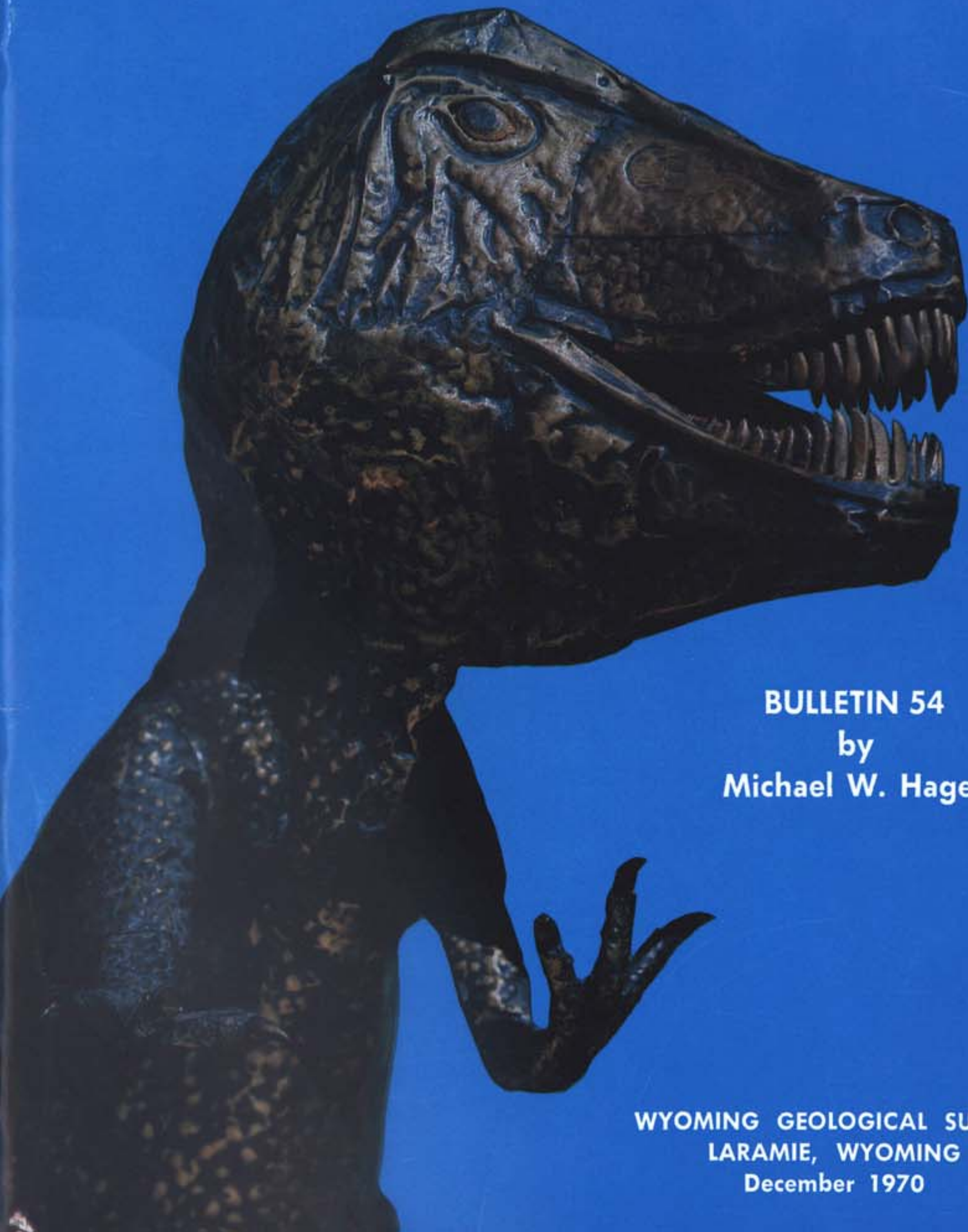
Fossils of Wyoming



BULLETIN 54
by
Michael W. Hager

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Front cover - One-tenth scale reconstruction of *Tyrannosaurus rex* by Dr. S.H. Knight. The full-sized reconstruction is on display outside the Geological Museum at the University of Wyoming.

THE GEOLOGICAL SURVEY OF WYOMING

DAN MILLER, State Geologist

BULLETIN 54

FOSSILS OF WYOMING

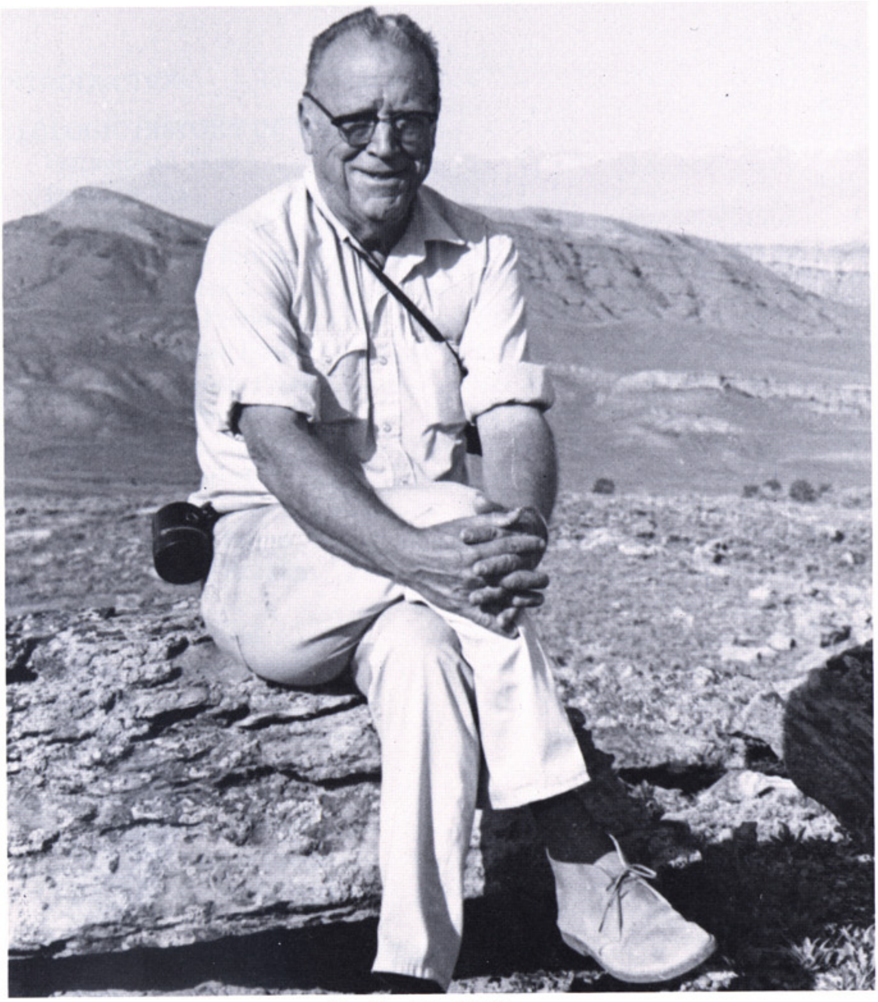
By

MICHAEL W. HAGER

UNIVERSITY OF WYOMING

LARAMIE, WYOMING

JANUARY, 1971



Dr. Paul O. McGrew

This publication is dedicated to Dr. Paul O. McGrew, Professor of Geology and Curator of the Museum at the University of Wyoming. For more than two decades his life has been devoted to research on the vertebrate fossils and Tertiary stratigraphy of Wyoming. He has made great contributions towards the training and teaching of geology students at the University of Wyoming and has amassed a large and valuable collection of fossils for all students of vertebrate paleontology.

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FOSSILS OF WYOMING

by
Michael W. Hager

INTRODUCTION

"Big Wonderful Wyoming" is a phrase familiar to most residents of the state. To fossil collectors, amateur and professional alike, Wyoming is truly big and wonderful. It has long been recognized for its magnificent geological formations and abundant fossils. Every summer, museum and university geologists from many parts of the United States come to Wyoming to collect fossils and study its unusually complete geologic history.

Fossils have little economic value but great academic value. They tell us about the history of our earth and the development of life throughout geologic time. Collecting fossils is hard work but the excitement of finding new specimens and glimpsing the life of millions of years in the past makes it all worthwhile.

The information gained from the study of fossils is needed to add to our knowledge about the history of life on earth. For the most part, fossils are fragile and great care must be taken to preserve them. Because of their scientific value, collectors should record the exact location of every fossil found. Without location data, fossils are mere curiosities and are useless for study purposes. By keeping good collection records and reporting unusual fossils to the state or university geologists, amateur collectors can help in the difficult task of interpreting our geologic past.

This booklet was prepared to help amateur collectors identify the common fossils of Wyoming. Wyoming is so rich in fossils it would require a very large book to illustrate every known fossil from the state. However, with this booklet, most fossils can be identified to phylum or general type, and the references listed in the back of this book can be used for more precise identification.

What is a fossil?

A fossil is evidence of prehistoric life preserved in the sedimentary rocks of the earth's crust. Included in this definition are such forms as ancient worm burrows, animal footprints, plant imprints, gastroliths (dinosaur "gizzard stones"), coprolites (animal excrement), and such conventional forms as shell and bone.

How are fossils preserved?

Fossils of shells, bone, and teeth are preserved when fat and other organic material decays after death and ground water soaks into the pores depositing minerals. This process is known as *permineralization.*

In other instances, water dissolves the original hard parts of the organism and replaces them with minerals. This process is known as *replacement.* If replacement takes place very slowly, the mineral matter closely duplicates the structure of the fossil. If replacement is too rapid, some of the detail of the fossil may be lost. "Petrified wood" is a good example of silica replacing cellulose wood fiber.

Some plants and animals are preserved as a thin film of carbon in the enclosing rock. The general outline of the fossil is retained and the process is known as *carbonization.* The Eocene fish from the Green River Formation of western Wyoming are good examples. They are the result of carbonization which produced the black outline and permineralization which preserved the skeletal parts.

A *mold* of a fossil is an impression of an animal or plant in the rock. Often, the original parts of the animal are removed by decay or dissolved by ground water leaving only the shape or form of the structure. If the mold is later filled with clay or sand or some other sediment, a natural *cast* or reproduction of the original is formed.

Other methods of preservation include freezing in glacial ice, drying in caves, and preservation in natural asphalt or amber.

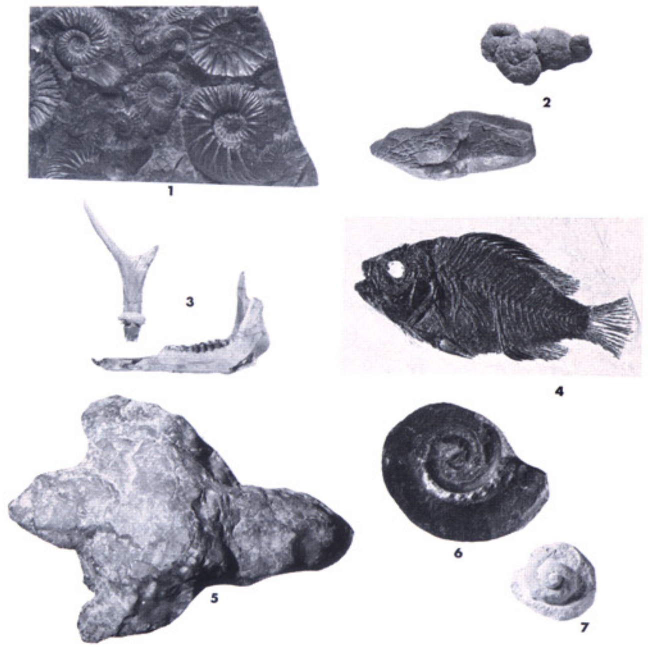

Fig. 2–Types of Fossil Preservation. (1) Ammonite external and internal molds (length individual fossils 3"). (2) Coprolites (animal excrement, length 2"). (3) Permineralized antelope horn and jaw (length of each 4½"). (4) Fish preserved by carbonization and permineralization (length 5"). (5) Dinosaur footprint natural cast (length 3½'). (6) and (7) Snail internal molds or "steinkerns" (length 2").

GEOLOGIC HISTORY OF WYOMING

Precambrian Time

Man's knowledge of the early history of the earth is highly interpretive and is based on studies of the oldest rocks from which we have samples. Estimates for the age of the earth vary but presently it is thought to be approximately 4½ billion years old. The Precambrian era began with the formation of the earth and ended nearly 600 million years ago. The geologic history of the Precambrian is not well known because of its great age, long duration, and scarcity of fossils.

During the Precambrian, great quantities of rock solidified from a hot liquid state. These rocks were later weathered, eroded, and uplifted into mountain ranges many times and finally eroded to a surface of low relief late in Precambrian time. These rocks are the foundation on which later sedimentary rocks (rocks derived from pre-existing rocks or precipitated from solution) were deposited and are referred to as the "basement complex." Precambrian rocks are exposed in the core of most mountain ranges in Wyoming.

The only known fossils from the Precambrian of Wyoming are marine algae (seaweed) called stromatolites. The stromatolites of the Medicine Bow Mountains are approximately 1.7 billion years old.

Fig. 3–Precambrian Algae. 1.7 billion year old Precambrian algae in the Medicine Bow Mountains, Wyoming. (Photo courtesy of Dr. S. H. Knight).

Paleozoic Era

Cambrian Period—Marine conditions prevailed in Wyoming during the Cambrian and shallow seas covered all but the southeastern part of the state. Most of Wyoming was emergent (above sea level) by the end of the Cambrian.

Marine life in the early Paleozoic seas was very much different than the life of modern seas. Animals and plants were abundant but consisted of only a few different species of organisms, most of which do not exist today. The most characteristic Cambrian fossils are trilobites, brachiopods, corals, sponges, and algae.

Fig. 4—Life of the Cambrian Seas. (1) trilobite-like arthropod; (2) algae; (3) trilobite-like arthropod; (4) trilobite; (5) segmented worm; (6) tribobite; (7) sponge; (8) jellyfish. (Courtesy of the Smithsonian Institution).

Ordovician Period—For the most part, Wyoming remained above sea level during the early and middle part of the Ordovician, except in the Black Hills area. During the latter part of the Ordovician, gentle subsidence occurred and seas advanced over the land covering much of the state.

Life in the seas changed considerably from the Cambrian to the Ordovician. Many new fossil forms are known from Ordovician rocks that are not known from the Cambrian. Large torpedo-shaped cephalopods, delicate flower-like crinoids, and fragile graptolites evolved and were added to the fauna inherited from the Cambrian. In addition to these new invertebrates, the oldest known vertebrates, primitive armored jawless fish made their first appearance. Fossils of these fish from the Big Horn Mountains of Wyoming are among the oldest known vertebrates anywhere in the world.

Fig. 5—Ordovician Sea Life. (1) large nautoloid cephalopod; (2) trilobite; (3) bryozoan; (4) nautoloid; (5) large colonial coral. (Courtesy of the Smithsonian Institution).

Silurian Period–Wyoming was almost completely emergent during the Silurian and much of the Devonian. This represents the only period in the geologic history of the state in which little evidence of deposition is found.

Life in Silurian seas in areas bordering Wyoming became extremely diverse and abundant. Nautiloid cephalopods continued to thrive in large numbers and great variety. Reefs of coral and algae were abundant. Brachiopods and bryozoans flourished as well as crinoids and trilobites, and clams and snails became abundant. Large scorpion-like arthropods, eurypterids, were predators on invertebrates and the small armored fish.

