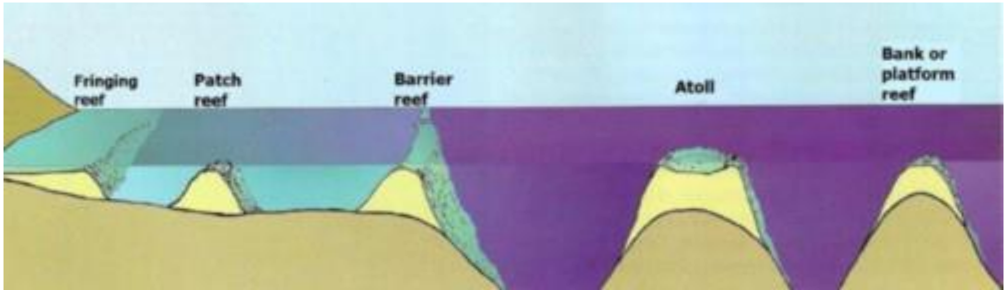
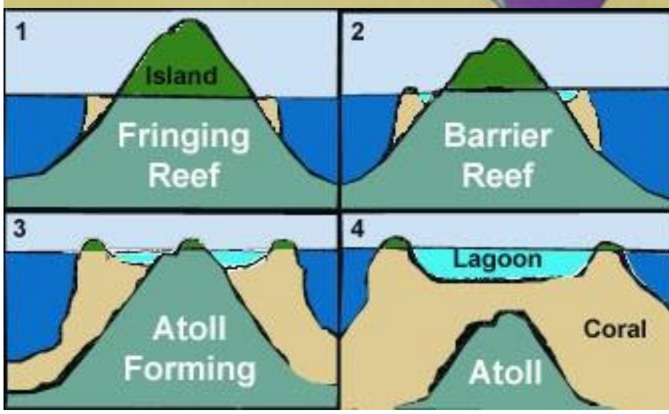
Coral Reef

- Coral reefs are built by and made up of thousands of tiny animals—**coral "polyps"**—that are related to **anemones and jellyfish.**
- Polyps are **shallow water organisms** which have a soft body covered by a **calcareous skeleton**. The polyps extract calcium salts from sea water to form these hard skeletons.
- The polyps live in colonies fastened to the rocky sea floor.
- The tubular skeletons grow upwards and outwards as a cemented calcareous rocky mass, collectively called **corals.**
- When the coral polyps die, they shed their skeleton [coral] on which new polyps grow.
- The cycle is repeated for over millions of years leading to accumulation of layers of corals [shallow rock created by these depositions is called **reef**].
- These layers at different stages give rise to various marine landforms. One such important landform is called **coral reef.**
- Coral reefs over a period of time transform or evolve into **coral islands (Lakshadweep).**
- The corals occur in different forms and colours, depending upon the **nature of salts** or constituents they are made of.
- Small marine plants **(algae)** also deposit calcium carbonate contributing to coral growth.

Coral Reef Relief Features

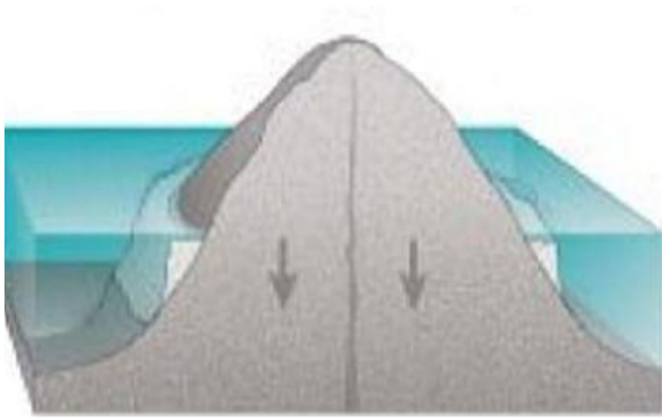
- **Fringing reef, barrier reef** and **atoll (coral islands are formed on atolls)** are the most important relief features.





Fringing Reefs (Shore Reefs)

- Fringing reefs are reefs that **grow directly from a shore**. They are located very **close** to land, and often form a **shallow lagoon** between the beach and the main body of the reef.
- A fringing reef runs as a narrow belt [1-2 km wide]. This type of reef grows from the deep sea bottom with the seaward side sloping steeply into the deep sea. Coral polyps do not extend outwards because of **sudden and large increase in depth**.
- The fringing reef is by far the ***most common*** of the three major types of coral reefs, with numerous examples in all major regions of coral reef development.
- Fringing reefs can be seen at the New Hebrides Society islands off Australia and off the southern coast of Florida.

