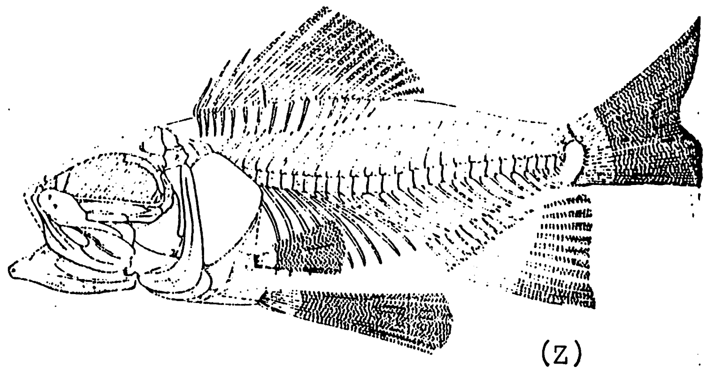
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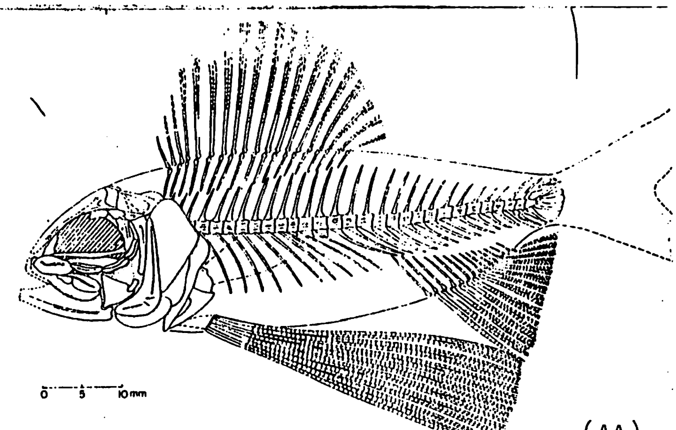
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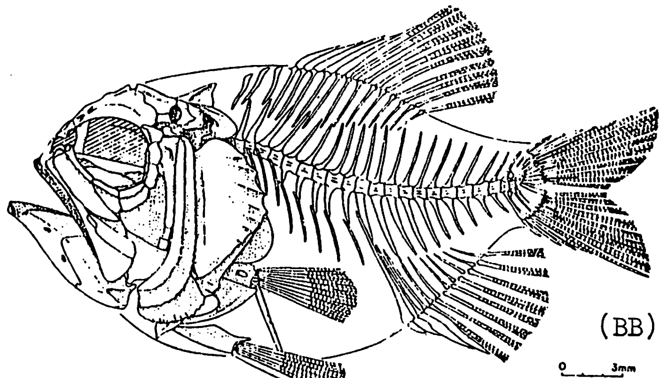
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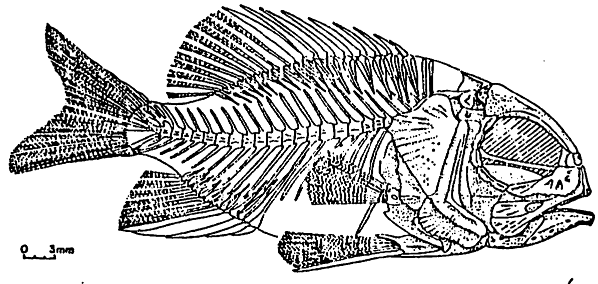
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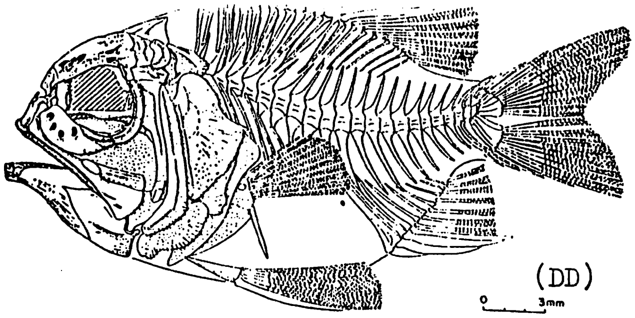

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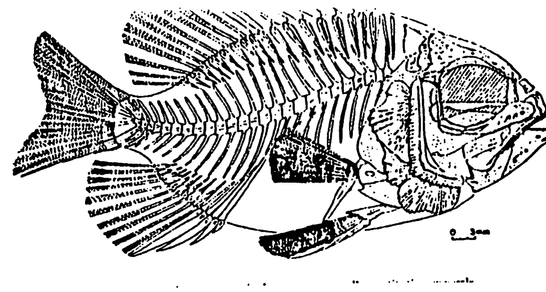

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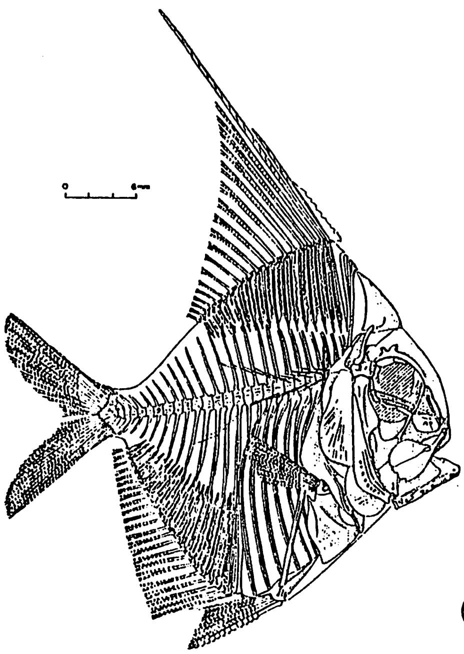

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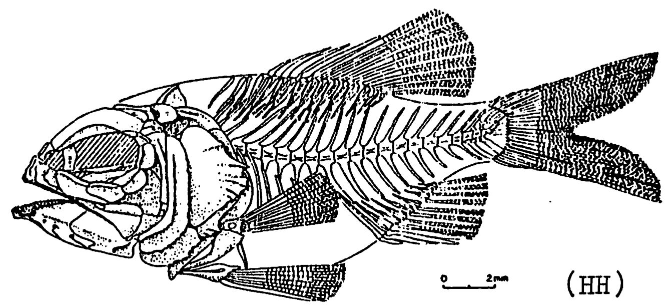

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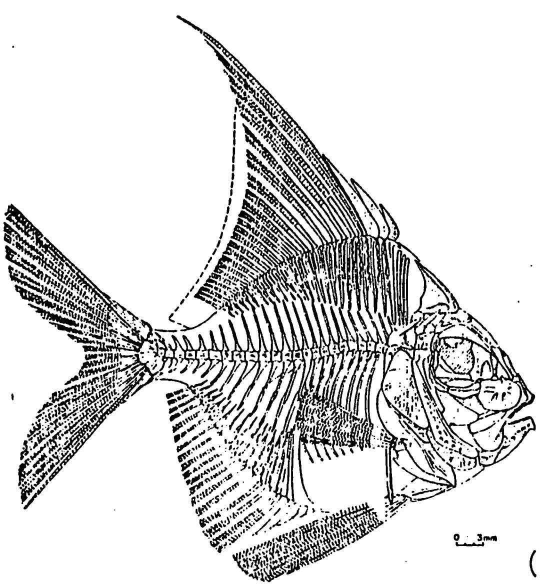

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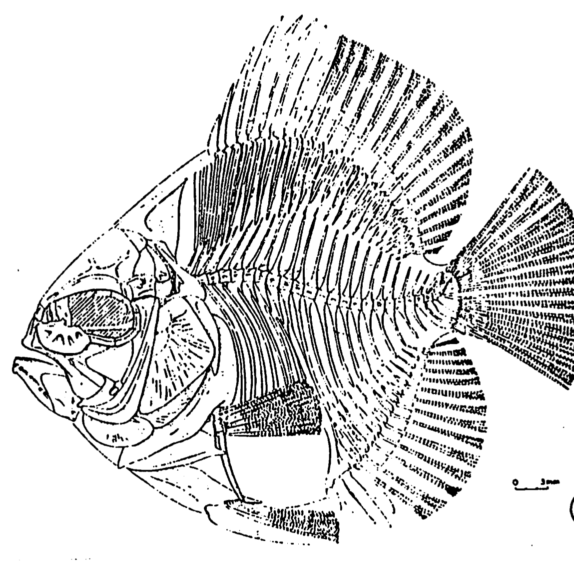

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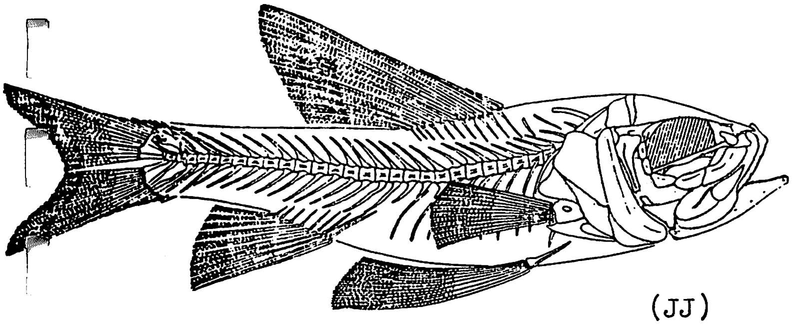

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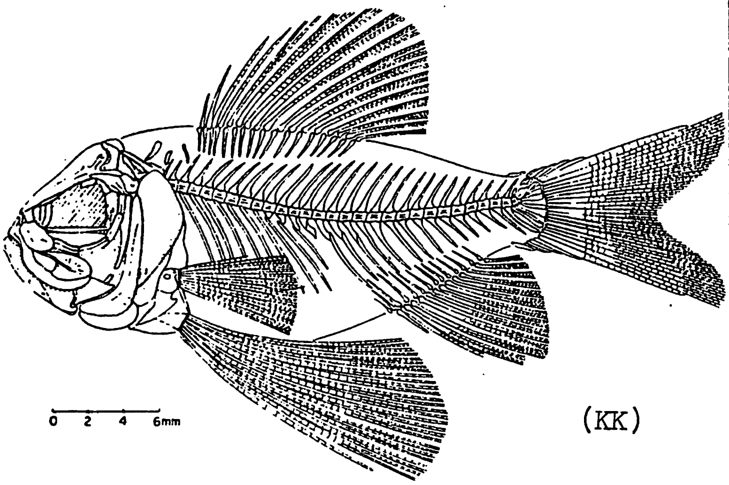

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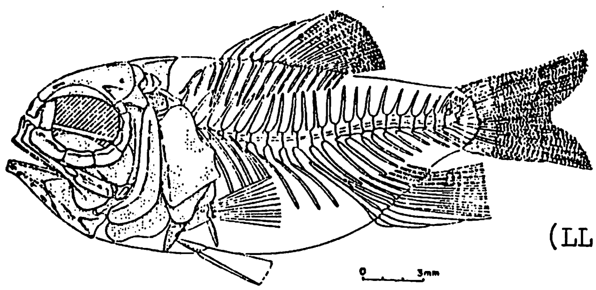

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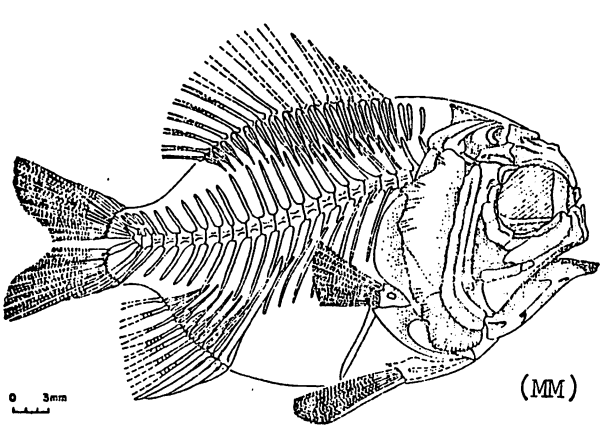

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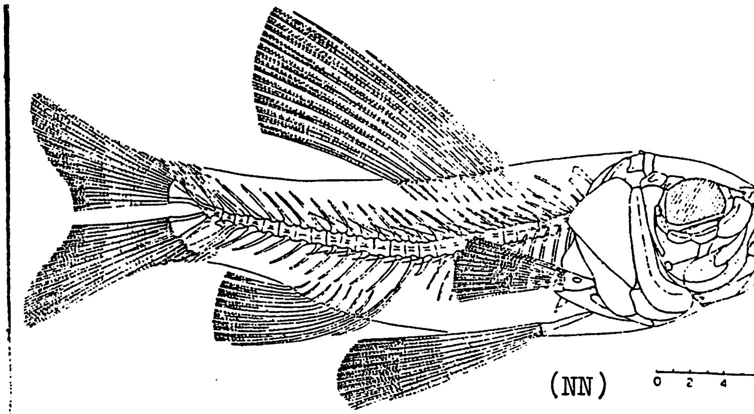