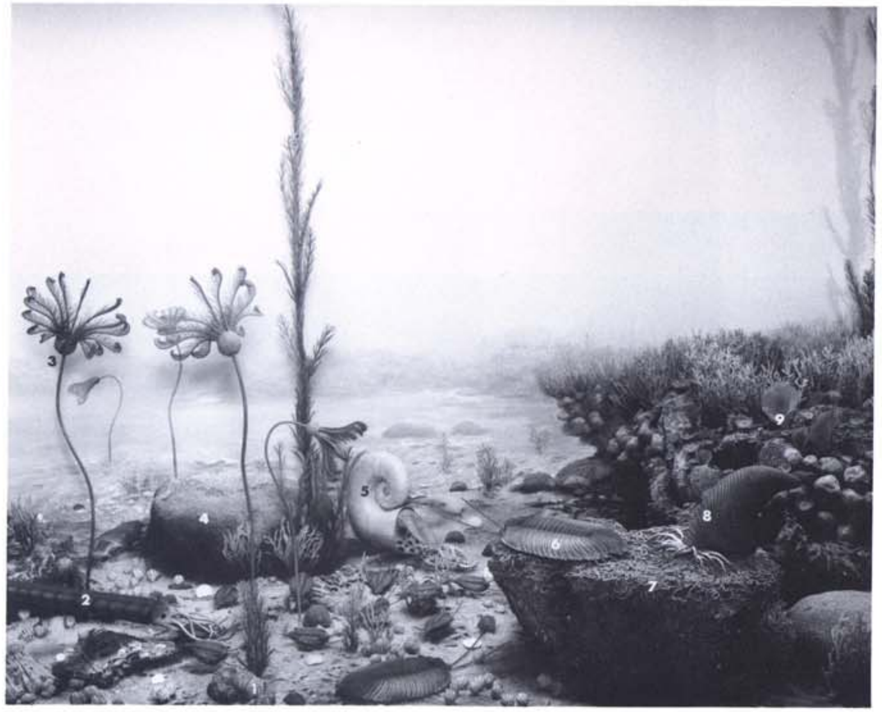

Fig. 6–Silurian Sea Life. (1) brachiopod; (2) nautoloid cephalopod; (3) crinoid; (4) coral; (5) coiled nautoloid cephalopod; (6) trilobite; (7) coral; (8) nautoloid; (9) bryozoan. (Courtesy of the Smithsonian Institution).

Devonian Period–In late Devonian time, the seas again advanced over the northern and western parts of the state.

Life during the Devonian was also abundant and very diverse but great changes in the fauna had taken place. Echinoderms and nautiloid cephalopods were greatly reduced in numbers and many different species of these animals became extinct. The flower-like crinoids and the ammonoid cephalopods became extremely abundant and diverse in form.

The primitive jawless fish of the Ordovician and Silurian gave rise to the primitive jawed fish of the Devonian. Once an effective jaw developed, a tremendous evolution of forms occurred and the success of the vertebrates was established. All but one order of jawless fish became extinct by the end of the Devonian.

While aquatic life was developing in the seas of Wyoming, terrestrial life was developing elsewhere. From primitive lobe-finned, air-breathing fish, amphibians evolved which were semi-aquatic, returning to water to lay eggs. Terrestrial vertebrates became fully independent of water in the *Pennsylvanian Period* with the evolution of reptiles from amphibians. Once independence was gained, an evolutionary radiation of vertebrate species occurred, including the evolution of birds and mammals from reptiles in the Mesozoic Era.

The only evidence in Wyoming of terrestrial life in the Devonian is found in fossil land plants. Plants were very primitive at this stage. The oldest terrestrial plant life known is from the late Silurian of Australia.

Fig. 7–Sea Life of the Devonian. (1) nautoloid cephalopod; (2) coral; (3) coral; (4) ornate coiled cephalopod; (5) crinoid; (6) trilobite; (7) snail; (8) large spiny trilobite; (9) coral. (Courtesy of the Smithsonian Institution).

Mississippian Period–The entire State was submergent during the early Mississippian time. Uplift later restricted the sea to the west and erosion removed much of the deposits and the enclosed fossils in southeastern Wyoming.

Marine life of this period differed from that of the Devonian in the great decline in corals and trilobites and a great expansion of crinoids, lacy bryozoans, and spiny brachiopods. Fish were undoubtedly abundant but were not commonly preserved in the fossil record.

Fig. 8–Mississippian Sea Life. (1) starfish; (2) crinoid; (3) algae; (4) crinoids. (Courtesy of the Smithsonian Institution).

Pennsylvanian Period–Early Pennsylvanian time was one of shifting seas. The sea reached its maximum extent in middle Pennsylvanian time and then retreated to the eastern and southwestern parts of the State.

Marine life of the period was more or less a continuation of that of the Mississippian. Terrestrial coal-forming plants dominant in many parts of the world were absent in Wyoming.

Fig. 9–Pennsylvanian Sea Life. (1) large coiled ammonite; (2) solitary coral; (3) crinoid; (4) sea urchin; (5) brachiopod; (6) brachiopod; (7) small coiled ammonite; (8) sponge; (9) snail; (10) ammonite; (11) snail (12) spiney brachiopod; (13) ornate coiled ammonite. (Courtesy of the Smithsonian Institution).

Permian Period–Most of Wyoming remained emergent until the middle Permian when subsidence of the earth's crust occurred and a sea advanced over western Wyoming. The sea completely withdrew late in Permian time.

Many of the characteristic groups of Paleozoic life disappeared by the end of the Permian. Trilobites became extinct and corals, crinoids, and brachiopods were greatly reduced in numbers and in diversity of types. Pelecypods and gastropods progressed but slowly.

Amphibians and reptiles had evolved before the Permian in other continental areas but conditions were either not favorable for them or for their fossilization in Wyoming and none have been found in the Paleozoic rocks of the state.

Fig. 10–Permian Sea Life. (1) ornate coiled ammonite; (2) aberrant brachiopod; (3) brachiopod; (4) coiled ammonite; (5) jointed sponge; (6) brachiopod; (7) solitary coral; (8) coiled ammonite; (9) glass sponge. (Courtesy of the Smithsonian Institution).

Mesozoic Era

Triassic Period–Subsidence resulted in the advance of seas over much of Wyoming in early Triassic time. Later, deposition of red sedimentary rocks (redbeds) took place in very shallow seas and low tidal flats under arid conditions. Few fossils have been found in these redbeds indicating unfavorable life conditions. Normal marine waters then re-advanced for a very brief time followed by uplift and the deposition of continental sediments.

Triassic seas to the west swarmed with large coiled ammonites and torpedo-shaped belemnites were common. The most common Wyoming fossils of this period are clams and snails.

The only common vertebrates of the Triassic of Wyoming are the phytosaurs, crocodile-like reptiles with nostrils high on their heads. Amphibians are known but are not common.

Jurassic Period–Once again, seas covered much of Wyoming. Due to uplift, the seas retreated in late Jurassic time and sediments were deposited on land.

The most common marine invertebrates were the belemnites. Clams and snails were abundant and sea urchins and crinoids were well represented.

Marine vertebrates include ichthyosaurs (dolphin-like reptiles) and plesiosaurs (long-necked marine reptiles) although their remains are not abundant. Fish were abundant and were the principle food source of marine reptiles.

Terrestrial life was abundant after the retreat of the seas late in the Jurassic. Dinosaurs were the dominant land animals. Beasts such as *Apatosaurus (Brontosaurus)* reached a length of 70 to 80 feet and weighed as much as 40 tons. Abundant dinosaur remains have been found at Como Bluff, Wyoming. Other terrestrial vertebrates such as turtles, lizards, and crocodiles were also abundant. Flying reptiles were dominant in the air although their remains are fragmentary. Inconspicuous among these large vertebrates were small and very primitive mammals.

Plant life thrived and consisted of pines, ginkgos, tree ferns, and an abundant undergrowth of ferns and scouring rushes. Grasses had not yet evolved.

Birds evolved from reptiles during the Jurassic but only a few bone fragments have been found in Wyoming.

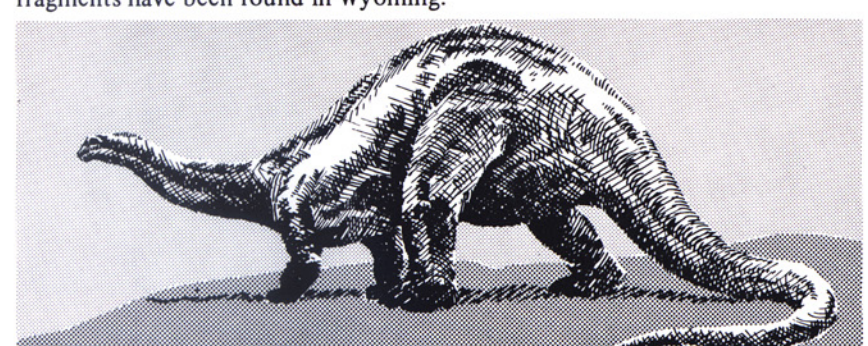

Fig. 11–*Apatosaurus,* a large Jurassic dinosaur.

Cretaceous Period—The Jurassic emergence was only temporary. Seas again encroached on the land and most of Wyoming was submergent by the middle of the Cretaceous. With the rise of the Rocky Mountains during the late Cretaceous, the seas retreated.

Cretaceous marine life in Wyoming is marked by a great decline in belemnites and an abundance of ammonites. Clams and gastropods were abundant as in the Jurassic and, with the exception of the cephalopods, the general animal types were similar.

Marine vertebrates of the Cretaceous seas of Wyoming include mososaurs (giant marine lizard), plesiosaurs (long-necked marine reptile), ichthyosaurs, turtles, and fish. The remains of the marine reptiles are not abundant. Fish remains are fragmentary but fish scales and shark teeth are very common fossils.

Dinosaurs returned to Wyoming in the Cretaceous as the seas retreated. The largest terrestrial carnivore of all times, *Tyrannosaurus rex,* is represented along with such familiar forms as *Triceratops, Anatosaurus,* and *Ankylosaurus.* Flying reptiles were dominant in the air but their remains are fragmentary.

Mammals continued to be rather inconspicuous among the large dinosaurs. However, two new groups appeared, the marsupials (pouched mammals like the opossum) and the insectivores (the group to which modern shrews and moles belong).

Fig. 12—Life of the Cretaceous Seas. (1) straight ammonite; (2) coiled ammonite; (3) ornate coiled ammonite; (4) clam; (5) snail; (6) irregular coiled ornate ammonite; (7) squid-like belemnite; (8) algae. (Courtesy of the Smithsonian Institution).

Plant life changed drastically during the early Cretaceous with deciduous trees (ones in which the leaves are shed seasonally) coming into dominance. By middle Cretaceous such modern forms as beech, birch, oak, walnut, and maple had made an appearance.

The close of the Cretaceous was a time of extinction for many animals. Dinosaurs, flying reptiles, and marine reptiles (with the exception of sea turtles) all died out. Many invertebrates also became extinct; most notably, the ammonites and most belemnites.

Rise of the Rockies

During the latter part of the Cretaceous, some 80-100 million years ago, Wyoming like the other Rocky Mountain states became involved in a period of massive crustal deformation. Great upheavals caused the basement complex and the overlying strata to buckle and shift. Huge faults developed and most of the mountains were uplifted to at least their present height.

This period of mountain building spans nearly 40 million years and is referred to as the *Laramide Orogeny.* At the same time the mountains were uplifted, intermontaine depressions or basins were formed. For the most part, the Cenozoic fossils of the Rocky Mountain area are found in the sediments of intermontaine basins and not in the mountainous areas.

Cenozoic Era

Tertiary Period

Paleocene Epoch—The climate of the Paleocene of Wyoming was warm and humid. Characteristic environments include tree dotted plains, freshwater lakes and swamps, extensive river systems, high mountains, and vast forests of lush tropical plants bordering rivers, lakes, and swamps.

The few rather inconspicuous species of mammals of the Cretaceous gave rise to abundant but very primitive mammals of the Paleocene. Most of these archaic animals (highly specialized but doomed to early extinction) became extinct before the Eocene. Small primitive Paleocene mammals gave rise to modern mammal types.

Characteristic of the fauna were opossum-like marsupials (animals which carry their young in a pouch after birth), multituberculates (archaic rodent-like animals), insectivores (shrew-like animals), primates, creodonts (archaic flesh-eating animals), archaic ungulates (hoof-bearing animals), and fish, turtles, and crocodiles. If we could have observed Paleocene life, we would recognize few of the animal types represented because of their early stage in evolution.

Eocene Epoch–The climate and environments of the Eocene were much the same as the Paleocene. In southwestern Wyoming, a very large lake bordered by extensive forests provided favorable life conditions for a great variety of animals. The Green River Formation, famous for its remarkable fish fossils and freshwater snails (*Goniobasis*), provide us with an unusually complete picture of the life and environments of the Eocene of Wyoming.

The archaic mammals of the Paleocene gradually disappeared and the animals of the Eocene began to take on a modern appearance. A diagnostic feature marking the beginning of the Eocene was the appearance of two groups of modern ungulates (hoofed mammals), the perissodactyls (odd-toed ungulates such as the rhinoceros and horse) and artiodactyls (even-toed ungulates such as pigs and camels). In addition to the ungulates, the fauna included primates, rodents, insectivores, bats, a variety of fish, crocodiles, turtles, and birds.

Fig. 13–An Eocene Landscape. (1) uintathere; (2) gnawing-toothed mammal; (3) primitive tapir; (4) early titanothere; (5) lemur-like monkey; (6) squirrel-like rodent; (7) a large flesh eater; (8) clawed, plant-eating mammal; (9) crocodile; (10) saber-toothed mammal; (11) ancestral horse; (12) even-toed hoofed mammal; (13) even-toed hoofed mammal; (14) armadillo-like mammal; (15) marmot-like mammal; (16) hyena-like mammal; (17) gnawing-toothed mammal. (Courtesy of the Smithsonian Institution).

Oliogocene Epoch–The climate of the Oligocene was cooler and drier than the Eocene. Subtropical plants were replaced by plants such as oak, beech, maple, and ash. Volcanoes had been active in northwestern Wyoming in the Eocene. They increased in number and intensity of eruption in the Oligocene providing great quantities of volcanic ash and dust to large areas of Wyoming, South Dakota, and Nebraska.

Most of the archaic mammals were extinct by the end of the Eocene including the multituberculates, archaic ungulates, most of the primates, and most of the archaic carnivores. Because of the absence of the archaic mammals and the presence of modern trees, the Oligocene had a more modern appearance than previous epochs.

The Oligocene landscape supported a great variety of animals including rhinoceros, camel, titanotheres (animals resembling the modern rhinoceros), large pig-like animals, oreodonts (small pig-like animals) and tortoises. The forests bordering streams and marshes supported the small three-toed horse–*Mesohippus*, tapirs, insectivores and rodents. Land snails were abundant. Preying on these animals were a host of carnivores including varieties of dogs, cats, and weasels.

Fig. 14–An Oligocene Landscape. (1) titanothere; (2) early rhinoceros; (3) sheep-like grazing oreodon; (4) archaic hyena-like mammal; (5) chevrotain-like mammals; (6) saber-toothed cat; (7) ancestral camel; (8) very small chevrotain-like mammal; (9) squirrel-like rodent; (10) small insect-eating mammal; (11) primitive rabbit; (12) ancestral dog; (13) remote hippopotamus relative; (14) bizarre horned mammal; (15) small three-toed horse; (16) giant pig-like mammals; (17) small fleet-footed rhinoceros; (18) early pecarry. (Courtesy of the Smithsonian Institution).

Miocene Epoch–The Miocene was a time of intense volcanic activity in northwestern Wyoming. The climate was similar to that of the modern Gulf Coast gradually becoming cooler toward the end of the epoch.

For the first time in geologic history, grasslands became prominent and supported a great variety of animals. The fauna was greatly modernized by this time with half of the living families of terrestrial mammals then in existence. Horses were numerous with at least four different genera evolving in the Miocene. Rhinoceros were very abundant and some forms were very large. Camels were abundant and varied as were the oreodonts. The first of the prongbuck "antelope" appeared in the Miocene with wide variation in horn types. Peccaries were present but the large pig-like beasts (entelodonts) became extinct. Rodents, including rats and primitive beaver-like forms, and rabbits were abundant. Carnivores were numerous including different types of dogs and cats, such as the sabertooth and the ancestors of the modern wild cats. Late in the Miocene, mastodons appeared.

