

= Scleractinia =

Scleractinia , also called stony corals or hard corals , are marine animals in the phylum Cnidaria that live on the seabed and build themselves a hard skeleton . The individual animals are known as polyps and have a cylindrical body crowned by an oral disc with a mouth and a fringe of tentacles . Although some species are solitary , most are colonial . The founding polyp settles on the seabed and starts to secrete calcium carbonate to protect its soft body . Solitary corals can be as much as 25 cm ( 10 in ) across but in colonial species the polyps are usually only a few millimetres in diameter . These polyps reproduce by budding but remain attached to each other , forming a multi @-@ polyp colony with a common skeleton , which may be up to several metres in diameter or height according to species .

The shape and appearance of each coral colony depends not only on the species , but also on its location , depth , the amount of water movement and other factors . Many shallow @-@ water corals contain symbiont unicellular organisms known as zooxanthellae within their tissues . These give their colour to the coral which thus may vary in hue depending on what species of symbiont it contains . Stony corals are closely related to sea anemones , and like them are armed with stinging cells known as cnidocytes . Corals reproduce both sexually and asexually . Most species release gametes into the sea where fertilisation takes place , and the planula larvae drift as part of the plankton , but a few species brood their eggs . Asexual reproduction is mostly by fragmentation , when part of a colony becomes detached and reattaches elsewhere .

Stony corals occur in all the world 's oceans . Hermatypic corals are mostly colonial and form part of reef structures ; most of these are zooxanthellate and are found in the shallow waters into which sunlight penetrates . Other corals may be solitary or colonial and do not form reefs ; some of these occur at abyssal depths where no light reaches . Stony corals first appeared in the Middle Triassic , but their relationship to the tabulate and rugose corals of the Paleozoic is currently unresolved . Much of the framework of modern coral reefs is formed by scleractinians . Stony corals numbers are expected to decline due to the effects of global warming and ocean acidification .

= = Anatomy = =

Scleractinian corals may be solitary or colonial . Colonies can reach considerable size , consisting of a large number of individual polyps .

= = = Soft parts = = =

Stony corals are members of the class Anthozoa and like other members of the group , do not have a medusa stage in their life cycle . The individual animals are known as polyps and have a cylindrical body crowned by an oral disc surrounded by a ring of tentacles . The base of the polyp secretes the stony material from which the coral skeleton is formed . The body wall of the polyp consists of mesoglea sandwiched between two layers of epidermis . The mouth is at the centre of the oral disc and leads into a tubular pharynx which descends for some distance into the body before opening into the gastrovascular cavity that fills the interior of the body and tentacles . Unlike other cnidarians however , the cavity is subdivided by a number of radiating partitions , thin sheets of living tissue , known as mesenteries . The gonads are also located within the cavity walls . The polyp is retractable into the corallite , the stony cup in which it sits , being pulled back by sheet @-@ like retractor muscles .

The polyps are connected by horizontal sheets of tissue known as coenosarc extending over the outer surface of the skeleton and completely covering it . These sheets are continuous with the body wall of the polyps , and include extensions of the gastrovascular cavity , so that food and water can circulate between all the different members of the colony . In colonial species , the repeated asexual division of the polyps causes the corallites to be interconnected , thus forming the colonies . Also , cases exist in which the adjacent colonies of the same species form a single colony by fusing . Most colonial species have very small polyps , ranging from 1 to 3 mm ( 0 @.@ 04 to 0 @.@ 12 in ) in

diameter , although some solitary species may be as large as 25 cm ( 10 in ) .

### == Skeleton ==

The skeleton of an individual scleractinian polyp is known as a corallite . It is secreted by the epidermis of the lower part of the body , and initially forms a cup surrounding this part of the polyp . The interior of the cup contains radially aligned plates , or septa , projecting upwards from the base . Each of these plates is flanked by a pair of mesenteries .

