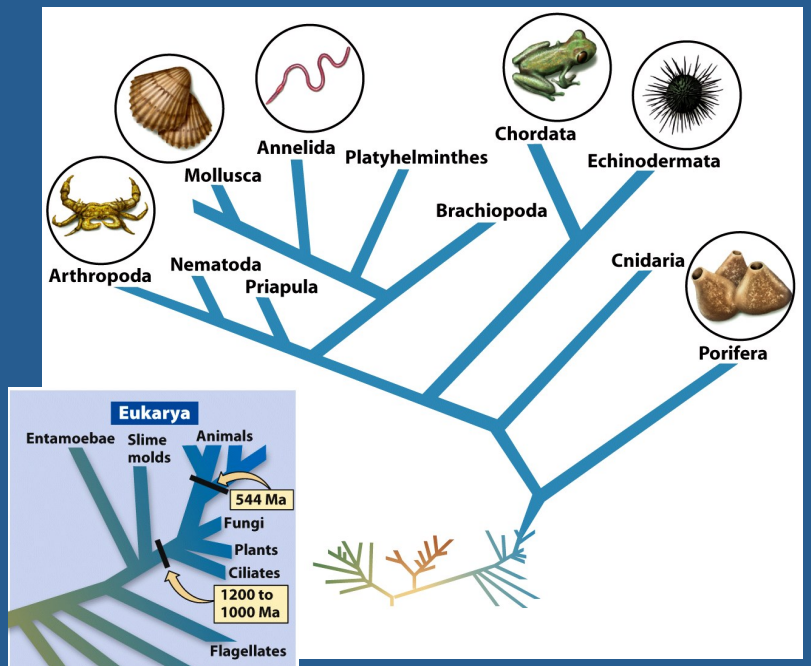
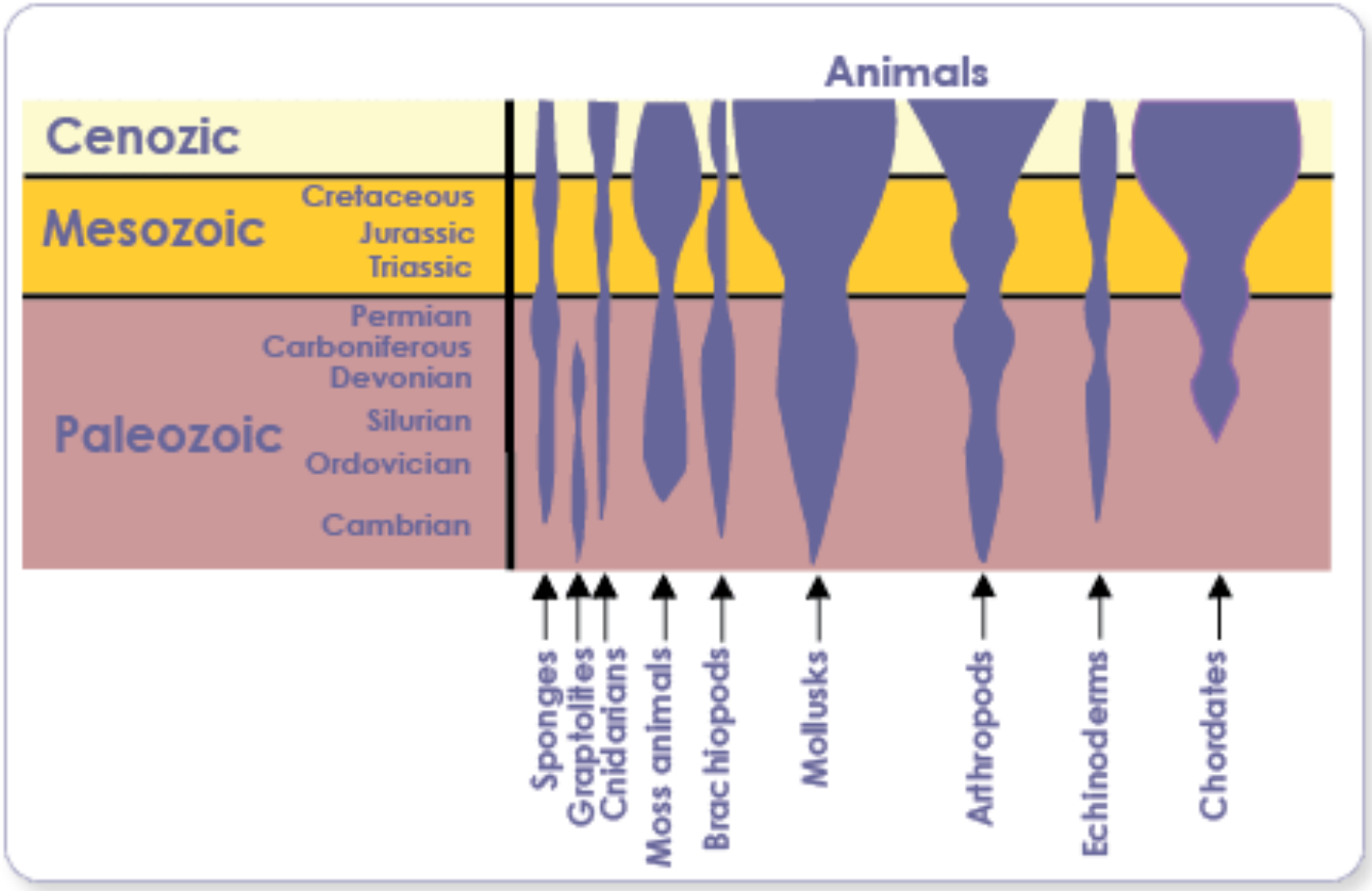
Cambrian Evolutionary Radiation

- Every major animal phylum that exists on Earth today, as well as a few more that have since become extinct, appeared within less than 10 million years during the early Cambrian evolutionary radiation, also called the Cambrian explosion.



Cambrian Evolutionary Radiation



Phylum Protista

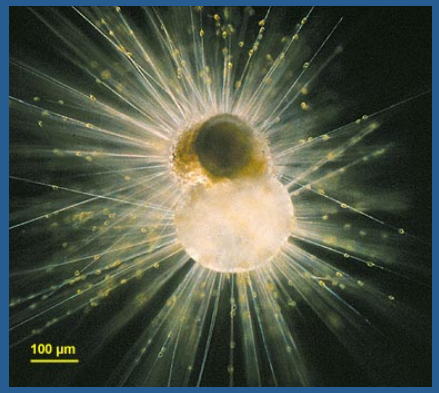
- Phylum Protista includes a diverse group of eukaryotic microorganisms which are mostly unicellular. They are not necessarily primitive, although some are. Only some have a skeleton that can be preserved as a fossil.

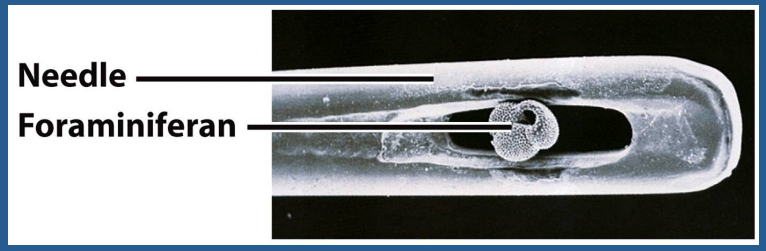
- Foraminifera and radiolaria are the most important examples. Coccolithophores, diatoms, and dinoflagellates are also examples.

Foraminifera

- Foraminifera are marine organisms that may be either planktonic, living in the water column where they float at various levels, or benthic, living on or within the seafloor sediment.