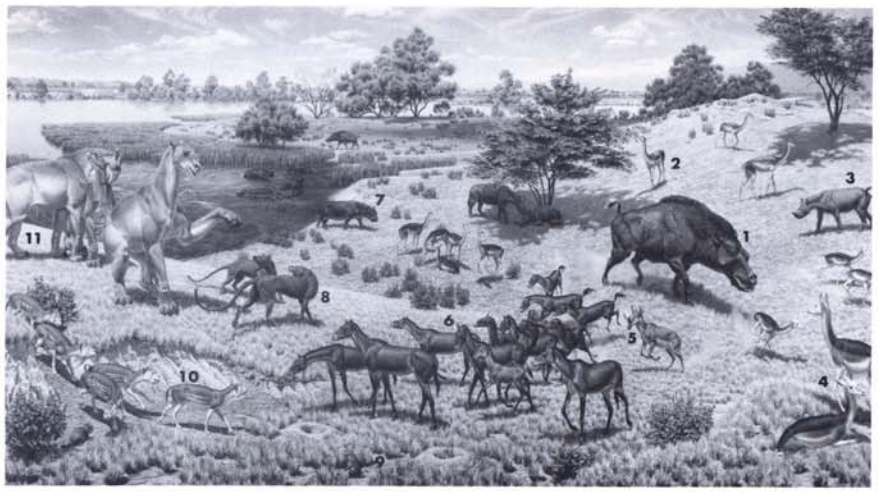

Fig. 15–A Miocene Landscape. (1) giant pig-like mammal; (2) long-legged camel; (3) pair-horned rhinoceros; (4) small camel; (5) antelope-like mammal; (6) three-toed horse; (7) pig-like oreodont; (8) large wolf-like dog; (9) burrowing beaver; (10) small even-hoofed mammal; (11) large clawed mammal related to horses. (Courtesy of the Smithsonian Institution).

Pliocene Epoch–The climate of Wyoming during the Pliocene was much cooler than the Miocene. Volcanic activity ceased in northwestern Wyoming. During the latter part of the Pliocene, the Teton Mountains reached nearly their present height, but were later carved into jagged peaks and ridges by Pleistocene glaciers.

Eighty percent of the families of terrestrial mammals then present are still represented by modern forms. The large pig-like entelodonts became extinct and rhinos and oreodonts were rare. There was a great radiation of the prongbucks, and camels and horses flourished. Carnivores were abundant and primitive bears appeared for the first time.

Because well exposed Pliocene deposits are relatively rare in Wyoming, Pliocene fossils are uncommon.

Fig. 16–A Pliocene Landscape. (1) shovel-tusked mastodon; (2) long-legged rhinoceros; (3) giant camel; (4) llama-like camel; (5) ancestral one-toed horse; (6) three-toed horse; (7) bear-like dog; (8) cat; (9) short-faced dog; (10) pecarry; (11) snout-horned, even-toed hoofed mammal; (12) burrowing horned rodent; (13) rabbit; (14) prongbuck antelope; (15) cranial-horned, even-toed mammal; (16) short-legged rhinocerous. (Courtesy of the Smithsonian Institution).

Quarternary Period

Pleistocene Epoch–Glaciers formed in the mountains of Wyoming during the Pleistocene and advanced at least four times. Areas near the former glaciers show evidence of subarctic to arctic conditions. Between advances, the climate warmed considerably and there is evidence that arid conditions prevailed. The Pleistocene, in general, is characterized by extreme climatic conditions.

Common fossils of the Pleistocene of Wyoming include horses, mastodons, mammoths, camels, and bison. Although not common, prongbuck, pecarry, rodents, and carnivores are known to have inhabited the state.

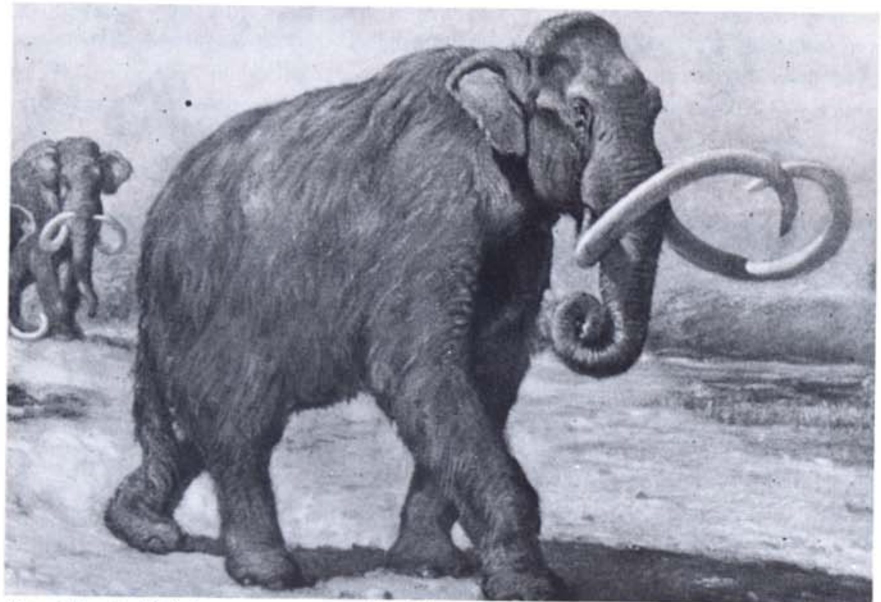

Fig. 17–A Pleistocene mammoth. (From Osborn, by permission American Museum of Natural History).

Recent or Holocene–Within a few thousand years after the ice age, animals such as camels, horses, mastodons, mammoths, and ground sloths were extinct in North America. Why? Most of them were seemingly well adapted to the environment from which they perished, and horses and camels survived to the present in Europe and Africa in similar environments. Most of these animals were in existence when man arrived in North America. The oldest record of man in Wyoming is 11,000 years before the present and we know that he hunted these beasts because stone implements have been found with the remains of some of them. Some scientists believe that early man was responsible for the extinction of these magnificent animals. This seems unlikely but remains a possibility. The mystery of the Pleistocene extinctions remains to be solved.

With the last of the ice ages, 6-8000 years ago, the fauna of North America has essentially remained the same to the present except that modern man has greatly reduced animal numbers and changed their environment in the last 150 years.

PROPER IDENTIFICATION OF FOSSILS AND USE OF THE TEXT

In a publication of this type, it is impossible to include every fossil form known. An effort was made to illustrate the common fossils of Wyoming and yet to be representative of the great variety of fossils found in the state. Several very rare fossils were included because of their great interest.

The scientific names used in this publication should not be applied indiscriminately to all fossils which resemble those illustrated. Many forms superficially resemble each other but, to the specialist, significant and often very slight differences in forms require different names. Since only a few of each fossil types known are illustrated it is best to identify fossils to general type and not to give them generic names unless a specialist or a more detailed text are consulted.

The age of the fossils illustrated applies only to those particular specimens and the range of the fossil is given only for Wyoming. In other areas, the same type of fossil or even genera may have an entirely different range.

The size indicated for each fossil illustrated is the size of that particular specimen. In most cases, this is representative. However, many types range greatly in size and, therefore, identification should be based on characteristics other than size.

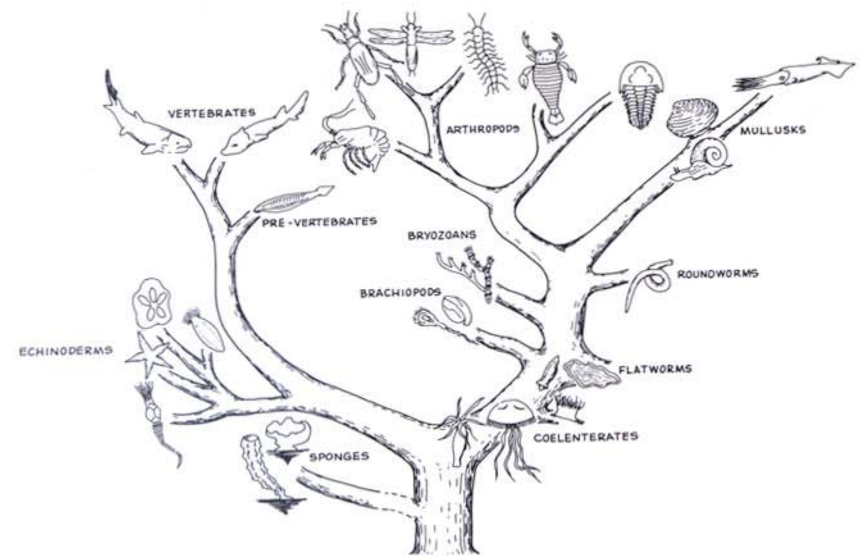

Fig. 18–Simplified Family Tree of Animals.

INVERTEBRATE FOSSILS

Invertebrates are simply animals which have no backbone. Invertebrate fossils include such familiar forms as starfish, clams, snails, and worms. Many fossil invertebrates seem familiar because they are similar to animals living today. However, some fossils such as trilobites are found which are not similar to modern forms and these appear strange and unfamiliar.

The following presentation of life forms will begin with the simplest and progress to the more complex. Keep in mind as you proceed through the text that this progression from simple to complex represents the broad concept of evolution of life through the ages.

Fig. 19–A sea floor accumulation of fossils etched from the rock with acid. Pictured are several types of brachiopods, corals, and bryozoans.

Protozoa

Protozoans are animals which consist of a single cell. They are best seen with the aid of a microscope but a few forms are visible without magnification. Because of their small size, fossil protozoans are commonly known as microfossils.

Only those protozoans with a shell were commonly preserved as fossils. The most common fossil protozoans in Wyoming are Foraminifera which are preserved only in sediments of marine origin.

1

2

Fig. 20–(1) *Neoflabellina,* a protozoan microfossil from the Niobrara Formation (Photo by P. O. McGrew, enlarged 25 times); (2) *Receptaculites,* a problematical sponge (length 6").

Porifera

The Porifera, that is, the sponges, have a skeleton of spicules or rods and only these hard parts are commonly preserved. *Receptaculites* resembles a sponge but its classification as a sponge is uncertain.

Coelenterata

The coelenterates include jellyfish, sea anemones, and corals. Since only corals have a hard skeleton, they are the only common fossil coelenterates in Wyoming.

Bryozoa

Bryozoans are often found as "lacy patterns" in the rock or on shells of other animals. Bryozoans are colonial animals consisting of hundreds of tiny individuals each living in a small opening at the surface of the colony. Colonies of bryozoans are common fossils in marine sediments of Wyoming.

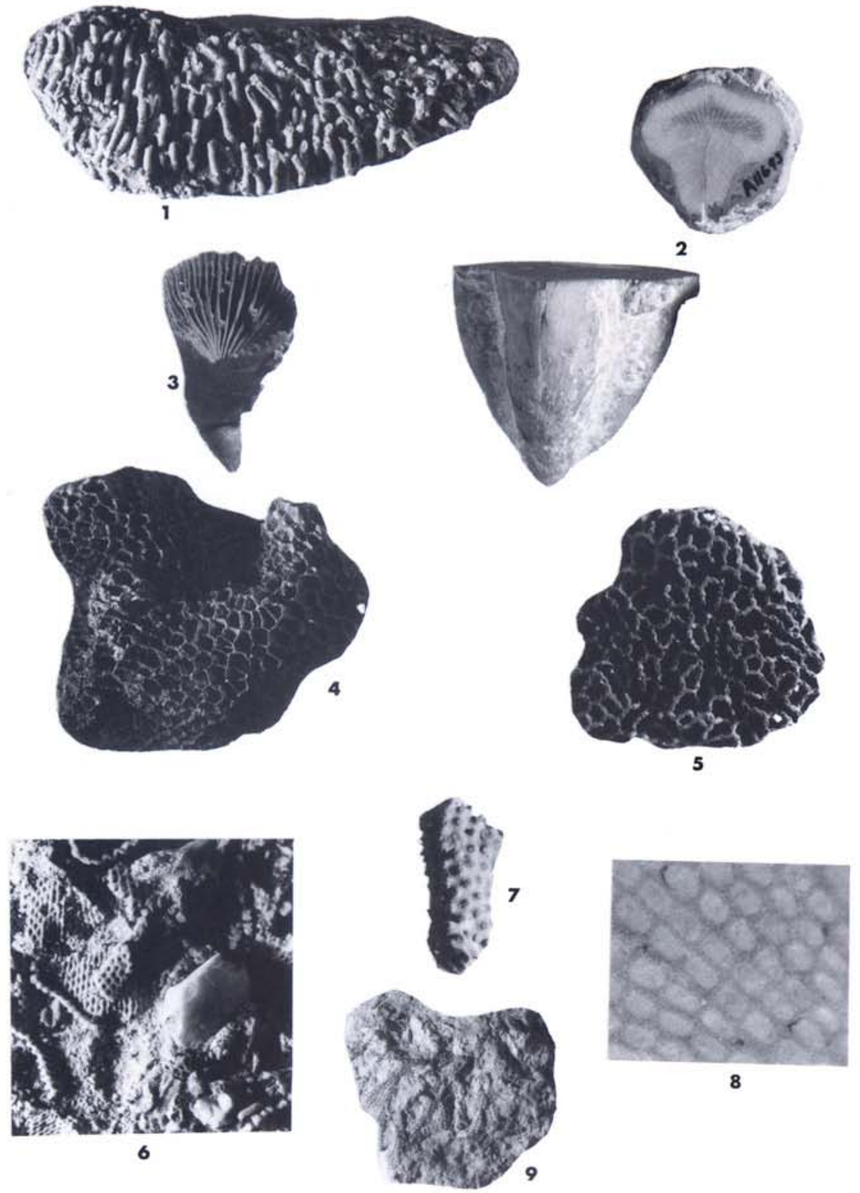

Fig. 21–Corals and Bryozoans. (1) *Syringopora,* a Mississippian colonial coral (size 8"); (2) *Streptalasma,* an Ordovician solitary coral (length 2"; range Ord.-Perm.); (3) Mississippian "Horn coral" (length 1"; range Ord.-Perm.); (4) Mississippian colonial coral, *Michelina* (size 5"; range Ord.-Perm.); (5) *Catenipora,* an Ordovician colonial coral (size 5"); (6), (8) and (9) Permian "lacy bryozoans" (6 and 9 actual size; range Miss.-Perm.) (8) 25 times enlargement of 9 to show living chambers; (7) Permian "twig-like" bryozoan (actual size; range Ord.-Perm.).

Brachiopoda

Brachiopods are commonly called "lamp shells" due to their resemblance to ancient Grecian oil lamps. Once a dominant form of sea life, they have declined in number and variety over the ages. Only a few forms have survived to the present.

The brachiopod animal is enclosed by a shell of two valves, one usually larger than the other. It lived on the shallow ocean floor, usually attached to solid objects by a fleshy stalk. Because they were once abundant and had a hard shell, brachiopods are one of the most common of all fossils.