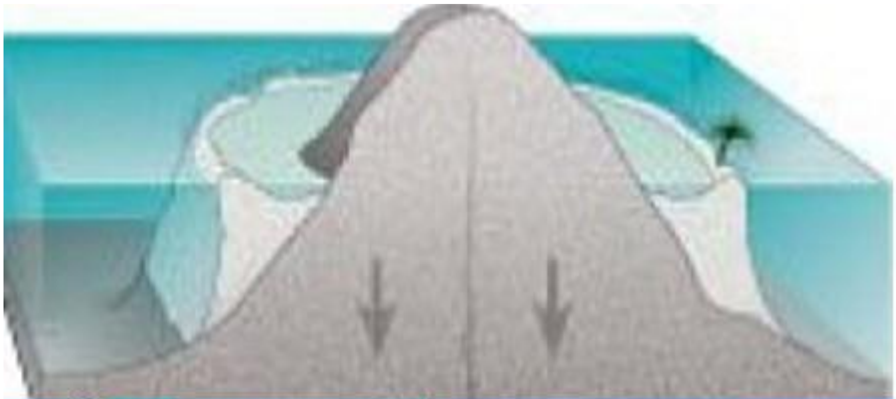


WHAT IS A "LAGOON"?

- A lagoon – as used in the context of coral reef typology – refers to a comparatively wide band of water that lies between the shore and the main area of reef development, and contains at least some deep portions.

Barrier Reefs

- Barrier reefs are **extensive linear reef** complexes that **parallel a shore**, and are separated from it by **lagoon**.



- This is the **largest (in size, not distribution)** of the three reefs, runs for hundreds of kilometres and is several kilometres wide. It extends as a broken, irregular ring around the coast or an island, running almost parallel to it.
- Barrier reefs are **far less common** than fringing reefs or atolls, although examples can be found in the tropical Atlantic as well as the Pacific.
- The **1200-mile long Great Barrier Reef** off the NE coast of Australia is the world’s largest example of this reef type.
- The GBR is not actually a single reef as the name implies, but rather a very large complex consisting of **many reefs**.

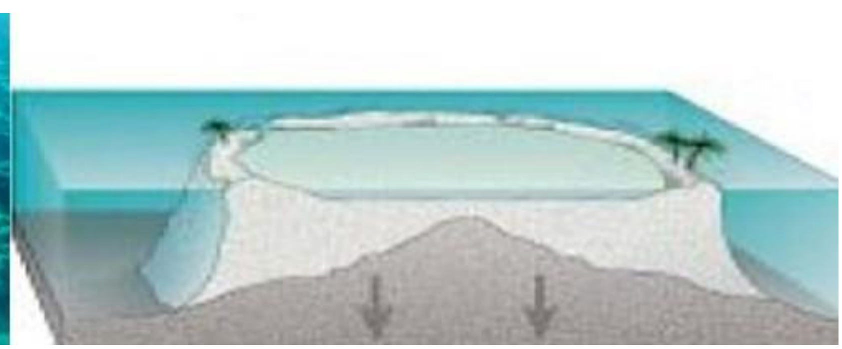
Atolls

- An atoll is a roughly circular (annular) oceanic reef system surrounding a large (and **often deep) central lagoon**.

- The lagoon has a depth 80-150 metres and may be joined with sea water through a number of channels cutting across the reef.
- Atolls are located at **great distances** from deep see platforms, where the submarine features may help in formation of atolls, such as a **submerged island or a volcanic cone** which may reach a level suitable for coral growth.
- An atoll may have any one of the following three forms-

1. **true atoll—a circular reef enclosing a lagoon with no island;**
2. **an atoll surrounding a lagoon with an island;**
3. **a coral island or an atoll island which is, in fact, an atoll reef, built by the process of erosion and deposition of waves with island crowns formed on them.**

