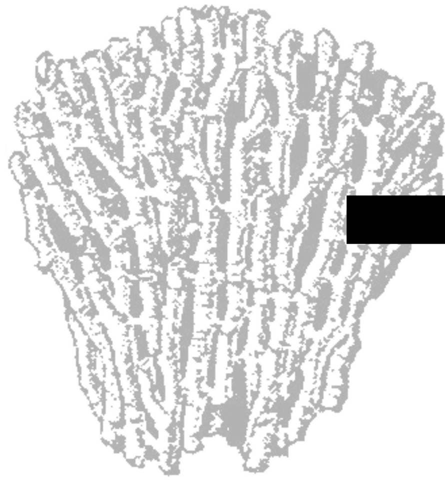

# Corals

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## Corals

All corals belong to the Phylum Cnidaria (Ni-da´-ri-a). The cnidarians are a natural group of invertebrate animals that have a simpler organization than most other invertebrates but have evolved a wide array of attractive, often colorful, solitary and colonial forms. Some of these swim or float in the water while others live attached or loose on the floors of oceans, lakes or rivers. Cnidarians may have no skeleton, organic protein skeleton or mineralized skeleton. Those lacking a mineralized skeleton are rare or unknown as fossils. The name CORAL is given to a group of cnidarians with calcareous skeletons that live on the sea floor, commonly attached to a hard surface. The fossil record of corals is good due to the easily preserved skeleton.

Cnidaria is a phylum that includes a variety of solitary and colonial animals in addition to the corals. Among these are sea anemones, hydroids, jellyfish, and sea pens. All cnidarians have stinging cells (cnidoblasts), commonly located in the tentacles; these characterize the phylum and give it its name. Two body forms, polyp and medusa, occur as alternating stages in the life cycles of many cnidarians. The medusae are jellyfish that float or weakly swim in the water with mouth and tentacles facing down. Polyps live on the bottom, temporarily or permanently attached with mouth and tentacles on their upper side. Although very different in general appearance, medusa and polyp are fundamentally alike with a sack-like body that has two tissue layers separated by a gelatinous material. The mouth is the only opening into or out of the sack. Alternating medusa and polyp stages characterize most members of two of the three main cnidarian classes. Most corals, however, belong to the Class Anthozoa which has polyps only.

The anthozoan Subclass Zoantharia includes polyps with and without skeletons. Those without skeletons are loosely termed anemones, those with skeletons are corals. Only the corals have a good fossil record. Coral skeletons are calcareous but may be either calcite or

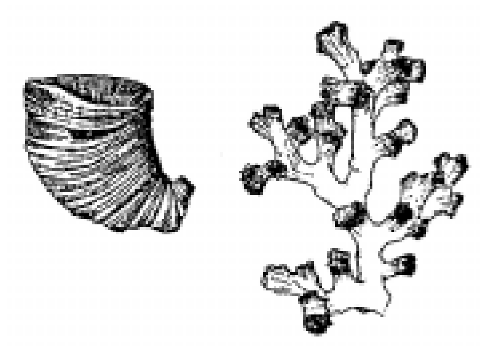

**Figure 1.** Solitary and colonial corals. Approximately one half life-size.

**Phylum Cnidaria**

Class Hydrozoa (hydroids, siphonophores including Portuguese man-o-war, some jellyfish)

Class Scyphozoa (most jellyfish including sea nettles)

Class Anthozoa

Subclass Octocorallia (most octocorals have horny, organic skeletons)

Subclass Zoantharia (includes sea anemones, and the stony corals with mineral skeletons)

**Table 1.** Simplified classification of the Phylum Cnidaria listing the better known members of the three principal classes.

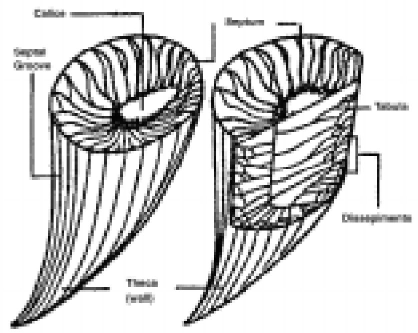

**Figure 2.** Parts of coral skeleton.

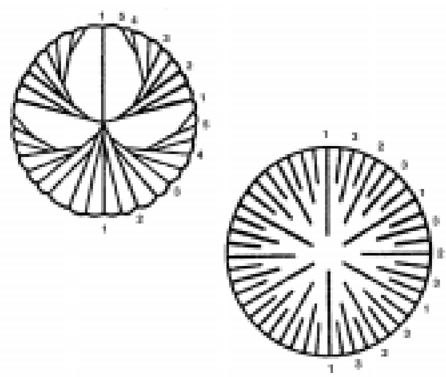

**Figure 3.** Diagramatic transverse sections of rugose (left) and scleractinian (right) corals. Numbers show the order of insertion of the septa: Rugosa, serial, four at a time; Scleractinia, cyclic, six at a time.

