Scleractinian Taxonomy

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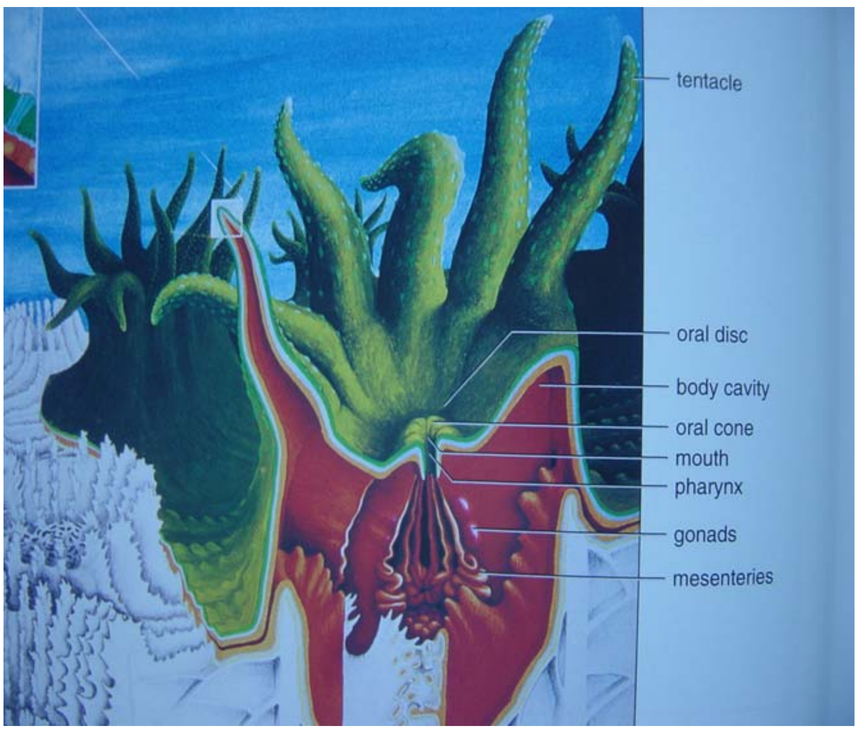
Introduction

In view of the above title this paper may appear dry, yet the classification of hard corals (scleractinian taxonomy) is at the very foundation of understanding the most diverse ecosystem in the world - the coral reef. Comprehension of a coral reef begins with the recognition of some common organisms that may lead to the identification of their distribution and abundance patterns. This appreciation could start with the most prolific organisms on any coral reef - the corals. To identify change on a coral reef, whether induced naturally or by human impact, the organisms should be recorded in a consistent, systematic way. This paper introduces Scleractinia, outlines their morphological differences and introduces their classification (see Cnidaria, in the Tree of Life)..