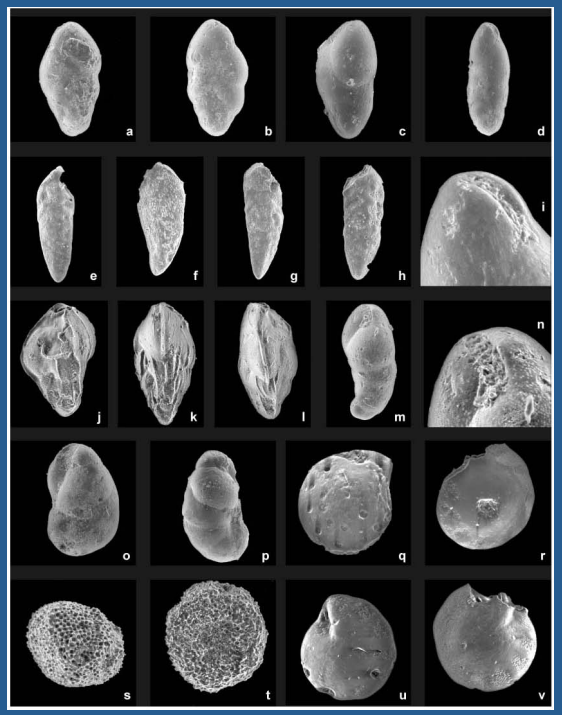
- They form relatively large (0.1 mm to 5 cm) porous internal skeletons called tests through which project strands of living cytoplasm. The single- to multi-chambered tests may be composed of organic matter, agglutinated sand grains or sponge spicules, or calcium carbonate.





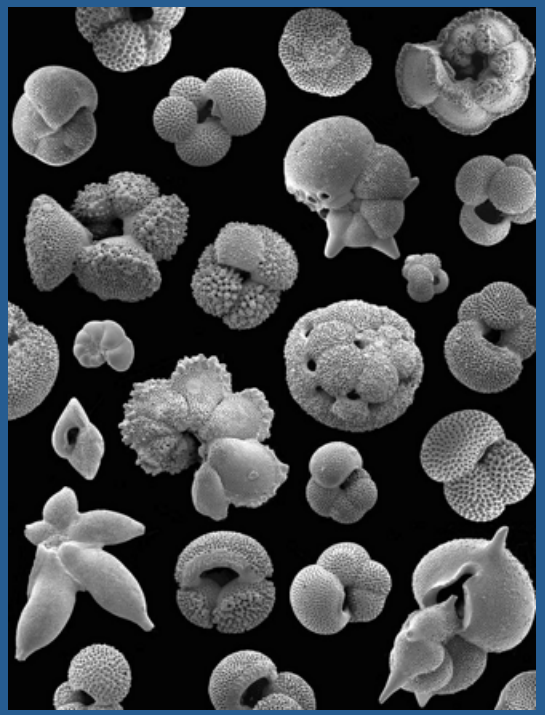
Fossil Foraminifera

- Benthic foraminifera (Cambrian to Recent).



Oligocene

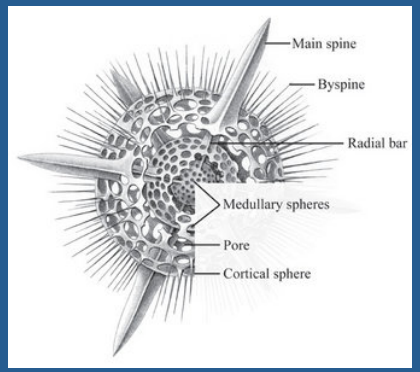
- Planktonic foraminifera (Jurassic to Recent).

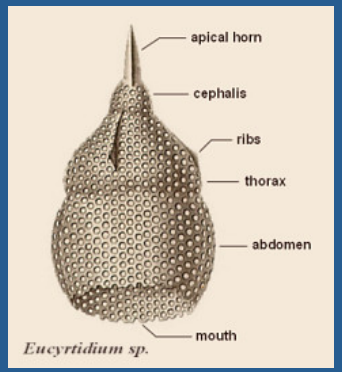


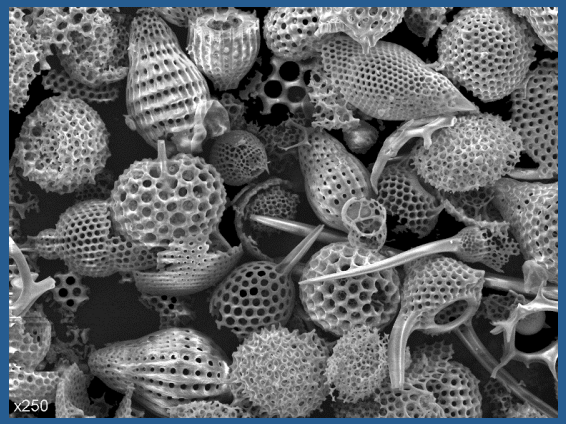
Eocene

Radiolaria

- Radiolaria are planktonic marine organisms that tend to live in relatively cold water.
- Their tests, often delicate and elaborate, are made of silica and presently accumulate on the floors of the parts of oceans that are deeper than those where foraminiferal tests are accumulating.

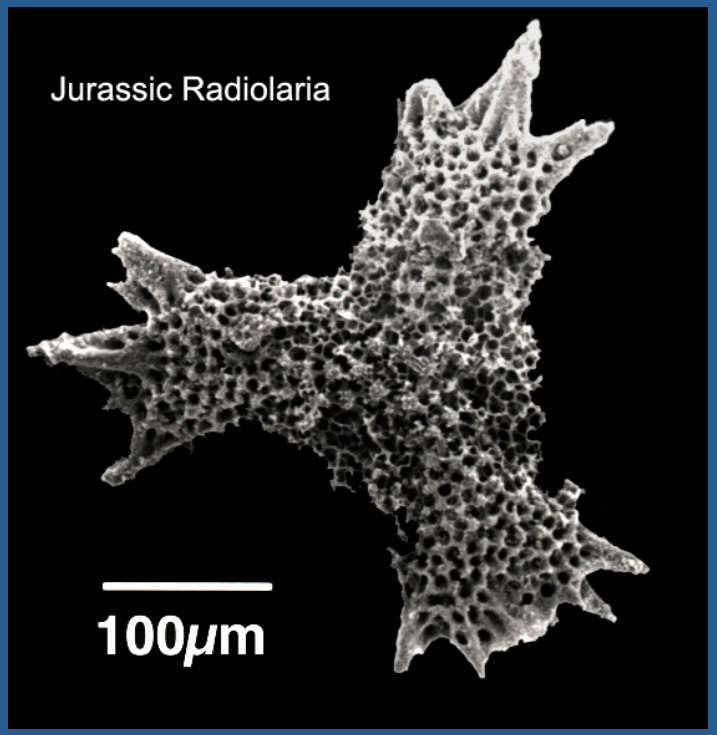




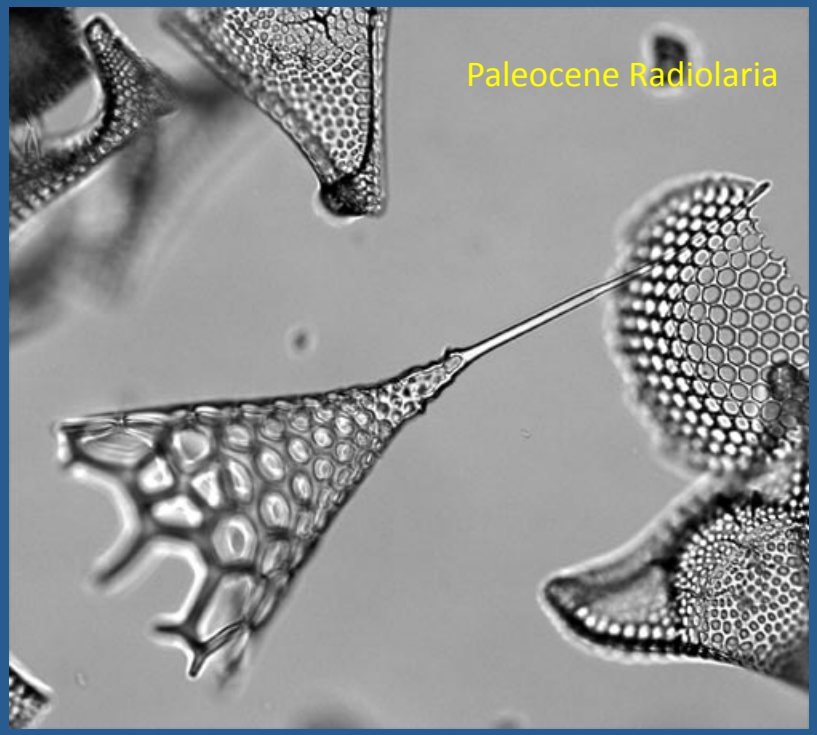


Fossil Radiolaria

- Radiolaria (Cambrian to Recent).

