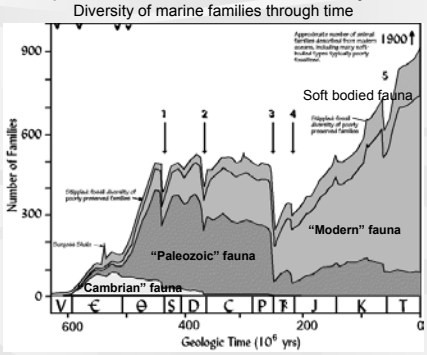
Revolutions in the History of Life
In the Phanerozoic

Jack Sepkoski's Three Great Evolutionary Faunas:

Diversity of marine families through time



Cambrian fauna: trilobites, inarticulate brachiopods, primitive molluscs & echinoderms
Paleozoic fauna: articulate brachiopods, crinoids, cephalopods, corals, ostracods
Modern fauna: mostly gastropods, bivalves, bony fishes, crabs & lobsters, echinoids

Cambrian Fauna

Back in the Cambrian, dominant organisms did not fill all the major modes of life

Only epifaunal, mobile deposit feeding modes of life were fully exploited.
Paleozoic Fauna

Cambrian Fauna: level of niche partitioning low

The Paleozoic dominants exploited more ecospace

They fully exploited epifaunal modes of life and became important pelagic organisms, too

Infaunal modes of life were not fully exploited, however, with shallow burrowing infaunal

Deposit feeding the only fully exploited general life style (deposit feeding is an easy way to make a living).

Partial decay makes nutrients readily available, and food buried in the sediment is not subject to fluctuation of productivity)

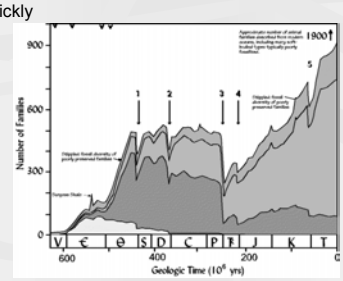
Paleozoic Fauna: Higher level of niche partitioning

Deposit feeders exploit shallow levels of sediment
Suspension feeders exploit multiple levels of water column, but more or less anchored
Predators and scavengers present, but relatively generalized

Effect of the Permian Extinction - Reorganization of Life in the Oceans

The shift in dominant taxa from Paleozoic to Modern fauna was largely a result of the selectivity of the Permian extinction

At no other time in geologic history did the nature of the world's fauna change so quickly



Many groups suffered in the Permian extinction:

50 % of marine families and 95 % of all species

Other groups did not suffer much in the Permian extinction and they blossomed in the Mesozoic

Some new groups also expanded to contribute to the dominant groups of the modern marine fauna

It was likely tied to (1) the increase in marine phytoplankton and (2) the increase in the average biomass of most marine animals

What permitted this increase in biomass? We don't know! It may have been an increased supply of nutrients - or an increase in metabolic efficiency of primary producers

One distinctive aspect of the change from the dominant Paleozoic groups to those dominant in the Mesozoic and Cenozoic is an increase in both body size and fleshy biomass

The Paleozoic Fauna: small and with low biomass

Only a few Paleozoic groups were fleshy, whereas most dominant modern organisms are fleshy

The Modern Fauna: larger and with more biomass than the Paleozoic Fauna

Biomass per individual is greater in modern dominant organisms

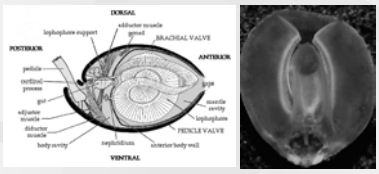
The size of the dominant organisms in Paleozoic seas was fairly small and Mesozoic and Cenozoic animals are generally larger than Paleozoic organisms

Brachiopods

Brachiopods look like substantial animals (when we look inside, hardly anyone is home!).