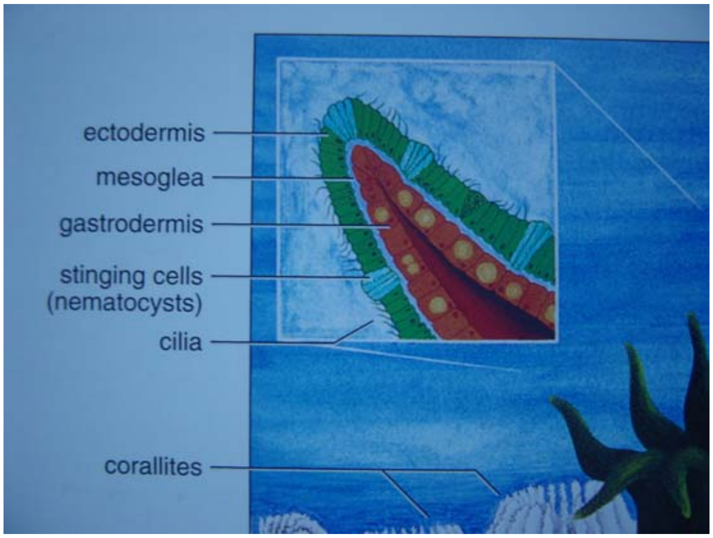
An individual coral animal is called a polyp. A polyp is soft-bodied and lives inside a hard cup-shaped, skeleton, called a corallite. The corallite is made of calcium carbonate. Calcium ions, taken from the surrounding water by the polyp, undergo transformation to be secreted as calcium carbonate structures. Corallites vary in size from a pinhead to the size of a shoe. Most polyps are small and live together in colonies; shoe size polyps are unusual because they are unattached and solitary (e.g. mushroom corals, *Fungia* species). Corallites multiply by a process called budding where a polyp will divide into two or more polyps (intra-tentacular) or where new polyps form on the side of the original polyp (extratentacular). Usually, thousands of genetically identical polyps, all interconnected, form a colony. Colonies grow by progressively building more and more skeletal mass. The soft-bodied polyps are "pulled up", like a sac hinged to scaffolding. Thin plates are progressively laid down underneath the soft tissue. Therefore, only the outer veneer of a colony supports the soft-tissue of the polyps, the rest is dead skeletal material (calcium carbonate).

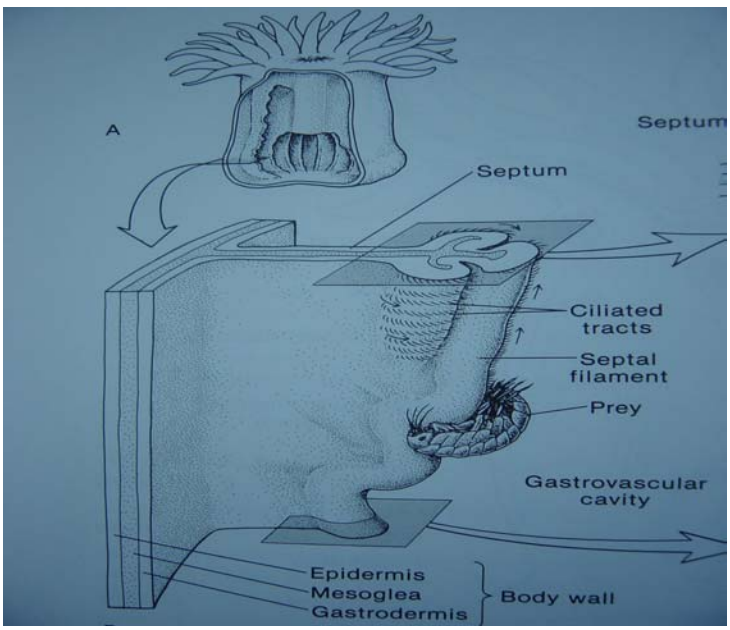
The polyps' anatomy is quite simple. Ingestion and expulsion are through a slit-like mouth. They have a small tube (or pharynx) which leads into the body cavity, which is divided radially by mesentries extending inwards from the inner surface of the wall. Coiled mesenterial filaments, are found along the inner edge of the mesentries. These organs are used in digestion, excretion and are the site where gonads develop in spring-time. Tentacles are found around the mouth, arranged in one or more rings. They are usually retractable. Tentacles contain batteries of stinging cells (nematocysts), used to detect and seize food particles (Figure 1). Although the corals are simple animals their skeletons are often complex, and it is the morphology of the skeleton that taxonomists have used to identify coral species, although many new techniques are examining genetic signatures[1].

Fig. 1. Coral anatomy. From Veron 2000.