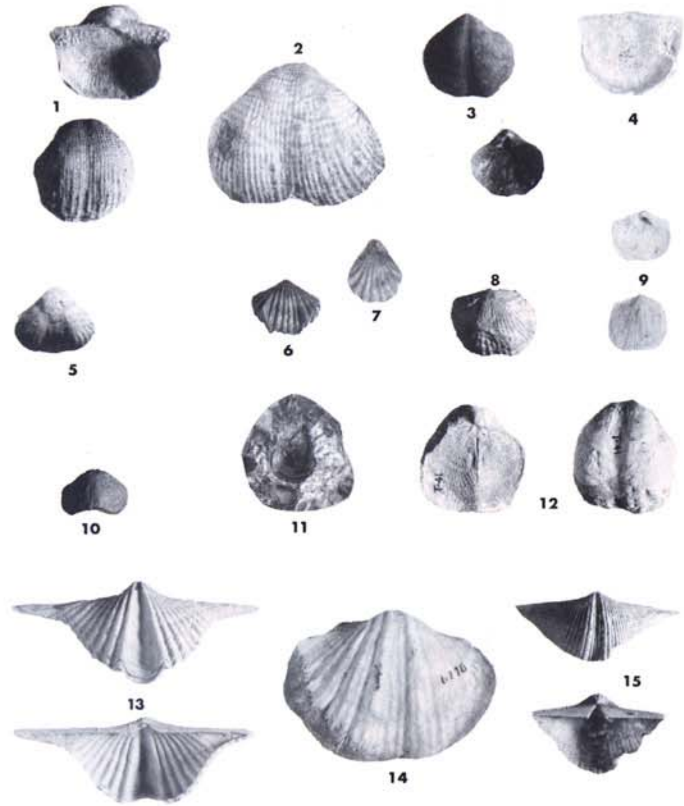

Fig. 22–Brachiopods. (1) and (2) *Dictyoclostus,* Permian (Range Miss.-Perm.); (3) *Ambocoelia,* Mississippian (Range Ord.-Perm.); (4) *Sowerbyella,* Ordovician (Range Ord.-Perm.); (5) *Lepidocyclus,* Ordovician (Range Ord.-Perm.); (6) *Camarotechia,* Mississippian (Range Ord.-Perm.); (7) *Hustedia,* Permian (Range Ord.-Perm.); (8) *Dinorthis,* Ordovician (Range Cam.-Perm.); (9) *Billingsella,* Cambrian (Range Cam.-Perm.); (10) *Rhipidomella,* Mississippian (Range Ord.-Perm.); (11) *Lingulepis,* Cambrian (Range Cam.-Cret.); (12) "productid", Permian (Range Miss.-Perm.); (13) "spiriferid", Permian (Range Miss.-Perm.); (14) *Neospirifer,* Permian (Range Miss.-Perm.); (15) "spiriferid", Mississippian (Range Miss.-Perm.) all specimens reduced approximately one-fourth.

Mollusca

Gastropods (snails), pelycypods (clams), and cephalopods (squid, octopus, and related fossil animals) comprise the most important classes of mollusks. All of these groups have a different external appearance, yet internally, their bodies are built on the same fundamental plan.

Gastropoda–Snails live in shallow marine water, lakes, streams, swamps, and a few forms live on land. Fossil snails are found in ancient sediments of all these environments in Wyoming. *Goniobasis,* the freshwater snail of the "Turritella Agate" of southwestern Wyoming, is the most common fossil snail in the state.

The shell is the only hard part of snails and is the only part preserved. Often, the shell is filled with sediment which later solidifies. If the shell is dissolved away, the form of the shell often remains preserved as an internal mold known as a "steinkern" (stonekernel).

Pelycypoda–Clams live in shallow marine and fresh water. They occur in great numbers and are readily preserved as fossils because of their hard shell. Internal molds of clam shells are also common. Fossil clams range in size from very small to "giant" forms like *Inoceramus,* some of which exceed three feet in length.

The shells of clams and brachiopods are similar in appearance but the soft body parts are very different and the two groups are not closely related. Since only the shells are preserved, the distinction between the two is based upon the form of the shell. Clams have a shell with valves of equal size, one a mirror image of the other. Brachiopods, on the other hand, have two shells of unequal size and one is not a mirror image of the other.

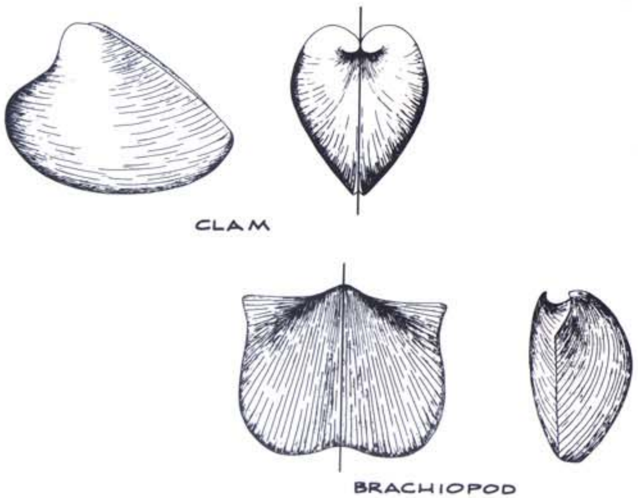

Fig. 23–A clam shell has two valves, one a mirror image of the other. Brachiopods have two valves of unequal size and one is not a mirror image of the other.

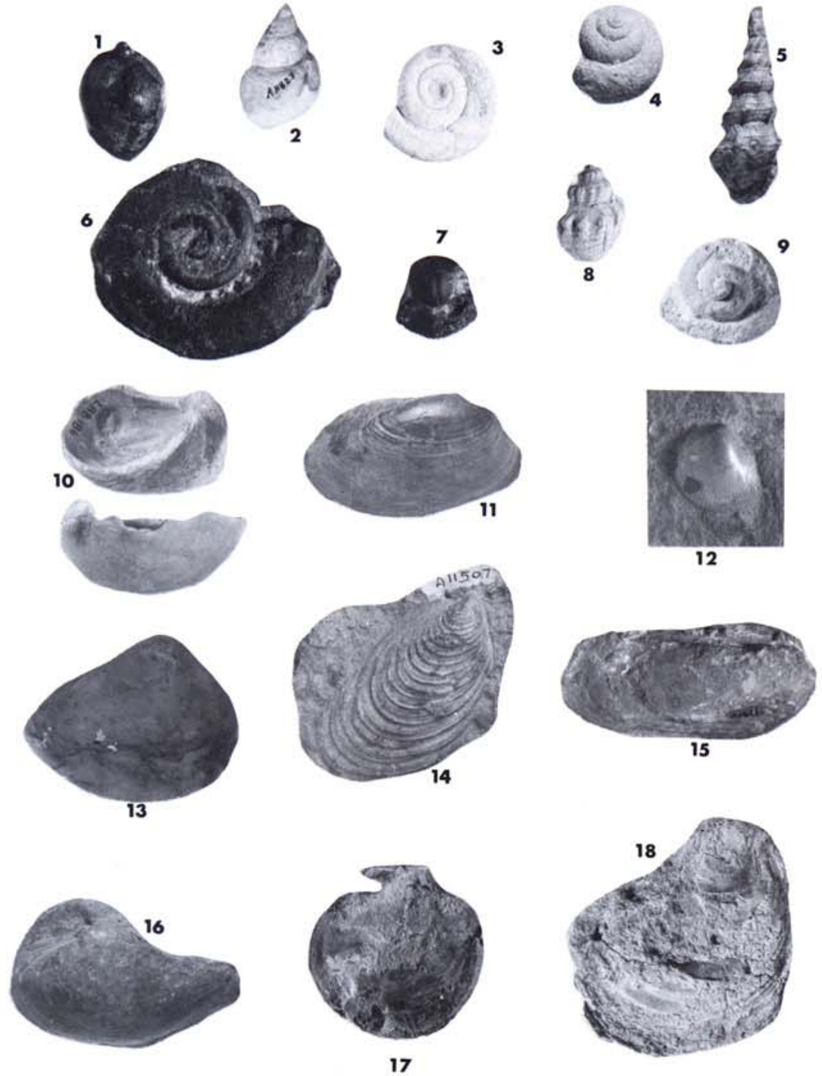

Fig. 24–**Gastropods and Pelycypods.** (1-5) Tertiary freshwater and terrestrial snails; (6-9) Marine snails; (10-16) Clams. (1) *Physa,* Eocene; (2) *Viviparus,* Eocene; (3) *Australorbis,* Eocene; (4) *Helix,* Oligocene; (5) *Goniobasis,* Eocene; (6) *Maclurites,* Ordovician (Range Ord.-Cret.); (7) *Bellerophon,* Permian; (8) *Pygrulifera,* Cretaceous (Range Ord.-Cret.); (9) *Liospira,* Ordovician (Range Ord.-Cret.); (10) *Gryphaea,* Jurassic; (11) *Elliptio,* Eocene(Range Tertiary); (12) *Melegrinella,* Jurassic (Range Miss.-Cret.); (13) *Kaibabella,* Permian (Range Miss.-Cret.); (14) *Inoceramus,* Cretaceous; (15) *Allorisma,* Permian (Range Miss.-Cret.); (16) *Corbula,* Cretaceous (Range Miss.-Cret.); (17) *Camptonectes,* a Jurassic scallop (Range Miss.-Cret.); (18) *Ostrea,* a Cretaceous oyster (Range Jur.-Cret.). All specimens reduced by approximately one-half.

Cephalopoda–Octopus and squid are the most highly developed and the largest of the invertebrate animals. In contrast to the sluggish, bottom-living invertebrates, cephalopods move about rapidly. With the aid of grasping tentacles and keen eyesight, they prey on other invertebrates and fish.

Some ancient cephalopods had a shell like that of the chambered Nautilus, a modern cephalopod of the South Pacific. The nautilus shell consists of a coiled tube divided into chambers. The animal lives in the forward chamber and, as it grows, it adds a new and larger chamber. When a new chamber is added, a line or suture is formed where the old and new chambers join.

Fossil cephalopod shells are classified for purposes of identification on the basis of the suture line between chambers. Nautiloids are those forms with a straight or simple suture pattern. Ammonoids are those forms with a folded pattern, sometimes highly complex. One group of cephalopods, the belemnites, developed an internal cigar-shaped shell which has a small circular opening at one end. Belemnites were probably similar to the modern cuttlefish which has an internal shell (cuttlebone). Belemnites are very common in Jurrasic rocks of Wyoming.

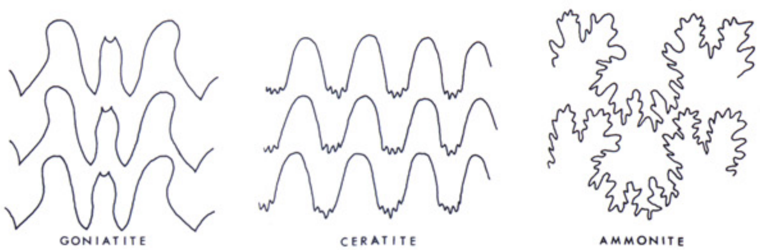

Fig. 25–There are three types of suture patterns in ammonoids, goniatite, ceratite, and ammonite. All Wyoming ammonoids have the ammonite suture pattern. The suture patterns are not visible unless the outer shell of the ammonite has been removed.

Fig. 26–A large Cretaceous ammonoid from the Cody Shale near Big Horn, Wyoming. (Courtesy Greybull Rockologist).

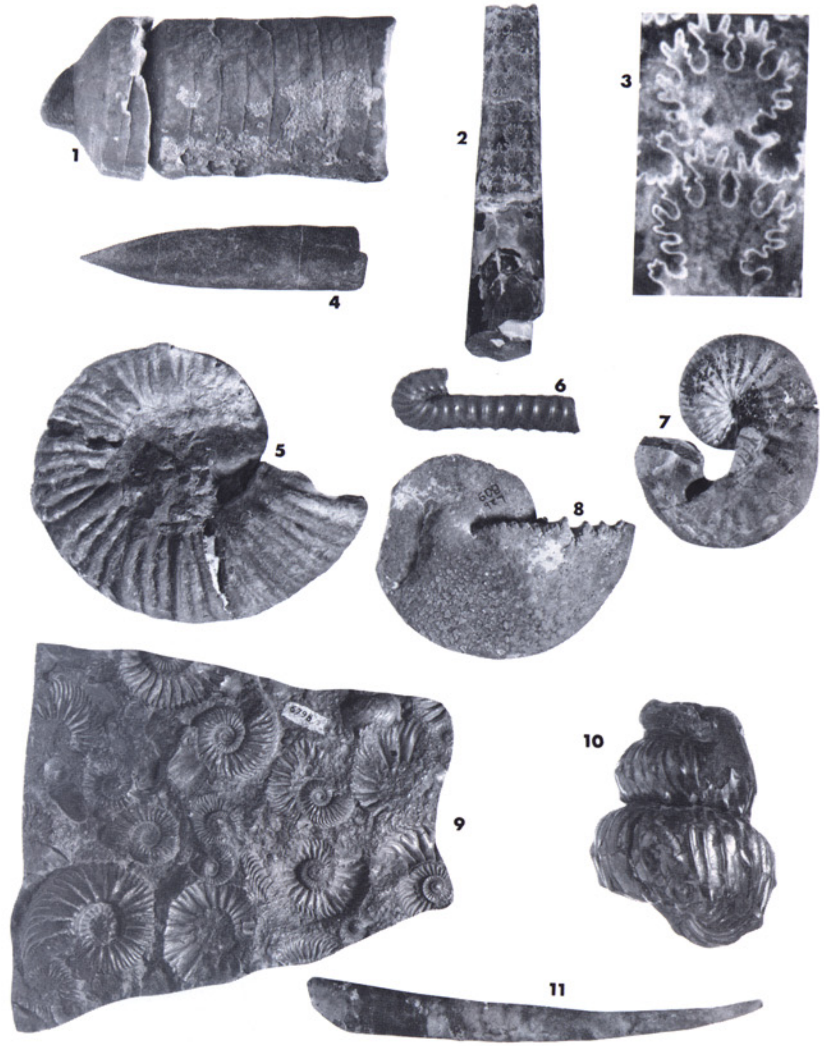

Fig. 27–Cephalopods. (1) *Endoceras,* Ordovician (length 5"); (2) *Baculites,* Cretaceous (length 3"); (3) enlargement of suture pattern of *Baculites*; (4) *Pachyteuthis,* Jurassic (length 3½"); (5) *Prionocyclus,* Cretaceous (size 4½"; range Jur.-Cret.); (6) *Oxybeloceras,* Cretaceous (length 2"); (7) *Scaphites,* Cretaceous (size 1"); (8) *Sphenodiscus,* Cretaceous (size 4½"; range Jur.-Cret.); (9) *Cardioceras,* Jurassic (size 3"; range Jur.-Cret.); (10) *Didymoceras,* Cretaceous (length 3"; range Jur.-Cret.); (11) scaphopod mollusk, Permian (length 3½"; range Perm.-Cret.).

Arthropoda

Common Arthropods include insects, crustaceans (crabs, lobsters, crayfish, and related forms), and spiders. As any gourmet knows, crab and lobster have a tough external skeleton. Though less notable, other arthropods also have a tough external skeleton which aids in their preservation as fossils.

The only common arthropod fossils in Wyoming are trilobites. As the name implies, trilobites (tri-3, lobite-segmented) have a segmented body consisting of three parts, the head, thorax (trunk), and tail. Upon death, the three parts of the skeleton usually separate. Complete fossil trilobites are relatively uncommon in Wyoming.

Trilobites were marine bottom-living animals. They were the most common form of life during the Cambrian. They steadily decreased in number and type after the Cambrian and were extinct by the end of the Permian.

Insects are relatively rare as fossils. They are found in only a few regions and formations in the world. The fine shales of the Green River Formation contain fossil insects but they are not common.

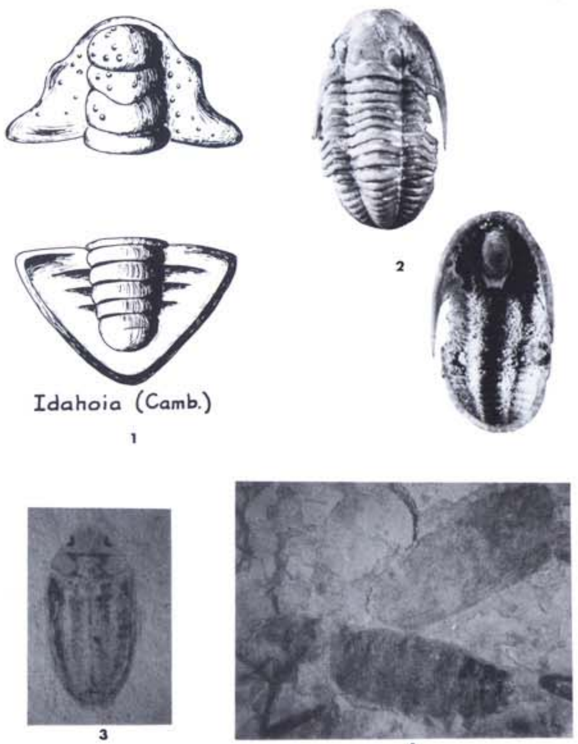

Fig. 28–Arthropods. (1) Sketch of *Idahoia*, a Cambrian trilobite, to show a disarticulated specimen. Separate halves of the animal are commonly found; (2) Mississippian trilobite (length 1/2"); (3) and (4) Fossil insects from the Green River Formation (enlarged by 2; courtesy of P. O. McGrew).