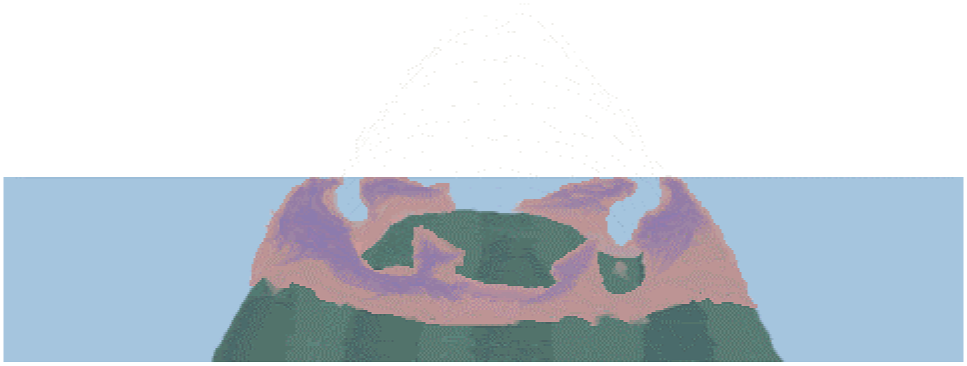
- Atolls are **far more common in the Pacific** than any other ocean. The **Fiji atoll** and the Funafuti atoll in the Ellice/Island are well known examples of atolls. A large 'number of atolls also occur in the **Lakshadweep Islands.**
- In the South Pacific, most atolls occur in mid-ocean. Examples of this reef type are common in **French Polynesia**, the **Caroline and Marshall Islands**, **Micronesia**, and the **Cook Islands.**
- The Indian Ocean also contains numerous atoll formations. Examples are found in the **Maldives** and **Chagos island groups,** the **Seychelles,** and in the **Cocos Island group**.