[1] there are developments in molecular studies on the direct and indirect sequencing of DNA which will eventually be compared with morphological traits of corals. Furthermore, research on hybridization of corals may change our understanding on the species concept. This paper describes taxonomy of corals from a classical viewpoint by using distinct morphological traits of the coral skeleton to distinguish coral species.


ectodermis
mesoglea
gastrodermis
stinging cells
(nematocysts)
cilia
corallites


A
Septum
Septum
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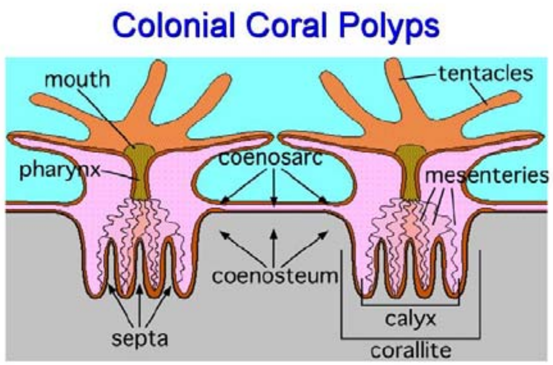
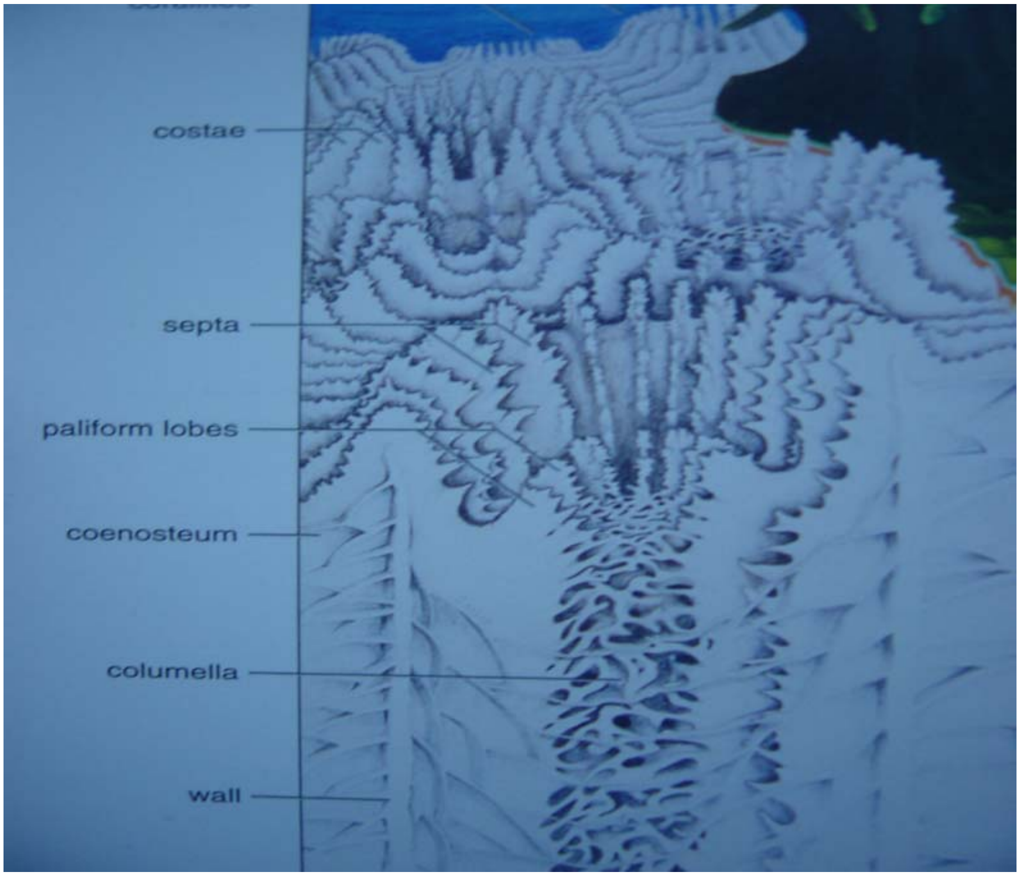
Body wall

Corallite morphology



The basic periphery of the corallite is called the corallite wall (Figure 1). Each corallite contains vertical plates radiating from the center; within the corallite they are called septa, and outside the corallite they are called costae, collectively these are the septo-costae. Some corals have vertical, pillar-like, projections on the inner margin of the septa, these projections are the paliform lobes. In the center of the corallite is the columella (which, depending on the species, may or may not be present). Corallites are joined together by horizontal plates called coenosteum. Individual coral polyps are connected via a coensarc, through which they can share indigested materials and photosynthetic by-products from the zooxanthellae[2].