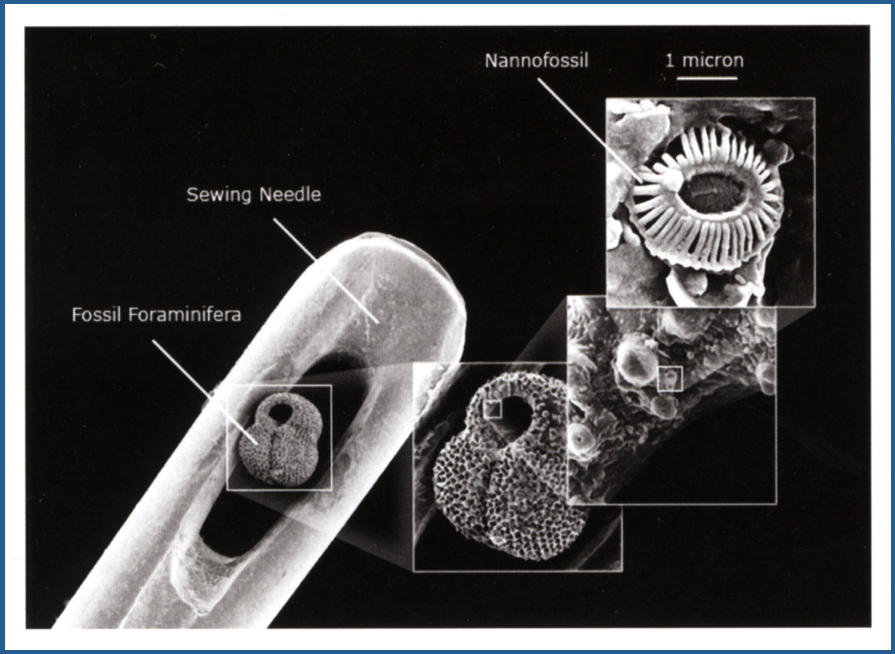


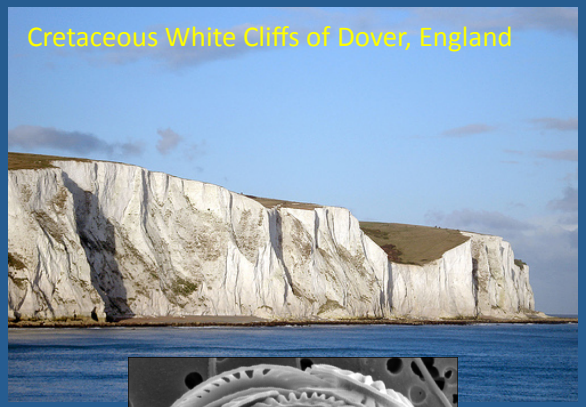
- Radiolaria (Cambrian to Recent).

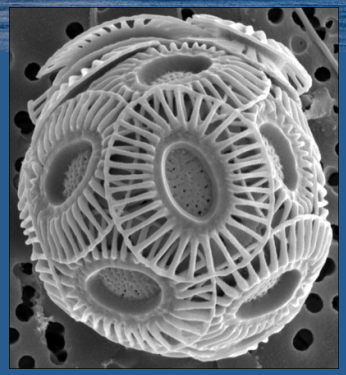


Coccolithophorida

- Coccolithophores (Triassic to Recent) are extremely small marine planktonic photosynthetic unicellular algae that are enclosed by plates of low-Mg calcite called coccoliths.

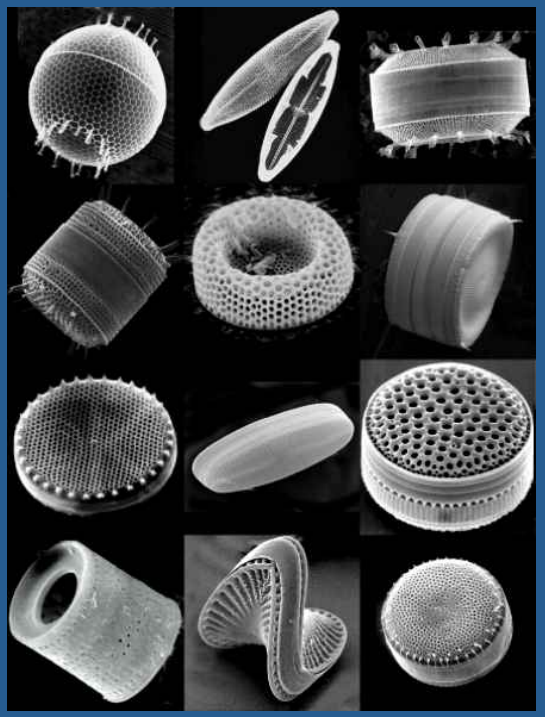






Diatoms

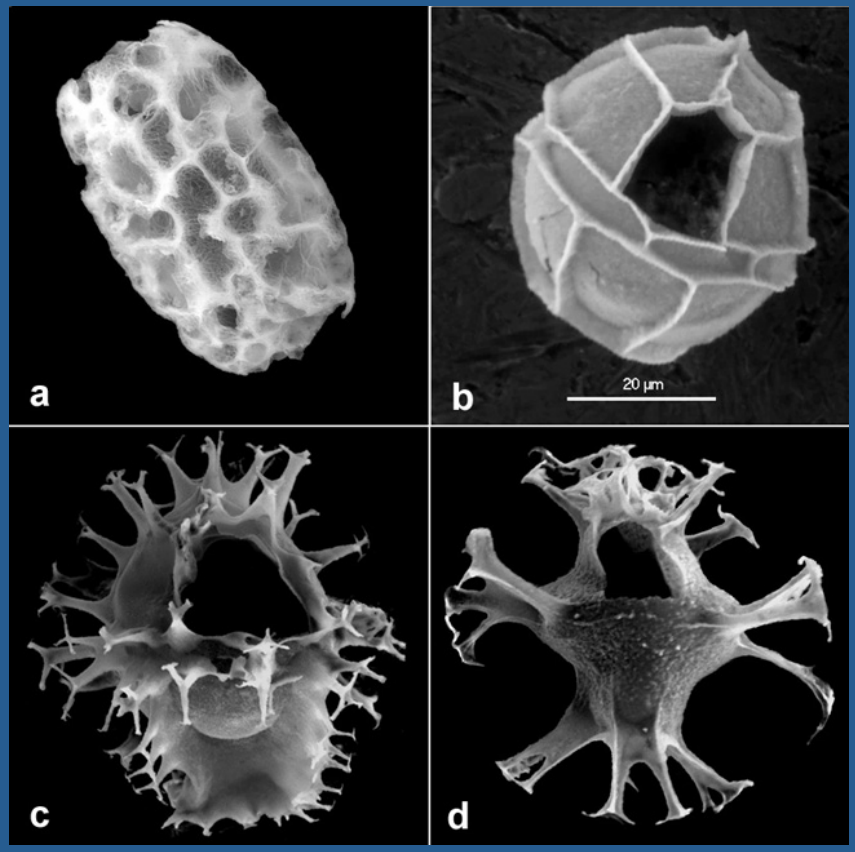
- Diatoms (Jurassic to Recent) are small freshwater and marine planktonic photosynthetic unicellular algae that are enclosed by a cell wall made of silica called a frustule.