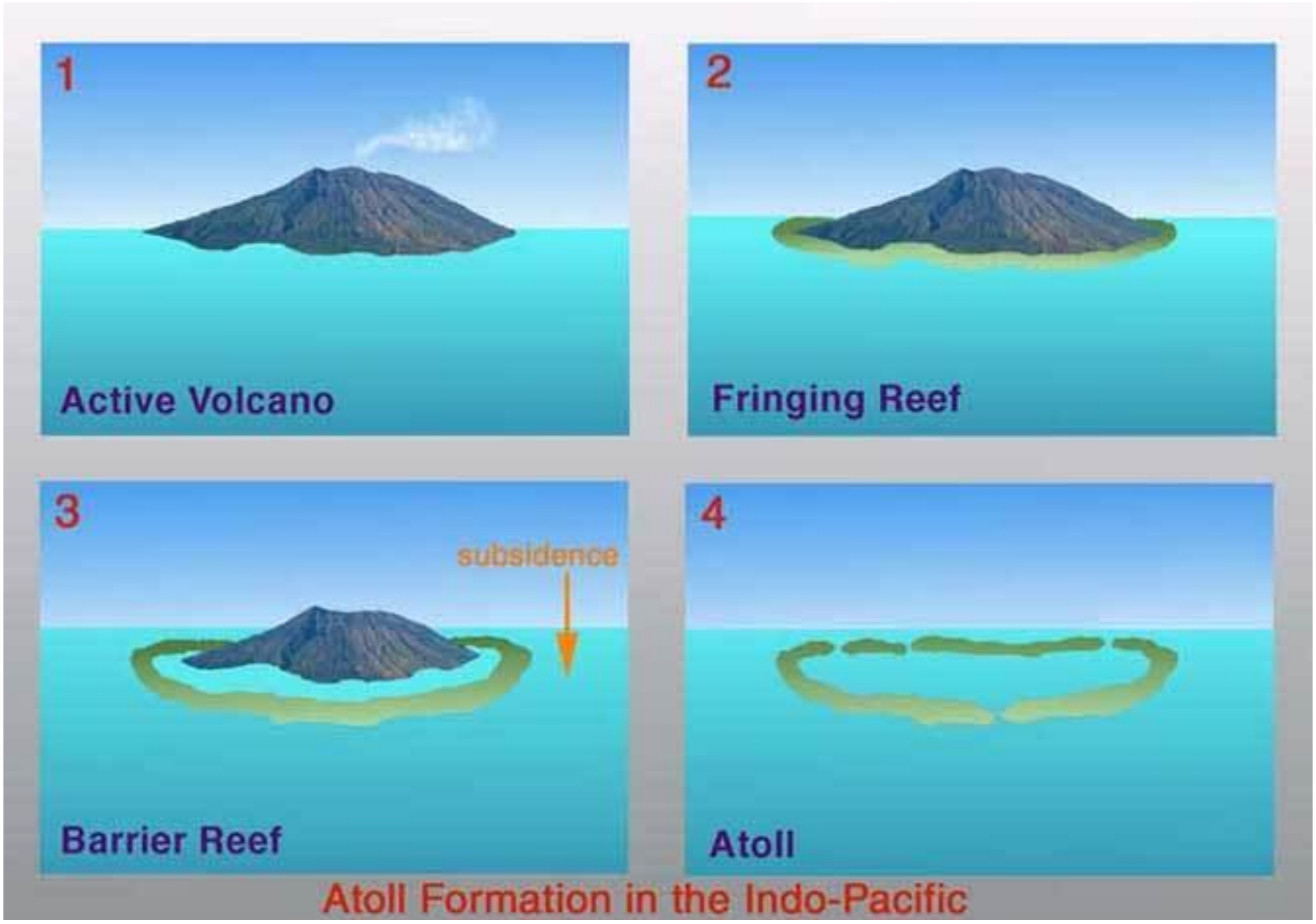
Development Of Major Coral Reef Types

Formation Of Lakshadweep Islands [You must include the concept of Hotspot]

- The basic coral reef classification scheme described above was first proposed by **Charles Darwin**, and is still widely used today.
- Darwin theorized that fringing reefs began to grow **near the shorelines** of new islands as ecological conditions became ideal for hard coral growth.
- Then, as the island began to gradually **subside** into the sea, the coral was able to keep pace in terms of growth and remained in place at the sea surface, but farther from shore; it was now a barrier reef.
- Eventually, the island disappeared below the sea surface, leaving only the ring of coral encircling the central lagoon; an atoll had formed.



1. Step 1: A fringing reef forms first, and starts growing in the shallow waters close to a tropical island.
2. Step 2: Over time, the island subsides and the reef grows outwards, and the distance between the land and the reef increases. The **fringing reef develops into a barrier reef**.
3. Step 3: If the island completely subsides, all that is left is the reef. The reef retains the approximate shape of the island it grew around, forming a ring enclosing a lagoon.