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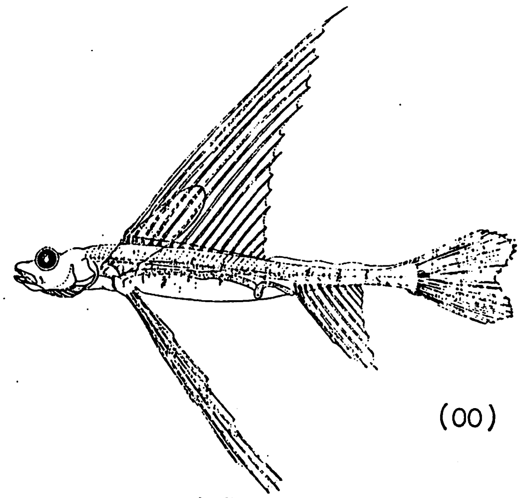

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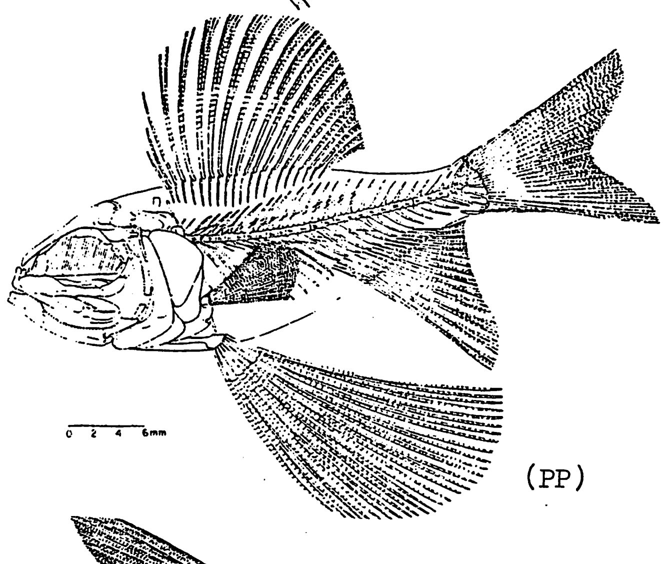

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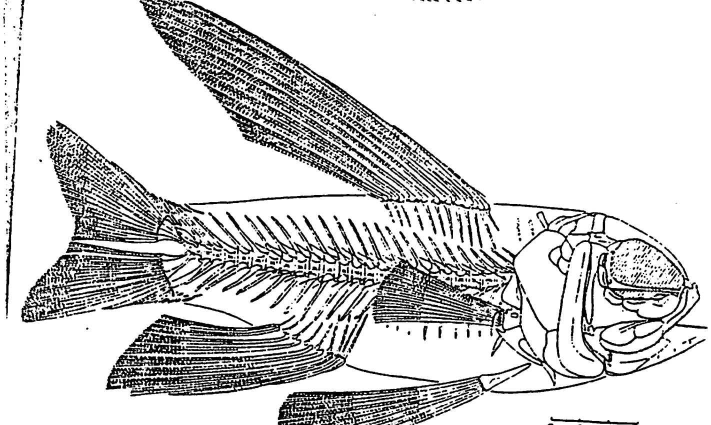

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LATE CRETACEOUS FISHES OF THE PLAINS STATES

David Jones
East Acres Pakr
Jones Fossil Farm
Worthington, Minnesota 56187

The class of telleosts or "bony fish" includes most of the game fish and food fish we are familiar with. The term "bony fish" refers to the fact that their skeletons are completely ossified, in contrast to other fish groups whose skeletons are more or less cartilage. Teleosts first appeared in the Jurassic period, and by the mid-Cretaceous they were many in numbers and variety.

For reasons not perfectly known, but perhaps connected to plate movements, much of the East Coast and Gulf Coast of North America sank below sea level during the latter half of the Cretaceous period. Also, a buckling of the crust caused all of the region now occupied by the Great Plains and Rocky Mountains to sink, so that the Gulf of Mexico extended north into Canada and divided the continent. Great numbers of fish swam in the warm and shallow waters of this interior sea.

The Niobrara Formation is a chalky limestone, formed from marl which accumulated on the bottom of the interior sea for several million years during the latter part of the Cretaceous. It now crops out over a wide area of west-central Kansas, around the base of the Black Hills in South Dakota, and along the valley of the Missouri River between Fort Randall Dam and Gavins Point Dam in southeastern South Dakota. It is the best source of fossil marine vertebrates, including sharks' teeth, bony fish remains, and the bones of swimming reptiles.

Most bony fish fossils found in the Niobrara formation are disarticulated or fragmentary. Cause of death for most fish was being eaten by other fish. For example, a shark may have chopped a fish in two, and while it was swallowing the portion in its mouth, the other half of the victim sank to the sea bottom, maybe to be found by a fossil hunter 80 million years later. Sometimes people will find a large fish tail in the limestone, and a fin some distance away. This may mean that a number of sharks ganged up on one large fish, and did to it what various taxing authorities do to your paycheck--each one took a bite until only a few fragments were left.

Fossils of the Niobrara Formation of west-central Kansas have been well-known since Charles Sternberg collected great quantities of them for Dr. Edward D. Cope over a hundred years ago. Mention of Sternberg naturally brings to mind the Sternberg Museum at Fort Hays State College in Hays, Kansas. A spectacular assortment of late Cretaceous marine vertebrates is on display here. Leading the parade is a 14-foot skeleton of the giant "bulldog tarpon," Portheus, containing in its belly the complete remains of of a six foot fish known as Ichthyodectes. It is to be feared that the giant predator swallowed this overly-festive meal at one gulp--and promptly sank to the floor of the sea and there expired of acute indigestion. To get to the museum, just turn off Interstate 70 at U. S. Highway 183, go one mile south through Hays, and turn right about 4 blocks to Fort Hays State College.

The Missouri River forms the boundary between northeastern Nebraska and southeastern South Dakota for many miles. For about 60 miles along this stretch, the river cuts down through the Niobrara Formation. Very good exposures of this bed are along the shore of the large lake which fills the valley of the Missouri above the Gavins Point Dam. The Lewis & Clark Boy Scout Camp is in the Missouri bluffs ten miles west of Yankton, South Dakota. Scouts and adults at the camp have found a variety of Cretaceous marine vertebrates. Several years ago one of the Scout masters split open a slab of the yellow, chalky limestone--and up came a nearly complete specimen of the salmon-like Apsopelix about a foot long. A Scout on the camp staff found a similar fish a few years ago. To reach the Scout Camp, go ten miles west of Yankton (or two miles east of the Bon Homme-Yankton County line) on South Dakota Highway 50, turn south on the Lesterville road about two miles, and take the right fork where the pavement ends. Scout Camp will be open from mid-June until the end of July, 1988.

Good hunting--and good fishing!

Families of late Cretaceous teleosts of the western interior

Ichthyodectidae:

Portheus xiphactinus, *Portheus molossus*

Ichthyodectes (*Gillicus*)

Saurodontidae:

Saurodon (*Saurocephalus*) (*Daptinus*)

Stratodontidae:

Stratodus

Empo nepaeolica (*Cimolichthys* Cope)

Osteoglossidae:

Anogmius

Salmonidae:

Pachyrhizodus

Pachycormidae:

Protosphyraena

Clupeidae:

Leptichthys
Apsopelix

Enchodontidae:

Enchodus

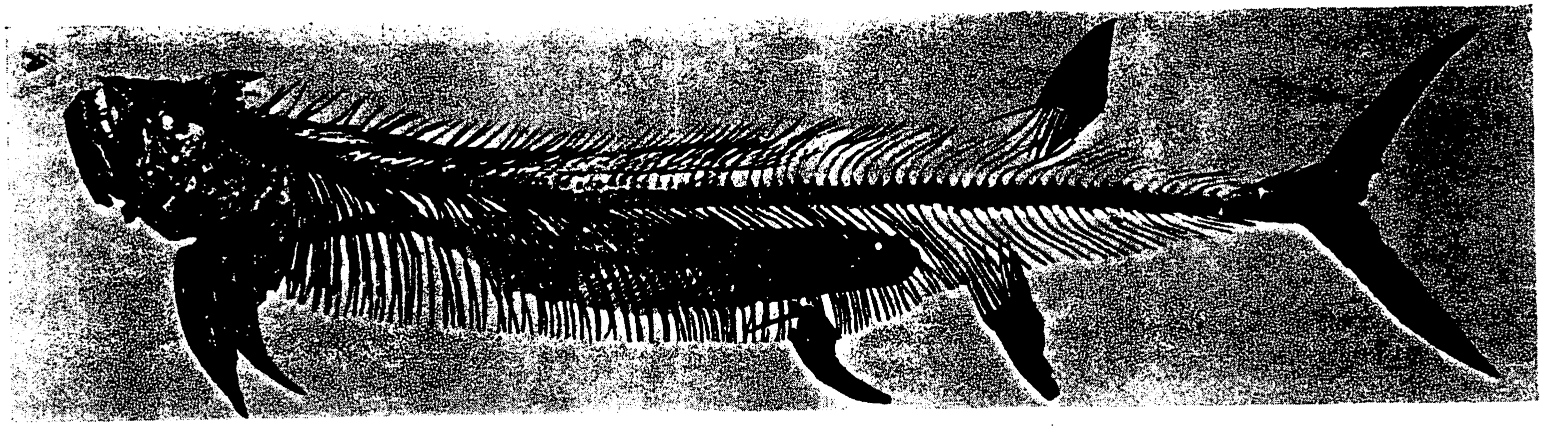
Dercetidae:

Leptecodon

Mugilidae:

Syllaemus

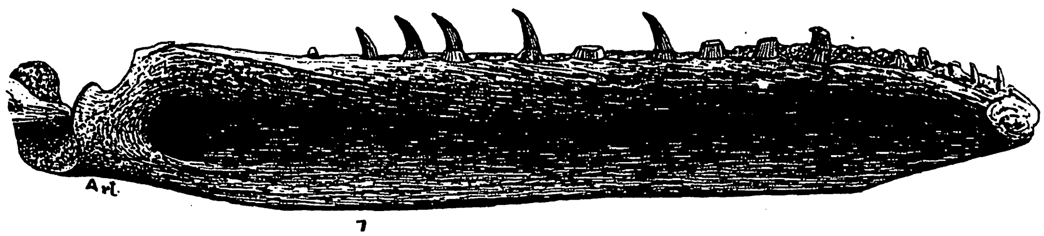
Source: Kansas University Geological Survey, vol. 6, 1900
Alban Stewart, *Teleosts of the Upper Cretaceous of Kansas*



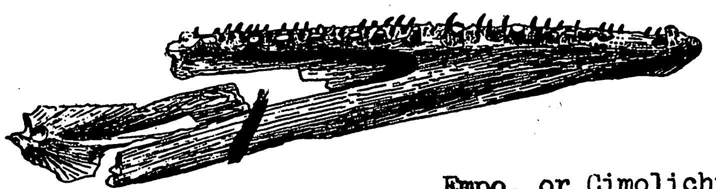
Skeleton of Portheus xiphactinus (Leidy), containing a fish identified as Gillicus arcuatus or Ichthyodectes, in its abdominal cavity. Scale, 1/25, or 4%, natural size. Fort Hays Sternberg Museum collection. Kansas University Geological Survey Paleontological Contributions.

Source: Alban Stewart, Teleosts of the Upper Cretaceous of Kansas, Kansas University Geological Survey, vol. 6, 1900

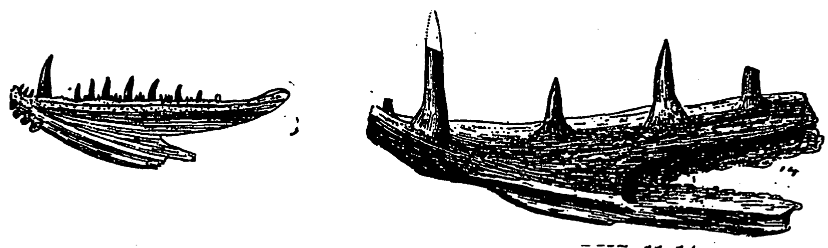
Acknowledgments: With thanks for the kindness of Dr. Hans Peter Schultze, Kansas University Museum of Natural History, and the staff of the Kansas University Geological Survey, Lawrence, Kansas



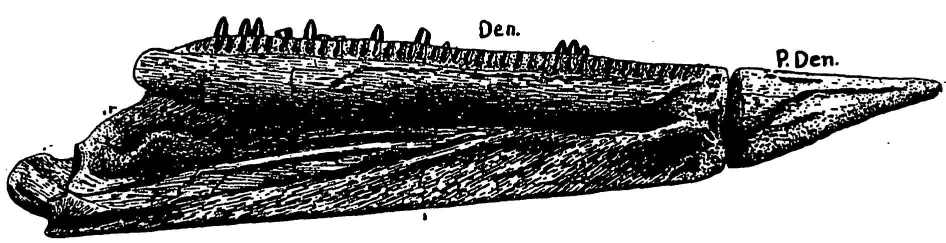
Pachyrhizodus sp. right lower jaw, natural size