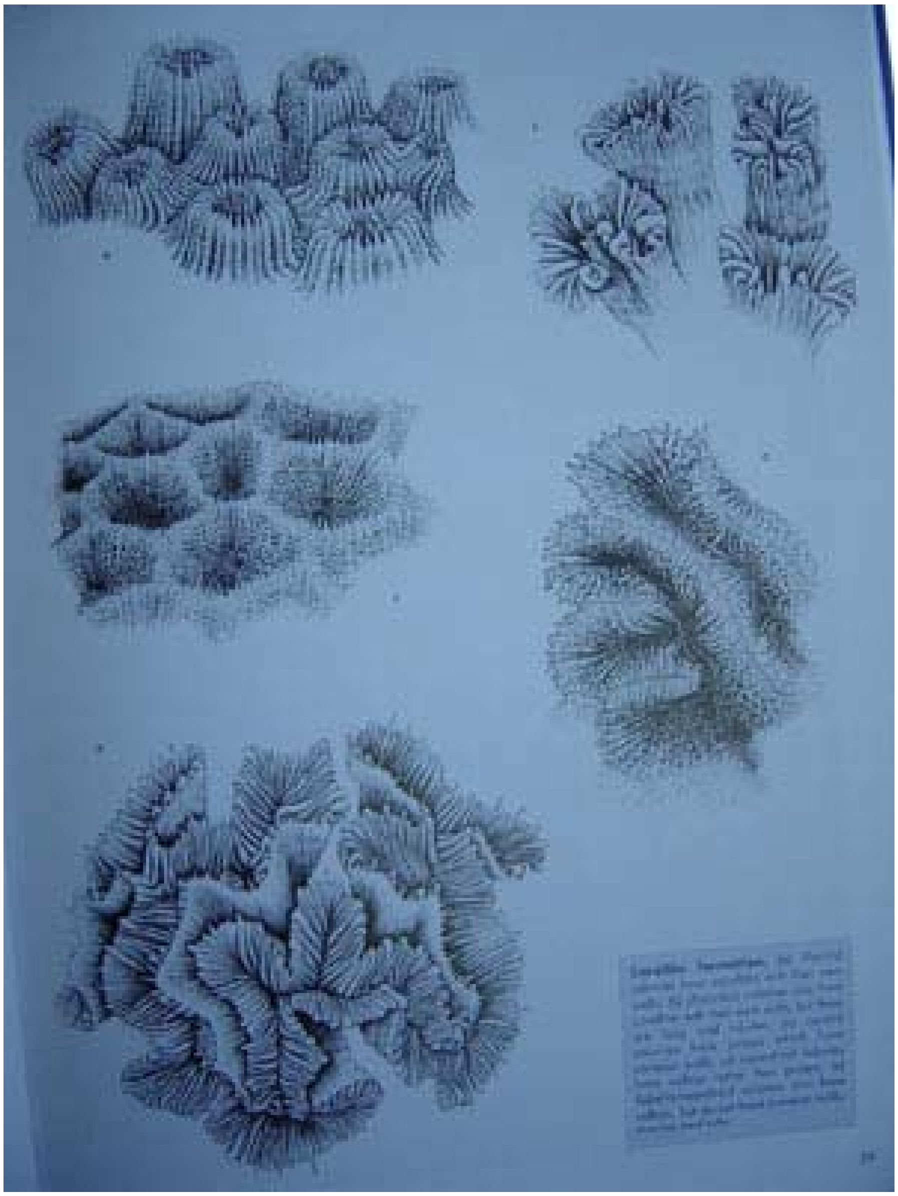
[2] Coral colonies support millions of symbiotic algae (zooxanthellae) in their soft-tissue. The algae photosynthetically fixes carbon compounds that are passed on to the animal and used as an energy source. The algae also saturate the polyp with oxygen, remove wastes and facilitate calcium secretion. In exchange the coral excretes ammonium, an excellent nutrient source for the algae.



