CORAL REEF

FOR SEMESTER 4 (CBCS) GEOGRAPHY

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INERESTING FACTS ABOUT CORAL REEFS

- 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.

Taxonomy of Corals

Corals are members of the phylum Cnidaria, which they share with jellyfish, comb jellies and sea anemones. Class Anthozoa denotes soft and hard corals (6,000 species total). Reef building corals (hermatypic corals) belong to the order Scleractinia. To date there are no freshwater corals.

Biogeography

Coral reefs are more diverse on the east coasts of continents. Thus, corals are found primarily in the Caribbean, Florida and Brazil in the Americas while there is very little coral development in California, Chile or any American Pacific coast. This may not seem logical until you think about the way ocean currents work.

Ocean currents move clockwise in the northern hemisphere and counter-clockwise in the southern hemisphere. This causes cold water currents to flow along coastlines towards the equator on the eastern sides of oceans.

Biodiversity centers

One interesting biogeographical phenomena is the presence of a central biologically diverse region of the world for coral reefs. The indo-pacific ocean, particularly around the waters of Indonesia has the most diverse coral reef ecosystems in the world. Diversity drops as you leave this epicenter. Coral reefs in the western Pacific have 75% more genera and 85% more species of corals than coral reefs in the Caribbean.

Physiology – Plants or animals?

The essence of what makes the coral reef work is the presence of of a unique symbiosis with unicellular algae called zooxanthellae. These zooxanthellae help the coral by giving the coral the by-products of their photosynthetic activity. Corals help the zooxanthellae by providing them with an environment to live. Zooxanthellae provide the corals with their diverse colors. Without them the corals are white. During bleaching events (conditions that stress corals such as high temperatures), corals release their zooxanthellae and become completely white.

While zooxanthellae allow corals to use the energy from the sun, corals themselves are not autotrophic. Corals are made up of individual coral polyps whom are carnivorous. Each has a small mouth and stinging tentacles. However, coral reefs are often found in clear blue water. This water is nutrient poor and thus corals are able to thrive because a large portion of their energy is actually acquired from their symbiosis with these small algae.

Reproduction

Corals can reproduce both sexually and asexually. Asexual reproduction occurs when fragments of a coral break off and start a new colony. Certain corals like staghorn coral rely on this method heavily.

Sexual reproduction in corals is a unique event that is often synchronous. On a few nights every year corals will have a mass spawning event. The most amazing thing about mass spawning events is the ability of coral species to synchronize to a given hour. In Australia, on the great barrier reef spawnings occur in November. During this event spawn are released and cover the surface of the water. When diving in an event like this it feels like it is snowing upside down!

Conditions favourable for Coral Growth

1. Corals cannot live if the temperature of the water falls below 20 deg. celsius.
They are therefore confined to tropical and near tropical areas within about 30 deg. North and south of the Equator, although locally , as in the case of the Bermudas, they may extend a little because in this case they are situated in the path of the Gulf Stream, which has temperatures exceptionally high for the latitudes.

2. Corals cannot live for long out of water , and are therefore rarely found above low tide level , while conversely they cannot grow at depths much exceeding 45-60m (25-33 fathoms.)

3. Corals need clear oxygenated water , with plentiful supplies of microscopic life as food and they cannot live in fresh or silt-laden water. Food supplies are most plentiful on the seaward side of a growing reef , so that the corals tend to grow more rapidly outward.

Coral reefs form around the edges of continents (Australia) and round the shores of islands (New Guinea and New Caledonia) and of volcanic peaks which rising steeply from the ocean floor , account for many of the scattered Pacific islands as Fiji and Samoa. They also form low coral islands rising from the ocean depths , such as the Gilbert and Ellice islands and the Marshall islands. Coral is most widespread in the western and central Pacific , but is also found in the Indian ocean in the Laccadives and Maldives west of Sri Lanka , the Andamans, Seychelles and Mauritius. In the Atlantic , it is almost entirely confined to the west Indian Archipelago .

Types of Coral Reef

Darwin divided reefs into three main forms :

1. The fringing reef
2. The Barrier Reef
3. The Atoll .

The **fringing reef** consists simply of an uneven platform of coral fringing the coast , with a shallow , quite narrow lagoon between it and the mainland , and with its seaward edge sloping down into deep water.

The **barrier reef** is separated from the mainland by a much deeper , wider channel . The largest in the world is the Great Barrier Reef off the Queensland coast , 2028 kms. In length . There are many more smaller examples , which often encirlcle an island, broken only by narrow and often hazardous channels (known as passes) through which shipping can move .

An **atoll** consists of a coral reef , circular, elliptical or horse-shoe shaped , enclosing a lagoon , but with no central island.