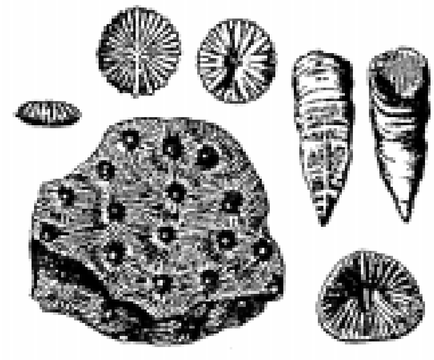

**Figure 4.** One colonial and several solitary rugose corals; on the right side are two views of the same specimen. Approximately two-thirds life size.

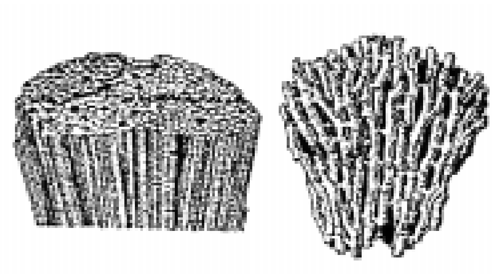

**Figure 5.** Massive and branching colonies of tabulate corals. Approximately one-half life size.

aragonite (two of the mineral forms of $CaCO_3$). Almost all Paleozoic corals secreted calcite skeletons; Mesozoic-Cenozoic skeletons are aragonite. Calcite is the more stable mineral form and Paleozoic corals are commonly well preserved. Aragonite is less stable and Mesozoic-Cenozoic corals are commonly poorly preserved.

The principal parts of the coral skeleton are illustrated in Figure 2. Most important for recognition purposes, are the wall (theca), the septa (sing. septum) that form a radiating pattern in top or transverse view, and "horizontal" structures such as tabulae (sing. tabula) and dissepiments. Since most fossil corals are found in rock matrix, specimens are ordinarily studied in thin sections (rock slices ground thin enough to transmit light and allow microscope study). Thin sections are usually prepared either through the axis of the skeleton (longitudinal) or perpendicular to the axis (transverse).

***Groups of corals (classification)***

Eight groups (orders) of corals are commonly recognized. All have good fossil records but some existed for only a short period of geologic time (see Geologic history). Three of the groups have long records and are important as fossils:

*Rugose corals* (Order Rugosa). Calcitic, solitary and colonial corals with principal septa added serially in four positions (Fig. 3). Limited to the Paleozoic, Middle Ordovician to Permian (Fig. 4).

*Tabulate corals* (Order Tabulata). Calcitic, exclusively colonial corals with slender corallites. Pores or connecting tubes between corallites are common. Septa are absent or occur as low ridges or rows of spines; tabulae tend to be numerous. Limited to the Paleozoic, Early Ordovician to Late Permian (Fig. 5).