The septa are secreted by the mesenteries , and are therefore added in the same order as the mesenteries are . As a result , septa of different ages are adjacent to one another , and the symmetry of the scleractinian skeleton is radial or biradial . This pattern of septal insertion is termed " cyclic " by paleontologists . By contrast , in some fossil corals , adjacent septa lie in order of increasing age , a pattern termed serial and produces a bilateral symmetry . Scleractinians secrete a stony exoskeleton in which the septa are inserted between the mesenteries in multiples of six .

All modern scleractinian skeletons are composed of calcium carbonate in the form of crystals of aragonite , however , a prehistoric scleractinian ( *Coelosimilia* ) had a non @-@ aragonite skeletal structure which was composed of calcite . The structure of both simple and compound scleractinians is light and porous , rather than solid as is the case in the prehistoric order Rugosa . Scleractinians are also distinguished from rugosans by their pattern of septal insertion .

### == Growth ==

In colonial corals , growth results from the budding of new polyps . There are two types of budding , intratentacular and extratentacular . In intratentacular budding , a new polyp develops on the oral disc , inside the ring of tentacles . This can form individual , separate polyps or a row of partially separated polyps sharing an elongate oral disc with a series of mouths . Tentacles grow around the margin of this elongated oral disc and not around the individual mouths . This is surrounded by a single corallite wall , as is the case in the meandroid corallites of brain corals .

Extratentacular budding always results in separate polyps , each with its own corallite wall . In the case of bushy corals such as *Acropora* , lateral budding from axial polyps form the basis of the trunk and branches . The rate at which a stony coral colony lays down calcium carbonate depends on the species , but some of the branching species can increase in height or length by around 10 cm ( 4 in ) a year ( about the same rate as human hair grows ) . Other corals , like the dome and plate species , are more bulky and may only grow 0 @.@ 3 to 2 cm ( 0 @.@ 1 to 0 @.@ 8 in ) per year . The rate of aragonite deposition varies diurnally and seasonally . Examination of cross sections of coral can show bands of deposition indicating annual growth . Like tree rings , these can be used to estimate the age of the coral .

Solitary corals do not bud . They gradually increase in size as they deposit more calcium carbonate and produce new whorls of septa . A large *Ctenactis echinata* for example normally has a single mouth , may be about 25 cm ( 10 in ) long and have more than a thousand septa .

### == Distribution ==

Stony corals occur in all the world 's oceans . There are two main ecological groups . Hermatypic corals are mostly colonial corals which tend to live in clear , oligotrophic , shallow tropical waters ; they are the world 's primary reef @-@ builders . Ahermatypic corals are either colonial or solitary and are found in all regions of the ocean and do not build reefs . Some live in tropical waters but some inhabit temperate seas , polar waters , or live at great depths , from the photic zone down to about 6 @,@ 000 m ( 20 @,@ 000 ft ) .

### == Ecology ==

Scleractinians fall into one of two main categories :

Reef @-@ forming or hermatypic corals , which mostly contain zooxanthellae ;

Non @-@ reef @-@ forming or ahermatypic corals , which mostly do not contain zooxanthellae

In reef @-@ forming corals , the endodermal cells are usually replete with symbiotic unicellular dinoflagellates known as zooxanthellae . There are sometimes as many as five million cells of these per 1 square centimetre ( 0 @. @ 16 sq in ) of coral tissue . The symbionts benefit the corals because up to 50 % of the organic compounds they produce are used as food by the polyps . The oxygen byproduct of photosynthesis and the additional energy derived from sugars produced by zooxanthallae enable these corals to grow at a rate up to three times faster than similar species without symbionts . These corals typically grow in shallow , well @-@ lit , warm water with moderate to brisk turbulence and abundant oxygen , and prefer firm , non @-@ muddy surfaces on which to settle .

Most stony corals extend their tentacles to feed on zooplankton , but those with larger polyps take correspondingly larger prey , including various invertebrates and even small fish . In addition to capturing prey in this way , many stony corals also produce mucus films they can move over their bodies using cilia ; these trap small organic particles which are then pulled towards and into the mouth . In a few stony corals , this is the primary method of feeding , and the tentacles are reduced or absent , an example being *Acropora acuminata* . Caribbean stony corals are generally nocturnal , with the polyps retracting into their skeletons during the day , thus maximising the exposure of the zooxanthallae to the light , but in the Indo @-@ Pacific region , many species feed by day and night .