Many reefs are not revealed even at the lowest tides, some may represent former barrier reefs which have been submerged.

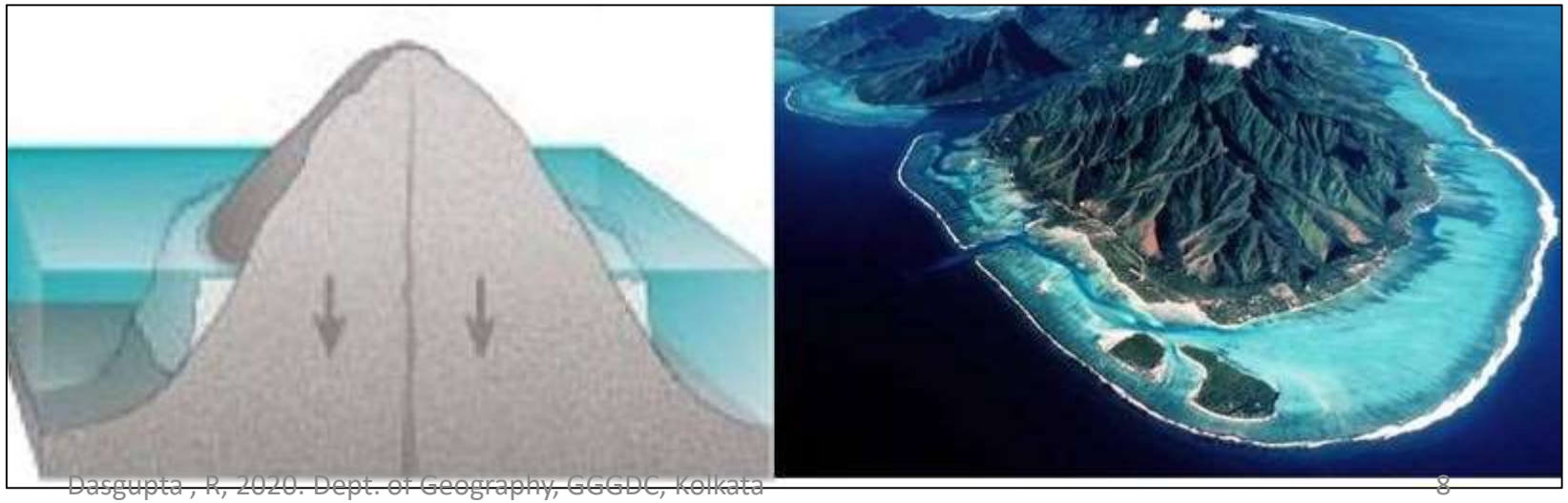
Fringing Reefs (Shore Reefs)

- ✓ 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**.

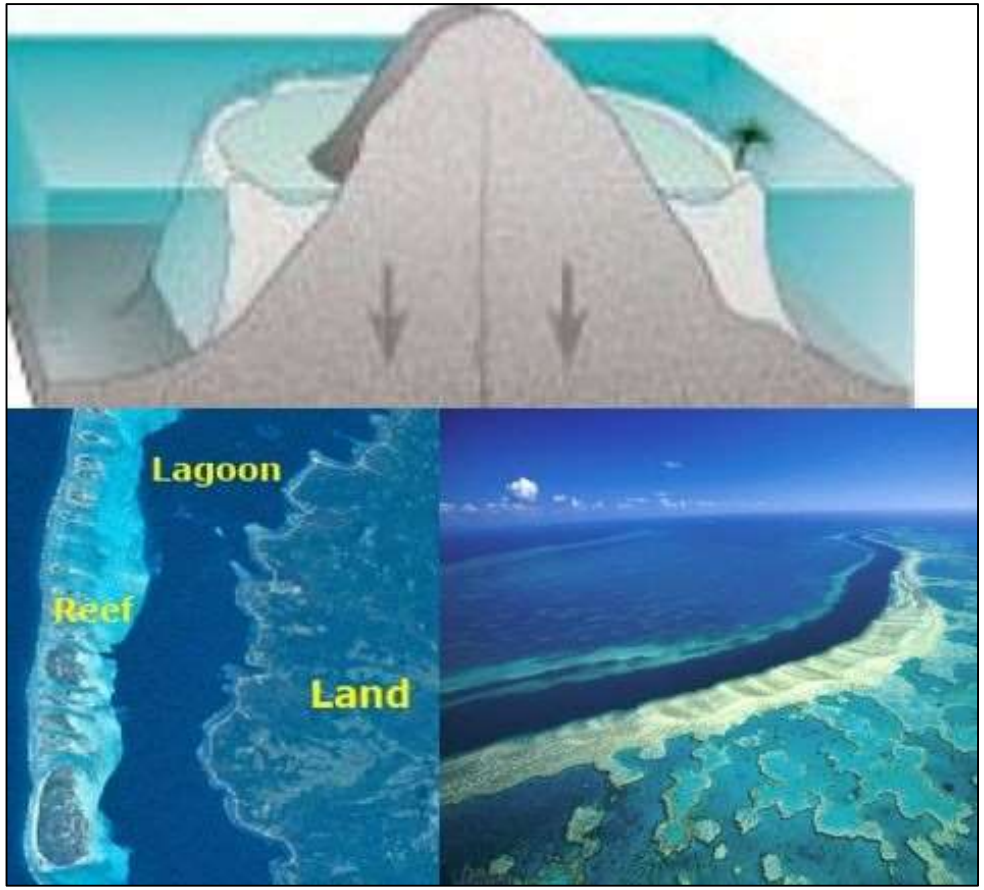
- ✓ The fringing reef is by far the ***most common*** of the three major types of coral reefs, with numerous examples in all major regions of coral reef development.