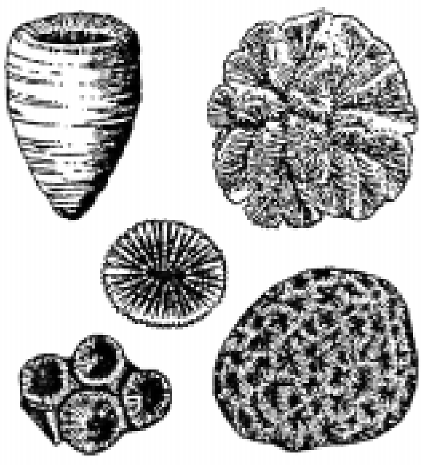

**Figure 6.** Solitary and colonial scleractinian corals. Approximately one-half life size.

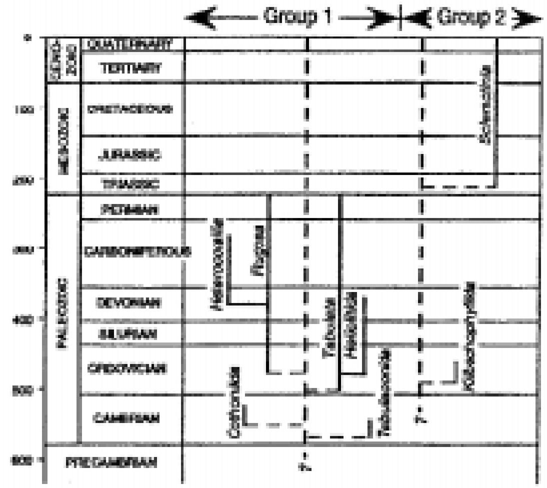


**Figure 7.** Stratigraphic ranges of eight orders of zoantharian corals (solid vertical lines) and the postulated ranges of orders of non-skeletal anemones (dashed vertical lines). Inferred evolutionary relationships are shown by horizontal connecting lines. Assignment to zoantharian Groups 1 and 2, discussed in text, are indicated. Numbers on left side are millions of years before present.

Scleractinian corals (Order Scleractinia). Aragonitic, solitary and colonial corals with septa added in cycles of six or multiples of six (Fig. 3). Limited to the Mesozoic and Cenozoic, Middle Triassic to Recent (Fig. 6).

### *Non-skeletal polyps*

Anemones are zoantharian polyps that are similar to coral polyps but lack a skeleton. Living anemone and coral polyps have paired mesenteries (radiating internal tissues) that are important in the development of septa. The calcareous septa of corals are formed between each pair of mesenteries. Two orders of living anemones develop mesenteries in cycles, as do scleractinian coral polyps, and are very similar to coral polyps in other respects. This suggests a close relationship that is currently being supported by molecular studies. Presumably, there were other anemones related to, and contemporary with, extinct coral orders but, if so, they have left no useable fossil record. However, one living order of “anemones” has serially inserted mesenteries and may be related to rugose corals. This is the basis for dividing the zoantharian corals and anemones into two groups in Figure 7; Group 1 with serial addition of septa and mesenteries and Group 2 with cyclic addition.

### *Geologic history and relationships*

The geologic record of the coral orders is shown in Fig. 7. There are more orders of corals in the Paleozoic than in the Mesozoic-Cenozoic but the overall complexity and adaptive success of the Scleractinia far exceeds that of the Paleozoic corals.

There is general agreement that the living orders of Group 2 (Fig. 7) are closely related. This was first suggested because of morphologic similarities and is being confirmed by molecular studies. The recognition of early Paleozoic Group 2 corals has led to the suggestion that Group 2 anemones, with cyclic addition of mesenteries, were present through most of post-Precambrian time, giving rise to the Group 2 orders.

The relationships of the Paleozoic coral orders suggested in Fig. 7, are based on comparative morphology and geologic time ranges. By analogy with Group 2, Group 1 anemones with serial addition of mesenteries are postulated. A living order of anemones is a possible survivor of this Group.

### *Coral reefs*

Corals are major components of many living and fossil reefs ranging in age from Ordovician to the present. Justly famous is the Great Barrier Reef, that extends for over 1800 km (1200 miles) along the northeast coast of Australia. Other areas of modern reef growth are the Florida Keys and Caribbean and in a number of places in the southern Pacific and Indian Oceans. Modern reef communities appeared during the Middle Triassic; this is also the time when many reef corals are thought to have developed a symbiotic association with a group of microscopic algae named zooxanthellae. These are found in the tissues of living reef building scleractinians but not preserved as fossils. However, zooxanthellae affect the shape, texture, and growth rate of the coral skeleton; these modifications seem to have first occurred in the Middle Triassic, not long after the first appearance of the Scleractinia.

Fossil reefs are preserved as limestone prominences of many different ages. Prime examples are seen in the Triassic of the Alps and the Devonian of Australia and western Canada. The Canadian reefs form important petroleum reservoirs because of porous limestones that result from reef growth.

***Suggested Readings***

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Prepared by:
Wm. A. Oliver, Jr.
U.S. Geological Survey (Emeritus),
Museum of Natural History, MRC 137,
Smithsonian Institution, Washington, DC 20560;

James E. Sorauf
Department of Geological Sciences
Binghamton University, Binghamton, NY 13902-6000

Designed by:
Diane Lonardelli
New Haven, CT.

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