Empo, or Cimolichthys sp., lower jaw, one half natural size

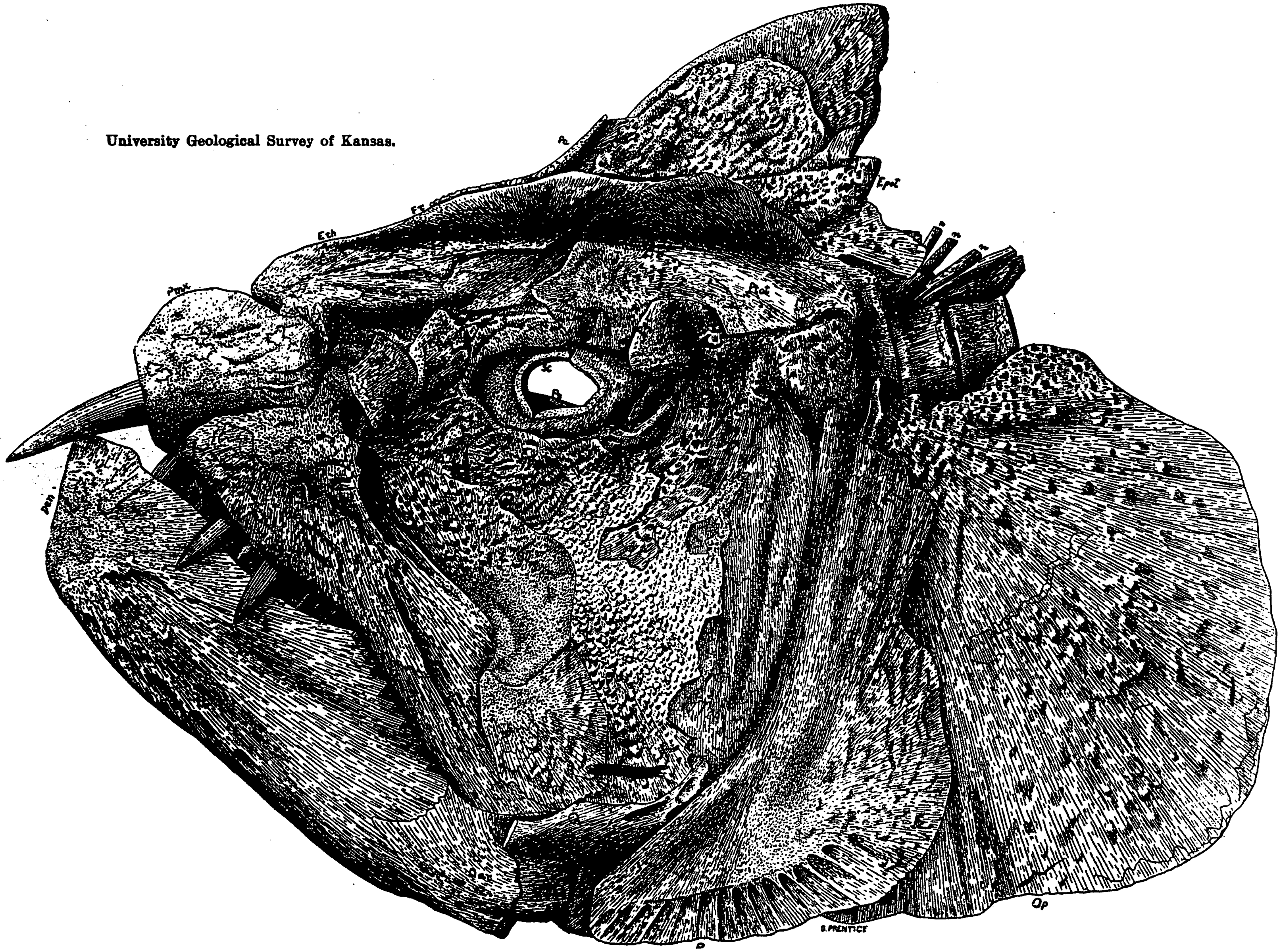


Two species of Enchodus, lower jaws, one half natural size



Saurodon sp. lower jaw, one half natural size; den, dentary; p den, pre-dentary

University Geological Survey of Kansas.



Portheus xiphactinus skull and jaw, one third natural size

ANGLING FOR THE STONE FISH

Edward M. Lauginiger
11 W. Holly Oak Rd.
Wilmington, Delaware 19809

Millions of years ago, during a period of time in the history of the earth which is known as the Eocene Epoch of the Tertiary Period, North America looked quite different than it does today. The large inland sea which had divided the eastern and western United States during the age of the dinosaurs was gone and the sea was beginning to recede from the land.

About 55 million years ago those ancient inland sea sediments and the rocks which were under them were pushed upward during a period of mountain building which is known as the Laramide Revolution. These upward movements helped to form the area which is now known as the Rocky Mountains.

As the mountains were raising, the areas between them began filling with water and eventually large lakes were formed. These lakes were the homes for the fish which can be found in what is now known as the Green River Fm.

The first Wyoming fossil fish were reportedly discovered by a geologist named John Evans and were described in 1856 by the Philadelphia Paleontologist Joseph Leidy.

During the summer of 1868 Ferdinand Hayden, the director of the newly formed United States Geological Survey visited the area near Rock Springs, Wyoming and described the chalky shales which he found there. He named the shales the Green River Formation because they could be best seen and studied along the banks of the Green River.

Railroad workers for the Union Pacific Railroad had collected numerous fossil fish during excavations and railroad construction. These fish are what brought Hayden to Wyoming. It helped to focus attention on the shales and their fish which has continued up to the present day.

The fish of Fossil Lake lived in an area with a tropical climate, an annual rainfall of about 30 inches, and an average temperature of around sixty-five degrees. This information can be deduced by studying both the fossils and the sediments which surround them.

During the summer months algae and other green plants combined with the higher daily temperatures lead to the production of large amounts of calcium carbonate. During the autumn and winter, many of the plants die and rains wash in silts, clays, and sands. The resulting bands of light and dark material may then be counted to determine the age of the rocks.

By using this method it has been determined that it took about 4,000 years for the famous "18 inch layer" to be deposited. The entire Green River Formation took about 6 million years.

The Green River Formation has produced 17 different genera of fish but only four of them may be considered as fairly common.

Of all of the fish which lived in Fossil Lake, by far the most common was the extinct member of the herring family called Knightia. This fish averaged four to nine inches in length and traveled in large schools. They most likely fed on algae and plankton and were an important source of food for the other fish which lived in the lake.

The second most common fish was also a member of the herring family and is called Diplomystus. Unlike the Knightia, however, this fish did not travel in schools. Diplomystus may get up to twenty inches in length and were surface feeders. Smaller ones most likely ate plants and insects but the larger specimens included other fish in their diets.

The Priscacara is one of the most prized specimens of all of the fish found in the lake. They look like the modern sunfish with a deep, oval body and raised dorsal spines, but they have no modern living relatives. The dorsal spines most likely kept larger predator fish from swallowing them. The Priscacara traveled in schools and most likely ate insects and plant material.

The Mioplosus, a member of the perch family, can be recognized by its two dorsal fins and its streamlined shape. Adult Mioplosus lived solitary lives but the juveniles traveled in groups for protection. This fish grew up to 16 inches in length and fed on other fish. Because of its thick scales and heavy bones, it is an easy fish to prepare.

Other, more uncommon fish include the Phareodus, one of the most efficient lake predators; the bottom feeding sucker-fish Notogoneus; and extremely rare Heliobatis or sting ray.

Fossils from the split-fish layer are obtained by splitting the finely bedded limestone into thin sheets and examining the resulting surfaces. Fish from this part of the formation need little or no additional preparation.

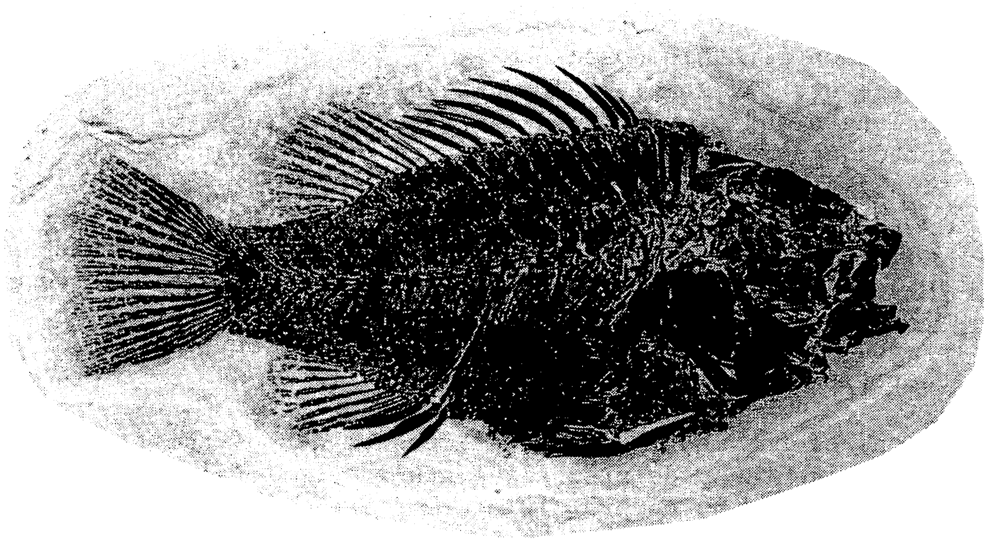
Material from the eighteen inch layer is usually enclosed in a protective coating of limestone which must be removed carefully in order to expose the fish. This preparation time may vary from two hours for a small specimen to as much as fifty for a large Diplomystus.

Wyoming fossil fish can be found in numerous museums such as the Denver Museum of Natural History and the Chicago Field Museum but they also make welcome additions to personal collections. Unprepared specimens are fairly inexpensive and the preparation techniques are easy to learn. Prepared fish are expensive due, in part, to the labor involved and the shipping

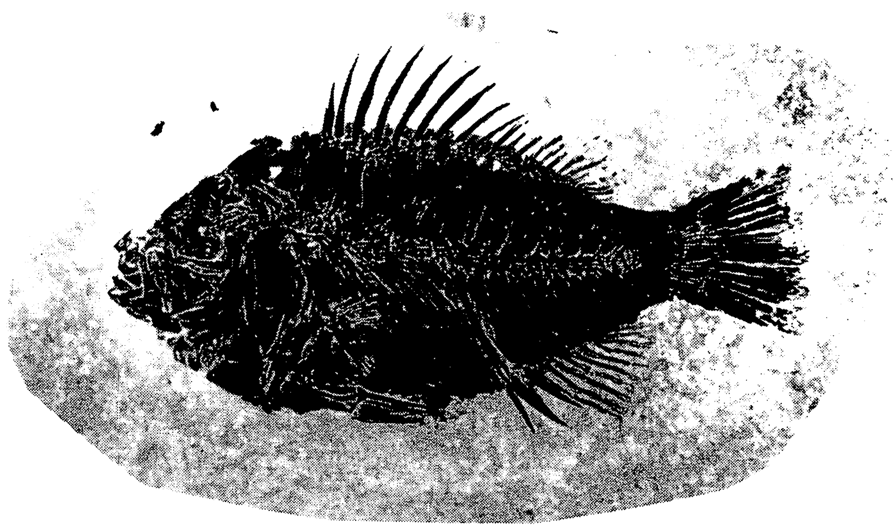
Fish may be obtained by visiting one of the fee areas in the area near Kemmerer, Wyoming, or by contacting one of the following sources:

Tynsky's Fossil Shop	Ulrich's Fossil Fish Gallery	Warfield Fossil Quarries
201 Beryl St	Fossil Station	Box 316
Kemmerer, Wyoming 83101	Kemmerer, Wyoming 83101	Thayne, Wyoming 83127

It doesn't matter if your collection is large or small, Wyoming fossil fish make welcome additions which will enhance anyone's collection.