- ✓ Fringing reefs can be seen at the New Hebrides Society islands off Australia and off the southern coast of Florida.



Barrier Reefs

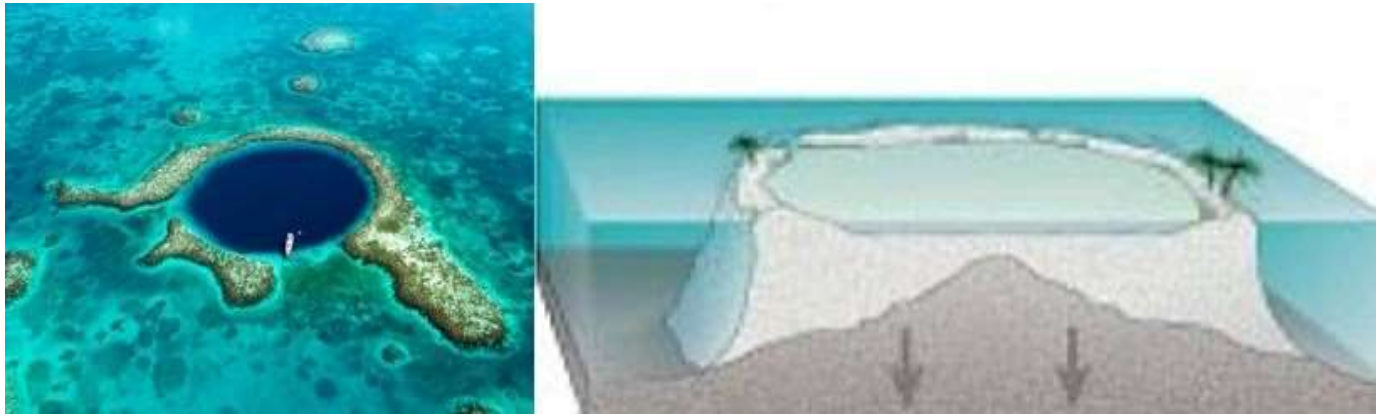
- Barrier reefs are **extensive linear reef** complexes that **parallel a shore**, and are separated from it by **lagoon**.
- This is the **largest (in size, not distribution)** of the three reefs, runs for hundreds of kilometres and is several kilometres wide. It extends as a broken, irregular ring 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**.



THE GREAT BARRIER REEF PHOTOGRAPHS

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-

- **true atoll—a circular reef enclosing a lagoon with no island;**
- **an atoll surrounding a lagoon with an island;**
- **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 goups,** the **Seychelles,** and in the **Cocos Island group**.

