Chapter 16 - The Early Mesozoic Era

I. Introduction
A. The Mesozoic Era is so named because it refers to “Middle Life” that represent the transition between the “Ancient Life” of the Paleozoic and the “Recent Life” of the Cenozoic. The Triassic and Jurassic together comprise the first 1/2 of the Mesozoic.
B. Pangea formed near the Permo-Triassic boundary. Pangea was so extensive that the climates were continental and arid. During the Jurassic, the Sundance Sea invaded the western interior leaving a much better record of conditions than during the Triassic.
C. Life in the oceans differed. Marine mollusks re-expanded became dominant. Reef building coral evolved. The oceans teamed with large swimming reptiles and fishes as predators.
D. **Gymnosperms** flourished in the terrestrial environment. Flying reptiles and birds appeared.
E. **Dinosaurs** emerged and diversified. **Mammals** appeared just after the dinosaurs but remained small

II. Life in the Oceans: A New Biota

Many groups did not recover from the Permo-Triassic Extinction. Gone were the fusulinids, lacy bryozoans, rugose corals and trilobites. Mollusks now filled many of the vacated niches. **Ammonoids** made a dramatic recovery. Only two ammonoid genera survived the Permo-Triassic Extinction. Over 100 genera evolved during the Early Triassic. Other groups recovered more slowly.

A. Seafloor Life - The Permo-Triassic Extinction left the marine niches briefly unoccupied.
1. **Stromatolites** made a brief return to the subtidal environments during the earliest Triassic that they were forced to leave during the early Paleozoic.
2. Bivalves and gastropods expanded during the Triassic to become a dominate marine invertebrate for the Early Mesozoic.
3. Sea Urchins evolved during the Paleozoic, but diversified during the first half of the Mesozoic. Some were floaters and others were burrowers.
4. **Reefs** did not recover until the Middle Triassic. Early reefs were built by sponges and algae similar to those built during the Permian. By the end of the Triassic, **hexacorals** evolved and became the dominant reef builders (Fig. 16-2). They are still successful today. Middle Triassic reefs were small mounds (~3 m). By Late Triassic, reefs were much more extensive and were constructed by more than 20 species.
5. The success of the bivalve and gastropods, sea urchins, and reef-building corals made the Late Jurassic look more like the modern seafloor than the Paleozoic seafloor.

B. Pelagic and Nektonic Life
1. The planktonic microorganisms that must have existed during the Triassic and Jurassic left no fossil record.
   a. **Dinoflagellates** are unicellular algae that make a shell or test out of silica (Fig. 3-16). Dinoflagellates underwent extensive diversification during the mid-Jurassic.
   b. Calcareous nannoplankton, a group of algae that make their shells out of calcite, appeared during the earliest Jurassic (Fig. 3-16).
2. **Ammonoids and belemnites** were important predators (Fig 16-4).
   a. Early recovered following the P-T extinction allowed for success throughout the Mesozoic. Extensive evolution makes them a useful guide fossil.
   b. Belemnites are squid-like (straight-shelled) relative of the ammonoid and pursued prey through jet propulsion.
3. Ray-finned fish were successful during the Mesozoic (Fig 16-5). However, they were still primitive compared with the modern ray-finned fish.
   a. Scales were diamond shaped and did not overlap.
   b. Skeletons were partly made of cartilage
   c. Jaws were still primitive
d. The **swim bladder**, a sac of gas that allows the fish to regulate their buoyancy, developed during the Mesozoic. Probably evolved from the lung that was present in some fish.

4. Sharks were well represented during the early Mesozoic. The family that includes the modern tiger shark evolved during the Jurassic.

5. Swimming reptiles invade the early Mesozoic seas.
   a. **Placodonts** are swimming reptiles (Fig. 16-6). They had the appearance of turtles.
   b. **Nothosaurs** were probably the first reptiles to invade the marine realm (Fig. 16-7).
      1. They had paddle like limbs, like the modern seal, and probably lived part of their life on land, like seals.
   c. Both the Placodonts and Nothosaurs became extinct at the end of the Triassic.
   d. By the mid-Triassic the **plesiosaurs** evolved (Fig. 16-7).
      1. These were fully aquatic reptiles and were important for the rest of the Mesozoic.
      2. They fed on fish and reached length of 12 m during the Cretaceous.
   e. The **ichthyosaurs** evolved by the Jurassic and are the most fishlike reptiles (Fig. 16-8; **Fish-lizards**).
      1. There were the top predators in the marine food chain.
      2. Large eyes and other modifications for swimming.
      3. Probably did not lay egg, but instead bore live young - embryo skeleton within adult female skeleton (Fig 16-9).
   f. **Crocodiles** were the last important group of early Mesozoic marine reptiles to evolve. While some were terrestrial animals during the Triassic, the ocean going form evolved during the Jurassic.