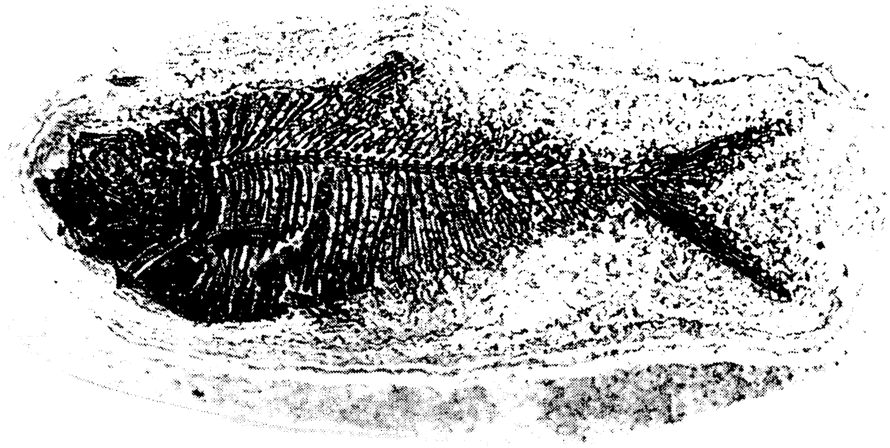


Priscacara serrata

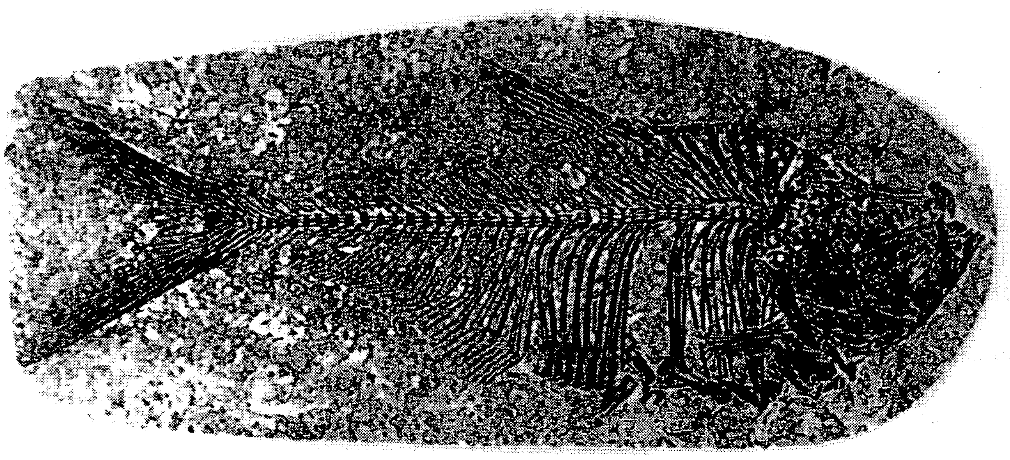


Priscacara liops

Phareodus encaustus

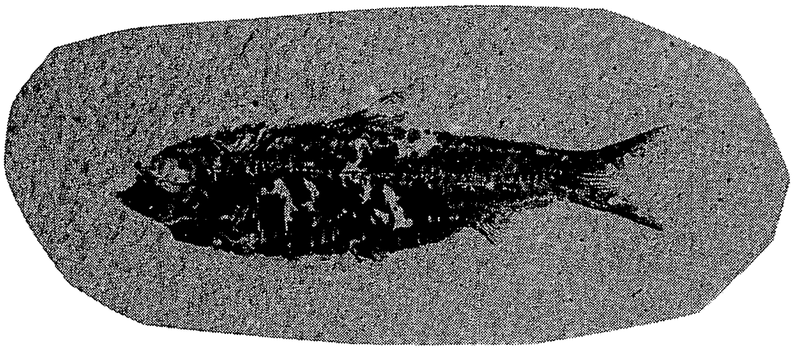


Diplomystus dentatus



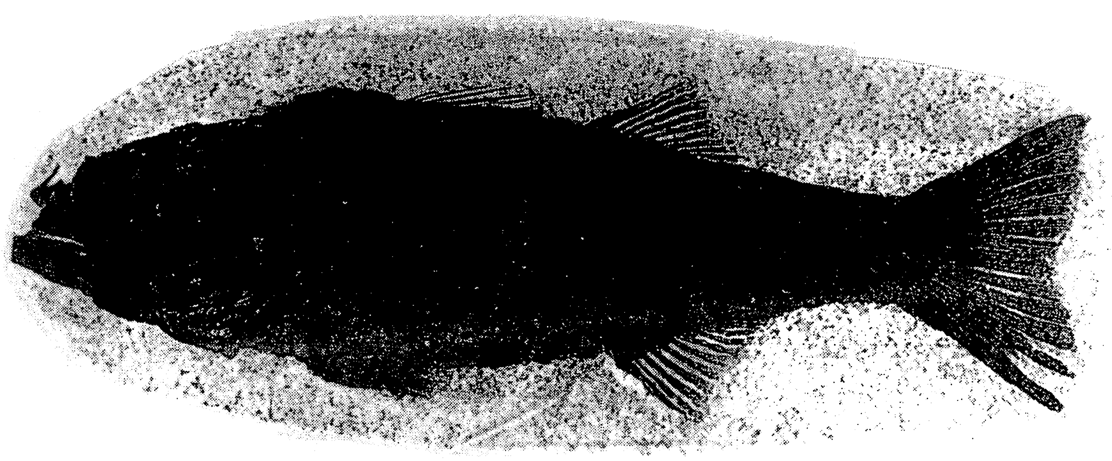
Diplomystus dentatus

Knightia eocaena



Knightia eocaena

Gosiutichthyes parvus



Mioplosus labracoides

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THE GREEN RIVER FORMATION

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What can I say: The Green River Formation is probably the most fantastic, unbelievable, extensive formation in the world. Doesn't matter if you study invertebrate or vertebrate fossils, everyone can understand Green River Formation fish and leaves. If you are an amateur, it is tough to understand a Trilobite or Crinoid. If you have been studying fossils for awhile, you can understand "noids and bites." But, anyone can RELATE to fossil fish and leaves in their every day life.

All of the following text, except parenthesis, has been taken from Bulletin 63, Paleontology of the Green River Formation, With A Review of the Fish Fauna, by Lance Grande, a Paleoichthyologist currently working at the Field Museum in Chicago. This work is a Geological Survey of the State of Wyoming, where most of the Green River Formation occurs. This publication is still in print, and can be obtained for $12.50 from the Geological Survey of Wyoming, Laramie, Wyoming.

Illustrations were drawn by Den Kingery. For you who haven't tried drawing a fossil fish, go ahead and try, it's tough.

O.K., let's start with a bit about the Green River Formation. (THANKS, LANCE!)

The Green River Formation represents one of the largest documented accumulations of lacustrine sedimentary rock in the world. It extends over an area of more than 65,000 square kilometers (25,000 sq. miles). (That's more area than the states of Rhode Island, Maryland, Connecticut, Delaware, and Hawaii combined), and averages about 600 meters (2000 feet) in thickness. It covers portions of three states (Wyoming, Colorado, and Utah,) but most of the pal0 eontological work in the Green River Formation has been done in Wyoming. Not only is the formation widespread, but at many localities there is an intricate record of both flora and fauna of the locality at the time of deposition. Several complex Eocene lake communities, containing organisms from the size of microscopic algae to 5 meter (16 feet) crocodiles, have been frozen in time for 40 to 50 million years to be reconstructed by paleoecologists today.

THE GREEN RIVER LAKE SYSTEM

The Green River system of Eocene lakes lay in a series of intermontane basins formed by geologic events that uplifted the Rocky Mountains during early Tertiary time. These basins filled from the drainage of nearby tectonic highlands and eventually contained freshwater lakes supportive of a varied and abundant fauna. Large amounts of ash found in the lacustrine sediments indicate that volcanoes were particularly active periodically throughout the history of this lake system.

The Eocene climate of the Green River lake system was much different from the desert-like climate of that area today. The climate of most of the area was similar to the present climate of the Gulf Coast and southern Atlantic regions of the United States: subtropical with an annual rainfall of 30 to 40 inches and with essentially frostless winters. The average annual minimum temperature was over 36 degrees F., and the overall average annual temperature was 60-70 degrees F. (NOT LIKE TODAY, INDEED)

The Green River system was composed of three lakes: Lake Uinta, Lake Gosiute and Fossil Lake. Lake Uinta was the first of the Green River lakes to form, and its Paleocene phase has been referred to as Lake Flagstaff. Lake Uinta gradually dried up in the South during Late Paleocene time, but expanded eastward into what is now the Uinta Basin while two other lakes were forming in what is now Wyoming.

Lake Gosiute occupied the Green River and Washakie basins; shortly after Fossil Lake was formed in Fossil Basin, a long narrow, north-south trending synclinal trough in southwestern Wyoming just west of Kemmerer. It is not known definitely that the lakes were connected, but is suggested that Lake Gosiute could have been connected by a narrow channel to the southern end of Fossil Lake for a brief period or periods.

Time ranges for these lakes differ. The short-lived Fossil Lake appears to have existed only in Early Eocene Time, whereas Lake Gosiute persisted from Early Eocene to Middle Eocene, and Lake Uinta from Late Paleocene to late Middle Eocene.

Fossil Lake

Fossil Lake had the smallest surface area of the three lakes, and was relatively short lived. It was the deepest of the three lakes during much of its existence, in contrast to the extensive but shallow Lakes Gosiute and Uinta. Evidence from edge of Fossil Basin indicates that Fossil Lake expanded and contracted several times.

The majority of Green River fossil fish in both public and private collections are from the Fossil Lake area, where they have been commercially mined since before the turn of the century. The two main fish-bearing units in Fossil Lake are the so-called "18-inch" and "split-fish" layers.

The 18-inch layer, a laminated, whitish to buff-colored calcite limestone with light to dark brown laminae of fine organic material, lies near the top of the Fossil Butte Member. It averages about 18 inches in thickness. The laminae may represent annual cycles of deposition, and for this reason are referred to as varves. The 18-inch layer contains about 4,000 couplets of fine light and dark laminae representing about 4,000 years of deposition.

The unit is conformably bordered above and below by thin oil shale units (the lowest of which contains abundant plant, insect, and molluscan fossils), possibly the result of minor transgressive and regressive events. The 18-inch layer probably represents a deep area far from shore, on the basis of its lack of clastic material (X-ray analysis indicates a sand, noncarbonate mud, and clay content less than 5%). The excellent preservation of varves and fossils within the 18-inch layer, together with the extreme rarity of bottom dwelling fish (such as catfish, stingrays, and suckers), suggest that the lake was chemically or thermally stratified (meromictic) during the deposition of the 18-inch layer.

The other main fossil-fish-bearing unit of Fossil Basin is commonly referred to as the "split-fish" unit. The split-fish unit is equivalent to the "light-colored limestones and marl" unit. Unlike the 18-inch layer, the split-fish beds are only faintly laminated, or not laminated at all. The split-fish matrix is brighter white than the 18-inch layer matrix, and is nearly pure calcite. The unit is generally about 2 meters (about 6½ feet) thick and is overlain in some areas by a massive, mollusk-rich marlstone. That stingrays and crayfish, both bottom dwelling animals, are much more common in this unit than in the 18-inch layer indicates better circulation of bottom waters.

Lake Gosiute

Lake Gosiute was a broad, shallow lake, currently thought of as a playa lake complex. There is strong evidence of large fluctuations in the position of the shoreline, and at times the lake became quite saline. It supported thick algal mats over much of its bottom during several stages of its history, and was probably more eutrophic than Fossil Lake. As with modern lakes, a eutrophic state made it productive of algae and plants, yet not supportive of the variety of fish species present in Fossil Lake. Suckers and catfish were plentiful in Gosiute, but the average size of the fish (such as herring) occupying the upper zones of the lake was smaller than in Fossil Lake. Lake Gosiute suffered several periods of contraction due to deposition of alluvial sediments, and possibly to periods of decreased rainfall. In the Middle Eocene, Lake Gosiute disappeared.

Most of the fossil fish collected from the lake area have been from the Laney Member, which is Middle Eocene in age. During the period of deposition of the Laney Member, the lake was at its greatest areal extent. The three main fish-bearing rock types of the Laney Memberare are the so-called "Farson," "Fontenelle," and "Fish-Cut" types.

The Farson type is a grey, tan, or e, or red siltstone which is often iron-stained and usually preserves the fossils only as external casts and impressions. Most of this material is collected around the Farson Dam near Farson, Wyoming. This is the "iron-stained mudstone" unit. The unit often produces the most detailed preservation of any of the Green River fossil localities; but it requires special preparation techniques and latex peels to observe maximum detail.

The Fontenelle type is a tan to light brownish white, muddy, shaley dolomite usually with fine, dark brown laminations. The laminations and fish appear similar in color and state of preservation to those of the 18-inch layer of Fossil Lake, but the matrix is slightly darker and much harder, so needle preparation is much more tedious. These beds are located near the shores of the Fontenelle Reservoir. That several plant and insect beds occur in alternating sequence with small fish beds probably indicates that the area dried up and was reflooded several times.

The Fish-Cut type of Fossil-bearing rock is similar to the Fontenelle type, but contains many dark, thin, kerogenrich layers.

Lake Uinta

Lake Uinta was the longest lived of all the Green River lakes, lasting for more than 17 million years, including its late Paleocene history as "Lake

Flagstaff." Because of the relatively continuous end of Lakes "Flagstaff" and Unita, Lake Flagstaff is considered in this paper to synonymous with Lake Uinta. Fouch (1976) reduced the Flagstaff Formation to member status and placed it in the Green River Formation. This extended the Green River Formation back into Late Paleocene time. The sedimentary rock of Lake Uinta represents one of the thickest documented accumulations of lacustrine sediments in the world, with thicknesses greater than 7,000 feet in places.

Throughout its history, Lake Uinta was very shallow, in spite of its huge geographic extent. Typically, Uinta was lagoonal to shallow lacustrine with many horizons of deltaic deposits, mudstones, shales, sandstone, and siltstones. The many zones exhibiting mudcracks interbedded with limestones indicate fluctuating shoreline.

Lake Uinta deposits include vast quantities of high-grade oil shale containing an estimated 290 billion barrels of oil. Though the economic potential for its oil has been well studied, far less is known of its paleontology than that of Fossil Lake and Lake Gossiute. The most frequently mined macrofossils from the Lake Uinta area are insects and plants. Unfortunately, due to the abundance of fish fossils in the Wyoming Green River Lake localities, the fish fauna of Lake Uinta has been essentially ignored.

The main insect, plant, and vertebrate fossil localities of the Lake Uinta area are Middle Eocene. (45,000,000 years).

HISTORICAL BACKGROUND OF RESEARCH

The first documented records of fossils from what is now called the Green River Formation were in various diaries, journals, and reports of early missionaries such as S. A. Parker (1840) and such explorers as J. C. Fremont (1845). They were writing reports of invertebrate fossils.