From Veron 2000.

After the basal plate (the first structure that a polyp secretes), the septa appear, " septal evolution is probably the key to scleractinian evolution and classification" (Vaughan and Wells 1943). A coral polyp will first lay down 6 septa, which is called the first septal cycle. Then it will lay down 12 new septa, two on either side of the primary septa. A third and fourth cycle may follow. The length of septa varies from species to species, usually written as the distance relative to the radius of the corallite. For example, primary septa ½R, indicate that the primary septa extend to half the radius of the corallite. The symmetric pattern of the septa are used to distinguish problematic species, for example the *Acropora* species. Within most corallites, the first cycle has the largest septa, regressing to the fourth which has the shortest, however there is an exception to the rule where the fourth-cycle septa extend out past the third cycle septa and fuse, this is called Pourtalès Plan.

Most polyps are small and live together in colonies; shoe size polyps are unusual because they are unattached and solitary (e.g. mushroom corals, *Fungia* species).The morphology or shape of corallites depends largely on how they divide. When corallites have their own walls they are called plocoid or phaceloid (where the latter is more elongate), ceroid when they share walls and meandroid when they form valleys. One more common form is when the valleys do not have a common wall, termed flabello-meandroid.



Veron 2000. a. Plocoid, b. Phaceloid, c. Ceroid, d. Meandroid, e. Flabello-meandroid.

Colony morphology

The shape of the corallum (colony) depends upon the character and size of the polyp, its growth rate, and mode of reproduction (Vaughan and Wells 1943).

Coral colonies are found as either:

1. Massive - similar in all directions
2. Columnar - forms columns
3. Encrusting - adhering to substrate
4. Branching - tree- or finger-like
5. Foliaceous - leaf-like
6. Laminar - plate-like
7. Free-living

From Veron 2000.

Only a few corals are restricted to <u>one</u> growth form, e.g. *Pavona cactus*, and this may restrict the species to specific habitats. For most corals, colony shape is not genetically constrained as considerable morphological plasticity exists that allows corals to adapt to a number of environmental conditions. In other words, many corals can change their shape in accordance with the habitat in which it is found. For example, the variation in available light (e.g. shallow or deep slope, clear or turbid water), and amount of wave action will have profound effects on the morphology of coral colonies. Reef crest corals, that are continually pounded by waves will support sturdy corals with short, stout branches, to resist dislodgement. The same species on a lower slope will have more delicate looking branches, because of reduced exposure and adaptation to reduced light. Small changes in light availability often associated with depth or turbidity can have substantial effects on coral morphology. Despite considerable variation in coral colonies because of physical forcing, there are still many characteristics which aid in coral taxonomy, although some knowledge of the habitat and water depth will greatly help the identification process of a coral specimen.

There are 15 Scleractinian families (Table 2). Distinguishing characteristics of these families are presented as follows. 1) Acroporidae is the most common and diverse family, it incorporates over a hundred species including the branching `staghorn' corals. These corals are all fast-growing, averaging 10 cm a year. 2 & 3) Faviidae and Poritidae are usually massive, hemispherical species, and are slow growing, averaging 1 cm a year. 4) Pocilloporidae are again branching with distinct wart-like verrucae (a clump of six of more corallites).

Fifteen scleractinian families.