Non @-@ zooxanthellate corals are usually not reef @-@ formers ; they can be found most abundantly beneath about 500 m ( 1 @, @ 600 ft ) of water . They thrive at much colder temperatures and can live in total darkness , deriving their energy from the capture of plankton and suspended organic particles . The growth rates of most species of non @-@ zooxanthellate corals are significantly slower than those of their counterparts , and the typical structure for these corals is less calcified and more susceptible to mechanical damage than that of zooxanthellate corals .

= = Life cycle = =

Stony corals have a great range of reproductive strategies and can reproduce both sexually and asexually . Many species have separate sexes , the whole colony being either male or female , but others are hermaphroditic , with individual polyps having both male and female gonads . Some species brood their eggs but in most species , sexual reproduction results in the production of a free @-@ swimming planula larva that eventually settles on the seabed to undergo metamorphosis into a polyp . In colonial species , this initial polyp then repeatedly divides asexually , to give rise to the entire colony .

= = = Asexual reproduction = = =

The most common means of asexual reproduction in colonial stony corals is by fragmentation . Pieces of branching corals may get detached during storms , by strong water movement or by mechanical means , and fragments fall to the sea bed . In suitable conditions , these are capable of adhering to the substrate and starting new colonies . Even such massive corals as *Montastraea annularis* have been shown to be capable of forming new colonies after fragmentation . This process is used in the reef aquarium hobby to increase stock without the necessity to harvest corals from the wild .

Under adverse conditions , certain species of coral resort to another type of asexual reproduction in the form of " polyp bail @-@ out " , which may allow polyps to survive even though the parent colony dies . It involves the growth of the coenosarc to seal off the polyps , detachment of the polyps and their settlement on the seabed to initiate new colonies . In other species , small balls of tissue detach themselves from the coenosarc , differentiate into polyps and start secreting calcium carbonate to form new colonies , and in *Pocillopora damicornis* , unfertilised eggs can develop into viable larvae .

## == Sexual reproduction ==

The overwhelming majority of scleractinian taxa are hermaphroditic in their adult colonies . In temperate regions , the usual pattern is synchronized release of eggs and sperm into the water during brief spawning events , often related to the phases of the moon . In tropical regions , reproduction may occur throughout the year . In many cases , as in the genus *Acropora* , the eggs and sperm are released in buoyant bundles which rise to the surface . This increases the concentration of sperm and eggs and thus the likelihood of fertilization , and reduces the risk of self @-@ fertilization . Immediately after spawning , the eggs are delayed in their capability for fertilization until after the release of polar bodies . This delay , and possibly some degree of self @-@ incompatibility , likely increases the chance of cross @-@ fertilization . A study of four species of Scleractinia found that cross @-@ fertilization was actually the dominant mating pattern , although three of the species were also capable of self @-@ fertilization to varying extents .

## == Evolutionary history ==

There is little evidence on which to base a hypothesis about the origin of the scleractinians ; plenty is known about modern species but very little about fossil specimens , which first appeared in the record in the Middle Triassic ( 240 million years ago ) . It was not until 25 million years later that they became important reef builders , their success perhaps a result of teaming up with symbiotic algae . Nine of the sub @-@ orders were in existence by the end of the Triassic and three more had appeared by the Jurassic ( 200 million years ago ) , with a further suborder appearing in the Middle Cretaceous ( 100 million years ago ) . Some may have developed from a common ancestor , either an anemone @-@ like coral without a skeleton , or a rugose coral . A rugose coral seems an unlikely common ancestor because these corals had calcite rather than aragonite skeletons , and the septa were arranged serially rather than cyclically . However , it may be that similarities of scleractinians to rugosans are due to a common non @-@ skeletalized ancestor in the early Paleozoic . Alternatively , scleractinians may have developed from a Corallimorpharia @-@ like ancestor . It seems that skeletogenesis may have been associated with the development of symbiosis and reef formation , and may have occurred on more than one occasion . DNA sequencing appears to indicate that scleractinian corals are a monophyletic group .