The first record of a fossil fish discovery in the Green River Formation was in 1856: Dr. John Evans, a geologist, collected a fossil fish from near what is now Green River, Wyoming, and sent it to Joseph Leidy, M.D., in Philadelphia. Leidy identified the fish as a herring, which he named <u>Clupea humilis</u> (1856), a name later changed to <u>Knightia eocaena</u> (as used here). (<u>KNIGHTIA WAS JUST NAMED THE STATE FOSSIL OF WYOMING *1987</u>)). Later, Ferdinand V. Hayden, director of the newly-established U.S. Geological Survey of the Territories, named this fossil local the "Green River Shales." (1869)

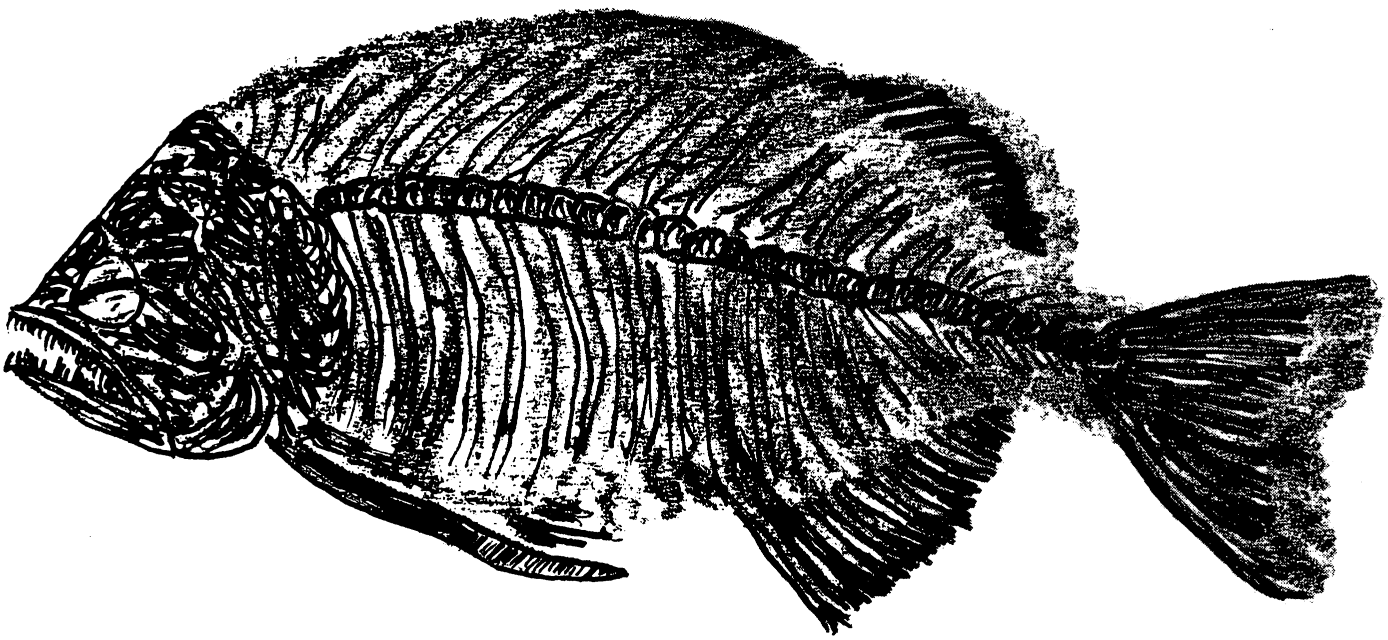
During the late 1860's the Union Pacific Railroad, while excavating about 2 miles west of Green River, Wyoming, uncovered the first major fossil fish layer of the Green River Formation. A. W. Hilliard and L. E. Ricksecker, employees of the railroad, were first to discover the fish, and collected many specimens which they turned over to Hayden. Hayden referred to this site as the "Petrified Fish Cut" (1871). These specimens were later studied and described by the famous pioneer vertebrate paleontologist Edward Drinker Cope in Hayden's 1871 report. The collection consisted of the genera <u>Phareodus</u>, <u>Knightia</u>, <u>Erismatopterus</u>, and <u>Asineops</u>. Cope collected specimens from the Fossil Basin area in the later 1870's at "Twin Creek Site" (1884), and described them in several small papers (1877, 1878, 1879, 1885, 1886) and in his classic monograph (1884).

Meanwhile, Geologists were reporting additional outcrops of the Green River Formation. In 1876, John W. Powell described secgions of the Green River Formation in the foothills of the Uinta Mountains in northern Utah, and A. C. Peal discovered outcrops of the formation in northwestern Colorado. Both Powell and Peale turned their collected fish fossils over to Cope for study and description.

Since publication of Cop's monumental works on the Green River fossil vertebrates, many authors have published papers on fossils of the Green River Formation. These references are listed throughout the paleontological sections of this paper (Paleontology of the Green River Formation" Grande.)

* * *

The following pages are the descriptions and general information of six of the most common Green River Formation fish fossils. For further information on other Green River fish see the Geological Survey.



Phareodus encaustus

Genus: Phareodus Leidy 1873

Phare--to have, odus--tooth

Phareodus is fairly abundant and very widespread in the Green River Formation. It is easily recognized by its long pectoral fin, large pointed teeth, large oval scales, and large median fins set close to the tail fin. Maximum length of Phareodus is about 30 inches in total length for the large species. The many sharp teeth in the mouth of Phareodus attest to a probable carnivorous habit. Percoid spines from Mioplosus and Priscacara often found in the stomachs of Phareodus provide evidence of a piscivorous diet.

The osteoglossids (Phareodus family) are represented today by four genera, all restricted to the tropical and semitropical fresh water regions of South America, central Africa, Southeast Asia, and northern Australia. The extant genus Osteoglossum, commonly called "arawana," is sold in tropical fish and pet shops.

The genus Phareodus is known from Eocene fossil deposits in North America and Australia.

Knightia eocaena

Genera: Knightia Jordan 1907
Knightia: Named in honor of the paleontologist Wilbur Clinton Knight

Gosiutichthys parvus Grande 1982 (Mini Fish)
Gosiut--referring to Lake Gosiute, ichthys--fish, parvus--small

There are two genera of clupeids (herring) described from the Green River Formation: Knightia and the smaller Gosiutichthys. These two genera are some of the most common complete vertebrate fossils in the world. In 1978 alone, as estimated 20,000 complete specimens were excavated in Wyoming, mostly by commercial fossil quarries and amateur collectors. Although Knightia is widespread throughout the Green River Formation, and is very common in most areas where it occurs, Gosiutichthys is known only from Middle Eocene deposits within the Laney Member, in Lake Gosiute.

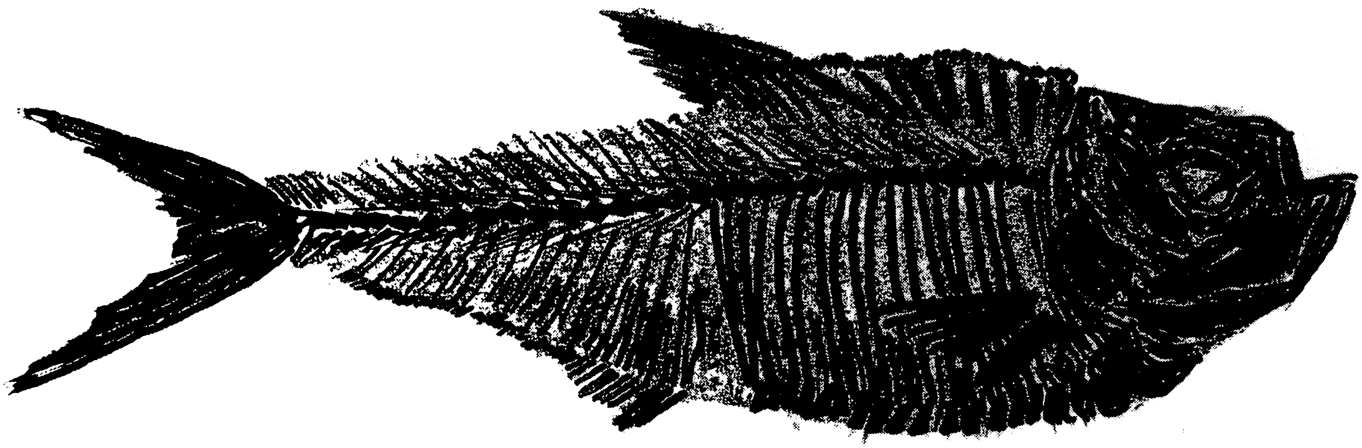
In Fossil Lake, where they reach the largest size, Knightia have a maximum length of about 10 inches. The maximum size known of Gosiutichthys is about 3 inches. (I FOUND ONE 3 11/16 INCHES, DEN)

Knightia, a schooling fish, frequently occures in mass mortality layers composed of millions of individuals overlapping and randomly arranged in a horizontal plane. These mass mortality zones of Knightia can be as dense as several hundred fish per squar meter. There are two particularly good exposures of these death layers, one of which is at the base of the 18-inch layer on Fossil Ridge and in Fossil Butte National Monument, composed of large Knightia eocaena (average 5-6 inches). Gosiutichthys, where it occurs, is even more frequently found in mass mortalities. The author has observed slabs of Gosiutichthys with densities of over 2,000 per square meter. Theories on these mass kills range from stratified water turnovers to poisons in the water produced by forms of blue-green algae. Modern fresh water herring (Alosa pseudoharengus, the alewife, in Lake Ontario) are known to have mass die-offs, usually in the summer. These mass mortalities are attributed to the fishes' inability to acclimate to rapidly rising or fluctuating temperatures. It is possible that, similarly, the tropical summer heat occasionally produced temperatures lethal to Knightia and Gosiutichthys in the shallow regions of the Eocene Green River Lakes.

Knightia and Gosiutichthys have several morphological differences, and are currently classified within different subfamilies (Knightia in Pellonulinae, Gosiutichthys in Clupeinae).

Knightia and Gosiutichthys seem to have been primary to secondary consumers, probably feeding on algae, diatoms, ostracods, insects, and, rarely smaller fish. A low position on the food chain is probably one reason for their abundance in the Eocene fish populations. Knightia and Gosiutichthys were very important links in the Green River lake system's food chain, with most of the larger fishes including them in their diet. Knightia and Gosiutichthys have been found fossilized in the mouths or stomachs of Diplomystus, Lepisosteus, Amphiplaga, Mioplosus, Phareodus, Amia, and Astephus.

Though sensitive to fluctuating temperatures, herrings such as Knightia and Gosiutichthys are not indicative of any particular climatic conditions. Modern herring have a wide range of optimum temperatures--from warmest tropical waters to very cold northern waters, depending on the species.



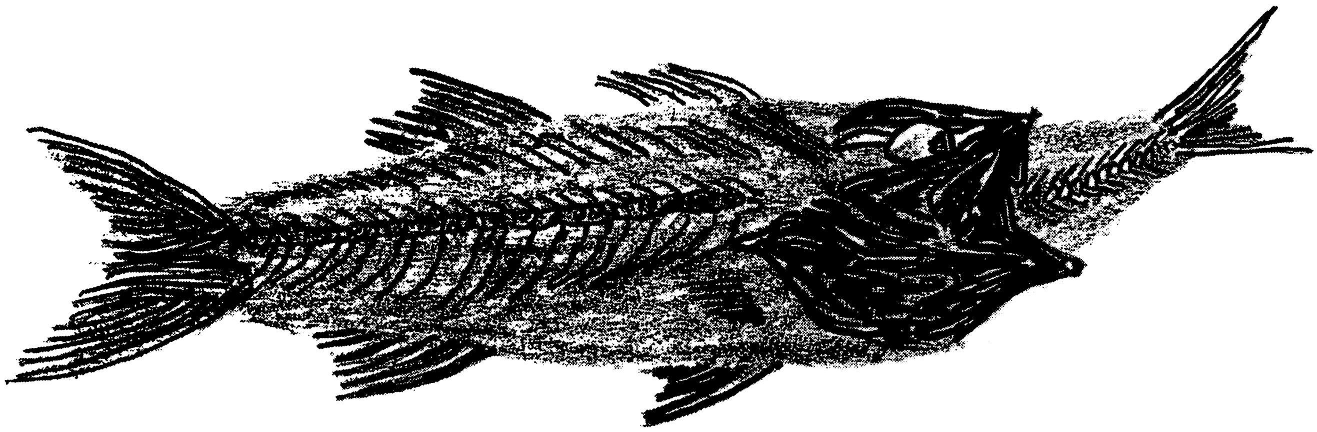
Diplomystus dentatus

Genus: Diplomystus Cope 1877
Diplomystus: diplo--double, mystus--hidden or recessed.

Diplomystus is not a member of the herring and herring-like fish order, Clupeiformes, (as once thought) although it belongs in the superorder Clupemorpha. Diplomystus is discussed in detail in Grande, 1982a.

Diplomystus is extremely common in Fossil Lake but uncommon in Lake Gosiute and Lake Uinta deposits. Diplomystus has a maximum length of about 26 inches. Diplomystus has the body form, size, and upturned mouth typical of a surface feeder, and fed on smaller surface-dwelling fish such as Knightia. Several specimens of Diplomystus have been found with Knightia fossilized in their stomachs and mouths.

Diplomystus is also known from Cretaceous (about 80,000,000 years before present) marine deposits of South America.