1. Acroporidae	5. Mussidae	9. Pectiniidae	13. Siderastreidae
2. Faviidae	6. Oculinidae	10. Dendrophylliidae	14. Astrocoeniidae
3. Poritidae	7. Agariciidae	11. Merulinidae	15. Trachyphlliidae
4. Pocilloporidae	8. Fungiidae	12. Euphyllidae	

The 12 remaining coral families are less common. 5) Mussid colonies have large corallites (up to 12 cm), with large septal teeth. 6) Oculinids have spikey plocoid corallites and a smooth coenosteum (surface between corallites), dominated by the ubiquitous *Galaxea*. 7) Agariciids have very small corallites < 3 mm, the septa are continuous between adjacent corallites 8) Fungiids are easily distinguished, they are the free-living mushroom corals with individual corallites up to 30 cm. 9) Pectiniid colonies are fleshy colonies with large septal teeth, generally forming thin plates, or thin protuberant plates with meandroid valleys. 10) Dendrophylliids, have smooth rounded corallites and laminar colonies. 11) Merulinids, comprise corals of the genera *Hydnophora, Merulina* and the very rare *Scapophyllia. Hydnophora* colonies have hydnophores, which are short conical mounds all over the corallum. *Merulina* colonies are fan-shaped, with short straight valleys. Scapophyllids are similar to Merulinids but the colonies are columnar. 12) Euphylliids have large protuberant polyps (bubble coral), and massive colonies. 13) Siderastreids have petal-shaped corallites < 3 mm, that are not fused. 14 & 15) Astrocoeniids and Trachyphylliids are rare. The generic characteristics of the Indo-Pacific corals detailed in Table 3.

Table 3. Summary of generic characteristics within Scleractinia (for further details see Veron and Pichon 1976; Veron and Pichon 1980; Veron and Pichon 1982; Veron and Wallace 1984; Veron 1986).

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1) Family Acroporidae

Acropora: most common coral, branching, tabular, bushy colonies. 2 types of corallites radial (side) and axial (top). No columellae, corallite walls and coenosteum are porous. Corallite 0.7 to 1.3 mm.
Montipora: all shapes of colonies, corallites empty, with no columellae, septa are vertical rows of inward projecting spines, walls are porous, corallite 0.25 - 1.0 mm
Astreopora: massive and encrusting colonies. Corallites immersed or conical. Numerous, short septa. Columellae deep. Corallite 1.6 to 2.2 mm.
Anacropora : branching colonies. Smooth coenosteum, radial corallites only, which are small and immersed. Only found in muddy waters. Corallite 0.4 mm.

2) Family Faviidae

Caulastrea: Phaceloid colonies. Corallites 8.0 to 12.0 mm.
Favia: Massive colonies. Monocentric, plocoid (has own wall). Corallites 3.0 to 25.0 mm.
Barabattoia: Colonies massive, corallites tube like (plocoid to sub-dendroid).Corallites 10.0 mm.
Favites: Colonies massive. Corallites monocentric, ceroid. Poorly developed paliform lobes. Corallites 5.0 to 17.0.
Goniastrea: Colonies massive. Honeycomb colonies. Paliform lobes. Corallites 3.5 to 14.0 mm.
Platygyra: Massive colonies. Meandroid corallites. No paliform lobes. Columellae have no centers, just a tangle of spines.Corallites 4.0 to 6.0 mm.
Leptoria: Massive. Neat order of septa and neat valleys (meandroid). Maze valleys, railway track type walls. Corallites 4.0 mm.

Oulophyllia: Massive, monocentric to meandroid. Broad valleys. Well defined columellae.12.0 to 15.0 mm.
Montastrea: Massive colonies. Extra-tentacular budding. Plocoid corallites. Corallites 4.0 to 10.0 mm.
Oulastrea: Encrusting, skeleton remains dark when dry. Found in dirty water. Corallites 4.0 mm.
Plesiastrea: Massive colonies. Monocentric, plocoid. Paliform lobes. Corallites 2.5 mm.
Diploastrea: Massive colonies. Monocentric, plocoid. Corallites 7.0 mm.
Leptastrea: Colonies massive, encrusting. Corallites between ceroid and plocoid. Septa inward projecting teeth. Columellae vertical pinnules. Corallite 2.5 to 6.0 mm.
Cyphastrea: Massive colonies. Corallites plocoid. No paliform lobes. Coenosteum granulated. Corallites 1.5 to 2.0 mm.
Echinopora: Colonies are plates or branches. Plocoid corallites. Granulated coenosteum. Corallites 3.5 to 4.5 mm.