Dinoflagellata

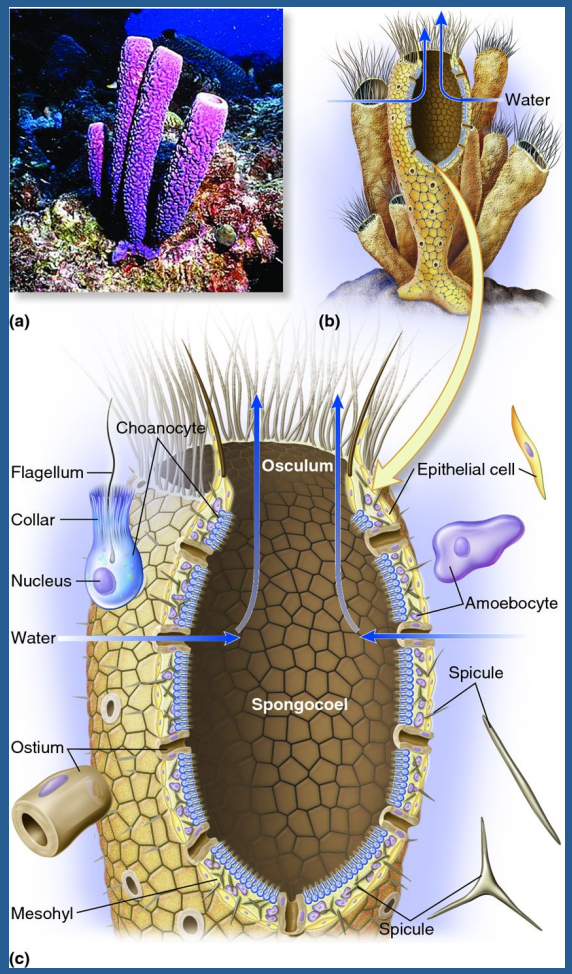
- Dinoflagellates are small freshwater and marine planktonic photosynthetic or mixotrophic unicellular organisms that produce fossilizable organic, calcareous, or siliceous cysts as part of their life cycle. The organic dinoflagellate cysts are made of a highly resistant organic material called dinosporin.

- Fossil dinocysts have been identified from the Middle Triassic, but molecular fossils (dinosteranes and 4α-methyl-24-ethylcholestane) suggest ancestors may have evolved during the Early Cambrian.



Phylum Porifera

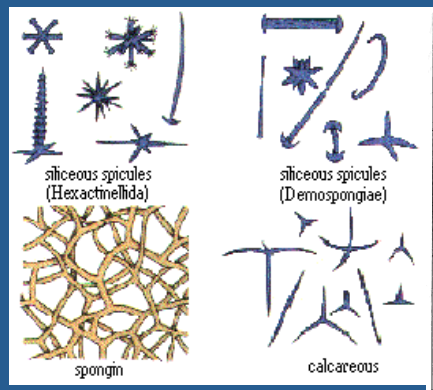
- Phylum Porifera is represented by the sponges, the simplest of multicellular organisms.
- Sponges are mostly marine, colonial organisms that attach to substrates and feed only on microscopic food particles that they take in along with water through numerous external pores. Undigested material and water pass out through an opening at the top called an osculum.
- Sponges do not have nervous, digestive, or circulatory systems. Instead, most rely on maintaining a constant flow of water through their bodies to obtain food, oxygen, and remove wastes.

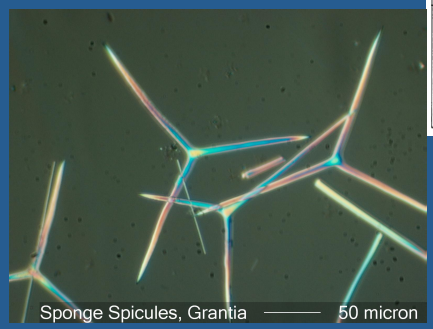


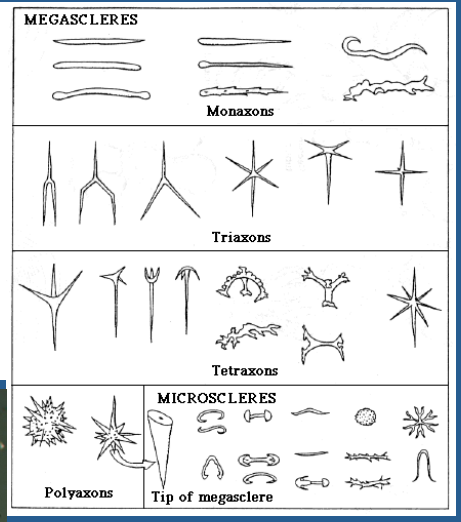
Sponges

- Only those sponges which have a skeleton can be preserved as fossils. In these the skeleton is built of separate elements called spicules which either remain separate and embedded in the wall of the sponge or united in a continuous scaffolding.

- Sponges are classified based on the composition and shape of their spicules. Spicules may be composed of opaline silica, calcite, or an organic compound known as spongin. Large spicules that are visible to the naked eye are referred to as megascleres, while smaller, microscopic ones are termed microscleres.







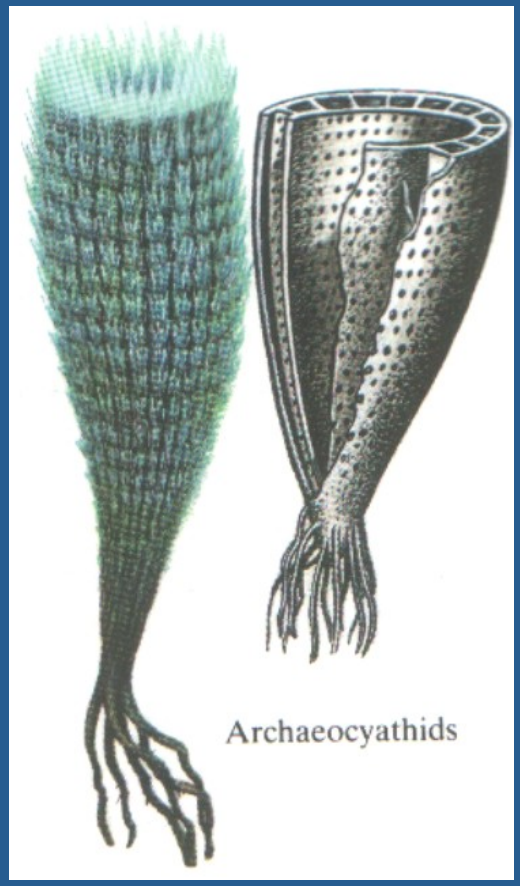
Fossil Sponges

- Both siliceous and calcareous sponge spicules have been reported from Early Cambrian rocks, but there is molecular fossil evidence (24-isopropylcholestane) to suggest that sponges evolved during the late Precambrian.

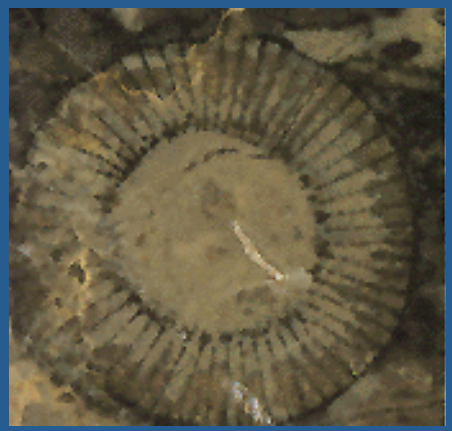
Hydnoceras (hexactinellid; Devonian to Mississippian)

Raphidonema (calcisponge; Cretaceous to Eocene)

Archaeocyatha



- Archaeocyathids are an extinct group of double-walled cone-shaped reef-building sponges that flourished during the Early Cambrian. Their cone-shaped skeletons are commonly constructed of two perforate walls separated by radially arranged vertical septa.



Stromatoporoids

- Some sponges called stromatoporoids secrete a basal skeleton of calcium carbonate. These layered, mound-like, or branching sponges were particularly common in shallow water deposits of Silurian to Devonian age and were important reef-builders.