Evolution of Coral Reefs

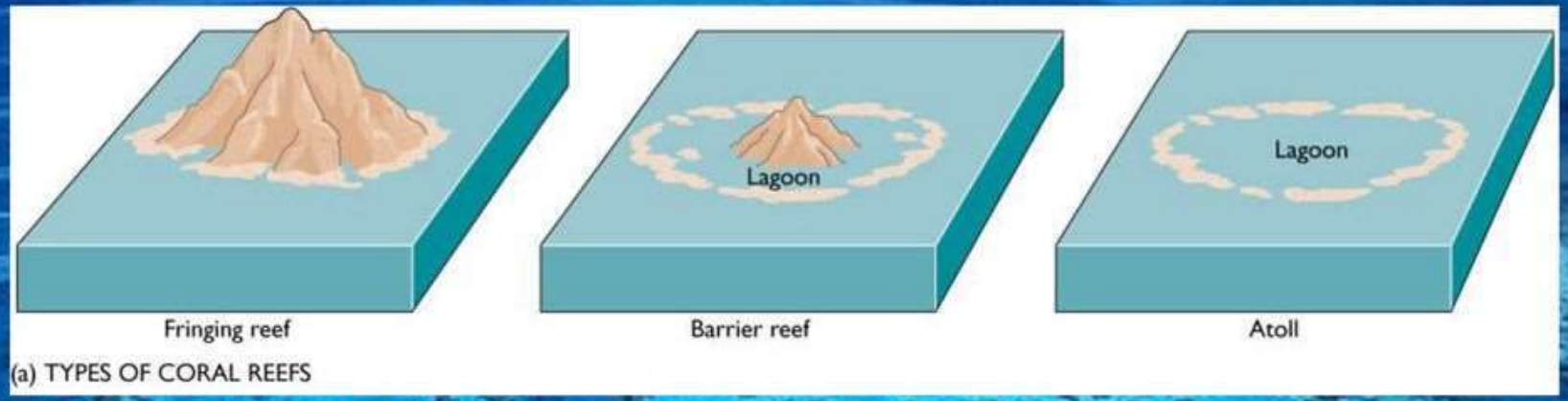


FIGURE 12.24a: Types of Coral Reefs.

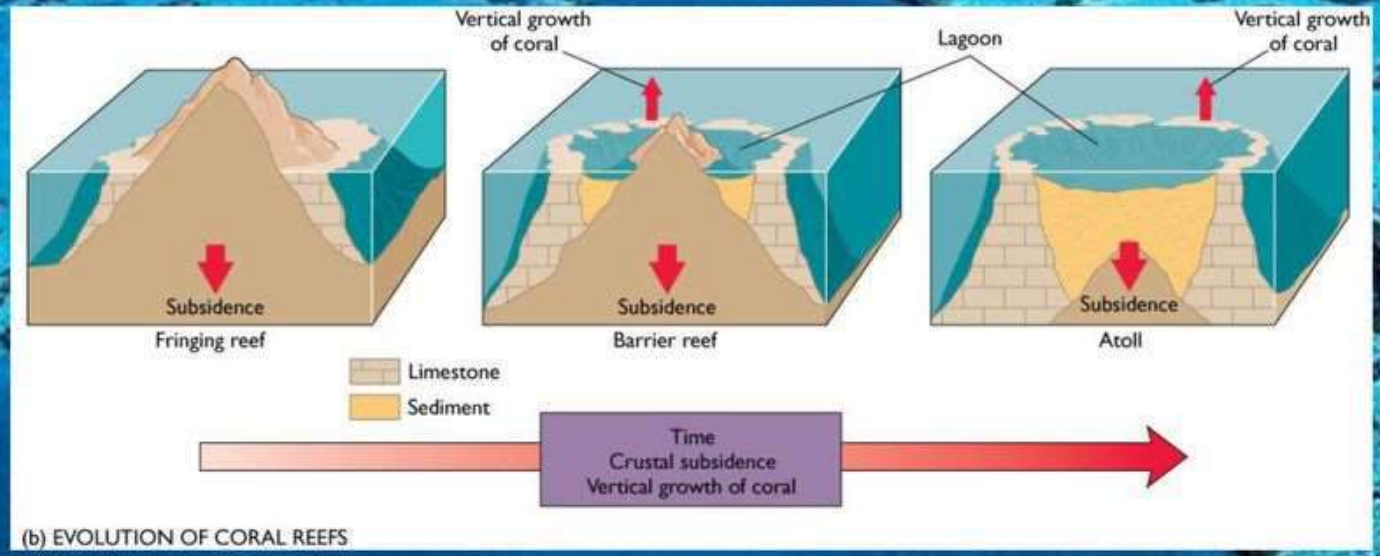


FIGURE 12.24b: Evolution of coral reefs.

Formation Of Lakshadweep Islands [Hotspot concept may be included here]

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.

Coral Reefs at the Deep Ocean Bottom

Subsidence Theory of Darwin's on formation of Coral Reef

In 1842, Darwin, independently supported by Dana and others , explained the growth of barrier reefs and atolls as a gradual process, the main reason for which has been subsidence . Thus a fringing reef grows around the coast of , for example a volcano. As this slowly subsides , the coral continues to grow upward keeping pace with the subsidence. Coral growth is more vigorous on the outer side of the reef so that it forms a higher rim , while the inner part comprises an increasingly deep and wide lagoon . Ultimately the inner island is wholly submerged , so forming the reef of the coral reef which is the atoll.