3) Family Poritidae

Porites: Flat, massive or branching colonies. Small, immersed corallites filled with septa. Corallites small 0.6 to 1.3 mm.
Goniopora: Massive or columnar colonies. Corallites have thick porous walls, compacted septa and columellae. Live colonies have 24 tentacles. Corallites 2.2 to 5.0 mm.
Alveopora: colonies very porous, light structure, fine

spines. Little internal structure in corallites, columellae tangle. 12 tentacles. Corallites 1.4 to 6.0 mm.

4) Family Pocilloporidae

Pocillopora: Clumped, branching colonies. Wart-like growths (verrucae) which cover the colonies. Many corallites on one verrucae. Corallites are immersed, usually with little internal structure. Coenosteum covered in granules. Corallite: 1.1 mm
Stylophora: Clumped, branching colonies. Corallites sometimes have hoods but are not in neat rows, six distinct septa. Corallite: 1.0 mm
Seriatopora: Fine branching colonies. Corallites in neat rows, usually the radial corallites have a hooded appearance. Corallite: 1.0 mm
Palauastrea: Branching colonies, corallites are star-like.Corallite : 1.0 mm

5) Family Mussidae

Large corallites. Heavy skeleton, large teeth on septa.
Lobophyllia: Dome shape colonies. Large corallites, one or several mouths are joined. Large septa with very long teeth. Corallites 13.0 to 35.0 mm.
Symphyllia: Colonies dome shaped. Brain shaped corallites (meandroid). Largest valleys of all corals. A groove runs on top of the walls. Corallites 13.0 to 22.0 mm.
Acanthastrea: Colonies look similar to Favia, however the they have tall . Septa have large teeth. Corallites 12.0 to 40.0 mm.
Cynarina: Circular colonies. Pointed base for attachment. Solitary. Septa have large teeth. Corallite 50.0 mm.
Blastomussa: Colonies are phaceloid. Corallites 6.0 to 13.0 mm.
Scolymia: Solitary corallites, 40 to 90 mm, saucer shaped.
Australomussa: Rare, dome shaped.

6) Family Oculinidae

Exert septa, smooth coenosteum.
Galaxea: Massive colonies. Septa very exert. Coenosteum blistery. Corallites 3.5 to 6.0 mm.
Acrhelia: Spikey appearance, branching colonies. Corallites 4.0 mm.

7) Family Agariciidae

Fine, small tentacles. Poorly developed walls, septa are continuous between adjacent corallites.
Leptoseris: Found in deep waters. Leaf like colonies. Central corallite, no walls, interconnected by fine septo-costae.
Coeloseris: massive, ceroid with no columellae. Like a railway track between corallites. Corallites 3.0 mm.
Pavona: small, shallow corallites which have poorly defined walls, inter-connected by septo-costae. Corallites 0.5 to 3.0 mm.
Pachyseris: Series of concentric ridges parallel with the margin. Corallites 0.5 mm.
Gardineroseris: massive, 1 or more corallites in deep cavities, very fine septo-costae. Corallite 3.0 mm.