Phylum Cnidaria (Coelenterata)

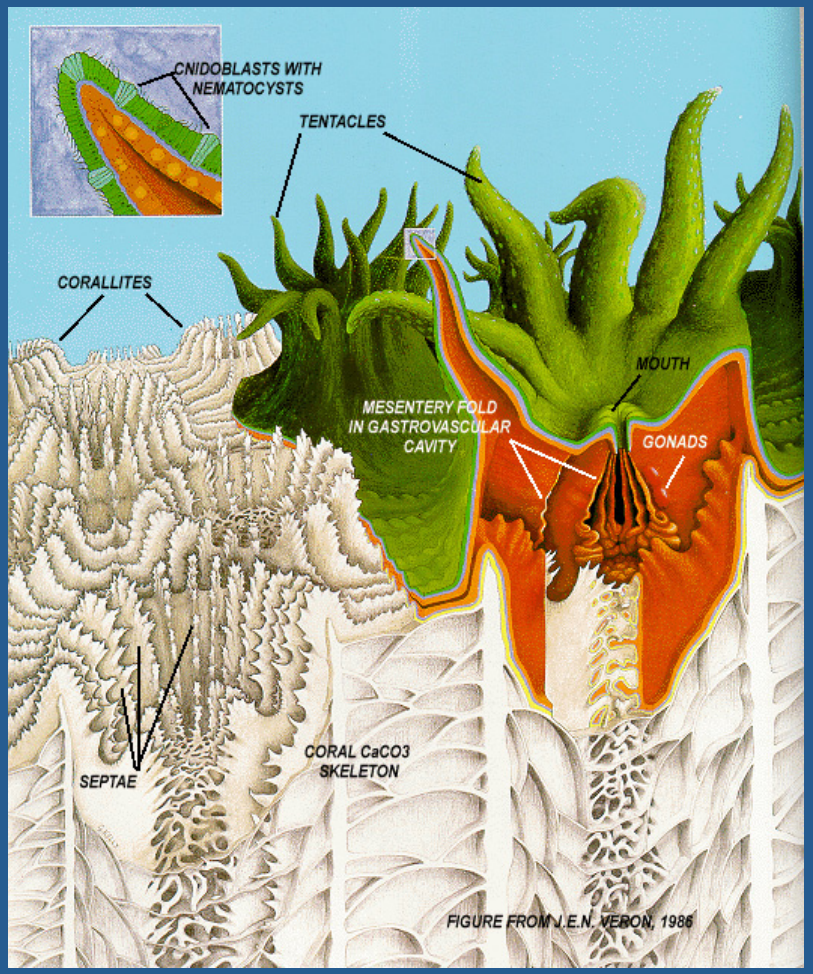
- Phylum Cnidaria may be divided into three classes of mostly marine, tentacled organisms, the Hydrozoa (*Hydra*, siphonophores), the Scyphozoa (jellyfish), and the Anthozoa (sea anemones, corals). Only the last class is important in the fossil record.

- Cnidarians have a two-layered body-wall consisting of an inner endoderm and an outer ectoderm. They show little development of organs specialized for digestion or circulation, nor do they possess a central nervous system.

Corals

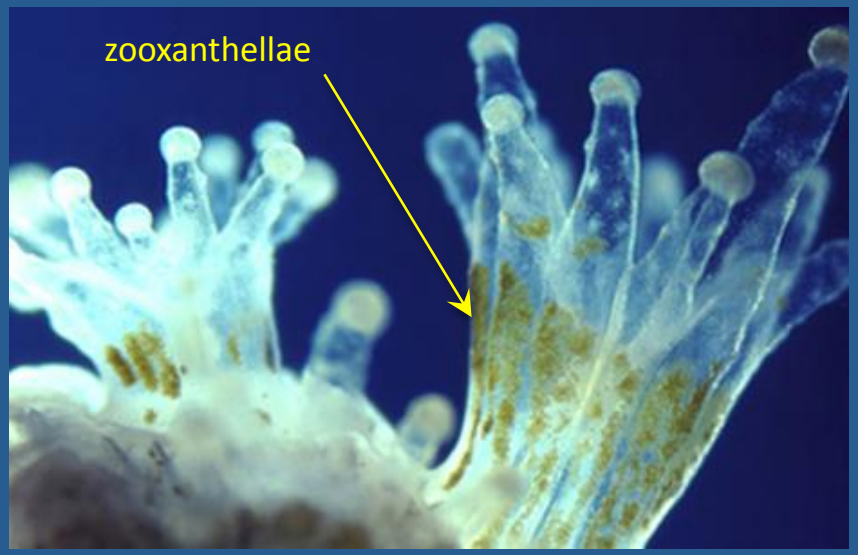
- Corals are marine animals that consist of polyps, bag-shaped structures with their interiors lined with endoderm forming digestive cavities and a ring of tentacles developed from ectoderm used to collect food.

- Most corals have a calcium carbonate skeleton secreted by ectoderm in the form of a cup, or corallite, in which the animal lives. Within the corallite there is usually a distinctive pattern of radiating vertical walls, or septa. In colonial corals, corallites are joined in a continuous structure to form a corallum.



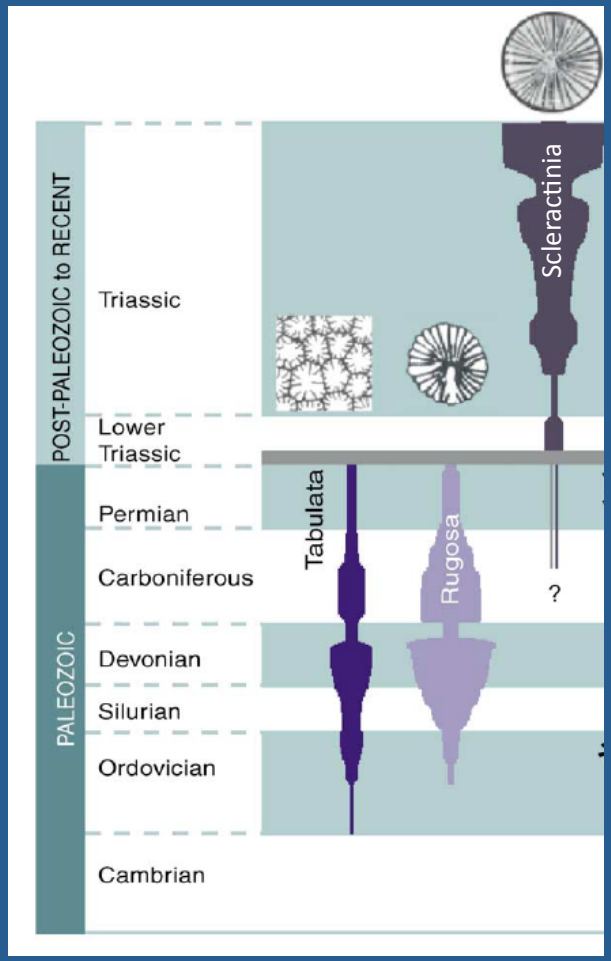
Corals

- All modern reef-building corals enjoy a symbiotic relationship with algae called zooxanthellae. These algae live protected within the soft tissues of the coral, in turn providing the coral with certain organic compounds for nutrition. In addition, the photosynthetic activity of the zooxanthellae assists the secretion of the calcium carbonate skeleton by the corals.



Fossil Corals

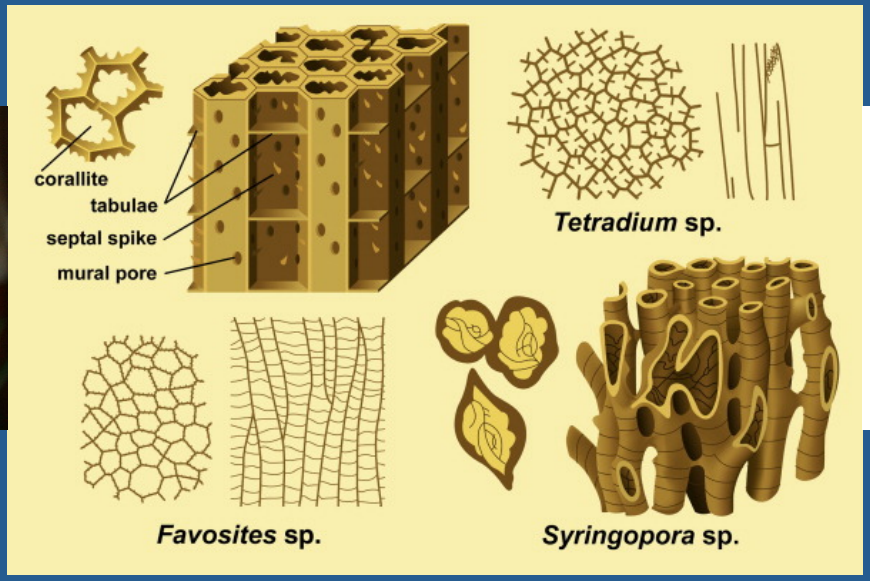
- Fossil corals may be generally divided into three groups. Two of these groups, the Tabulata and the Rugosa, first appeared by the Ordovician but went extinct at the end of the Permian. The third group, the Scleractinia, arose in the Triassic and includes the reef-building corals found in modern oceans.