Echinodermata

Starfish, sea urchins, sea cucumbers, sand dollars, and crinoids comprise the echinoderms. Although all of the echinoderms mentioned are found as fossils, the only common echinoderm fossils in Wyoming are crinoids.

Crinoids resemble flowers and are commonly known as sea lilies. Most crinoids attach to the sea floor by means of a long stem or stalk. The body organs occupy a small cup-like swelling at the top of the stem. The animal feeds by filtering small organisms from the water with the aid of arms surrounding the mouth. Whole crinoids are rarely found as fossils. More commonly, only small sections of the stem that resemble beads are found.

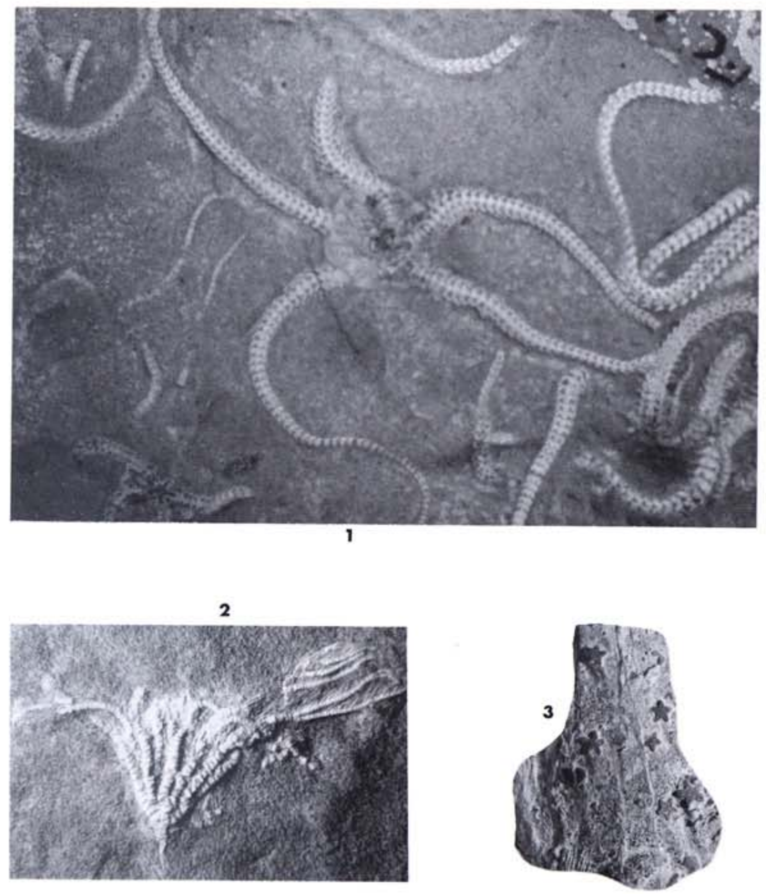

Fig. 29–Echinoderms. (1) Jurassic "brittle star" (Range Jur.-Cret.; photo courtesy of Tom Wheelock); (2) Jurassic crinoid cup and arms (Range Ord.-Cret.; photo by P. O. McGrew); (3) Star shaped plates from crinoid stalk (Range Ord.-Jur.).

VERTEBRATE FOSSILS

Early Evolution

The concept of gradual change in life forms through time is an important concept to grasp and it is well illustrated by the evolution of vertebrates from invertebrates. Invertebrates are animals without a backbone in contrast to vertebrates which have a backbone. Where did the backbone come from and why is it so important? Sometime in the past, a gradual change from bottom-dwelling rather sluggish invertebrates to free-swimming, fast-moving forms took place. They continued to change generation by generation spurred on by their success in competition with other invertebrates. This was not the first time the free-swimming habit had evolved but this time a backbone gradually developed. The backbone was the key to success for vertebrates because it is a light weight internal skeleton which grows with the animal and provides a place for muscle attachment necessary for rapid locomotion. Freed of a bulky external skeleton and a sedentary bottom-dwelling existence, vertebrates gradually developed new sensory organs, appendages, and intelligence with which to exploit new environments. In their earliest stages of development vertebrates were competing with highly developed, well-established invertebrates.

Fish

Among the oldest known vertebrates are fossil fish from Ordovician deposits in the Big Horn Mountains. These primitive fish had no limbs and belong to the class Agnatha which means jawless. Agnathids were heavily armored with bone plates and sheilds, probably for defense against large invertebrates.

Fig. 30–Head plate of a primitive jawless fish from the Big Horn Mountains. (Photo courtesy of Robert H. Denison).

Sharks, skates, and rays belong to the class Chondrichthyes which means cartilaginous fish. The shark skeleton is made entirely of cartilage (gristle) and is not readily preserved. Shark teeth, however, are common fossils in marine rocks throughout the state. Fish of the class Osteichthyes are the most advanced and abundant of all fish. The name Osteichthyes refers to their boney skeleton. Typical modern representatives of the class include trout, bass, perch, and all other modern fish excluding the sharks and its relatives, and eels. Wyoming is famous for its well-preserved fossil fish from the Eocene Green River Formation. In addition to these fine fossils, fish scales and skeletal elements are found in both marine and freshwater deposits throughout the state.

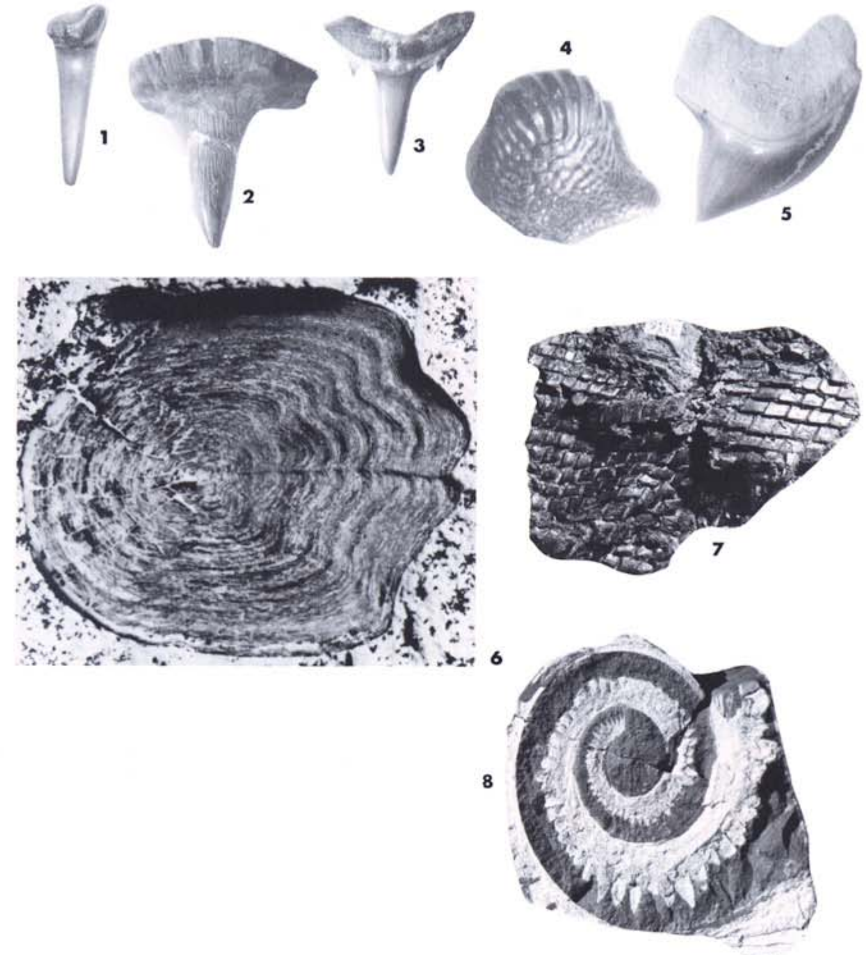

Fig. 31–Fish Teeth and Scales. (1-5) Shark teeth from Frontier Formation. All are approximately 1" in length; photos by P. O. McGrew. (1) *Isurus*; (2) *Cladodus*; (3) *Odontaspis*; (4) *Ptychodus*; (5) *Corax*; (6) fish scale greatly enlarged to show growth rings; (7) Gar scales (each scale approximately 1/2" long); (8) Tooth whorl of *Helicoprion*, a Permian shark. The front teeth of this shark were not shed as in other sharks but were retained and buried in the inner part of the spiral of replacing teeth. (Photo courtesy of Frank Kistner; approximately 7" wide).

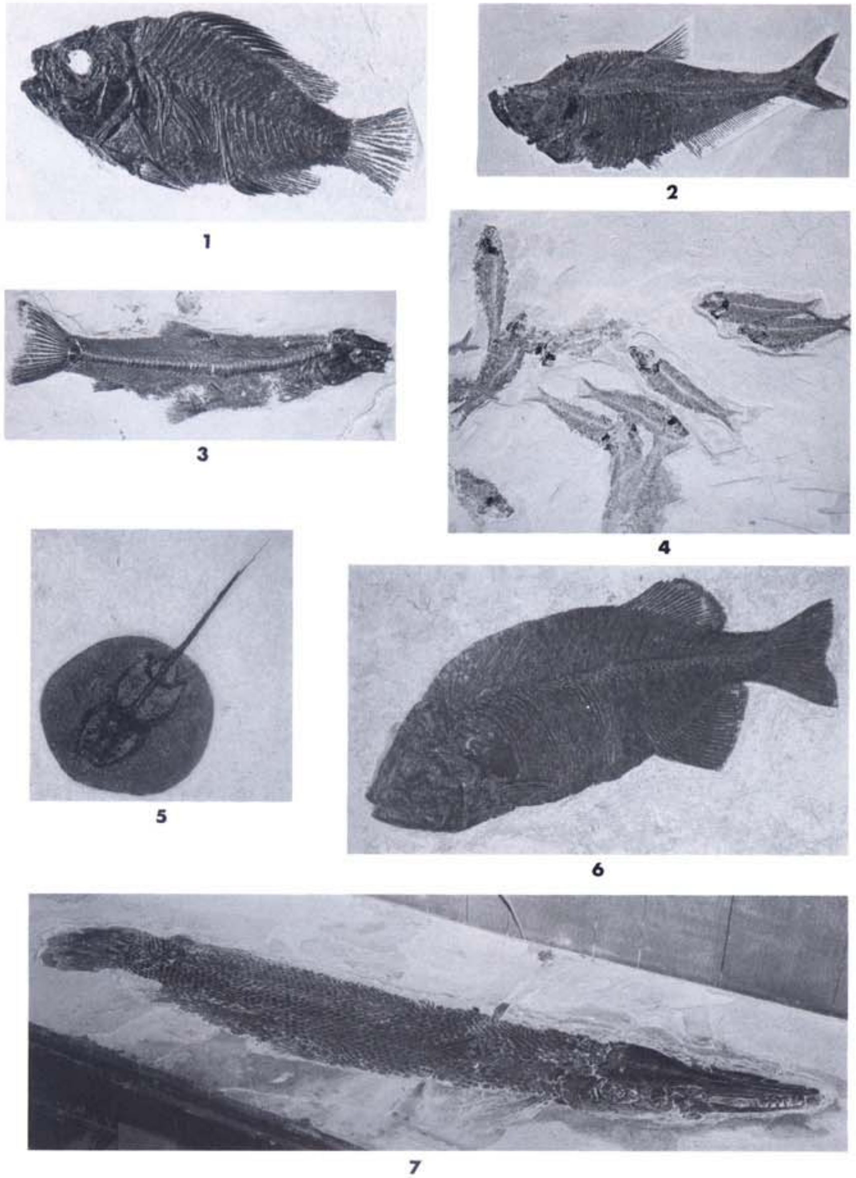

Fig. 32–Fossil Fish from the Eocene Green River Formation. (1) *Priscacara,* a member of the bass family (length 5"); (2) *Diplomystus,* a member of the herring family (length 18"); (3) *Notogoneus,* (length 2'); (4) *Knightia,* a herring-like fish (length 5"); (5) a "sting ray" (length 14"); (6) *Phareodus,* a member of a family of fish presently restricted to tropical regions (length 2'); (7) a large gar, 5'9" long (photo courtesy of Wallace Ulrich).

Amphibians

Modern lungfish of Africa and Australia have the ability to breath air and crawl about on land for short periods of time. Amphibians evolved from fish similar to the modern lungfish by the gradual change over millions of years of fins to limbs and improvements in the lung. The word amphibian means "both kinds of life." Anyone who has witnessed the miraculous change of a fishlike tadpole to a frog is aware that amphibians do indeed live "both kinds of life." Amphibians do not stray far from water because they must return to it to lay their eggs.

Few amphibian fossils are found in Wyoming and those that are found are fragmentary. The amphibian skull illustrated (Fig. 37) is from Texas but represents one type of amphibian that inhabited Wyoming.

Reptiles

The major feature in the evolution of reptiles from amphibians was the development of an enclosed (shelled) egg which "liberated" reptiles from the semi-aquatic environments of amphibians. They were then free to exploit the land but were restricted to warm climates. Reptiles are "cold-blooded" (unable to maintain a constant body temperature) and could not survive in cold climates.

Marine Reptiles–No sooner did reptiles evolve than some of them returned to the water. Ichthyosaurs resembled modern dolphins and presumedly lived much like dolphins feeding on fish. Mososaurs (giant marine lizards) are known to have reached 45 feet in length and also fed on fish.

Dinosaurs–Most spectacular of the fossil reptiles are the dinosaurs. The word dinosaur means "terrible lizard," a fitting name for giants such as *Brontosaurus* and *Tyrannosaurus* but, somewhat of a misnomer for small dinosaurs no larger than a rooster. The six most common groups of dinosaurs are discussed below.

Theropoda (Carnivores or "meat eaters")–The best known of the meat eaters is the Cretaceous *Tyrannosaurus rex* ("king of dinosaurs") the largest land-dwelling flesh eater known. *Tyrannosaurus* reached a length of 47 feet and stood 20 feet high. It walked on powerful hind legs. The front legs were very small and were too short to reach the mouth and probably too weak to seize prey. Another well-known carnivorous dinosaur is *Allosaurus (Antrodemus).* It was slightly smaller than *Tyrannosaurus* and lived during the Jurassic.

Sauropoda (Giant Herbivores)–Sauropods were plant-eaters which reached gigantic size and walked on all four legs. They were heavily built animals with powerful limbs, a long tail, and long neck with a small head. *Apatosaurus* (incorrectly called *Brontosaurus*), and *Diplodocus* are the best known of these giants. *Apatosaurus* was about 80 feet long and weighed up to 40 tons. *Diplodocus* was slightly smaller. Both *Apatosaurus* and *Diplodocus* have been found in the famed Como Bluff dinosaur beds.