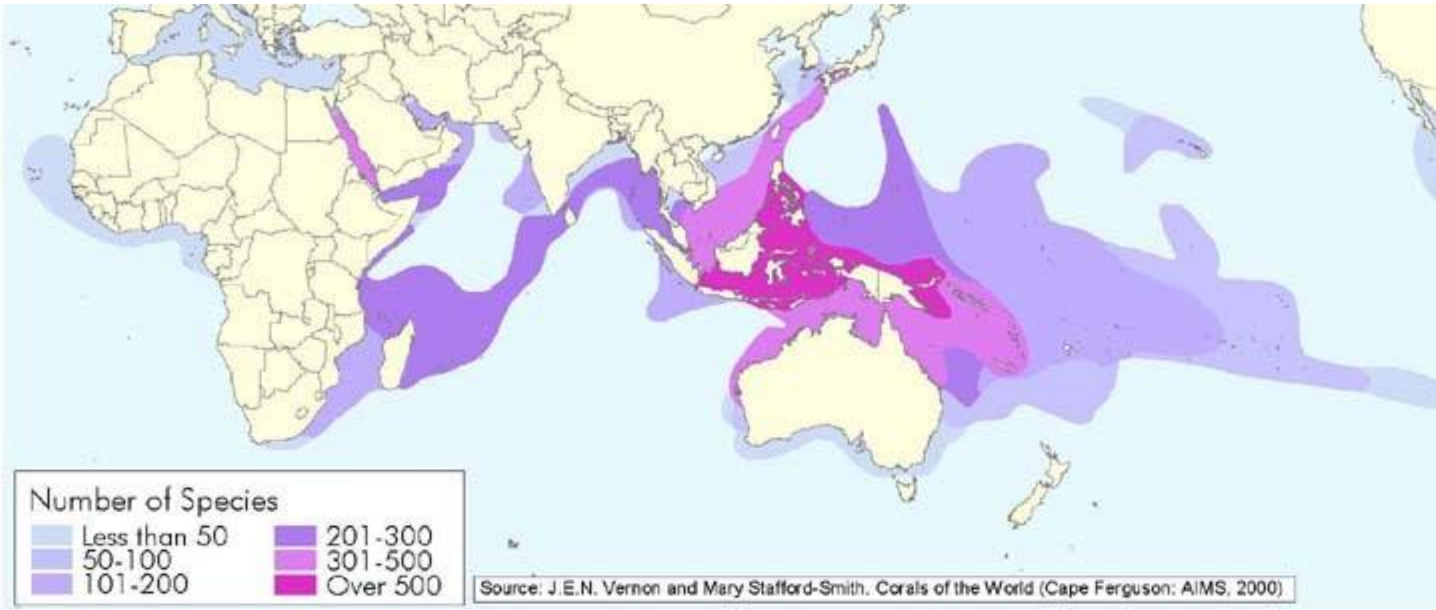
Ideal Conditions for Coral Growth

- **Stable climatic conditions:** Corals are highly susceptible to quick changes. They grow in regions where climate is significantly stable for a long period of time.
- **Perpetually warm waters:** Corals thrive in **tropical waters** [30°N and 30°S latitudes, The temperature of water is around 20°C] where diurnal and annual temperature ranges are very narrow.

- **Shallow water:** Coral require fairly good amount of **sunlight** to survive. The ideal depths for coral growth are 45 m to 55 m below sea surface, where there is abundant sunlight available.
- **Clear salt water:** Clear salt water is suitable for coral growth, while both fresh water and highly saline water are harmful.

- **Abundant Plankton:** Adequate supply of oxygen and microscopic marine food, called **plankton [phytoplankton]**, is essential for growth. As the plankton is more abundant on the **seaward side**, corals grow rapidly on the seaward side.
- **Little or no pollution:** Corals are highly fragile and are vulnerable to climate change and pollution and even a minute increase in marine pollution can be catastrophic.

Distribution of Coral Reefs



Corals and Zooxanthellae

- Many invertebrates, vertebrates, and plants live in close association with corals, with **tight resource coupling and recycling**, allowing coral reefs to have extremely high productivity and biodiversity, such that they are referred to as **'the Tropical Rainforests of the Oceans'.**
- Scleractinian corals build skeletons of calcium carbonate **sequestered** from the water.
- Scleractinian corals come under **Phylum Cnidaria**, and they receive their nutrient and energy resources in two ways.

1. They use the traditional cnidarian strategy of capturing tiny planktonic organisms with their tentacles (All about Phylum Cnidaria is given in NCERT).
2. Having a symbiotic relationship with a **single cell algae** known as **ZOOXANTHELLAE.**

- Zooxanthellae are **autorophic [prepare their own food] microalgaes** belonging to various taxa in the **Phylum Dinoflagellata.**

Coral == Phylum Cnidaria.