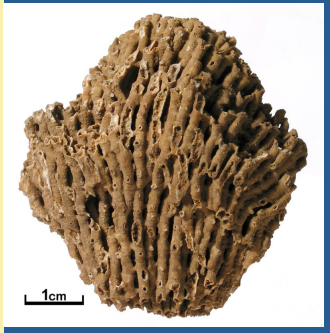


Tabulata

- The tabulate corals are all colonial, with calcite corallites joined to form a corallum. Vertical septa are weakly developed but horizontal partitions, or tabulae, may be well-developed. Examples include *Favosites*, the honeycomb coral (Ord.-Dev.), and *Syringopora*, the organ pipe coral (Ord.-Perm.).

Favosites



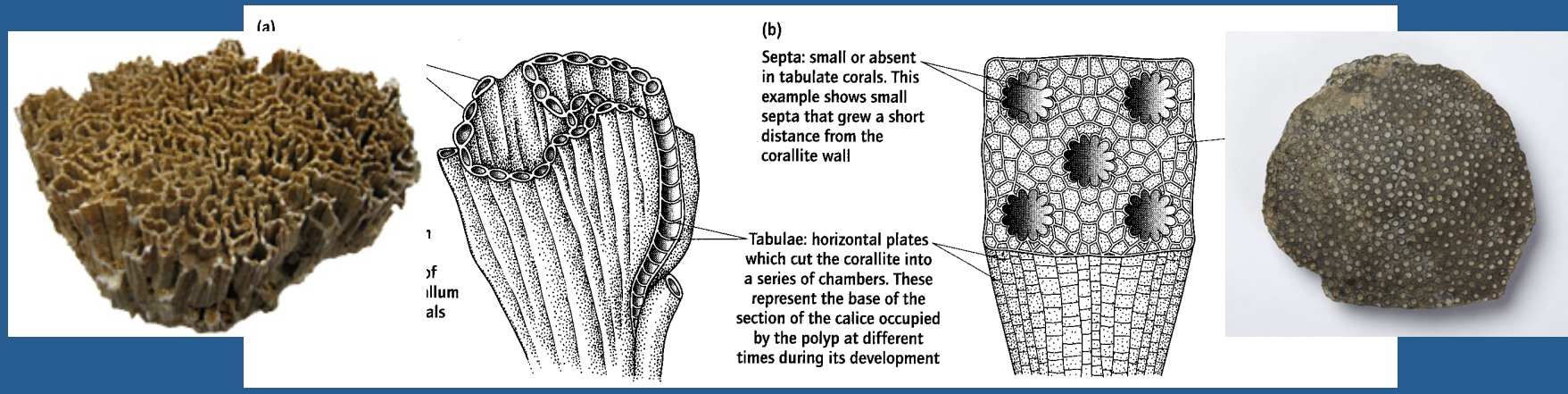


Syringopora

Tabulata

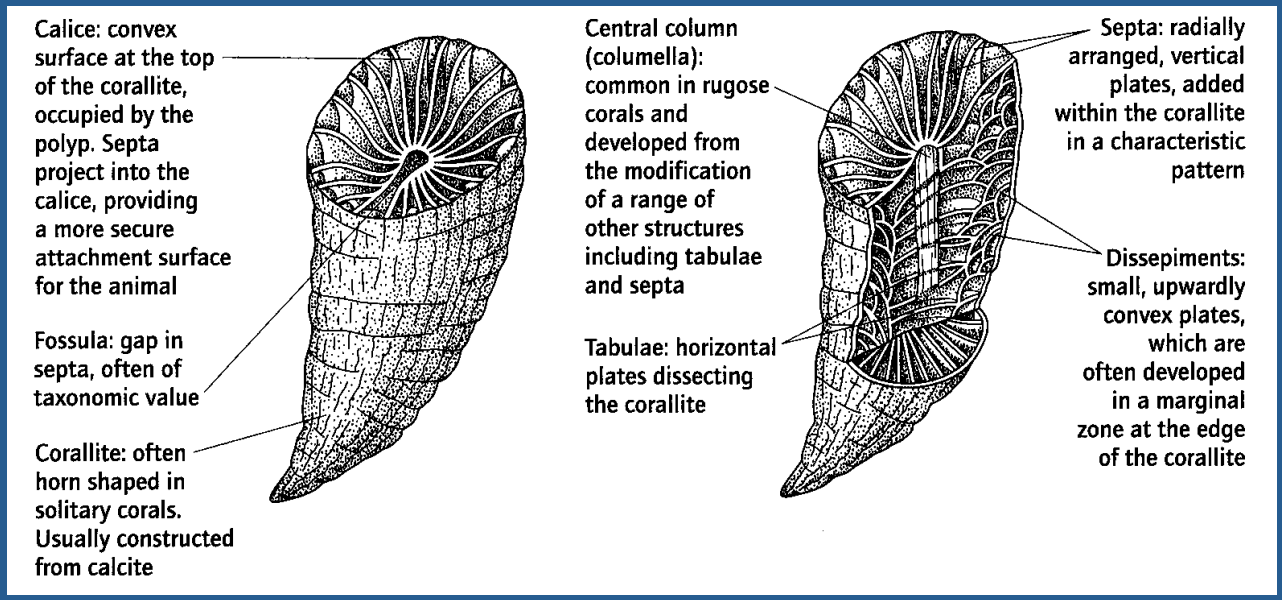
- The tabulate corals are all colonial, with calcite corallites joined to form a corallum. Vertical septa are weakly developed but horizontal partitions, or tabulae, may be well-developed. Examples include *Halysites* (Ord.-Sil.), the chain coral, and *Heliolites* (Ord.-Dev.).

Halysites *Heliolites*



Rugosa

- Most rugose corals are solitary, but some are colonial, and they tend to be more complex than the tabulate corals. Many of the solitary rugose corals have horn-shaped corallites composed of calcite. Septa inside the corallites are typically arranged in four quadrants, leading to them being known sometimes as Tetracoralla.