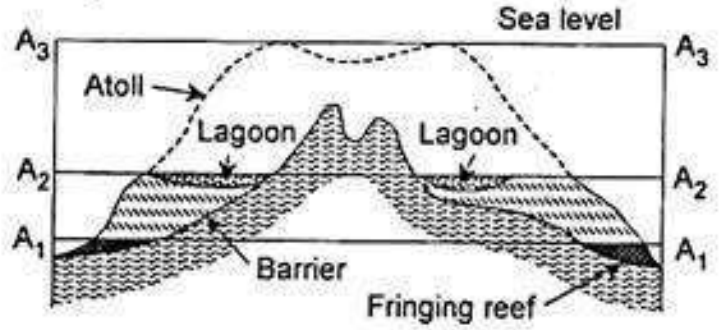
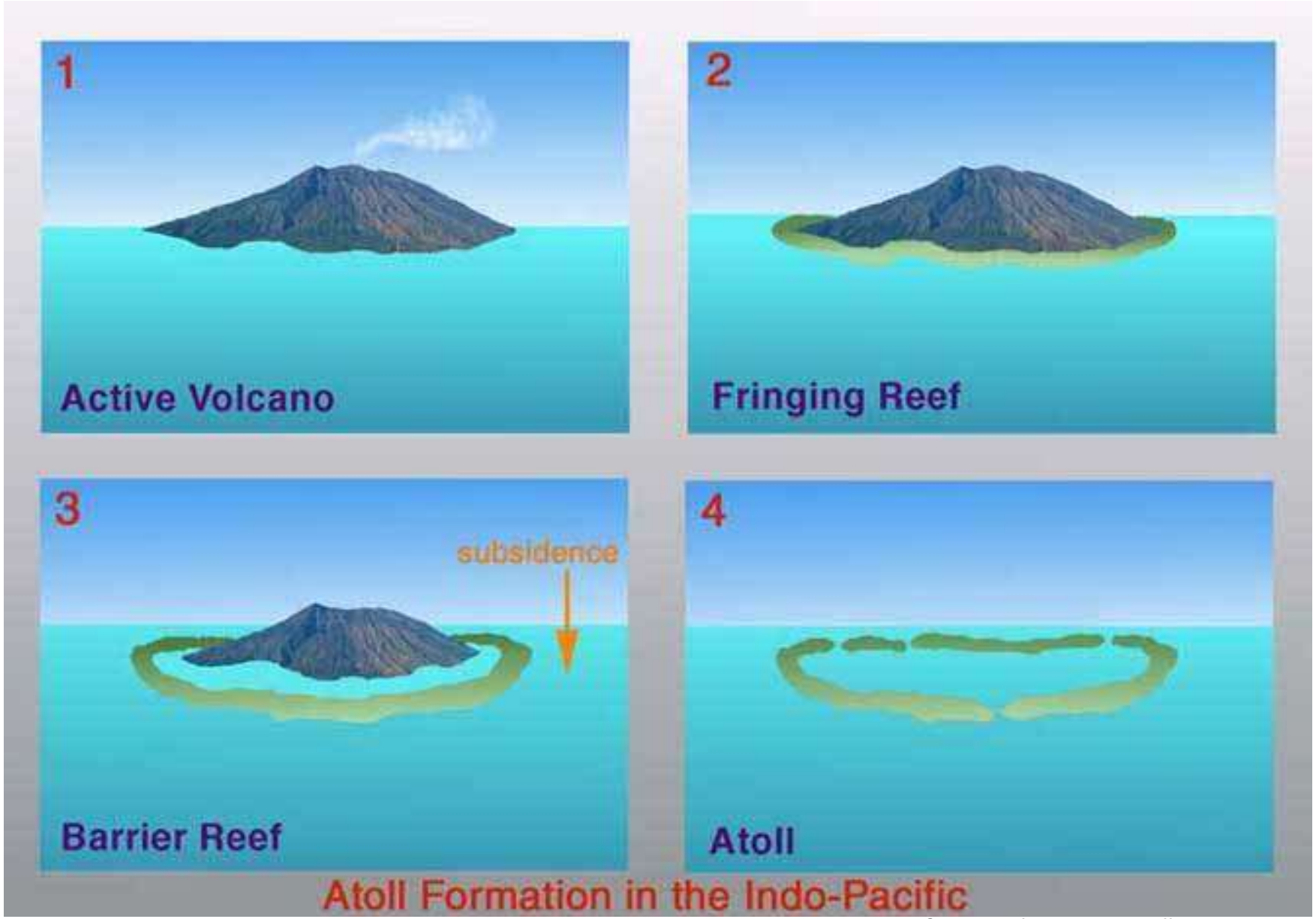


Fig. 30.4 : Origin of coral reefs according to Charles Darwin. A_1-A_1 = Sea-level and the formation of fringing reefs, A_2-A_2=sealevel after subsidence and the formation of barrier reef and A_3-A_3 = sealevel after complete submergence of the island and the formation of atoll reef.