III. Life on Land

Dinosaurs are the dominant life form during the Mesozoic, but the land plants were distinctive as well.

A. Land Plants: The Mesozoic Gymnosperm Flora
   1. Permo-Triassic extinction did not seem to affect the land plants. The decline of the Paleozoic floras began well before the boundary.
   2. Lycopsids (coal swamps) sphenopsid and cordaite trees (higher ground) decreased in diversity.
   3. **Ferns** and seed ferns survived into the Triassic.
      a. Seed ferns did not make it to the Jurassic.
      b. Ferns were the most abundant terrestrial fossil of the early Mesozoic
   4. **Gymnosperm** trees stood above the ferns and belong to three groups. Gymnosperms have exposed seeds. Pollination occurs by wind.
      a. Cycads (Fig 3-4) were dominant and the Jurassic is often referred to as the “**Age of the Cycad**”
      b. Conifers (p. 108) all of the modern conifers (except pine) evolved during the Mesozoic.
      c. Ginkgos (Fig 16-10) has one surviving species which dates back to ~60 million years ago.

B. Terrestrial Animals: The Age of Dinosaurs Begins

What remained after the Permian extinction were the large herbivore *Lystrosaurus* (fig 8-10) and a few predatory genera.

1. **Early Mammals**
   a. **Therapsids** rediversified in the early Triassic only to go nearly extinct in the Jurassic.
   b. However, **mammals** evolved from these early Triassic therapsids.
   c. Mammals remained small during the Mesozoic, reaching sizes no larger than house cats.
   d. Dinosaurs evolved first and quickly rose to dominance.

2. Dinosaur Origins
   a. **Thecodonts** evolve in the earliest Triassic and were the evolutionary ancestor to dinosaurs.
   b. Some thecodonts developed the bipedal capabilities.
c. The first Dinosaurs resembled bipedal thecodonts (fig. 16-12), but differences in the skull and teeth structure set them apart. **Herrerasaurus** (Fig. 16-13) is an example of the earliest dinosaurs.

d. Dinosaurs did not become huge until after the Triassic. Triassic dinosaurs reached lengths of 6 m (20 ft; Fig 16-13).

3. The Fall of the Therapsids and the Rise of Dinosaurs

a. At the end of the Triassic, a mass extinction took its toll on terrestrial life. **A few therapsids survived this event.** Thus, the stage was set for dinosaurs to become the dominant animals for the rest of the Mesozoic.

b. The early Jurassic record is too fragmented to chart the evolutionary step. However, Lower Jurassic rocks contain huge dinosaur fossils, indicating that they evolved rather quickly.

c. Dinosaurs fall into “**bird hipped**” and “**lizard-hipped**” groups (fig 16-14).

d. Bird-hipped dinosaurs are herbivores and include Stegosaurus, Triceratops, Parasaurolophus.

e. Lizard-hipped dinosaurs are herbivores and carnivores. The largest dinosaurs are the Sauropods and are lizard hipped. Allosaurus, Tyrannosaurus, Apatosaurus,

4. Creatures that Took to the Air

a. **Pterosaurs** are reptiles that took to the air during the Late Triassic. Long wings and hollow bones facilitated flight. Probably was a good walker and climber (Fig 16-17).

b. The oldest fossils of birds are Late Jurassic age. **Archaeopteryx**, which means ancient wing, looked like a dinosaur with feathers (Fig 16-18). It had teeth, a large tail, and clawed fore limbs all of which are absent in modern birds.

c. Archaeopteryx was probably a clumsy flyer, having no breastbone onto which flying muscles could attach.

d. There is some evidence for birds in the Late Triassic, but not yet verified.

IV. The Paleogeography of the Early Mesozoic World

At the beginning of the Mesozoic, all of the continents formed the super continent **Pangaea** (Fig. 16-19). Near the end of the Triassic, the breakup of Pangaea began. The Tethys Ocean intruded into Pangaea. The **Mediterranean** is the last remnant of the Tethys.

A. Pangaea during the Triassic Period

1. Three types of floras existed during the Triassic: Gondwana flora in the south, Siberian in the north and Euroamerican along the equator.

2. Pangaea had a strong season climate due to its large size (fig 16-19). Strong monsoon winds must have come seasonally. Strong summer heating and severe winters caused this pattern.

B. The Breakup of Pangaea

1. The **Tethys Ocean** rifted further apart and allowed the seaway to move inland during the Triassic. This rift separated what is now Africa and Europe.

2. Rifting propagated to the west and separated Africa and North America. Further rifting separated North and South America during the Jurassic.

3. Gondwana continents remained intact until the Cretaceous.

4. The rift between North and South America gave rise to the **Gulf of Mexico** during the Jurassic. Intermittent connections to the Pacific Ocean produced a thick sequence of evaporites. The **Luann Salt is the base of the Gulf of Mexico** deposits. The low density and plasticity of the salt produces salt domes.