The earliest scleractinians were not reef builders , but were small , phaceloid or solitary individuals . Scleractinian corals were probably at their greatest diversity in the Jurassic and all but disappeared in the mass extinction event at the end of the Cretaceous , about 18 out of 67 genera surviving . Recently discovered Paleozoic corals with aragonitic skeletons and cyclic septal insertion ? two features that characterize Scleractinia ? have strengthened the hypothesis for an independent origin of the Scleractinia . Whether the early scleractinian corals were zooxanthellate is an open question . The phenomenon seems to have evolved independently on numerous occasions during the Tertiary , and the genera *Astrangia* , *Madracis* , *Cladocora* and *Oculina* , all in different families , each have both zooxanthellate and non @-@ zooxanthellate members .

## == Classification ==

The taxonomy of Scleractinia is particularly challenging . Many species were described before the advent of scuba diving , with little realisation by the authors that coral species could have varying morphologies in different habitats . Collectors were mostly limited to observing corals on reef flats , and were unable to observe the changes in morphology that occurred in more turbid , deeper @-@ water conditions . More than 2 @, @ 000 nominal species were described in this era , and by the rules of nomenclature , the name given to the first described species has precedence over the rest , even when that description is poor , and the environment and even sometimes the country of the type specimen is unknown .

Even the concept of " the species " is suspect , with regard to corals which have large geographical

ranges with a number of sub @-@ populations ; their geographic boundaries merge with those of other species ; their morphological boundaries merge with those of other species ; and there are no definite distinctions between species and subspecies .

The evolutionary relationships among stony corals were first examined in the 19th and early 20th centuries . The two most advanced 19th century classifications both used complex skeletal characters ; The 1857 classification of the French zoologists Henri Milne @-@ Edwards and Jules Haime ? s was based on macroscopic skeletal characters , while Francis Grant Ogilvie 's 1897 scheme was developed using observations of skeletal microstructures , with particular attention to the structure and pattern of the septal trabeculae . In 1943 , the American zoologists Thomas Wayland Vaughan and John West Wells , and Wells again in 1956 , used the patterns of the septal trabeculae to divide the group into five suborders . In addition , they considered polypoid features such as the growth of the tentacles . They also distinguished families by wall type and type of budding .

The 1952 classification by French zoologist J. Alloiteau was built on these earlier systems but included more microstructural observations and did not involve the anatomical characters of the polyp . Alloiteau recognized eight suborders . In 1942 , W.H. Bryan and D. Hill stressed the importance of microstructural observations by proposing that stony corals begin skeletal growth by configuring calcification centers , which are genetically derived . Therefore , diverse patterns of calcification centers are vital to classification . Alloiteau later showed that established morphological classifications were unbalanced and that there were many examples of convergent evolution between fossils and recent taxa .

The rise of molecular techniques at the end of the 20th century prompted new evolutionary hypotheses that were different from ones founded on skeletal data . Results of molecular studies explained a variety of aspects of the evolutionary biology of the Scleractinia , including connections between and within extant taxa , and supplied support for hypotheses about extant corals that are founded on the fossil record . The 1996 analysis of mitochondrial RNA undertaken by American zoologists Sandra Romano and Stephen Palumbio found that molecular data supported the assembling of species into the existing families , but not into the traditional suborders . For example , some genera affiliated with different suborders were now located on the same branch of a phylogenetic tree . In addition , there is no distinguishing morphological character that separates clades , only molecular differences .

The Australian zoologist John Veron and his co @-@ workers analyzed ribosomal RNA in 1996 to obtain similar results to Romano and Palumbi , again concluding that the traditional families were plausible but that the suborders were incorrect . They also established that stony corals are monophyletic , including all the descendants of a common ancestor , but that they are divided into two groups , the robust and complex clades . Veron suggested that both morphological and molecular systems be used in future classification schemes .

= = Families = =

The World Register of Marine Species lists the following families as being included in the order Scleractinia :