Some of Darwin's supporters have shown that submergence has indeed taken place , for neighbouring coastlines reveal distinct evidence of drowned valleys. This is shown along parts of the coast of Indonesia, and the edge of the coastal plain of Queensland, for example has certainly been down-faulted. Some reefs however occur in areas where there is no evidence at all of submergence , even where it would have shown on neighbouring coasts had it so happened. In Timor and elsewhere , moreover reefs have obviously been uplifted beyond present sea-level. More difficult is the case where both atolls and raised coral reefs appear in the same group of islands.



Step 1 A fringing reef forms first, and starts growing in the shallow waters close to a tropical island.

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**.

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.

The following evidences and points strongly support the validity of Darwin's subsidence theory:

(i) The shallowness of lagoons indicates gradual subsidence of land. If the land is taken to be stable, the lagoon would be filled due to deposition of sediments.

(ii) The absence of cliffs along the coral islands validates the idea of subsidence of land because cliffs are found along only those coral islands which are stationary.

(iii) The coasts and the islands of the Pacific Ocean having raised beaches (indicative of emergence of land) are devoid of barrier and atoll reefs.

(iv) The islands having atolls are characterized by very steep slopes. It may be mentioned that very steep slopes are found only along the upper parts of the islands. This fact also denotes subsidence of the land.

(v) The thickness of coral reefs increases downward. This feature reveals the fact that coral reefs are formed along the subsiding base of submarine platforms.

Evaluation of the Theory:

If fringing reefs, barrier reefs and atoll reefs, as maintained by Darwin, are only three stages of the evolutionary growth of a reef, then fringing reef and barrier reef should not be found on either side of the same island at the same level but observations and new discoveries have revealed the existence of such situations. If the subsidence theory is accepted then most of the islands of the Pacific Ocean would be submerged. There are also some evidences of the existence of coral reefs associated with the emerging islands.

Stand Still Theory of Murray's on Coral Reef Formation

An alternate hypothesis put forward by Sir John Murray after his voyage in the Challenger in 1872 and supported by Agassiz, Semper and others , claimed that in most cases subsidence was not involved. His idea of atoll formation is that the base of a reef consists of a submarine hill or plateau rising from the ocean floor. These eminences reaching within about 60m (33 fathoms) of the surface consist either of subsurface volcanic peaks and wave-worn stamps , or of an accumulation of various pelagic deposits which have been built up on deeper plateau until they reach within 60m of the surface. As pelagic deposits accumulate extremely slowly , and could not build up at the necessary steep angle, this latter possibility seems quite incredible.

According to Murray, a barrier reef has also been formed without involving subsidence . As a fringing reef grows, pounded by the surf , masses of coral fragments gradually accumulate on the seaward side of the reef, washed there by the waves and become cemented into a solid bank. As corals tend to grow more strongly on the seaward side, it build out farther and farther on banks of its own debris. While this is happening the corals on the inner side of the reef are deprived of food and so die. Murray also supposed that much of this dead coral was dissolved in the water, so forming a much deeper lagoon. But some scientists claim that filling-in-of the lagoon with sediments and coral fragments will more than outweigh any possible loss by solution.

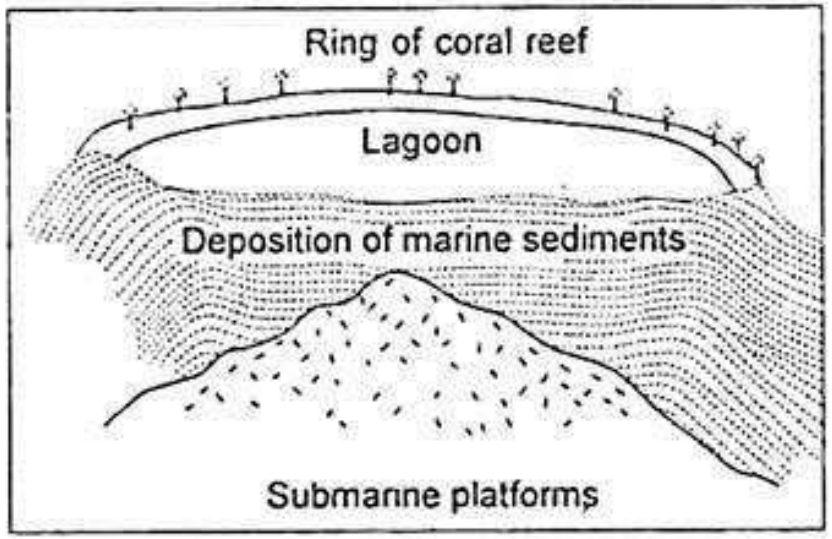


Fig. 30.6 : Formation of coral reefs according to Murray.