The shell volume is really a nearly empty filtaration chamber to help the filmy lophophore

filter food. The living tissue is just a thin sheet coating the inside of the shell



Trilobites

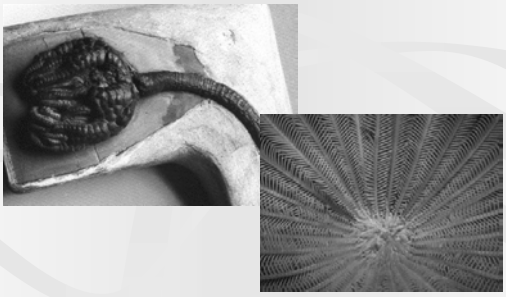
Trilobites look like large animals, yet we have learned from unusual specimens in which their

soft tissues were replaced before decay occurred, that they really were composed of stringy

muscles and a straight gut with thin legs and gills covered by a flat skeleton. They were not fleshy critters

Crinoids

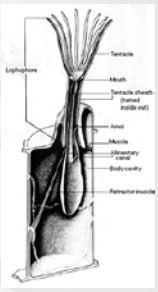
The crinoids (sea lilies) had small bodies supported on long stalks and were fed by their large filtration fans of arms - again, rather low biomass

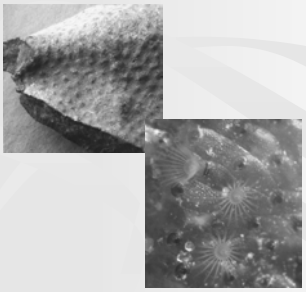


Bryozoa

Bryozoans, which were also dominant in the Paleozoic, are tiny creatures that just form a thin

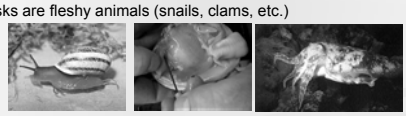
film on the surface of their colonial skeleton



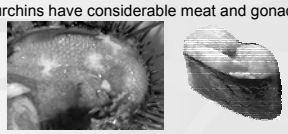


The dominant animals of the **Mesozoic** and Cenozoic are often big and tend to have greater biomass than Paleozoic creatures

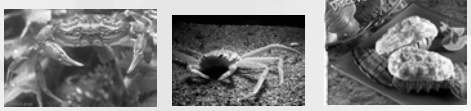
Mollusks are fleshy animals (snails, clams, etc.)



Sea urchins have considerable meat and gonad in their globular test



Crabs and lobsters are often big and have a lot of flesh



Modern Fauna: Very high diversity driven by arms race

Deposit feeders exploit shallow, moderate and deep levels of sediment
Suspension feeders exploit multiple levels of water column, but more or less anchored
Predators and scavengers become very specialized, inhabit multiple levels of sediment and water column

The **Mesozoic Marine Revolution** is clearly expressed by the fact that all different major modes of life we know today are occupied

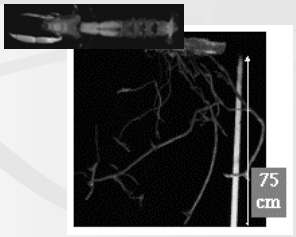
Many infaunal modes of life are fully exploited for the first time.

Expansion in two general modes of life are particularly important: deep burrowing and predation

Geoduck (deep burrowing bivalve)

Burrowing (tiering down into the sediment) expanded into deeper sediment when comparing
with the Paleozoic

The number of different **organisms** that feed from sediment below 10 cm (four inches) increased in the **Mesozoic**, as did the rate at which **organisms** reworked the sediment



Ghost shrimp
(deep burrowing crustacean)

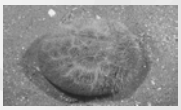
Examples of increased diversity associated with increased burrowing habit

Clams (bivalve mollusks).
The marked increase in diversity of bivalves in the **Mesozoic** and Cenozoic was almost entirely related to the evolution of siphons and the exploitation of deep burrowing.

This mode of life provides protection form predation.

geoduck

Echinoids expanded in diversity in the **Mesozoic** and Cenozoic. What is interesting is that much of this diversity increase is related to infaunal groups.



Heart urchin

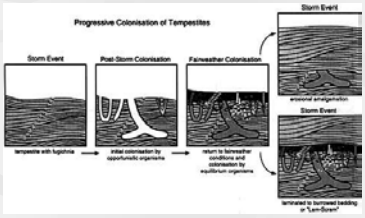
Sand dollar

Impact of deep burrowing on the nature of sedimentary record

Increased depth and intensity of burrowing had an impact on the way beds of sediment were preserved

In the Paleozoic burrowing couldn't destroy the layering of the larger storm events because common burrowers only burrowed down a few inches

But in the **Mesozoic** and Cenozoic lamination or even storm event bedding are rarely preserved because **organisms** burrowed through all layers and mixed them together



Increased predation characterizes the Mesozoic Marine Revolution

Predatory Groups Diversified in the Mesozoic and Cenozoic

Crabs diversify in the Cretaceous. Most crabs are predators and use their claws to catch prey.