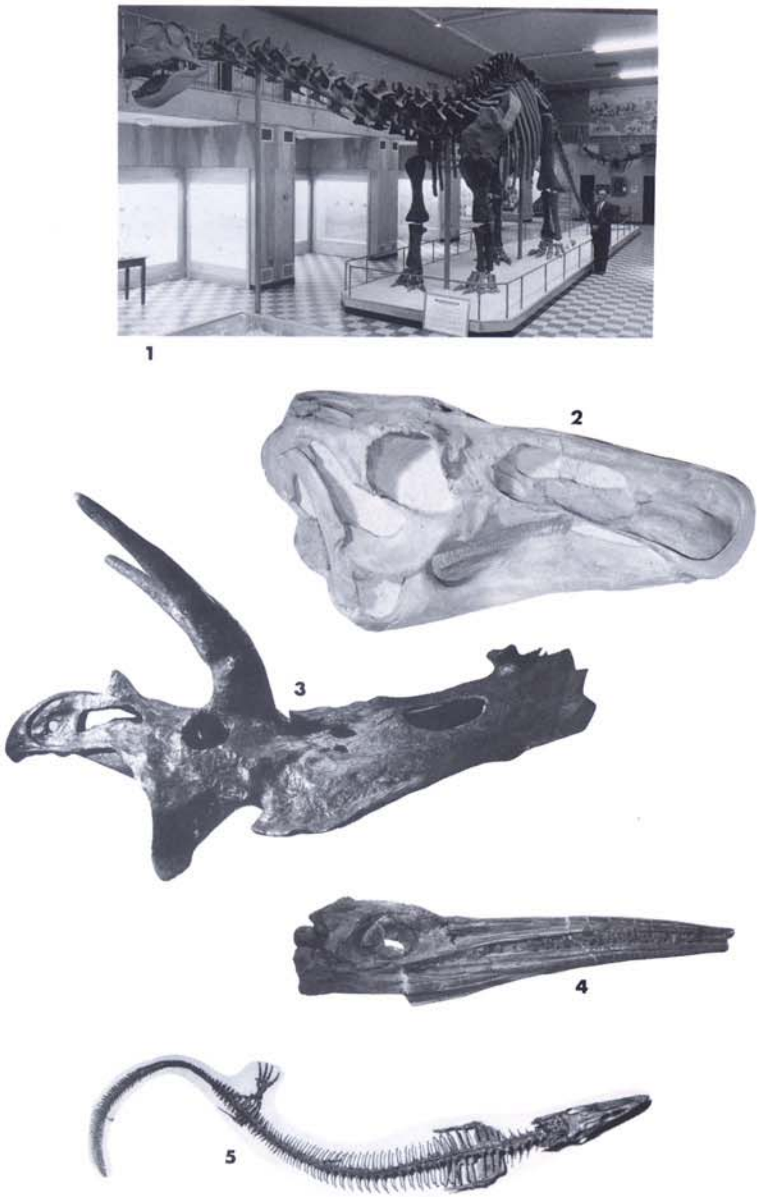

Fig. 33–Large Mesozoic Reptiles. (1) *Apatosourus* [*Brontosaurus*], prepared by Dr. S. H. Knight (standing beside the dinosaur). This specimen is 75' long, 15' tall, and probably weighed over 30 tons. (2) *Anatosaurus*, a duck-billed dinosaur skull (length 3½'); (3) *Anchiceratops*, a three-horned dinosaur (length 5'); (4) Ichthyosaur skull (length 4'); (5) A "giant marine lizard" or mososaur, *Clidastes* (length 25').

Ornithopoda (Duck-billed dinosaurs)–The duck-billed dinosaurs had a toothless flat beak and a jaw that contained leaf-like grinding teeth. Duck-bills fed on soft vegetation in swamps and lakes. Remains of duck-bill dinosaurs are quite common in Cretaceous rocks of northeast Wyoming. One specimen was found which had dried before burial and impressions of its skin were preserved in the rock.

Stegosauria (Plated Dinosaurs)–*Stegosaurus* was about 20 feet long and walked on all four legs. The front legs were shorter than the hind legs and *Stegosaurus* was a slow moving creature. The most conspicuous feature of this beast was the double row of plates and spines down its back. The tip of its tail had long boney spikes which were used for protection from predators. Stegosaurs, like many other dinosaurs had an exceedingly small brain and a swelling of the spinal cord in the hip region larger than the brain which carried out some of the nervous functions usually associated with the brain. This arrangement inspired a poem by Bert Leston Taylor, THE DINOSAUR.

The Dinosaur*

Behold the mighty dinosaur,
Famous in prehistoric lore,
Not only for his power and strength
But for his intellectual length.
You will observe by these remains
The creature had two sets of brains–
One in his head (the usual place)
The other at his spinal base.
Thus he could reason "A priori"
As well as "A posteriori."
No problem bothered him a bit;
He made both head and tail of it.
So wise was he, so wise and solemn,
Each thought filled just a spinal column.
If one brain found the pressure strong,
It passed a few ideas along.
If something slipped his forward mind,
"Twas rescued by the one behind,"
And if in error he was caught,
He had a saving afterthought.

*First published in the Chicago Tribune.

Ankylosauria (Armored Dinosaurs)–Ankylosaurs, sometimes called "reptilian tanks," were the best armored of the reptiles. They resembled the modern "horned toad" in general appearance. ***Ankylosaurus*** was about 17 feet long, 6 feet wide, and 4 feet high. It's back was covered with boney plates and the sides had long spines.

Ceratopsia (Horned Dinosaurs)–Triceratops is perhaps the best known of the horned dinosaurs. It was 16-20 feet long with the head making up a third of the length. The disproportionate length of the skull is due to a backward extension of bone which provided protection to the neck and shoulders. As the name implies, *Triceratops* had three long horns on the skull for protection. The first "horned dinosaur" ever found was discovered near Lance Creek, Wyoming.

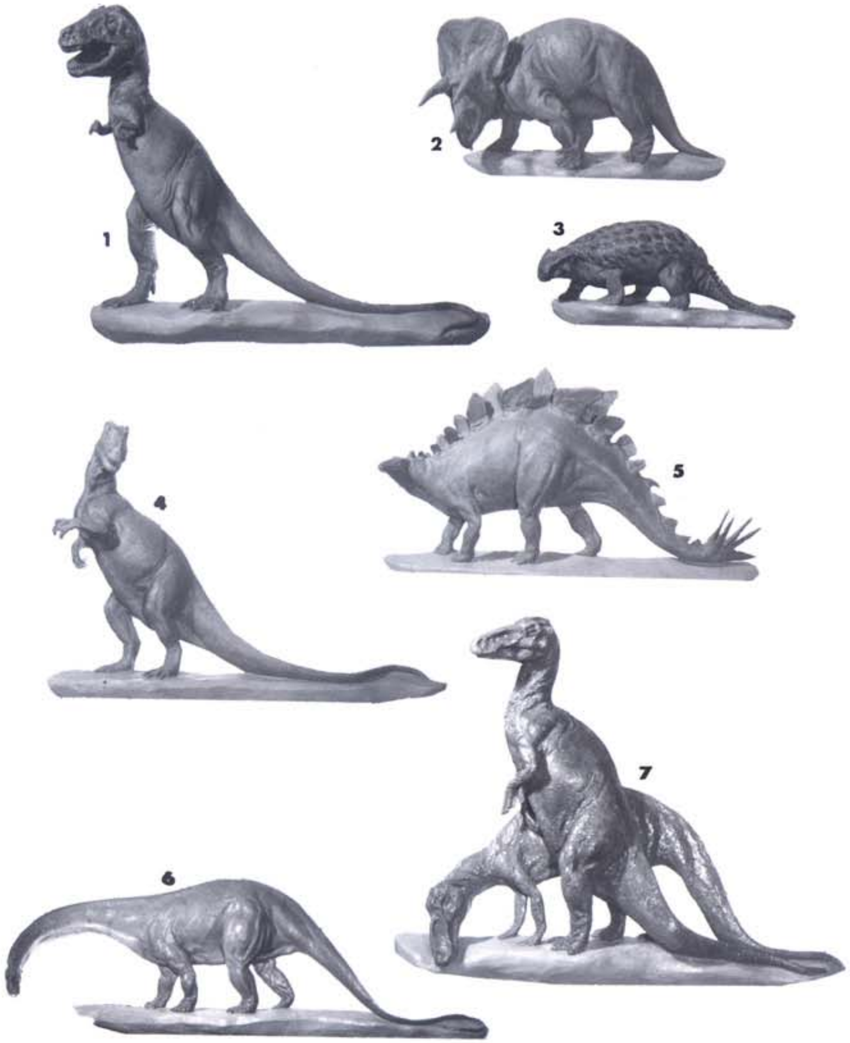

Fig. 34–Dinosaur Reconstructions. (1) *Tyrannosaurus* (Cretaceous); (2) *Triceratops* (Cretaceous); (3) *Ankylosaurus* (Cretaceous); (4) *Allosaurus* (Jurassic); (5) *Stegosaurus* (Jurrasic); (6) *Apatosaurus* [*Brontosaurus*] (Jurassic); (7) *Anatosaurus* [*Trachodon*] (Cretaceous).

Fig. 35–Life size reconstruction of ***Tyrannosaurus rex*** by Dr. S. H. Knight, outside of the University of Wyoming Geology Museum. (Photo by Ted Edeen, U.W. Photo Service).

Turtles–Turtles of freshwater lakes and swamps and tortoises ("land turtles") are very common fossils in Paleocene, Eocene, and Oligocene rocks. Turtle shells are composed of many individual pieces held together by organic matter. In most turtle fossils, the pieces of the shell have come apart and must be carefully put back together like a jig saw puzzle.

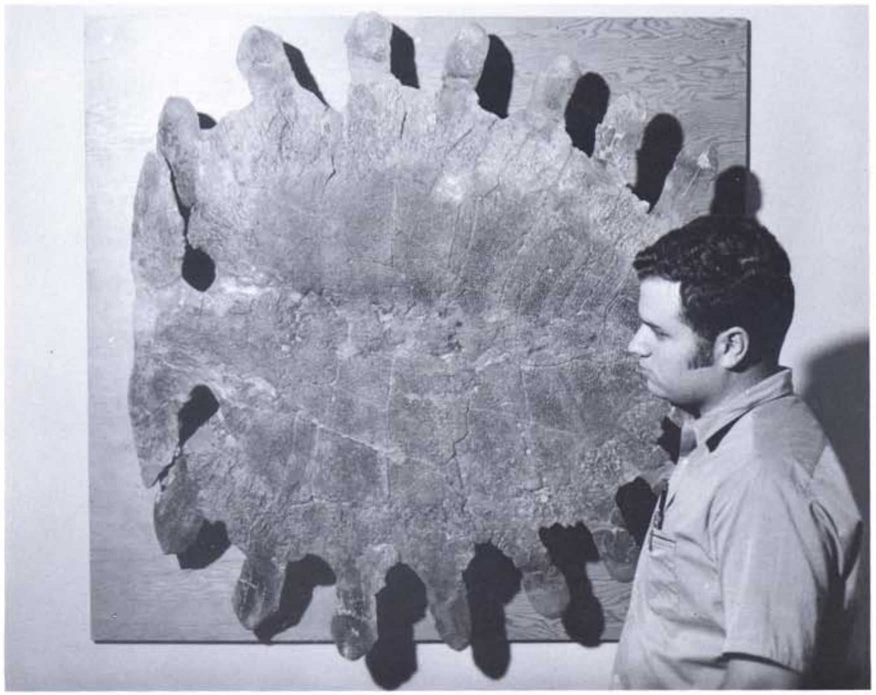

Fig. 36–55 million year old soft-shelled turtle from the Bridger Formation, Lincoln County, Wyoming. Viewing the turtle is Danny Walker, museum preparator.

Crocodiles–Crocodiles lived in the swamps and rivers of Wyoming in the warm humid climates of the Paleocene, Eocene, and Oligocene. Whole crocodile skeletons are rare but skulls are occasionally found.

Birds

Much to the horror of bird lovers, birds have been described as "glorified reptiles." Through a process of gradual change over millions of years, birds evolved from reptiles by the Jurassic period. They are rarely preserved as fossils because of their lightweight delicate bones. A few good bird fossils have been found in the Eocene rocks of the Green River Basin.

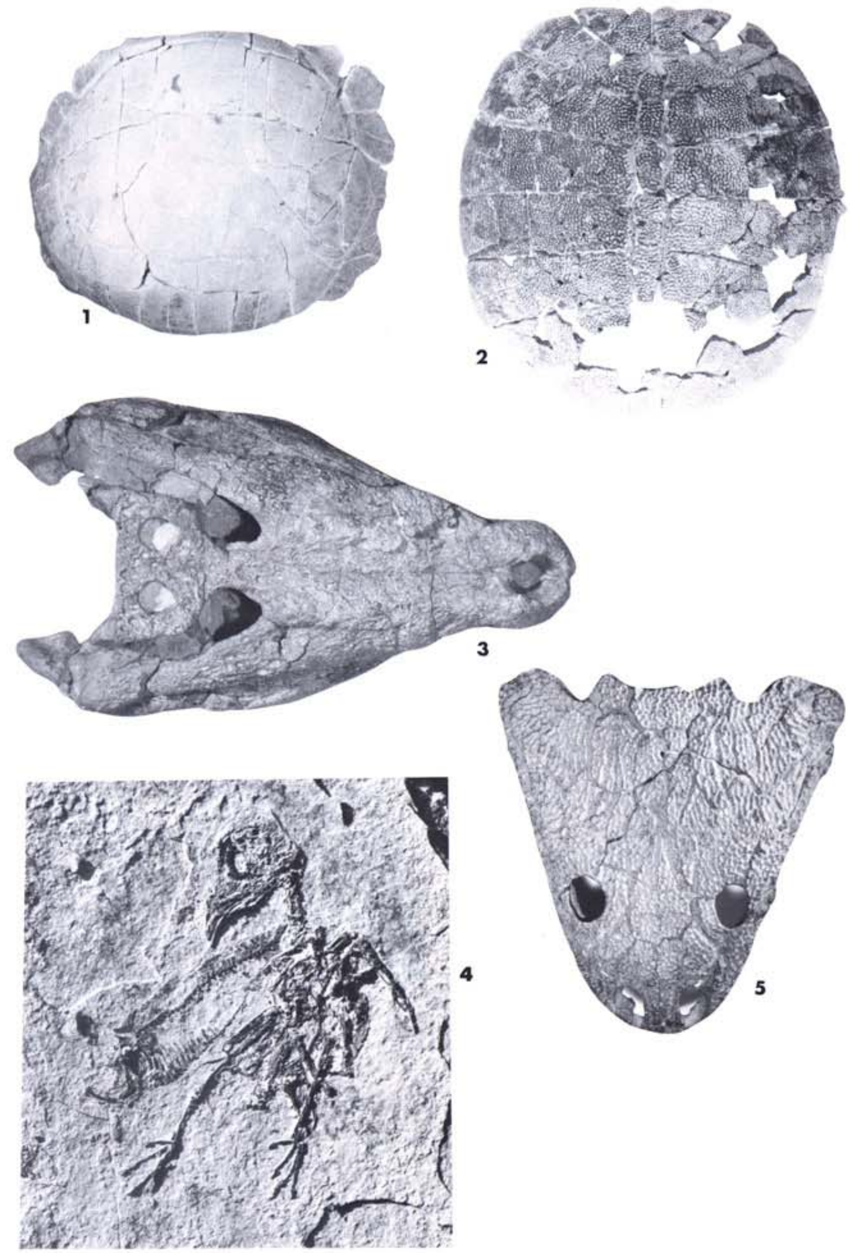

Fig. 37–Amphibian, Reptiles and Birds. (1) Oligocene tortoise (length 12"); (2) An Eocene turtle, *Trionyx* (length 18"); (3) An Eocene crocodile skull (length 2½'); (4) a very rare Eocene bird fossil and a small fish (length 4"; photo courtesy of Frank Kistner); (5) A triassic amphibian skull from Texas of the type found in Wyoming (length 20").

Mammals

Humans are mammals. Mammals are born alive (not hatched from an egg), and they are nourished with milk. Mammals have hair, and are able to maintain a constant body temperature (98.6° in humans). They are able to withstand extremes of temperature because of their constant body temperature and are said to be "warm-blooded."