Evaluation of the Theory:

The non-subsidence theory of Murray acclaimed wide popularity in the beginning but later on it was severely criticised on the following grounds:

(1) Murray's theory requires the existence of numerous suitable submarine platforms the depth of 180 feet but the existence of such features is not possible.

(2) Murray has described two contradictory views of marine erosion and deposition at the depth of 30 fathoms (180 feet) at the same time over different submarine peaks. Such proposition is not possible.

(3) A limit of 30 fathoms for deposition and erosion cannot be accepted.

(4) According to Murray, the lagoon is formed due to solution of dead corals. This mechanism is also doubtful because if the lagoon may be formed due to solution of corals, the pelagic deposits laid down on the submarine platforms or peaks would also be dissolved.

(5) If the land or submarine platforms and peaks are stable then the lagoons would be completely filled up with the marine sediments and thus the lagoons would disappear.

(6) According to Murray coral reefs cannot be found beyond the depth of 30 fathoms but these have also been found at greater depths.

Glacial Control Theory of Daly on Coral Reef Formation

- As an alternative to subsidence, it was suggested that a rise of sea-level might be responsible, a rise which certainly did take place in late and postglacial times as the ice-sheets melted.
- Daly discovered traces of glaciation on the sides of Mauna Kea in Hawaii , which means (a) that the water in those latitudes must have been so much cooler during these glacial times that all corals were destroyed and (b) that sea level must have been about 100m(54 fathoms) lower due to the withdrawal of water contained in the ice-caps.
- It follows that all preglacial reefs and other islands were planed down by marine erosion to the sea-level of that time.
- The bevelled platforms thus formed provided bases for the upward growth of coral when the temperature of the sea increased and the receding ice-sheets slowly returned their melt-water to the oceans, causing a rise of sea-level.
- This theory helps to account for the narrow, steep-sided reefs which compose most of the atolls. Sometimes their slopes are as steep as 75^{0}, and it seems impossible this could be a bank of fragments , or could be anything but solid coral.
- The lagoons would be partially filled with sediments , particularly debris washed from the reef itself.