8) Family Fungiidae

Fungia: Free-living. Found on reefs. Circular corallite, upto 300 mm.
Cycloseris: Small, free-living. Found on sand between reefs. 40 to 80 mm.
Heliofungia: Free-living. Septa have large lobed teeth. Similar to Fungia but polyps extend during day. Corallites180 mm.
Ctenactis: Free-living. Similar to Fungia but elongate colonies. Single mouth. 250 mm.
Herpolitha: Free-living. Large heavy, elongate colonies. Axial furrow with many mouths. Mouths also on rest of colony. Corallites 5.0 to 10.0 mm. Colonies as big as 1000 mm.
Polyphyllia: Free-living. Elongate and dome-shaped. A more smooth even appearance than Herpolitha. Axial furrow indistinct. Primary septa short. Corallites 4.0 mm, colonies upto 400 mm.
Halomitra: Free-living, dome-shaped, jagged appearance. Corallites widely spaced. Similar to a free-living Podabacia. Corallites 6.0 mm.
Sandalolitha: Large, free-living. Similar to Halomitra but less spikey. Rounded, dome-shape colonies, corallites evenly spaced apart. Corallites 3.5 mm.
Zoopilus: Attached. Fine septal ridges running out like the spoke of a wheel. Difficult to distinguish mouth. Corallite 300 mm.
Lithophyllon: Attached, and encrusting. Petal-like protrusions. Septa long. Mouths are usually in concentric rows, separated parallel to the outer margin more so than their separation perpendicular to margin. Corallites 3.5 mm.
Podabacia: Attached encrusting. Similar to

Sandalolitha but the former is attached. 3.0 mm.

Thick and fleshy colonies. Generally colonies are thin plates, or with thin protuberant plates with meandroid valleys. Large septal teeth.
Pectinia: Thin, high walls, short valleys. Corallites 4.5 to 24 mm.
Oxypora: thin plates. Corallites are round, coenosteum pitted. Few septa. Corallites 5.0 mm.
Echinophyllia: encrusting or foliaceous colonies. Round corallites. Numerous septa, well developed columellae. Corallites 4.0 to 15.0 mm.
Mycedium: Colonies are flat plates. Nose shaped corallites, with the open nostril end facing the outer margins. Corallites 1.8 mm.

10) Family Dendrophylliidae

Turbinaria: Laminar, massive or foliose colonies. Corallites round, porous walls. Porous coenosteum. Septa short. Columellae broad and compact. Corallites 1.5 to 4.0 mm.

11) Family Merulinidae

Hydnophora: Hydnophores (common walls intersect and form conical mound) present. Corallites at base of hydnophores. Corallites 3.0 to 4.0 mm.
Merulina: Fan-shape colonies. Short, straight valleys, spreading like a fan. Corallites 3.5 mm.
Scapophyllia: Columnar colonies. Meandroid valleys. Corallites 3.2 mm.

12) Family Euphyllidae

Euphyllia: Colonies are dome-shaped. fabelloid, phaceloid or meandro-phaceloid. Smooth are large. Columellae absent. Corallites 23.0 to 32.0 mm.

9) Family Pectiniidae

Catalaphyllia: Flabello-meandroid. Corallites 50.0 mm
Plerogyra: Bubble coral. Connected valleys, flabello-meandroid. Large septa. No columellae. Corallites 35.0 mm.
Physogyra: Massive colonies. Meandroid, with short valleys. Large septa. No columellae. Corallites 18.0 mm.

13) Family Siderastreidae

Immersed corallites, poorly defined walls. Septa fused on inner margin to form fan-like group. Corallites very small.
Coscinaraea: Encrusting colonies. Corallites in short valleys, walls are indistinct. Septo-costae are fused. Heavily serrated to heavily granulated. Corallites 3.0 to 3.5 mm
Psammocora: Encrusting and digitate colonies. Corallites in small shallow valleys. Septo-costae form petal-like shapes. Corallites 1.0 to 3.0 mm

14) Family Astrocoeniidae

Stylocoeniella: encrusting colonies, coenosteum covered in fine spinules and large pointed styles, sharp to touch. Corallite: 0.8 mm

15) Family Trachyphylliidae

Trachyphyllia: Colonies massive. Flabelloid-meandroid. Colonies 80 mm, corallites 16.5 mm.

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