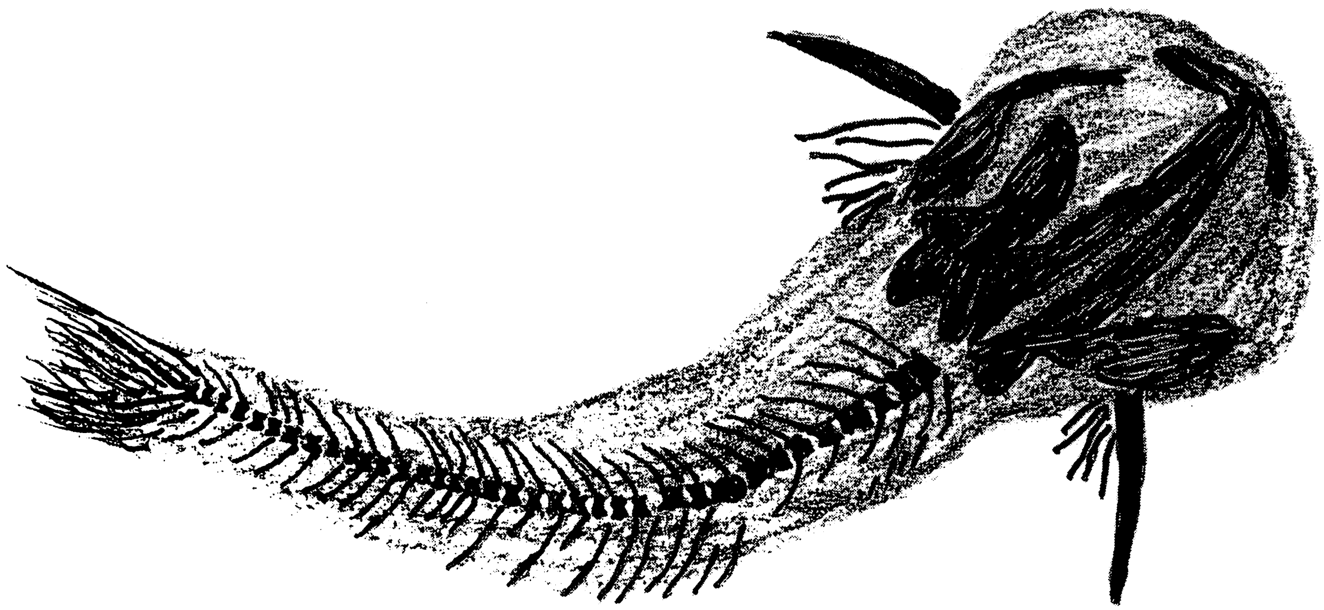


Mioplosus labracoides
chocking on a
Knightia eocaena

Genus: Mioplosus Cope 1877
Mioplosus: Unknown: one possible etymology is mio--Miocene, plosus--near. When Cope erected the genus, the Miocene was the recognized time epoch after the Eocene.

Mioplosus is a fairly common fish in the Fossil Lake deposits, but very rare in Lake Gosiute and Lake Uinta deposits. All of Cope's type specimens for Mioplosus were collected at his "Twin Creek" locality. Mioplosus was a perch-like fish with a strongly built, long body, similar in appearance to the living perch, Perca. In the Green River Formation, it is easily recognized by its two dorsal fins, its large fan-shapped tail, and its second dorsal fin and anal fin which are sub-equal in size and positioned opposite each other. Mioplosus is known from Eocene Lakes Gosiute and Uinta mostly by fragments which indicate an average size smaller than those specimens found in Fossil Lake. Specimens from Fossil Lake deposits range in size from 3/4 inch for very young juveniles to a maximum total length of about 20 inches. Like living perches today, Mioplosus probably occupied the shore areas and the middle and upper lake zones. Mioplosus, as indicated by its many pointed teeth, was a voracious predator, taking fish up to half its own length. Unlike the herring, trout perch, and Priscacara of Fossil Lake, Mioplosus is not found fossilized in groups within the mass-mortality zones: thus, it was probably a solitary predator as an adult.

Today, living percids can be found in fresh waters over most of the Northern Hemisphere. Fossil percids are known from North America, Asia, Europe and New Zealand.



Astephus antiquus

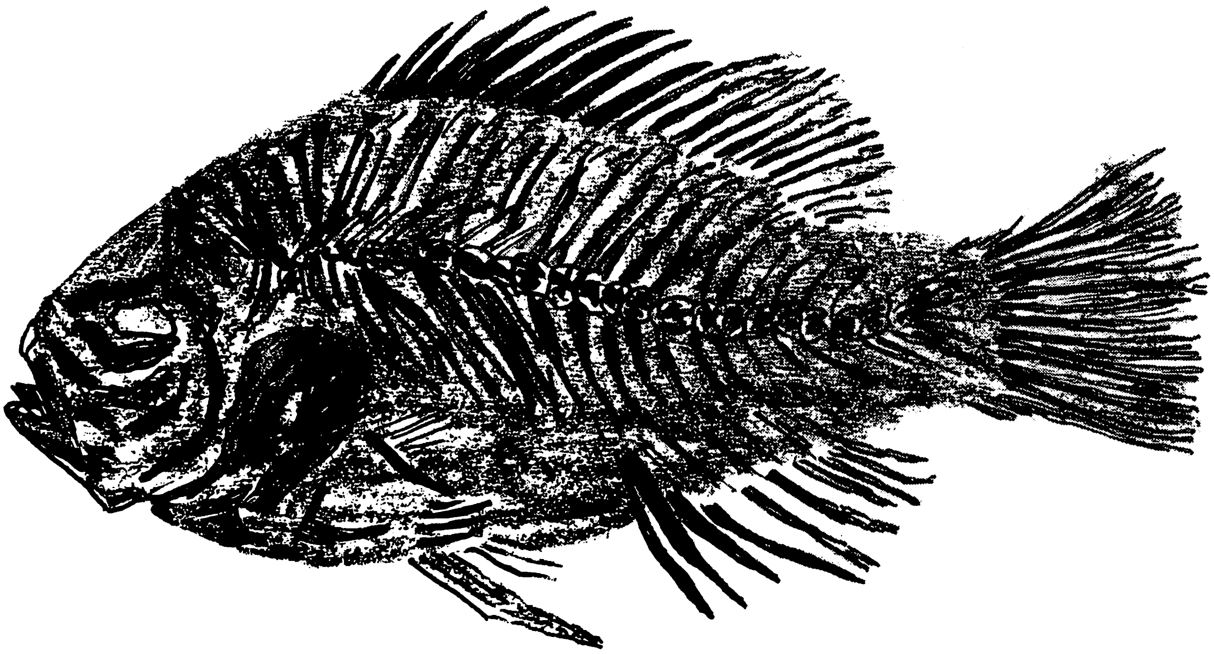
Genera: Astephus Cope 1873 (CATFISH)
Astephus: having a crown

Astephus (catfish) is known from all the Green River catfish localities. In the Green River Formation, Astephus has a maximum total length of about 12 inches. Green River catfish are easily recognized by their stout dorsal and pectoral spines which are serrated or toothed on one edge, scaleless bodies, and broad skulls. They also have whisker-like barbels, a weberian apparatus, and an adipose fin, but these features are only rarely preserved.

Mouth structure indicates that the diet of Green River catfish was probably similar to that of living ictalurids: smaller fish, crayfish, mollusks, and plant material. Astephus, like their living counterparts, were probably bottom feeders. One possible reason for their scarcity in Fossil Lake could be a preference for river and stream habitats connected to the lake.

Ictalurid catfish are known from Paleocene to Recent time. The Green River forms are the earliest known nearly complete ictalurids. Most or all of the fragmentary Paleocene material is questionable in its assignment to the Ictaluridae. Fossil catfish fragments erroneously reported from Cretaceous deposits of Montana were found to be sturgeon elements.

Today, living ictalurid catfish are restricted to fresh waters of North America (southern Canada to Guatemala) and are represented by 5 genera and 11 species.



Genus: Priscacara Cope 1877
Priscacara: prisca--primitive, cara--head.

Priscacara is a common fish in the Fossil Lake quarries and fairly rare in the Gosiute and Uinta quarries. Priscacera is easily identified by its deep-oval, sun fish-like body and its stout dorsal and anal spines which may have protected it from being swallowed from behind by the more voracious fish in the Green River lakes. Its size is highly variable. Priscacara is known in the Green River Formation from specimens 7/8 inch to 15 inches.

Priscacara, like Knightia, appears to have been a schooling fish. It occurs in at least one mass mortality zone near the middle of the 18-inch layer at Fossil Ridge, at an average density of about 2 or 3 per square meter (occasionally as high as 8 to 10 per square meter). Priscacara serrata has massive pharyngeal bones covered with obtuse grinding teeth, and probably fed mainly on snails and crustaceans. That Priscacara spines are occasionally found in large Phareodus specimens indicates that it was preyed upon by that genus. Priscacara is known only Eocene deposits, and occurs in fresh water deposits as far north as Horsefly, British Columbia.

PREPARATION OF FOSSIL FISH

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The preparation of fossils can be an arduous and often times tedious task for anyone. However, armed with the proper knowledge and tools, the preparator can produce a fossil which becomes a point of pride and achievement.

The Green River Formation of Wyoming, Colorado, and Utah is well known for its abundance of fossils, mostly fish, and quality of preservation. In only a handful of quarries near Fossil Butte National Monument does the so-called "18-inch layer" containing dark brown to black colored fish occur. Preparation of these "black fish" is the focus of this article.

Historically, the "black fish" were dug up and split down the middle, just as any other fossil fish, until it was noted that the rock would psplit around the fish more often than splitting through the fish. At that time, some entrepreneurs discovered the fine art of hand preparation using the most versatile of tools, the pocket knife.

Today, the novice, amateur, and professional have a plethora of tools and equipment to choose from, depending on the type of preparation chosen--manual, mechanical or chemical. The preferred method of preparation by the novice and amateur, mostly due to cost, is hand preparation.

Essential tools required for hand preparation include an X-acto or similar knife with the #22 curved blade, a hand scribe, and a pin vise with a sharpened needle. Keep the tools sharp, as you will be actually cutting the matrix away. By pushing the tool away from you large amounts of matrix may be removed, and by drawing it towards you, small amounts of matrix can be carefully removed exposing bone, fin, or scale. For detailed work, an Optivisor with magnifications from 2X to 10X may be used. Fish found in soft or medium hardness matrix are prepared most successfully using this method.

The mechanical method is used most frequently by the commercial and scientific preparators, where air powered tools predominate. Pneumatic scribes, such as the Chicago Pneumatics Airscribe take the first step in uncovering the fossil fish. The Airscribe is efficient at removing thick covering of matrix over the fossil, and with a back and forth movement, the depth of cut can be closely controlled to prevent damaging the fossil. The fish is never actually exposed by this tool, but the matrix is reduced to a thickness about 1/16" over the fossil. Following the "roughing" operation with the Airscribe, the ARO Marking Pen can be used to remove matrix directly from the fossil. The marking pen is held lightly and moved back and forth on the matrix. Never actually touch the fossil with the pen, as the vibration can damage the fossil fish. It is important to realize that when air or other power tools are used, a much greater potential for damaging the fossil fish exists than if the preparation had been done with hand tools.

To finish the job started by the Airscribe and the ARO Marking Pen, the most commonly used tool is the air abrasive machine, sort of a miniature sand blaster. Instead of sand, the air abrasive shoots abrasive powders of varying hardnesses. The air abrasive draws powder from a reservoir and feeds it through a hand held nozzle under high air pressure. With the nozzle aimed and the button pushed, the powder stream cuts quickly into the matrix, and possibly the fossil too, if you don't move the nozzle or let up on the button. The powders used range in Moh's hardness from 1 for talc to 9+ for silicon carbide, whereas the most commonly used powders are sodium bicarbonate at 2-1/2 and dolomite at 4. The goal of the preparator is to find the powder hard enough to cut the matrix but soft enough to minimize damage to the fossil. Our solution is a mixture of dolomite and sodium bicarbonate.

Air abrasive machines range from the very simple and inexpensive, to the overly complex and expensive. For the person of limited means, the Pache Air Eraser, a completely self contained, hand held tool will perform adequately, and can be had for less than $50.00. Its drawbacks include the very small powder reservoir which has to be refilled continually and the lack of air pressure controls. On the high end, costing nearer to $2,000, the Comco Micro Blaster and S. S. White Airbrasive fulfill the need for heavy duty and versatility. If the air supply to the air abrasive is by compressor as opposed to bottled carbon dioxide gas, an inline water trap and air drier are necessary to prevent forming mud in the air lines and orifices of the machine. The ease of use, the speed, and the precision made possible by an experienced and careful preparator makes the air abrasive machine the most valuable tool in the lab.

The last method of fossil fish preparation here to be discussed should also be the last resort because of great potential damage to the fossil and preparator. Chemical preparation of fossil fishes is performed by the careful application of an acid to the matrix covering a specimen, and performed only when hand and mechanical preparation methods are impractical.