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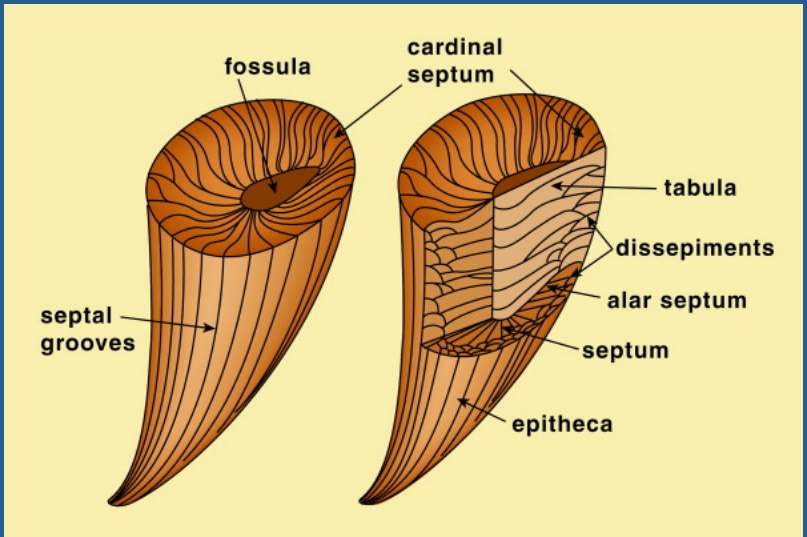
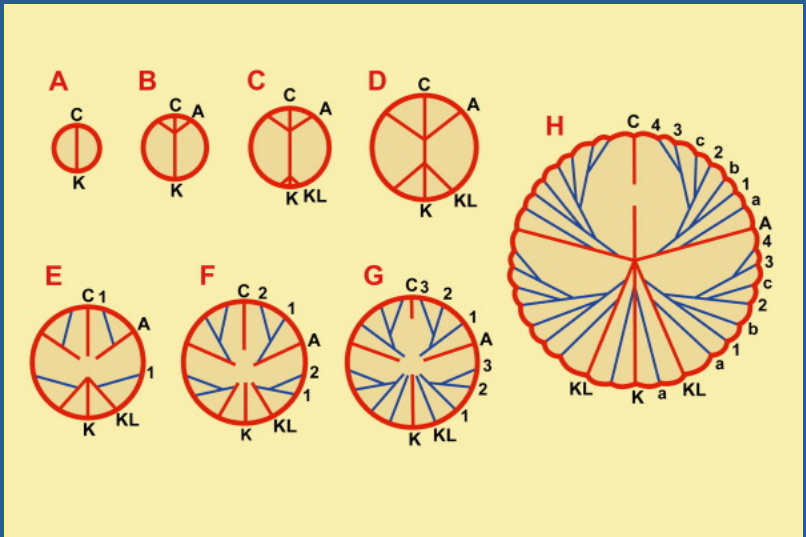
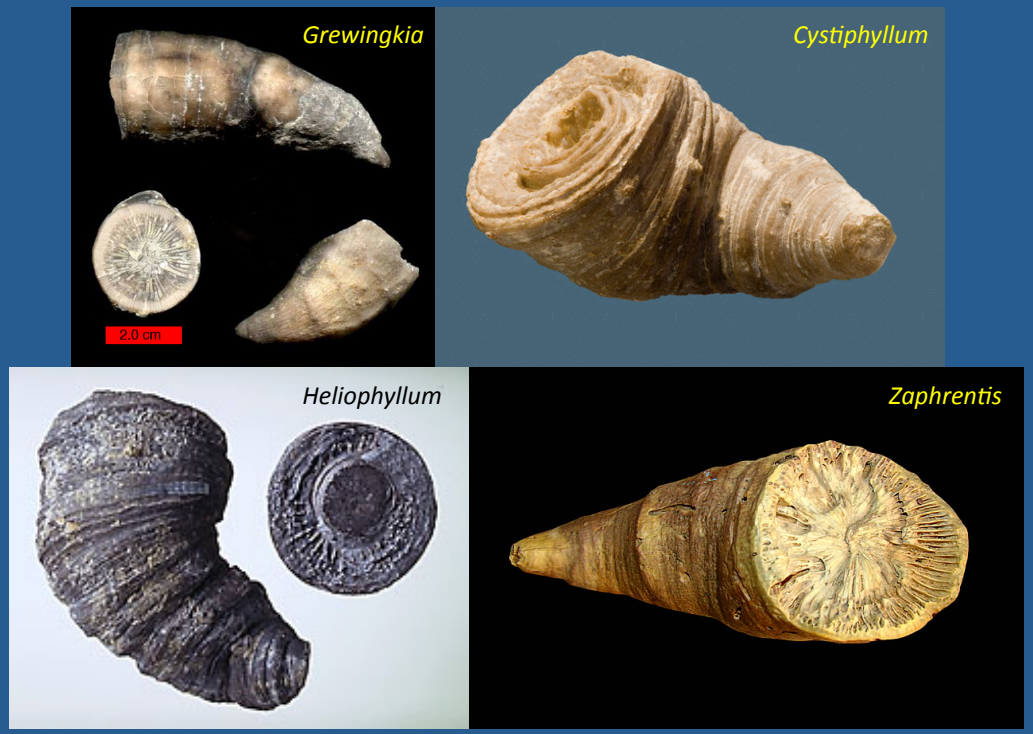




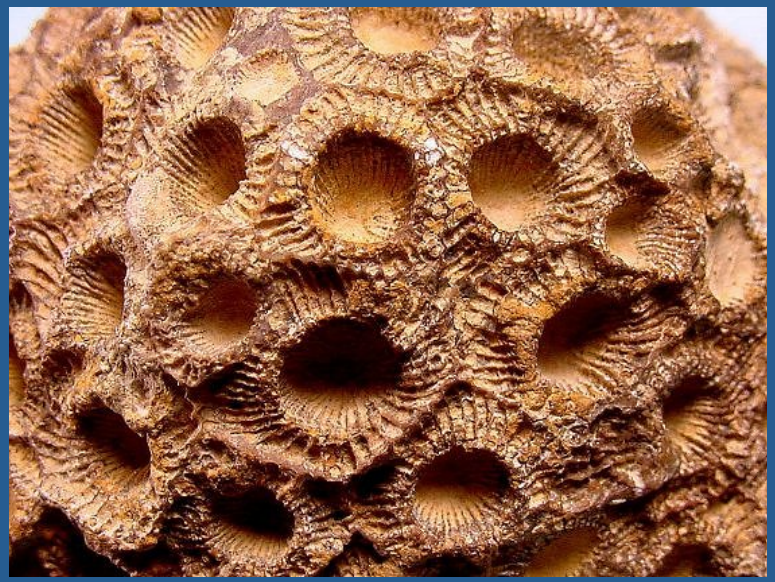
Rugosa

- Examples of solitary rugose corals include *Grewingkia* (Ord.), *Cystiphyllum* (Sil.-Dev.), *Heliophyllum* (Dev.), and *Zaphrentis* (Dev.-Miss.).

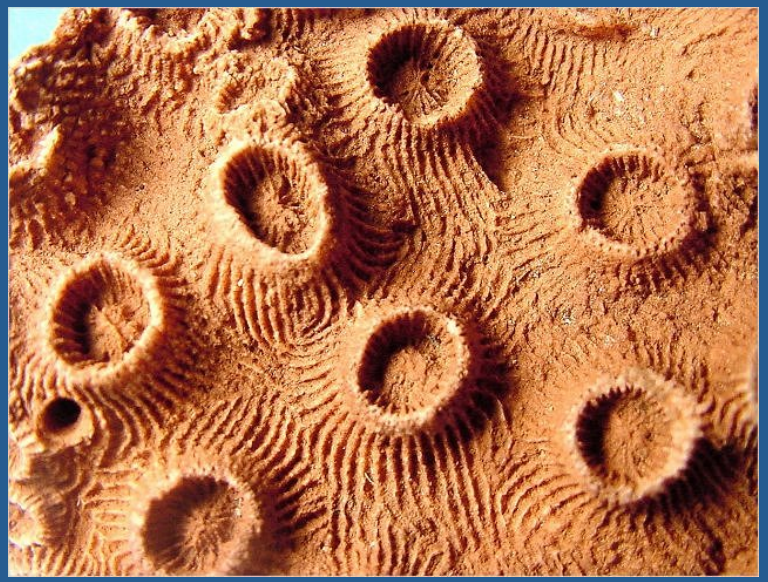


Rugosa

- Examples of colonial rugose corals include *Hexagonaria* (Devonian) and *Pachyphyllum* (Devonian).