Lobsters also use their claws to catch prey

Octopus, a fleshy molluscan predator (a large animal that needs lots of biomass to feed it)



Note predators require large amounts of food

The major diversity increase in snails was in predatory groups


Moon snail


Cone shell
(the poison dart snail)

Among arthropods, the shell-crushing crabs are the big news

Co-evolution of predators and prey is a common factor in changing the nature of the **marine** fauna

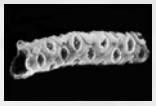
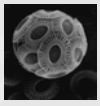
The cartilagenous fishes (sharks and rays) declined in the Permian and Triassic, but new groups, almost all of which are predators, diversified widely in the Jurassic and Cretaceous

The bony fish had a huge **Mesozoic** radiation. The major radiation was in the group of ray- finned fish called teleosts. Many of these fish are predators, although they have many feeding types

Consequence of increased productivity and biomass

One other change in the **marine** biosphere should be noted - the variety and abundance of phytoplankton, the base of the food chain in the oceans, also increased in the **Mesozoic**

Phytoplankton are at the base of the **marine** food chain. The variety of phytoplankton increased markedly in the **Mesozoic** and Cenozoic. Many groups were added to the planktonic flora: Calcareous nannoplankton (including the algae that secrete the material used to make chalk) and diatoms both evolve and diversify in the **Mesozoic** and Cenozoic


Large chalk accumulations formed white cliffs of Dover

These additions permitted the increase in animal size and biomass that characterizes the **Mesozoic** and Cenozoic - and fed the increase in predation

The escalation of ecologic complexity, biomass and predation characterize the change in the **marine** fauna from the Paleozoic to the **Mesozoic** and Cenozoic

Predation Reaches an All Time High: Marine Reptiles

At the highest tier of the food chain in the marine realm were numerous large reptilian predators.

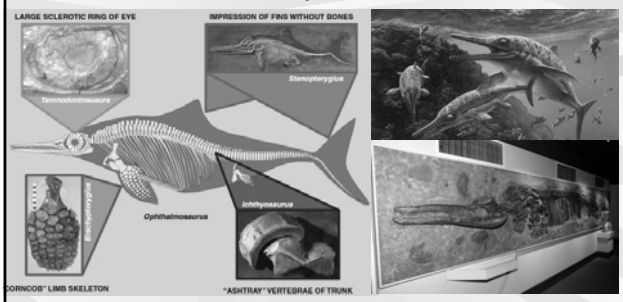
The high biomass provided by the “modern” invertebrate fauna and lower vertebrates (fishes) permitted great success of several groups including marine turtles, ichthyosaurs, mosasaurs and plesiosaurs

Turtles

During Mesozoic, marine turtles also got pretty darn big !

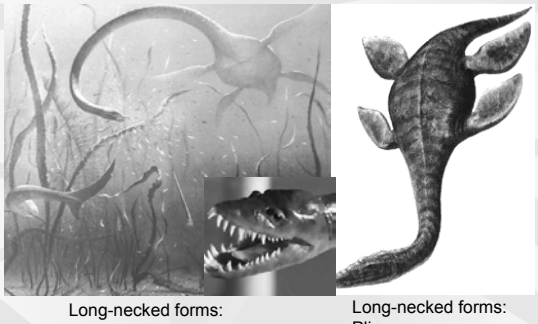
Cretaceous turtle *Archelon*

Ichthyosaurs



Evolved from land-dwelling reptile
Note modification of body for life in sea
(fins on back and tail, modification of limbs to form flippers)

Plesiosaurs



Long-necked forms:
Elasmosaurs

Long-necked forms:
Pliosaurs

As with ichthyosaurs, evolved from a land-dwelling reptile
Modification of limbs to form flippers, and lengthening of neck for darting movement to catch prey

Mosasaurs

Evolved from land lizard, retaining lizard-like body
But limbs and tail modified for swimming

Mesozoic Marine Revolution - A Summary

Increased phytoplankton means increased primary productivity

Increased food for the whole food chain

Increased burrowing implies that there was more food buried and therefore it was worth the effort to go down to get it

Increased biomass of many kinds of organisms (fed by the increased amount of phytoplankton) meant there was more food for predators

Evolution of very large predators (especially reptiles)

BUT REMEMBER: CHANGES WERE ALSO OCCURING ON LAND

On land gymnosperms of various sorts dominated floras in the Mesozoic

Angiosperms evolved, becoming important in the late Cretaceous and Cenozoic

Dinosaurs were the dominant land vertebrates, but the mammals had evolved in the Triassic and would become dominant after the dinosaurs went extinct

END OF LECTURE