To be done safely, work with acids should be carried out under a fume hood with running water available. The most useful acids are Acetic acid (as in vinegar, but much stronger), Hydrochloric (or Muriatic) acid, and Formic acid. Don't use any others as they present serious safety problems. First, under the hood we dilute the acid 1:10 with water (1 part acid to 10 parts water, always add acid to water). Then to prevent the acid from soaking into the matrix surrounding the fish, the rock can be coated with a sealer. An alternate method is to soak the fossil fish and matrix in water until the rock is saturated. With the fossil wet, carefully apply the acid with a small paint brush or toothbrush directly on the area to be etched. Do not allow it to dry off, but once the effervescence has stopped, rinse immediately under running water. Reapply and rinse as needed until the matrix covering the fossil fish has disappeared or when slight damage is first observed. Rinse the specimen in fresh water for at least twice as long as the acid was in contact with the fossil, then allow to dry. If performed cautiously, fossil fish prepared by acid will retain as much detail and appearance as those prepared by the other methods.

Properly armed with knowledge, tools, experience, and foremost patience, the preparator exposes a fifty million year old portion of our natural heritage; but without patience to uncover it carefully, that portion of our heritage would best be left to remain obscure.

PREPARATION OF FOSSIL FISH FROM WYOMING

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The preparation of fossil fish from Wyoming can be interesting and fun with little frustration if just a few simple steps are followed. Anyone can do it--even an exsheepherder--as the story that follows illustrates.

Several years ago my father and I were filling 10 gallon water cans from a spring on our sheep range in Wyoming. The spring is named Warfield Springs and has the best water for many miles in any direction. Years ago the Indians fought for this water and that is how the spring got its name. In those days the range was a very remote place accessible only with 4 wheel drive. To go to the spring took effort, and so, it was visited only be a few sheepherders, antelope, deer, coyotes and, some say, the spirits of the Indians that once roamed the area. However, once the effort was made the peace and beauty of the place made all the obstacles seem insignificant.

While I was dipping clear water out of the spring with a bucket and pouring it into the cans my father held, I noticed a rock with something different on it at the bottom of the spring. I picked it up to examine and when I turned it around in my hands there was a fish on it. I was amazed and said, "Look, Dad, this is one those fossils we have heard about in Kemmerer." Abandoning the buckets and water cans we grabbed shovels and started digging near the spring. The weathered rock on top produced some fossil fragments, but once into good rock we were finding pretty fossil fish in abundance. That first thrill of discovery did something to us. We left that day vowing to return better equipped to dig and determined to learn more about those amazing fossils.

Since those early days a lot has happened, enough to fill a book. Warfield Springs today is the same as it was then, except that the road into it is bladed and graveled making for a pleasant trip, and the visitor list has expanded to include fossil lovers and hunters from the world over. There is even a hot shower and a flush toilet! If you would like to hear the story, come and visit the quarry and I will share it with you beside the warm evening fire under a million stars. For now, a brief paragraph will do so that we can move on to the preparation of fossil fish.

In a short time an oil boom hit Southwestern Wyoming and oil rigs sprang up around our quarry (which lies in the heart of the famous "overthrust belt"). The only real good that came out of it in my opinion was the improvement made to the roads. At the same time the livestock business took a nose dive and my father began to talk of retirement. Since finding that first fossil fish my addiction to and knowledge of fossils had grown tremendously. I was not too eager to invest in sheep when the market was down and interest rates high, so my dad and I sold out of the sheep business. I turned toward the fossils as my sole livelihood and invested in sophisticated tools and a shop to work in. Today I collect fossils for about 5 months of the year and clean, prepare and sell them the other months of the year.

It is easy to clean and prepare fossil fish from the Green River Formation in Wyoming without a lot of expensive tools. I did it for many years. Your prep kit should include: a light weight hammer or wooden mallet; an engraving tool or small screwdriver to chip with (the type that comes with a mini-tool kit or a sewing machine); a sharp thin chisel or butcher knife with the tip cut off and ground sharp (remember to take off the cutting edge to avoid serious cuts); an Exacto knife with a curved blade; a dental pick or dissecting needle and some glue. For the glue I recommend "hot stuff". Johnson Brother's sell it and you can find their ad in any lapidary magazine. They also sell a thicker version called "Super T", which is very useful. You should also have some Elmer's glue, an art gum eraser, a shock absorbing foam pad at least 1/2" thick to lay your fossil on, and a clear protective sealant to cover your fossil after it is prepared. There are many different kinds of protection available as sprays or by the can. I use Glyptal diluted with acetone, but a good quality clear varnish diluted thin works just as well. The spray-on clear acrylic used by artists works good and covers the whole plate which keeps the dust from coming off. It will change the color of the rock a little and make it a bit shiny. If you decide to mix from a can, you can paint the mixture on the fossil only with a small brush. The method you decide on will be a matter of personal preference. Add to the above list a good dose of common sense and you are ready to prepare fossil fish.

The first step in preparation is to stabilize the rock using the thin super glue. Apply it <u>only</u> from the backside or along the edges of the rock, and put it in any hairline cracks or splits. If your fossil is in several pieces, do this to each piece. Do not attempt to glue the pieces together at this point. Next is to get rid of any excess rock to reduce bulk and weight. Decide how you want your fossil to be displayed and draw with faint <u>pencil</u> lines the area to be squared-off. Be sure to leave lots of space around your fossil in case it is a bigger fish than you expect. It is always easier to remove more rock than it is to add some. A regular hand saw with a sharp edge will cut most of the rock from our quarry. Occasionally, a saw with a masonry blade will have to be used. A suggestion for a more attractive presentation of the fossil is to avoid having the fish lie straight across the plate. Give it some action by cutting the plate so that the fish is tipped slightly up or down in the matrix.

Now it is time to thin the matrix if it is more than 1 inch thick. A larger fossil can have slightly thicker matrix and a smaller fossil can go thinner. The secret to this process is to start at the backside of the plate and take off a thin layer at a time. You might have to repeat this process 2 or 3 times but better that than a broken fossil. Remember a simple rule, the thin piece will be the one to break. If you are impatient your fossil could be easily damaged. Use your hammer and thin chisel or butcher knife. Gently coax the rock to split by chasing the split all the way around the plate. Do not just beat away in one place and expect the rock to cooperate. The Green River Formation is made up of thousands, perhaps millions of compressed sedimentary layers, so with a little persuasion your rock can be opened up like the pages of a book. If you are lucky you might even find another fossil!

At this point you should be ready to begin to clean your fossil. The object here is to remove the matrix that covers the bone with the minimum amount of damage to the bone. I always tell my customers to remember that it took millions of years to make this fossil, so they can afford to take some time to clean it. Using your small screwdriver, engraver, exacto knife, dental picks or dissecting needles you can begin to gently chip, flake, scrape, and scratch at the rock until you have revealed the fossil beneath. Some layers will be very soft and scrape easily, while others seem as hard as concrete. Fortunately, all the layers can be removed from the bone with care. Utilize your art gum eraser and erase the thin powdery layers and dust to see how you are progressing. Avoid digging with the sharp tools using strong force or you are likely to punch through the bone. The most important thing in this process is not to overdo it. A lot of overzealous preparators have damaged scientifically valuable specimens by simply overcleaning the fossil. This has also been one factor that has hurt the reputation of amateur collectors.

After the fossil has been cleaned the next step would be to glue the parts together (assuming it was not in one piece to begin with). A good secret here is to use the Elmer's glue on one edge and Super T on the other edge. Before applying the glue, fit the parts together and make sure that it is a good, clean fit. If there are any bits of loose rock or other debris be sure to remove them. The combination of Elmer's and Super T sets up fast so there is no room for mistakes, and the bond is strong and lasting. Be careful not to use too much glue as this will then squish out onto the front of your fossil.

In filling the cracks on your fossil plate, I suggest "rock hard" water putty. We add powdered tempera to adjust the color to match the matrix. Water putty can also be used on the back of the plate to reinforce it. After the putty is dry the specimen is ready for the protective coating discussed earlier. This will keep the fossil from dehydrating over the years.

This should cover all you need to know to prepare the average fossil fish. It is always helpful to have a picture of the particular specimen you are working on so that you will know where to look for the fins and the shape of the tail. If you have any questions or want to know where you can go to "dig your own" feel free to call. I am listed in the MAPS Directory. Looking forward to seeing you at EXPO in April.

I DIG FOR -- PROFIT?

Dennis Kingery
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(An eyeball view of digging "MINI FISH" for fun and profit!!)

TIme: 5:30 a.m. It's a beautiful Friday morning in early October.
Place: "Banana Belt" of Wyoming--Rock Springs.

I had just awakened the "slaves" who chose to stay in my extra bedrooms for the short night. We headed for breakfast--three sleepy 15 year olds, and I. At the Outlaw Inn, the boys, Jake, Troy, and Sean, tried to eat my wallet dry. (Figured we wouldn't have enough for gas that way). I surprised them by going to my sock and pulling some extra money out.

After breakfast we headed for the local 7-11 for gas and foodstuffs. It was only three blocks away, but the boys were already asleep. I woke them up to pick out their lunch. We then started on our trip to the "MINI DIGS".

Two miles down the road, the boys were asleep. (My turning on the country western music helped). After 40 miles of paved road, 20 miles of rough dirt, and 5 miles of "two trailers", we arrived at the location of the dig.

I had been there for the two previous days prospecting for the twenty inch fish layer. I found it 8½ feet down. The hole I had dug was 5 x 3 x 8½ ft. deep. The boys looked at my hold and laughed. "You brought us out here to dig a 'well' like that?" they asked. "Not exactly," I said. I then marked a small rectangle in the dirt for them to start digging. I was only 9 x 11 ft!

We traded off digging. I find if there are four of us digging, I take only three shovels. That way, at least one is resting at all times. I won't say who has the most rest periods, but being the boss does have its privileges.

We dug through 8 to 10 inches of sandy shale material--lazy digging. Then came a foot of small boulders, we call the first nodual layer. This is very difficult digging. The shovel won't go into the layers of rock easily. One has the tendancy to bend over and throw the noduals out of the hole by hand. With a hole this large, removing the noduals takes a long time.

The four of us broke for lunch. Jake's donuts, Sean's chips, and Troy's cherry pie. I had my usual cheese, crackers and milk. The boys then devour their candy bars, pop, and other tooth destroyers. After about 15 minutes I tell them 'lunch hour' is over--"let's hit it."

We dig through some more difficult layers. It took Mother Nature 50 million years to fit all this shale, sandstone, clay, siltstone and dirt into this hole. We are trying to dig it out in 6 hours. Finally, realizing we wouldn't finish this day, we head for home.

After an hour of rough road, we come to a small town, with a small general store, with HUGE ice cream cones. My van, being on auto-pilot, pulls into this store. We all stuff down this delicious ice cream.

Next day--same procedure. More layers of rock, shale, noduals, etc. We thought we would reach the fish layer. However, perhaps, the boss bit off more than we could chew in a short week-end.

Sunday came. The boys, fed and paid well, said "let's go for it." They wanted to hit "layer" before they had to go back to school on Monday. We finally hit what we call the "paper layer." This is a layer of shale about a foot thick that splits very easily in thin sheets. There are "Mini Fish" in these layers, but unfortunately, preserved very poorly. Next the "mud" layer--hard clay--no fish. This was our clue that the "layer" was next. We hit it at 11:30 a.m. Sunday. Two and half days to hit "layer." A lot of work, a lot of strong words, and a lot of sweat.

The only way out of the hole at first was by rope. We were down so far now that we had to use a ladder. We took our tools of the trade, (picks, square and round pointed shovels, masonary hammers, and very thin chisels) down the ladder, plus boxes for the fish. Our next trick was to pull out the flat, layered silt stone. The pieces come out, hopefully, about 12 x 18 inches. Unfortunately, some come out much smaller. We then take the 4 inch thich rock, set it on adge, and use the thin chisels to split it open. Tap, tap, tap--very carefully. When a thin line starts, we would run the chisel along the line, all the way around the rock, if necessary, until it splits open. Then, if lucky, a <u>Gosiutichthys parvus</u> appears. YES, that's what we are after.

The <u>Gosiutichthys parvus</u>, more commonly called a "MINI FISH," is a fresh water fossil herring. The "MINI FISH," was labled by all those who hunted them for the last half century, <u>Knightia</u>. However, in 1982, Mr. Lance Grunde, a Paleoichthyoligist with the Field Museum, Chicago, Illinois, now described them as a separate genera and species. These "MINI FISH" are one of the current beginner fossils. In museum shops, gift shops, tourist shops, etc., all across the country, and the world, there are "MINI FISH" being sold. Many young and old buy these as a natural object from the Earth's crust. They look at them, study them, and eventually many start their own collections of other fascinating and exciting fossils. They often buy the "MINI FISH" first because they can relate to them. Instantly, they can tell what it was--and is. No paint, no plaster, no restoration. Just a natural fossil.

We work awhile splitting more layers. We are filling our boxes with fish. This is the fun time, the good time. No more digging, little shoveling, and mostly splitting. Afternoon closes, it's a long way home. Against their will I take the "fish splitting slaves" home. They love to split, hat to dig. Gosh, that is hard for me to understand!

Monday morning I head back out to the dig by myself. I split all day, and the next four days. Saturday, the boys help me again. We finish the 20 inch layer on the following Sunday. We not only find hundreds of fish, but also a grasshopper, a large crane fly, some Plantanis (Sycamore) seeds, a catfish and a few seed buds. All in all, a successful dig.