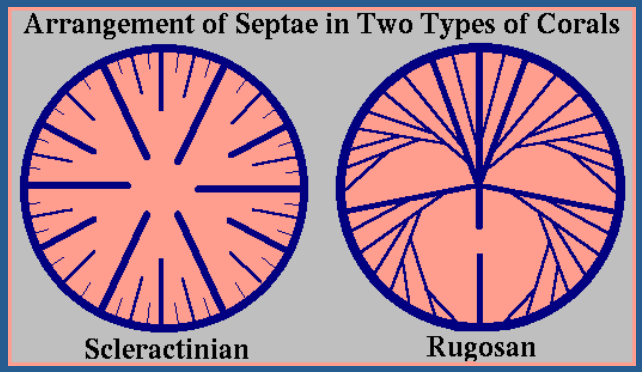
Hexagonaria



Pachyphyllum

Scleractinia

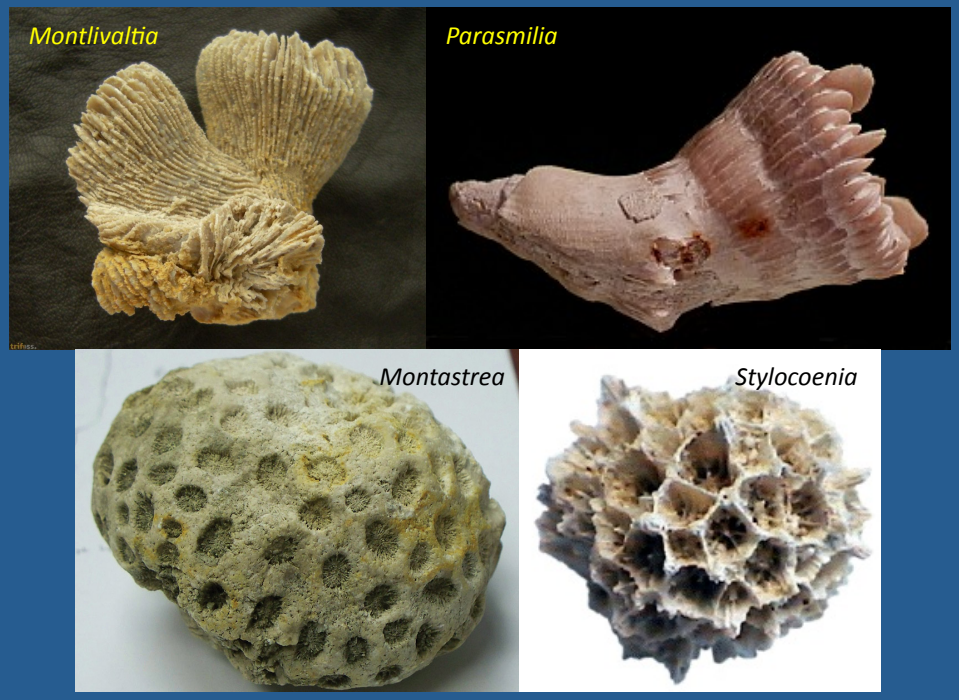
- The corallites of both solitary and colonial scleractinian corals are composed of aragonite. Septa arrangement is in groups of six, leading to them being known sometimes as Hexacoralla.



- Scleractinian corals have taken over most of the habitats of the extinct Rugosa. Colonial scleractinians form most of today's coral reefs and are generally confined to the tropics in places where the mean annual temperature of the upper 20 m of water is above about 25°C (77°F).

Scleractinia

- Examples of solitary scleractinian corals include *Montlivaltia* (Tri.-Cret.) and *Parasmilia* (Cret.-Rec.). Examples of colonial scleractinian corals include *Montastrea* (Jur.-Rec.) and *Stylocoenia* (Pal.-Mio.).



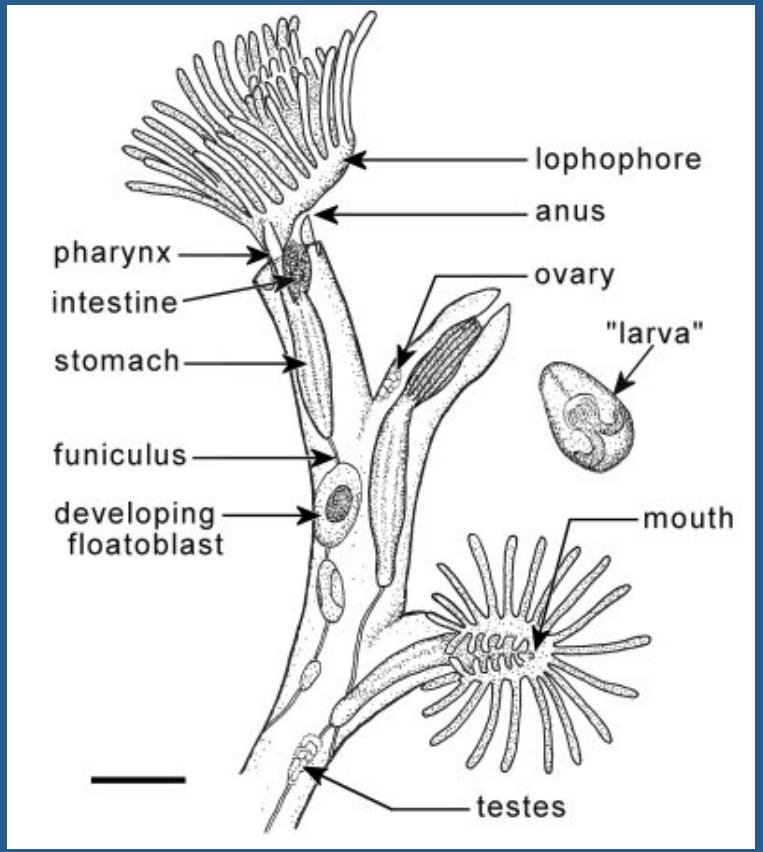
Phylum Bryozoa

- Phylum Bryozoa is represented by the bryozoans, or "moss animals." Bryozoans arose in the Early Ordovician and are still represented today.

- Bryozoans are small, marine or freshwater animals that are almost always colonial. Most marine species live in tropical waters, but a few occur in oceanic trenches, and others are found in polar waters.

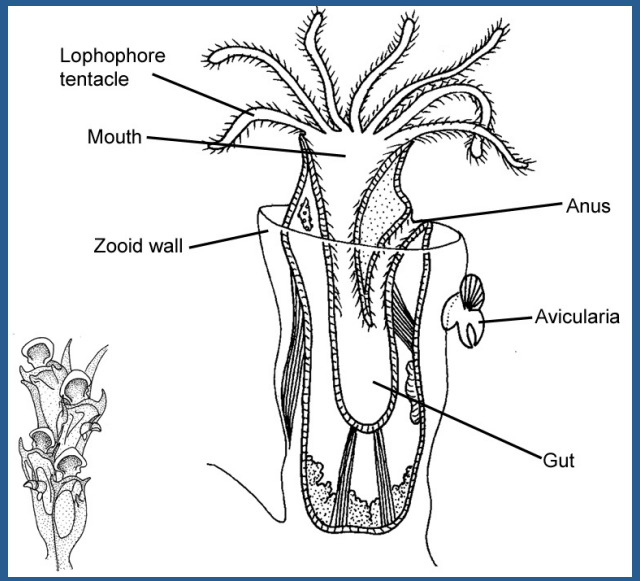
Phylum Bryozoa

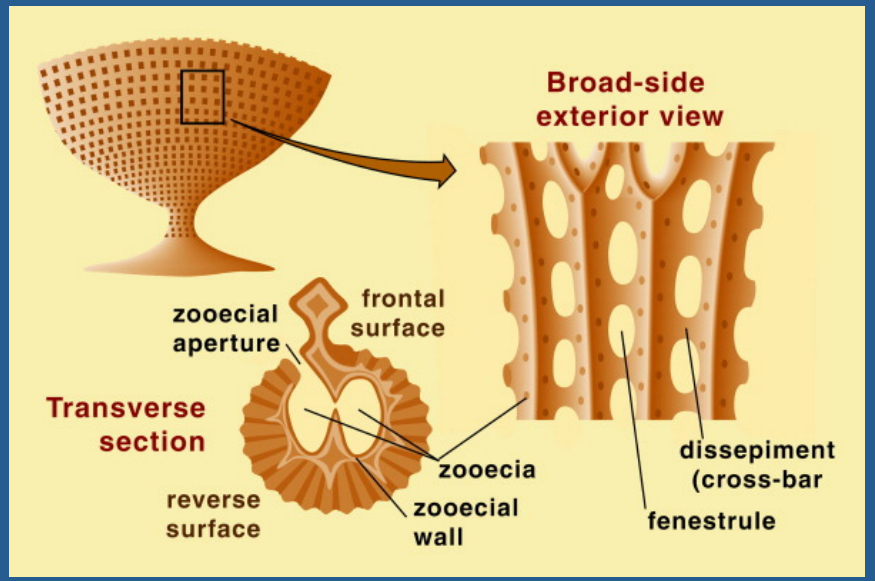
- Bryozoans are filter feeders that sieve food particles out of the water using a retractable lophophore, a “crown” of hollow tentacles lined with cilia that surrounds the mouth. The mouth and anus of the digestive track are close to one another on the upper surface of the animal. The lophophore also serves for respiration. Bryozoans possess a highly organized central nervous system.



Bryozoa

- Each individual of a bryozoan colony is called a zooid and is enclosed in a membranous or calcareous double-walled cup, the zooecium. The colony is called a zooarium.





Fossil Bryozoa

- Fossil bryozoans include the encrusting *Fenestella* (Ord.-Perm.) and *Prasopora* (Ord.-Sil.), and the branching *Parvohallopora* (Ord.-Sil.).