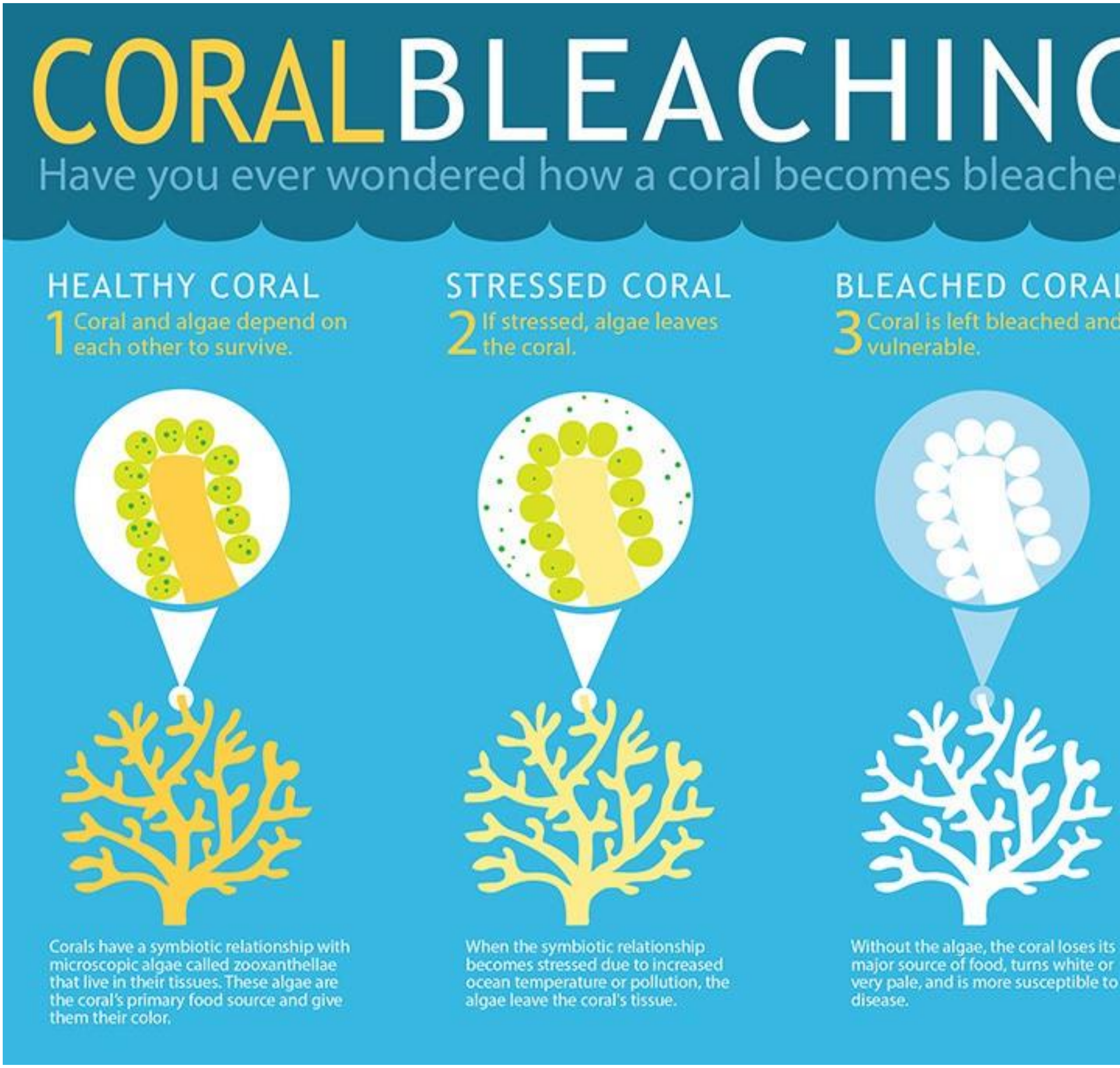
Zooxanthellae == Phylum Dinoflagellata.

Symbiotic Relationship Between Corals And Zooxanthellae

- Zooxanthellae live symbiotically within the coral polyp tissues and **assist the coral in nutrient production through its photosynthetic activities**.
- These activities provide the coral with **fixed carbon compounds for energy, enhance calcification, and mediate elemental nutrient flux.**
- The host coral polyp in return provides its zooxanthellae with a **protected** environment to live within, and a **steady supply of carbon dioxide** for its photosynthetic processes.
- The symbiotic relationship allows the slow growing corals to compete with the faster growing multicellular algaes. The corals can feed by day through **photosynthesis** and by night through **predation**.

The tissues of corals themselves are actually not the beautiful colors of the coral reef, but are instead clear. The corals receive their coloration from the ZOOXANTHELLAE living within their tissues.

Coral Bleaching or Coral Reef Bleaching


CORALBLEACHING
Have you ever wondered how a coral becomes bleache
HEALTHY CORAL
1 Coral and algae depend on each other to survive.
STRESSED CORAL
2 If stressed, algae leaves the coral.
BLEACHED CORA
3 Coral is left bleached and vulnerable.
Corals have a symbiotic relationship with microscopic algae called zooxanthellae that live in their tissues. These algae are the coral's primary food source and give them their color.
When the symbiotic relationship becomes stressed due to increased ocean temperature or pollution, the algae leave the coral's tissue.
Without the algae, the coral loses its major source of food, turns white or very pale, and is more susceptible to disease.

- Disturbances affecting coral reefs include anthropogenic and natural events.
- Recent accelerated coral reef decline is related mostly to anthropogenic impacts **(overexploitation, overfishing, increased sedimentation and nutrient overloading).**
- Natural disturbances which cause damage to coral reefs include **violent storms, flooding, high and low temperature extremes, El Nino Southern Oscillation (ENSO) events, sub aerial exposures, predatory outbreaks and epizootics.**
- Coral reef bleaching is a common **stress response** of corals to many of the various disturbances mentioned above.
- Bleaching occurs when

1. **the densities of zooxanthellae decline and/or**
2. **the concentration of photosynthetic pigments within the zooxanthellae fall. [it is no more useful for the coral and the coral will bleach it]**

- When corals bleach they commonly **lose 60-90% of their zooxanthellae** and each zooxanthellae may **lose 50-80% of its photosynthetic pigments**.
- If the **stress-causing** bleaching is not too severe and if it decreases in time, the affected corals usually regain their symbiotic algae within several weeks or a few months.
- If zooxanthellae loss is prolonged, i.e. if the stress continues and depleted zooxanthellae populations do not recover, the coral host eventually dies .