C. The Jurassic World

1. The marine and terrestrial fossils indicate that the Jurassic world was quite warm and equitable.

V. Mass Extinctions

A. **End of the Trissac**
1. Struck both land and sea – Conodonts and placodont reptiles died out. The bivalves, ammonoids, plesiosaurs (Fig 16-8) and ichthyosaurs (Fig 16-9) were hard hit but recovered during the Jurassic.
2. The large amphibians and mammal-like reptiles include the terrestrial victims.
3. Dinosaurs were the beneficiary and radiated rapidly.
4. Appears to have been a two step process on land. The cause is still unknown but may have been related to climate change. (Increased aridity?)

B. End of the Jurassic
1. Lost several of the more popular dinosaurs – Stegosaurus and large sauropods like Apatosaurus (Figs. 16-14,15).

VI. North America in the Early Mesozoic Era
A. Eastern Fault Basins
During the Early and middle Triassic, the Appalachian Mountains underwent severe erosion. During the Late Triassic, fault basins developed from Nova Scotia to the southern Appalachians (Fig 16-23).
1. Newark Supergroup was deposited in a faulted basin that stretched from NYC to Virginia.
   a. Accumulation of non-marine sediment that reached 6 km thick in lake centers. Continued subsidence allowed the lakes to accumulate such thick sequences.
   b. The cycles of deposition recorded alternating lake levels between wet (deep lake) and dry (aeolian). The wet cycles have abundant fish fossils and dinosaur foot prints.
   c. Periodically, basalts would move up the fault zones and form sills or flows. The Palisades sill (Fig 16-25) is a textbook example of this process. It is visible along the western side of the Hudson River. It is dated as 201 Ma.
2. Conjugate rift basins formed along the South America and Africa. Intermittent connections to the Tethys Ocean filled these basins with sea water that evaporated and formed thick evaporite deposits.

B. Western North America
1. Terrestrial and Marine Environments
   a. Much of western North America was non-marine during the Triassic. Many of our national Parks has non-marine sedimentation. The Chinle formation in Arizona has a spectacular Petrified Forest (Fig 16-26). The Navajo Sandstone is an eolian deposit from Zion National Park.
   b. Sea levels rose during the middle and late Jurassic. The Sundance Sea represents the largest and last of the Jurassic transgressions (Fig. 16-27).
2. Subduction and the Accretion of New Terranes
   a. Subduction and accretion are the theme for the Mesozoic western North America. This began with the additions of the Klamath Terrane during the Antler Orogeny of Devonian age.
   b. During the latest Permian to early Triassic, the Golconda Arc approached the Pacific margin. This was the Sonoma Orogeny. However, the Sonoma orogeny added not only the Golconda Arc, but also a circular microcontinent called Sonomia (Fig 16-29).
   c. Brief interlude of tectonic quiescence during the middle Triassic.
   d. During the Jurassic, the subduction zone under the western North American margin thickened the continental crust. This period of intrusion and addition of exotic terranes to the north (Wranglia and Stikine) mark the period known as the Nevadan orogeny (fig 16-28).
      1. Large Batholiths were emplaced in the Sierra Nevada range (Fig 16-31).
      2. Accretionary prisms in front of the subduction zone were pastered onto the margin (Franciscan melange) (Fig. 16-31).
3. Deposition in a Foreland Basin
   a. During the latest Jurassic, the thrusting and compression associated with the mountain building to the west produced a fore land basin.
b. However, it appears that it was always above sea level. The resulting deposition of molasse occurred in rivers, lakes an swamps. The **Morrison formation** is famous for its dinosaur fossils.

VII. Chapter Summary
A. The invertebrate taxa of the Triassic and Jurassic seas differed. Gone were the fusulinid foraminifera, rugose and tabulate corals, and trilobites. New bivalve, gastropods, ammonoids, sea urchins and hexacorals, bony sharks and swimming reptiles
B. Ferns were abundant during the Triassic - Gymnosperms dominated the Jurassic
C. Mammals originated during the Triassic, but Dinosaurs were the kings. Flying reptiles evolved during the Triassic and birds later evolved from Dinosaurs
D. Triassic ended with mass extinction but was less severe than the end Permian event.
   Moderate extinction event at the end of the Jurassic
E. At the beginning of the Triassic, all of Earth’s crust was united in the supercontinent called Pangea. Evaporite deposits mark the zones of separation between the continents during the Mesozoic.
F. Fault block basins in eastern North America received thick deposits of sediment due to the rifting between North America and Africa. This separation eventually produced the North Atlantic Ocean.
G. The Sundance Sea invaded western North America during the Jurassic. Nevadan Orogeny caused uplift and sediment influx into the Sundance Sea. Dinosaur fossils are richly preserved in these sediments.