This scene goes on by myself, and other professional diggers year round. Some are tougher than me, and dig in the winter. Frozen ground, snowy conditions, high wind, and other deprivation is their reward. The common, but hard to dig "MINI FISH," are sold to many shops. The rarer material is given to the scientific community for study. The "MINI FISH," once out of the ground, must be clipped or sawed, washed and dried, sorted, priced and sold.

Most diggers won't admit it, but the best part of the job is when he splits that rock and there appear the Gosiutichthys parvus, and the digger is the first human who has ever seen it.

QUARRYING THOSE BEAUTIFUL GREEN RIVER FISH

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Probably most everyone has a Green River fossil fish in his/her collection. Viewed from a distance one can see them as they swim up or dive down on a picture perfect buff colored slab of limestone. Come with me on a beautiful summer day to visit a quarry--a fish quarry, that is--a little North of Kemmerer Wyoming to see how your fishes came to be.

MAPS member Bari Sines and I drove West on I-80 from Rock Springs, Wyoming, to rendezvous with Dennis Kingery and his collecting partner in downtown Kemmerer. The sky in that part of the country was a beautiful blue--no cumulus puffy clouds in sight. No big city industrial haze--just a clear summer day. One is in powerful country there. To a midwesterner used to many deciduous trees and green rolling hills of grain or alfalfa, the Wyoming country takes getting used to. Clumps of sage brush dot the landscape. Bristlecone pines are the survivors here. Their twisted trunks and branches testimony to the constant blowing winds. No wheat or corn fields on this arid land. I-80 appears to run on a plateau. Off to the South occasional giant scoops of land are missing revealing browns, reds, and grays coloring gigantic rock formations. The Westerners love this land. For me it is lonely and powerful, and harsh. It takes getting used to and I'm glad I am with a friend. There must be a constant struggle between man and nature. It is no place for the feint of heart. If we watch, we see antelope, deer, and if we are lucky a moose.

Before long we leave I-80 to head for Kemmerer. We've brought shovels, hammers, and thin bladed chisels to split the rock. Like all fossil forays, it's exciting. A first in a very different environment. Fishes the order of the day. For me a quarry is a huge cavity with some chunks of rock around the edges brought down from the walls by blasts of dynamite. Often there is powered rock grinding equipment and big heavy-duty rock hauling trucks. I have never been to a fish quarry so I do not know what to expect.

Kemmerer is a green oasis in the arid landscape of tumbleweed and sagebrush. There's a town square and we find a little restaurant where we get a bowl of soup while we wait for Dennis. It is easy to talk with the people in the restaurant and they are very aware of the fish quarries surrounding the town. When we leave, Bari recognizes Dennis' van next to hers so we know we will be on our way soon.

The fish quarry is to the North and West of the town. For awhile we follow a hard surfaced road but after awhile we turn off on a meandering gravel road. The road resembles what might once have been a wagon trail. It is narrow and dusty, and rutted with gullies. There is no evidence of man now, only open country and the meandering road can be seen for miles ahead. A pair of deer run in front of us, their winter coats hanging in loose chunks. Another first for me. I had seen buffalo shed huge patches of winter fur but it never occurred to me the antelope and deer do the same. The beautiful pair provide a life-time minute vacation.

Dennis has already reached the spot where we are to leave Bari's van. The view is magnificent. We are actually high on the edge of a rim. We slide into Den's van and start down a steep incline to the edge of the quarry. The quarry is nestled on a plateau with a beautiful green valley far below.

A fish quarry differs from a gravel, cement quarry. The biggest difference is that only occasionally does someone come in to remove the rock with heavy duty equipment. As the rock is split one tosses it over the shoulder in any direction which allows the least intrusion on the quarrying. Dennis and his partner have cleared an area and are chiseling out huge chuncks of buff limestone. The size is determined by the capacity of the "fisherman." The limestone is relatively soft and once separated from the rock formation is split in layers. Sometimes there is indication of a fish (a brown margin is visible along the edge of the limestone.) Layer upon layer of sediment must have been laid down and the gamble on the layer choice is the digger's. I watched for awhile before moving into an area of my own. It is quite warm now with the sun reflecting off the buff rock. Piles of split rock are everywhere. Sometimes it has split along natural lines and a weathered fish is visible. It is hard not to just examine the rubble but Dennis says the rock has been pretty well examined and mined.

Bari is already digging out a chunck to split, and so I find an area for myself. Like gravel quarries one can climb up over chunks of rock to dig out what appeals to the imagination. Sometimes one is rewarded with a fish and sometimes there is nothing. One never sees a gastropod or a brachiopod or a chephalopod--either fish or nothing. The wind helps to cool one. Without it it would be extraordinarilly warm. No one will go away empty handed, Dennis promises.

Sometimes a split reveals part of a fish, sometimes there is a thin layer which needs to be removed, sometimes a jumble of something--bones, scales, and tails, but not a complete fish. Like any fossil trip some specimens are destroyed by where the chunck is chisseled out, or the preservation is not good. But there is more possibility of going after a piece still buried in the rock wall here because the limestone is not hard as in some quarries I have been in.A first of anything is the best. Later the fossil may be bigger or finer but the first is still the best. A split and there it is--a fish. A squeal and I run to Bari with a Diplomystus, she says. The very tip of the tail is missing and it's not perfectly placed on a big slab--in fact it is on a little slab and in a perfect horizontal position, but it's beautiful. I suppose I would not buy this fish at an EXPO because he's too big for the slab he's on and a piece of that tail is missing, (Dennis wouldn't bring it anyway) but this fish will always be front and center in my display case and he will always precipitate a smile. Every time I look at it I get the same feeling as when that rock split and there it lay.

It turned out to be "the Day of the Dyplomystus." I found a perfect matched positive and negative and Bari cut the slab so it looks great. One can imagine it is diving for a Knightia. Bit by bit and split by split we each gathered our treasures. After awhile I went over to the one tree at the edge of the "rim". Below, in the green valley were many sheep. One could see a wagon and hear the herder who stays there all summer, Dennis said. He played a tune on the harmonica and the walls of the canyon worked acoustical magic. The notes floated up to us on the edge of the rim. The sheep wandered up a draw as they munched the green grass. A perfect picture from a page out of Zane Grey right there before one's eye.

Later as we got back on I-80 and headed East to Rock Springs, Bari spotted a moose--it's true. The trip was almost too good to be true. It provided a storehouse of memories of generous people, hidden treasures revealing windows into ancient fresh water lakes. Someday there is the lure of the campfire and a story under a canopy of a million stars, Rick Hebdon narrator. But that will be another day.

Pliocene Fish on a Bed of Diatoms

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In the spring of 1975, as I was preparing my manuscript on Diatoms for National Geographic, I went to California to begin preparations for an X-ray Telescope planned for flight on a sounding rocket. While in Los Angeles, I paid a visit on Kent Cochran, Advertising Manager of Grefco, Inc., which is a major manufacturer of diatomite products. Diatomite is a rock produced by the accumulation of immense numbers of the silica shells of microscopic plants called diatoms. These plants are a major component of the plankton of the oceans. They have played a most important role in global ecology since they first appeared abruptly on Earth at the Cretaceous-Tertiary boundary. For several years, Kent had been purchasing my photomicrographs of diatoms for use in Grefco's advertising program. Kent was just leaving for Lompoc, California to visit their largest diatomite quarry and he invited me to go along. I jumped at the chance. The Lompoc area is famous for its extremely pure and snowey white pliocene diatomite. The Lompoc deposit is one of the largest in the world---in some places it is over three thousand feet thick. This deposit is primarily of the pliocene Sisquoc formation. It was formed by the accumulation of untold trillions upon trillions of shells of diatoms that fluorished in the rich upper pliocene sea, approximately between 0.5 and 1.5 million years ago. It primarily occurs in the *Nitzschia reinhoeldii* zone.

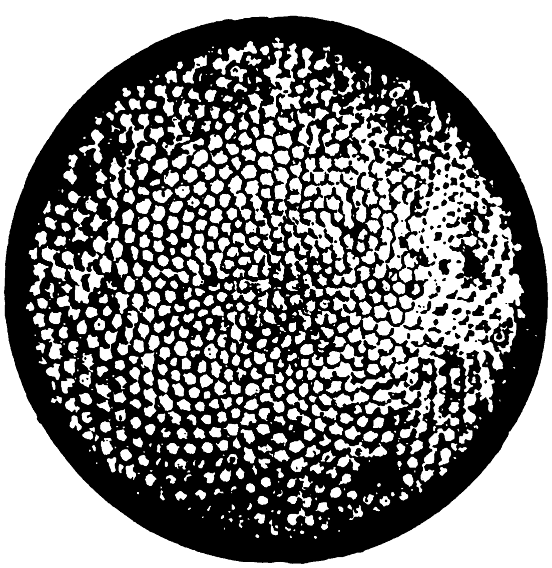
When we arrived at the quarry, we were greeted by the plant foreman. He immediately took us for a tour of their operation. The quarry was vast and most impressive. Gigantic earth movers roamed the quarry floor like strange alien spacecraft. Each was capable of carrying many tons of the fluffy diatomite to the processing facility. As we drove along the rim of the quarry, the plant foreman's bright red Cadillac rapidly turned white from the swirling cloud of diatoms.

The foreman brought the car to an abrupt halt. A large 4'X3'X2' boulder of diatomite was sitting squarely in the middle of the road, blocking our path. With a smile and a slight apology, the foreman stepped out of the car, picked up the white boulder and tossed it over the side of the cliff. I photographed this event, convinced that it would be perfect as an illustration for the National Geographic article to show how light diatomite truly is. To my great surprise, the illustrations editor chose instead a picture of Kelly Phelps (whoever he is) holding a small stack of diatomite rocks. This is not nearly as impressive as a man hoisting a rock bigger than a bale of hay above his head to toss it over a cliff! There is just no accounting for taste!

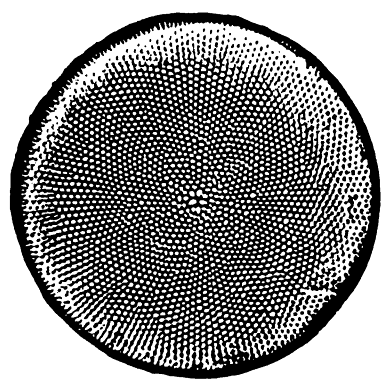
The light fluffy quality of diatomite is caused by the myriad of pores that perforate the silica shells of the diatoms which comprise it. And these tiny holes also give it the ability to yield a superb filter material. Diatomite rock is so light that it easily floats on water. Filters made of diatomite are used in fish tanks and swimming pools. Grefco also sells their diatom filter materials to the finest wineries and breweries in the world---sparkling clear wine and beer are just one of the many legacies these tiny plants have given to mankind.

When we returned to the plant, the foreman took us to his office. I was astonished to discover that his office was adorned with large slabs of diatomite covered with beautiful fish fossils. I asked about them and learned they were from a different area of the quarry. Soon we were back in the car to go "fishing". We drove for several miles. He pulled over and honked the horn to attract the attention of a worker in a large bulldozer. When the engine of the great machine was killed so we could talk, the foreman addressed the operator "See that hill over there?". He nodded his head 'yes' and the foreman said "Go knock hell outa it for us!" Within minutes the hill was reduced to a pile of large pieces of white rock. We walked to the rubble and found many large slabs covered with beautiful pliocene fish. The fish ranged in size from 4 to 10 inches in length. Sometimes the diatomite surface was brownish as the fossil fish covered it so thickly with their reddish brown remains. I selected several slabs that were 2 foot square and at least 2" thick. Thinner slabs were also present but diatomite is so fragile that I was sure the thinner material would disintegrate during my trip home. I carefully wrapped my treasures and returned to Huntsville with them snuggled between suits in my suitcase.

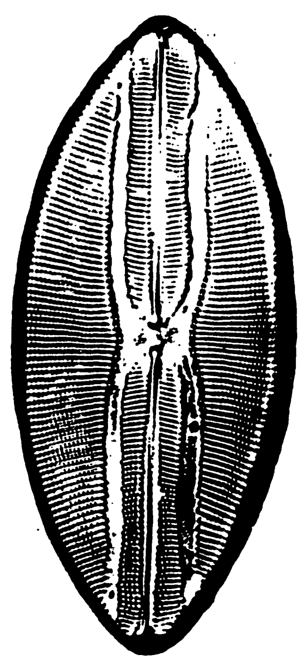
I studied the diatoms of a few small fragments that broke off my beautiful slabs. I found them to be full of exquisite diatoms---large and beautifully preserved *Coscinodiscus oculus-iridis, Coscinodiscus asteromphalus, Navicula lyra* and many other species. National Geographic finally published my article "Those Marvelous Myriad Diatoms" in June, 1979. And the Rocket X-Ray Telescope we began planning that spring day of 1975 was just launched from the White Sands Missile Range last October to produce the most spectacular X-ray images of the sun ever obtained. Some of these pictures will soon be published in SCIENCE. And I still have the lovely slabs with reddish brown fish from Lompoc, California. To date, I have not been successful in my attempts to identify my precious fish on a bed of Pliocene diatoms. Perhaps some of the experts reading this article can provide me with the correct identification. I would be most delighted to know the genus and species of these beautiful pliocene fish.



Coscinodiscus oculus-iridus



Coscinodiscus asteromphalus



Navicula lyra

Pliocene fish on slab of pure diatomite from Lompoc, California