Mammals evolved from reptiles during the Triassic period. A few Jurassic animals are known from Como Bluff, Wyoming, and a few Cretaceous mammals are found in the Lance Formation, but mammals were rare until the Paleocene epoch.

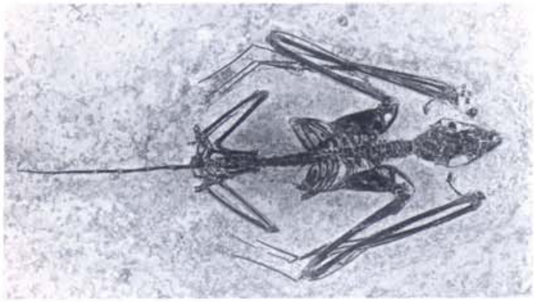

Fig. 38–Oldest known flying-mammal, a bat from the Eocene Green River Formation of western Wyoming. (Photo courtesy of Princeton University Museum of Natural History).

Primates–Primates lived in the warm humid climates of the Paleocene, Eocene, and Oligocene of Wyoming. They are rare fossils and usually only their teeth are found.

Carnivores–Carnivores are flesh-eating mammals with clawed feet and sharp teeth adapted for tearing and cutting flesh. Dogs and cats are typical carnivore representatives. They are uncommon fossils because carnivores are solitary in habit and, obviously, fewer in numbers than animals on which they prey.

Archaic Mammals–Some of the early mammals were bizarre grotesque creatures. These groups were not in the main line of evolution but were highly specialized branches which soon became extinct.

Uintatherium and *Coryphodon* are examples of archaic mammals found in Paleocene and Eocene rocks in Wyoming. *Uintatherium* was as large as a rhinocerous with four boney knobs on its skull and large canine teeth. *Coryphodon* was a large, heavily-built animal with a large body, short legs, and feet resembling those of elephants. It had a large skull and the males had large canine teeth probably used in fighting.

Proboscideans–As the name implies, proboscideans (elephants and their relatives) have a long proboscis or trunk. Most of them also have long tusks (modified teeth) that may measure several feet in length. Among the early elephants in Wyoming was a form with long shovel-shaped tusks used for "grubbing" in the mud for soft plants. A few ice age mammoths have been found in the State. One important discovery near Rawlins was a nearly complete mammoth skeleton associated with an early Indian stone knife blade.

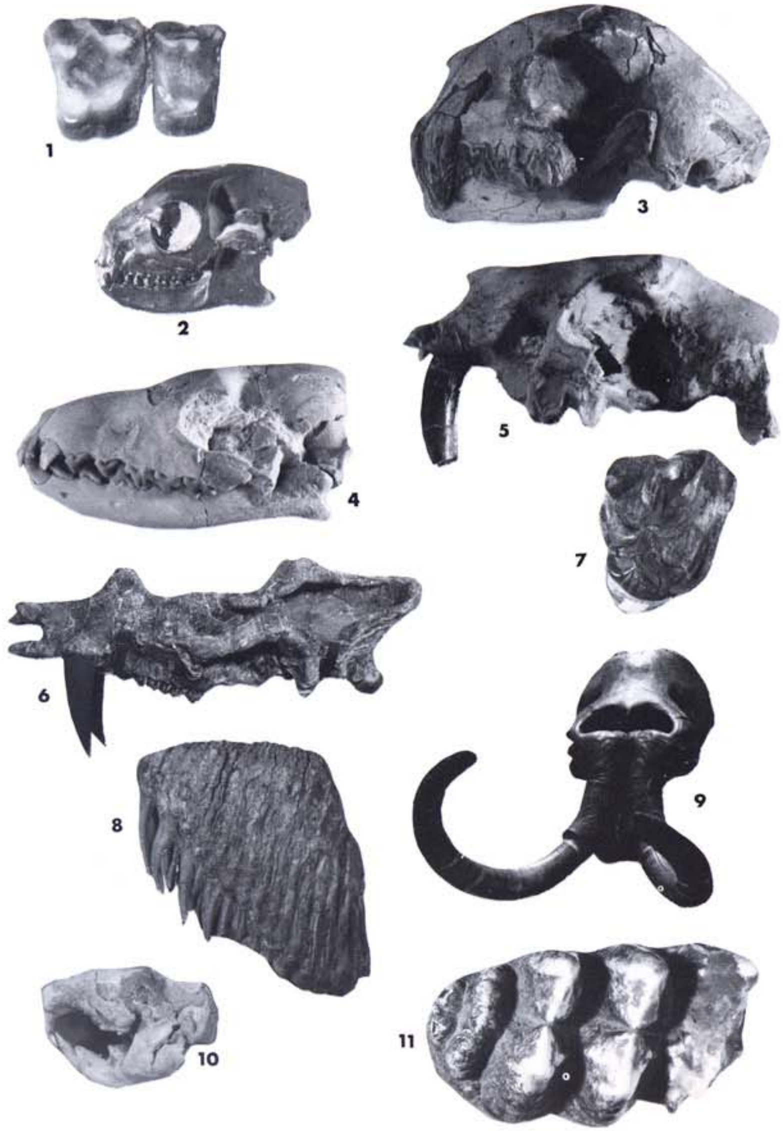

Fig. 39–Mammal Skulls and Teeth. (1) Eocene primate teeth, *Notharctus* (length of each tooth ¼"); (2) An Eocene primate skull (length 3"); (3) *Dinictus*, an Oligocene false-saber tooth tiger (skull length 5"); (4) *Hyaenodon*, an Oligocene dog-like carnivore (skull length 11"); (5) *Hoplophoneus*, an Oligocene saber-tooth tiger (skull length 5"); (6) *Bathyopsis*, an Eocene archaic mammal (skull length 18"); (7) Tooth of *Coryphodon*, an Eocene archaic mammal (length 2"); (8) Pleistocene mammoth tooth (length 8"); (9) Pleistocene mammoth skull, *Mammuthus*, found near Rawlins associated with indian artifacts (tusk length 6'); (10) Miocene beaver skull (length 2½"); (11) Pleistocene mastodon tooth (length 8").

Perissodactyls–Perissodactyls include the rhinocerous, titanothere, and horse in which the central or "odd-toe" provides the main body support. Fossil perissodactyls are relatively common and much is known of their evolution.

Rhinoceros–"Rhinos" lived in Wyoming from the Eocene to the Pliocene. They increased greatly in size from small Eocene creatures to beasts 12 feet in length by the Miocene. "Rhinos" are readily identified by the π-shaped pattern of their molars.

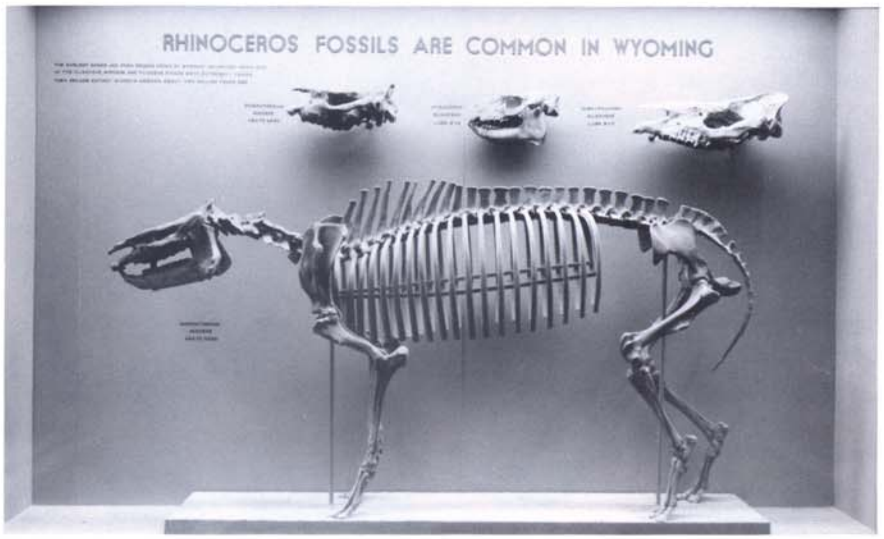

Fig. 40–Rhinocerous exhibit in the University of Wyoming Geology Museum.

Titanotheres–Titanotheres were animals which looked somewhat like the modern "rhinos." Eocene titanotheres were small (40 inches high at the shoulders) but they soon reached gigantic proportions of over 12 feet in length, 8 feet high, and they may have weighed as much as 4 tons. The upper molars of titanotheres are diagnostic and consist of w-shaped crest on one side of the tooth and a large cone on the other.

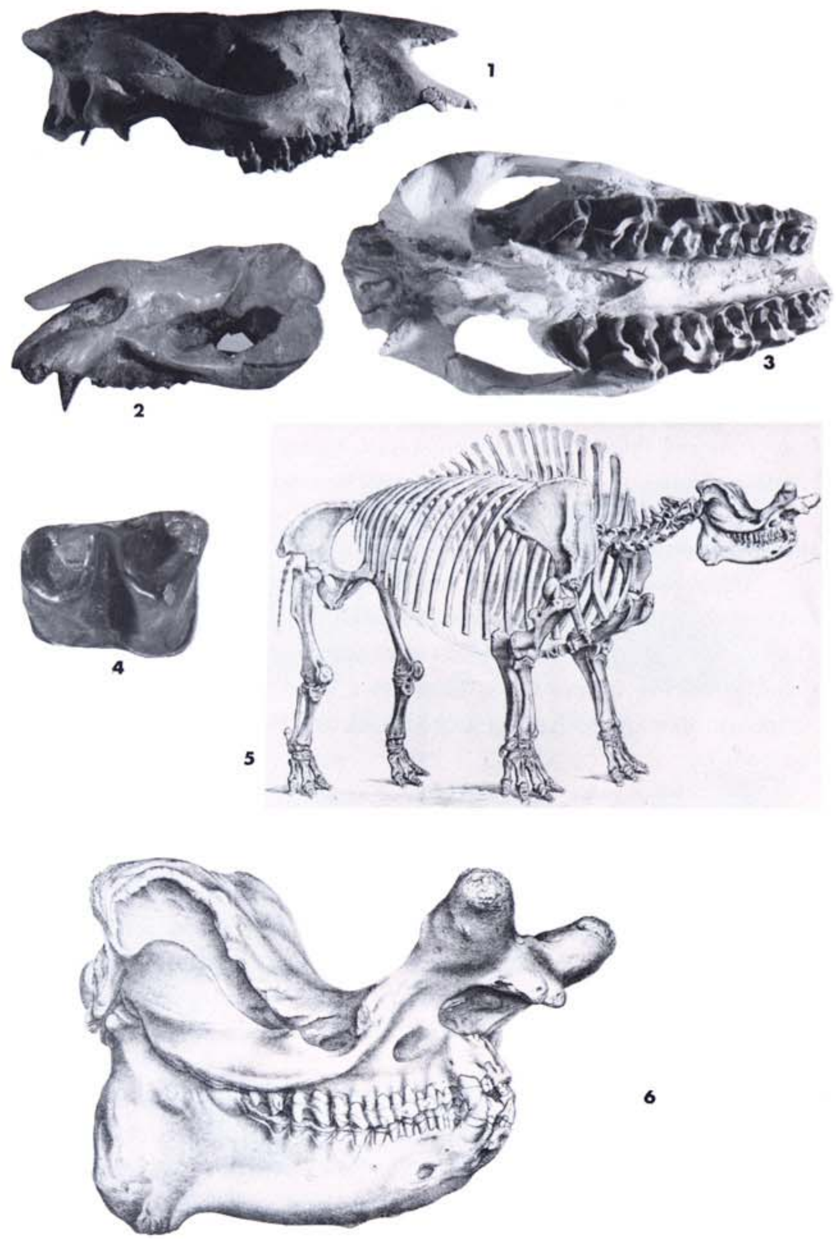

Fig. 41–Perissodactyls. (1) Eocene *Hyrachyus* skull (length 11"); (2) *Limnohyops*, an Eocene titanothere (skull length 22"); (3) *Caenopus*, an Oligocene rhinoceros (skull length 14"); (4) titanothere tooth (length 3"); (5) and (6) An Oligocene titanothere (height at the shoulders as great as 12'; from Osborn, by permission American Museum of Natural History).

Horses–Through study of hundreds of specimens, a very complete picture of the sequence of gradual change in the horse lineage has emerged. The history of the horse family is one of the clearest and most convincing demonstrations of the fact of evolution. A number of fossils, from the oldest known horse to the modern horse can be laid in a series in which adjacent fossils of slightly different age are very difficult to tell apart but fossils further apart in the series and in age can readily be separated. From such a series, the fact of gradual change with time (evolution) becomes evident.

Horses lived in North America from the Eocene to the Pleistocene Epochs. Fossil horses from rocks of each succeeding epoch show a gradual increase in size, a reduction of toes from 5 to 1, and a change in tooth pattern.

The oldest known horse, *Hyracotherium* (better known as "eohippus," the dawn horse) was about 20 inches high at the shoulders and had four toes on the front foot and three toes on the hind foot. *Hyracotherium* was a forest dwelling animal and had low-crowned teeth adapted to a diet of soft leaves.

Eohippus gradually changed during the Eocene, giving rise to *Orohippus* and *Epihippus* but they were only slightly different.

Mesohippus, an Oligocene horse, was about as large as a collie dog. Its teeth were low crowned and, like *Eohippus,* fed on leaves and soft vegetation. The toes on the feet of *Mesohippus* were reduced to three in front and back and a vestige of the former toe is found as a small splint on the leg bone. Like *Eohippus, Mesohippus* had an arched back and the hind legs were longer than the front legs.

Mesohippus was followed by a number of horse genera, the most important in terms of a series leading to the modern horse was *Merychippus,* a Miocene horse. It was about as large as a Shetland pony. The middle toe of each foot was large and the side toes were short. The teeth of *Merychippus* were high-crowned and the enamel pattern was complex and set in cement, an adaptation for grazing on harsh prairie-grasses which were becoming abundant for the first time. The legs adapted for running and the teeth adapted for grazing indicate that *Merychippus* and later horses took up life on the prairies and plains.

Changes from *Merychippus* to the modern horse (*Equus*) involved mainly an increase in size, perfection of the grinding teeth, and the loss of toes. Horses became extinct in North and South America before the discovery of the Americas by white men. Modern horses were reestablished in their former homeland by early settlers and explorers.

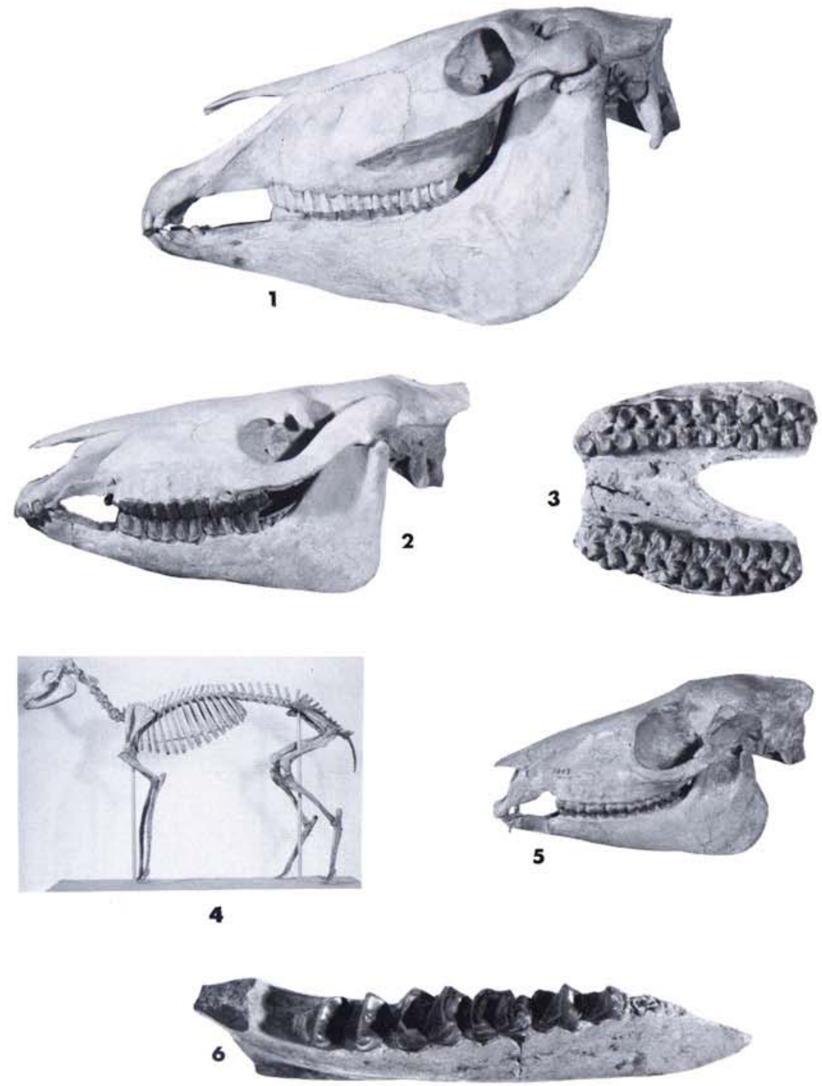

Fig. 42–Perissodactyls. (1) *Equus,* a modern horse (skull length 24"); (2) *Parahippus,* a Miocene horse (skull length 12"); (3) Upper jaws and teeth of *Mesohippus,* an Oligocene horse (length 4½"); (4) *Mesohippus* skeleton (3' high at the shoulders); (5) *Mesohippus* skull (length 6"); (6) *Hyracodon* lower jaw fragment (length 5").