Ecological Causes of Coral Bleaching

Temperature

- Coral species live within a relatively narrow temperature margin, and **anomalously low and high sea temperatures [corals are absent on the west coast of tropical temperate continents because of the cold currents]** can induce coral bleaching.
- Bleaching events occur during sudden temperature drops accompanying intense upwelling episodes [El-Nino], seasonal cold-air outbreaks.
- Most reefs recovered, with low levels of coral deaths, but damage has been severe at places.
- This is an instance of coral reefs' susceptibility to increased water temperatures combined with **OCEAN ACIDIFICATION.**
- While the rising temperatures have increased the frequency and intensity of bleaching, acidification has **reduced corals calcifying ability.**
- Small temperature increase over many weeks or large increase (3-4 °C) over a few days will result in **coral dysfunction.**
- Coral bleaching has occurred mostly during the summer seasons or near the end of a protracted warming period.

- They are reported to have taken place during times of **low wind velocity, clear skies, calm seas and low turbidity.** The conditions favor localised heating and high ultraviolet (UV) radiation.
- UV radiation readily penetrates clear sea waters. The corals actually contain UV-absorbing compounds which can block potentially damaging UV radiation. But rising temperatures mean reduction in the concentration of these UV absorbing compounds in corals.

Sub aerial Exposure

- Sudden exposure of reef flat corals to the atmosphere during events such as extreme low tides, ENSO-related sea level drops or tectonic uplift can potentially induce bleaching.
- The consequent exposure to high or low temperatures, increased solar radiation, desiccation, and sea water dilution by heavy rains could all play a role in zooxanthellae loss, but could also very well lead to coral death.

Fresh Water Dilution

- Rapid dilution of reef waters from storm-generated precipitation and runoff has been demonstrated to cause coral reef bleaching.
- Generally, such bleaching events are rare and confined to relatively small, near shore areas.

Inorganic Nutrients

- Rather than causing coral reef bleaching, an increase in ambient elemental nutrient concentrations (e.g. **ammonia and nitrate**) actually increases zooxanthellae densities 2-3 times.

- Although **eutrophication** is not directly involved in zooxanthellae loss, it could cause secondary adverse effects such as **lowering of coral resistance and greater susceptibility to diseases.**

Xenobiotics

- When corals are exposed to high concentrations of chemical contaminants like copper, herbicides and oil, coral bleaching happens.

Epizootics

- **Pathogen** induced bleaching is different from other sorts of bleaching.
- Most coral diseases cause patchy or whole colony death and sloughing of soft tissues, resulting in a white skeleton (not to be confused with bleached corals).

Spatial and temporal range of coral reef bleaching

- Nearly all of the world's major coral reef regions (Caribbean/ western Atlantic, eastern Pacific, central and western Pacific, Indian Ocean, Arabian Gulf, Red Sea) experienced some degree of coral bleaching and mortality during the 1980s.
- Prior to the 1980s, most mass coral moralities were related to non-thermal disturbances such as storms, aerial exposures during extreme low tides, and Acanthaster outbreaks. Coral bleaching accompanied some of the mortality events prior to the 1980s during periods of elevated sea water temperature, but these disturbances were geographically isolated and restricted to particular reefs zones. In contrast, many of the coral bleaching events observed in the 1980s occurred over large geographic regions and at all depths.

Bleaching may also be Beneficial

- Recent research has revealed that corals that are consistently exposed to low levels of stress may develop some kind of resistance to bleaching.

The third global coral bleaching

- The third global coral bleaching is in progress (2015-16) — after events in 1998 and 2010.
- The present one is the longest and most severe so far.
- The longest and most severe **El Niño** ever is the main cause.

Consequences of global coaral bleaching

- Coral reef ecosystems are less than 0.1% of the ocean area but provide food and shelter to 25% of all marine species.
- They support fish stocks on which some 500 million people are dependent globally.

Mass bleaching can turn a coral dominated reef to an **algae dominated** one in the space of a few months — a process that can take decades or longer to reverse.