Artiodactyls–Artiodactyls are animals such as pigs, camels, deer, antelope, cattle, sheep, goats, entelodonts, and oreodonts in which the even-numbered hoofed toes support the weight equally (cloven-footed).

Entelodonts–Entelodonts were pig-like beasts which flourished during the Oligocene. They are not true swine but due to their large size are often referred to as "giant pigs." One such entelodont, *Dinohyus,* was 10½ feet long and 7 feet tall at the shoulders.

Oreodonts–Oreodonts were small, stocky animals somewhat pig-like in appearance. They flourished during the Oligocene and Miocene and are the most common fossils of that time.

Camels–The major part of the evolutionary development of camels occurred in North America. Camels were abundant in Wyoming during the Oligocene, Miocene, and Pliocene. They became extinct in North America at the end of the Pleistocene.

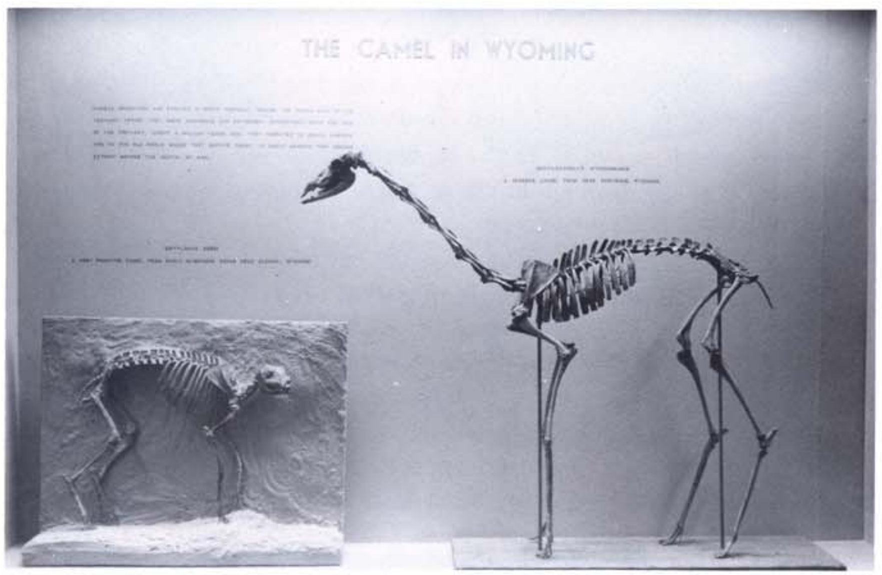

Fig. 43–Camel exhibit in the University of Wyoming Geology Museum.

Deer–*Leptomeryx,* a small deer, was very common in Wyoming during the Oligocene. It was 18-20 inches tall and resembled the modern Chevrotain of Asia and Africa. *Hypisodus,* a close relative of *Leptomeryx*, was not much larger than a modern rabbit.

Pronghorn Antelope–The ancestors of pronghorn "antelope" are found in Miocene and Pliocene rocks. Herds of *Merycodus* roamed the plains 10-20 million years ago as the modern pronghorn (*Antilocapra americana*) do today.

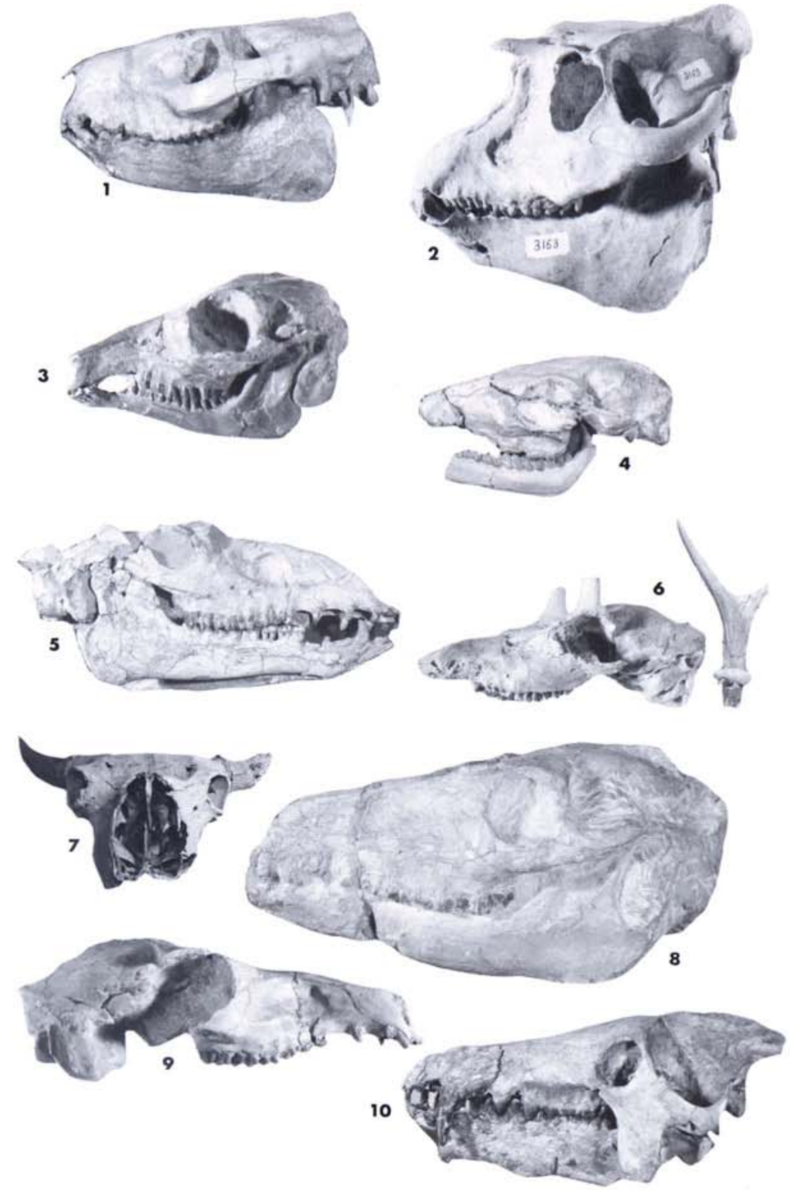

Fig. 44–Artiodactyls. (1) *Merycoidodon,* an Oligocene oreodont (skull length 8"); (2) *Brachycrus,* a Miocene oreodont (skull length 8"); (3) *Hypisodus,* a small Oligocene deer (skull length 2½"); (4) *Leptomeryx,* a small Oligocene deer (skull length 3½"); (5) *Oxydactylus,* a Miocene camel (skull length 1½'); (6) *Merycodus,* a Miocene and Pliocene prongbuck (skull length 6"); (7) Recent *Bison* skull; (8) and (9) *Poebrotherium,* an Oligocene camel (skull length 7"); (10) *Archaeotherium,* an Oligocene "giant pig" (skull length 20").

PLANTS

Many fossil plants are very useful to geologists because they reliably indicate the temperature and precipitation that prevailed at the time the plant was living. Cycads, tropical fern-like evergreens, were common during the Mesozoic Era. Palm leaves from the Eocene Green River Formation of western Wyoming indicate a warm, humid tropical environment. As the climate very gradually changed from the Eocene to the Oligocene, palms and other tropical plants were replaced by plants such as oak, beech, and maple, that thrive at cooler temperatures. During the ice ages, pine trees were widespread at lower elevations. They are presently restricted, in Wyoming, to the cool moist environment of the mountains.

Fossil plants are known to occur in various Pennsylvanian formations in the state. They are also common in some Cretaceous and Cenozoic strata, including coal beds.

Fig. 45–Petrified tree trunk of Oligocene Age in Fremont County, Wyoming. (Photo courtesy of Dr. J. D. Love).

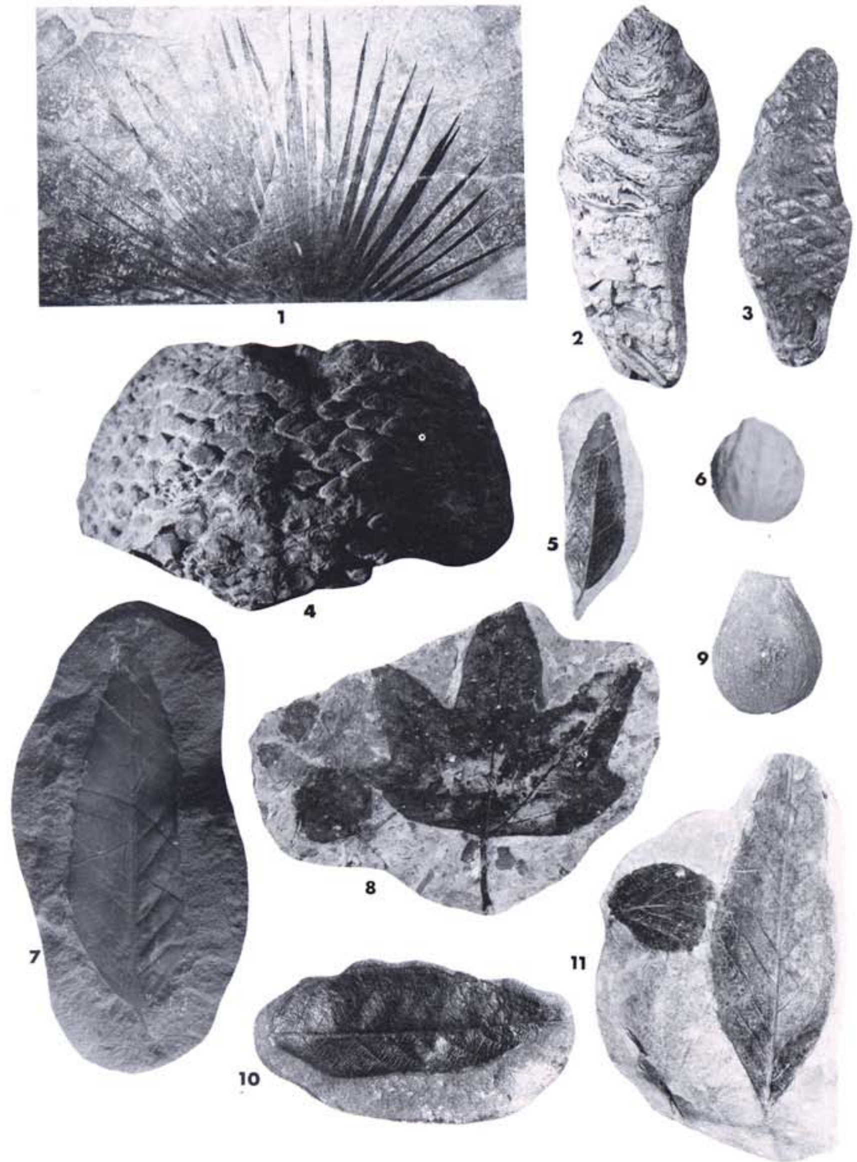

Fig. 46–Fossil Plants. (1) Eocene "Sabal Palm," *Sabalites* (length individual leaf 45"); (2) Eocene palm bud (length 8"); (3) pine cone (length 4"); (4) Jurassic cycad, a palm-like plant (length 1'); (5) Paleocene oak, *Quercus* (length 5"); (6) Oligocene hackberry seed, *Celtis* (1/16" diameter); (7) Paleocene oak leaf (length 5"); (8) Paleocene maple, *Acer* (large leaf, length 9") and hawthorn, *Crataegus* (small leaf, length 3"); (9) fig nut (length 1"); (10) hickory (?) leaf (length 4"); (11) Paleocene oak leaf (large leaf, length 8") and hawthorn, *Crataegus* (small leaf, length 3").

SUGGESTED READING

The Dinosaur Book by E. H. Colbert, published in 1951 by McGraw-Hill Book Co., Inc., New York. A well-illustrated non-technical account suitable for all ages.

The Fossil Book by Carroll Lane Fenton and Mildred Adams Fenton, published in 1958 by Doubleday and Co., Inc., New York. An extremely well-written and well-illustrated book highly recommended to anyone interested in fossils.

Creation of the Teton Landscape by J. D. Love and John C. Reed, Jr., published in 1968 by the Grand Teton Natural History Association, Moose, Wyoming. An excellent booklet telling the geologic story of Grand Teton National Park.

Fossils, An Introduction to Prehistoric Life by William H. Matthews III, published in 1962 by Barnes and Noble, Inc., New York. A useful booklet which discusses many aspects of fossils including collection, preparation, and display of fossils as well as an account of most of the major groups.

Marsh's Dinosaurs by John H. Ostrom and John S. McIntosh, published in 1966 by Yale University Press, New Haven, Conn. An extremely interesting historical account of the Marsh Expedition to collect dinosaurs at Como Bluff, Wyoming in 1877.

Horses by George Gaylord Simpson, published in 1961 by the American Museum of Natural History and Doubleday and Co., Inc., New York. A vivid account of living and fossil horses.

Fossil Ichthus by Wallace Ulrich, published by Ulrich's Fossil Fish Preparatory, Kemmerer, Wyoming. A small booklet which illustrates and describes the fossil fish from the Green River Formation of western Wyoming.

REFERENCES FOR FOSSIL IDENTIFICATION

Invertebrate Fossils by Raymond C. Moore, Cecil G. Lalicker, and Alfred G. Fischer, published in 1952 by the McGraw Hill Book Co., Inc. A college level text, good for detailed information and identification of invertebrate fossils.

Vertebrate Paleontology by Alfred Sherwood Romer, published by the University of Chicago Press, third edition 1966. A college level text with numerous illustrations and detailed information about vertebrate fossils.

Index Fossils of North America by H. W. Shimer and R. R. Shrock, published in 1944 by John Wiley and Sons, Inc., New York. A comprehensive survey of common invertebrate fossils of North America.

Treatise on Invertebrate Paleontology edited by Raymond C. Moore, published in 1962 by the Geological Society of America and the University of Kansas Press. A large set of many volumes which is the standard source of reference for invertebrate fossils.

ACKNOWLEDGEMENTS

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The professional talents and painstaking work of Charles R. Swain are deeply appreciated. All photographs without specific line credits are by Charles R. Swain of the University of Wyoming Photo Service.

All drawings were prepared by Dick Monckton and the drafting was done by Frank Henning. Stephanie Aker and Susan Randolph patiently typed and retyped the manuscript; Germaine St. John typed the final draft. My wife, Denise, provided moral support through the project. Dr. Don Lane helped with the tedious task of proof-reading.

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