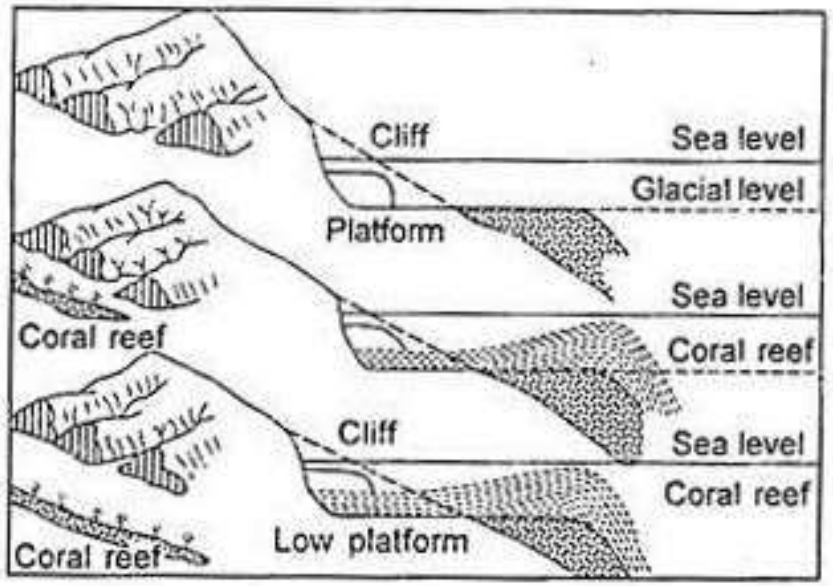
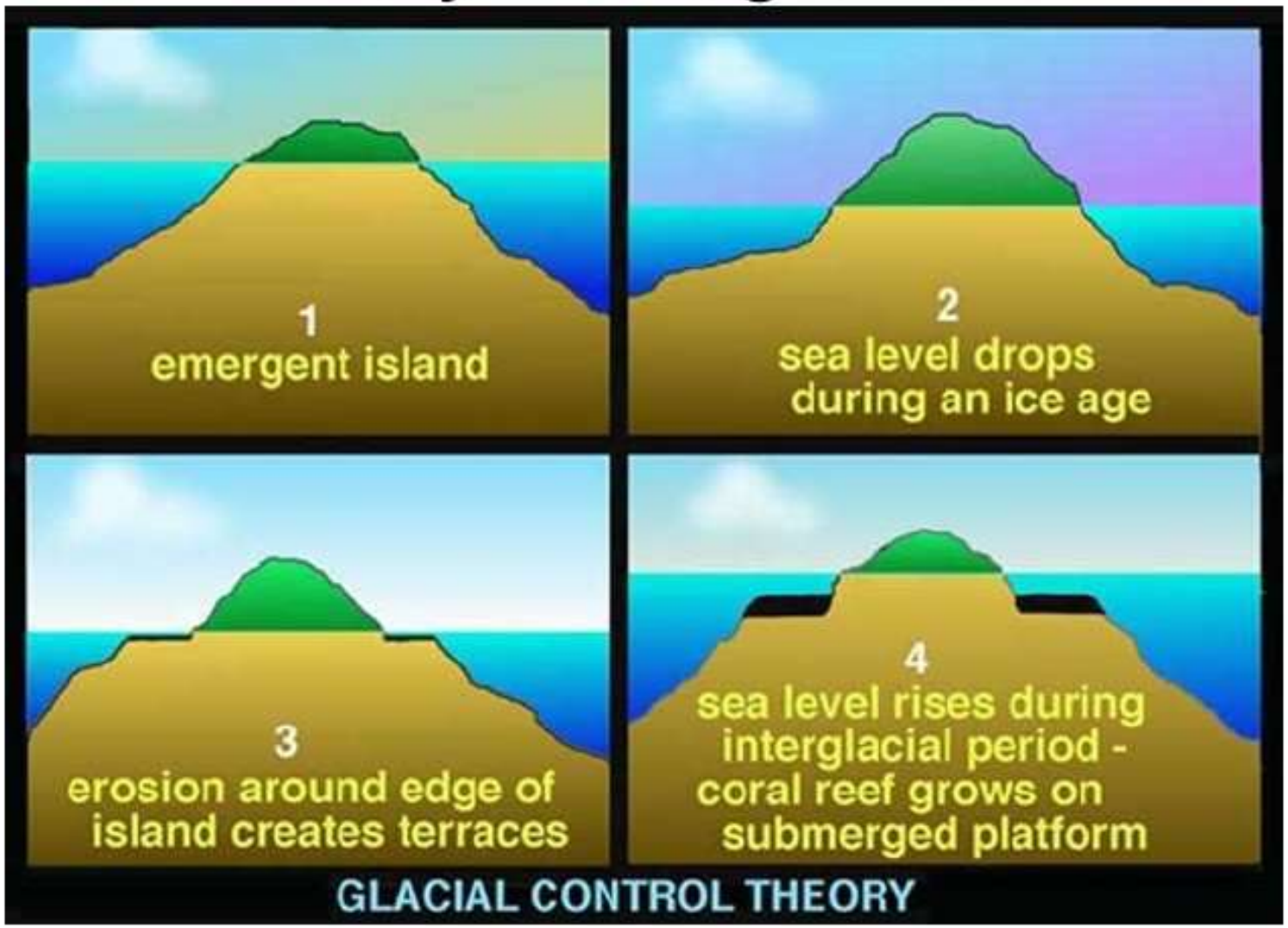


Fig. 30.7 : Origin of coral reefs according to Daly

Daly in Diagrams



Concept Of W.M. Davis On Coral Reef Formation:

- The famous American geomorphologist W.M. Davis postulated his concept of the origin of coral reefs in 1914-18 and revived the subsidence theory as postulated by Darwin and others. He presented several physiographic evidences in support of subsidence theory and to explain hither to unsolved several problems related to the formation of coral reefs. According to him corals grow along the subsiding land.

- The presence of indented and embayed coast lines found in the coral seas validates the subsidence and consequent submergence of land. According to him the flatness of the bottoms of lagoons and their uniform depth are not due to uniform lowering of sea level and these (bottoms) are not true bottoms but they are due to deposition of marine sediments.

- The shallowness of lagoons is because of deposition of debris. If the submarine platforms are taken to be stable then the deposition of marine sediments would fill up the lagoons and the overflowing of water would kill the living corals on the seaward side of the reefs. On the other hand, any amount of debris may be accommodated in the lagoons on the basis of subsidence theory because the bottom is subjected to continuous subsidence. Davis has presented many more evidences in support of subsidence theory.

Recent Research

A considerable body of cooperative research has been undertaken in recent years by geomorphologists, geologists, botanists and marine zoologists into the coral reef problem using modern sophisticated techniques. These include the determination of ocean temperatures during the Pleistocene from the remains of Foraminifera deposited on the ocean floor (actually figures of about 3° C in the Pacific and of 4 to 5° C in the Indian Oceans differ little from Daly's estimate) ; exact measurement of the rates of coral growth and of its destruction by biological, chemical and mechanical processes , hence the determination of a reef calcium carbonate budget ; the dating of core material derived by drilling into the seafloor, dated by Carbon-14 or in some cases by uranium isotopes; and seismic profiling of reefs to determine tectonic changes in adjacent land areas. Local and short term factors have also been examined , such as the destructive effects of hurricanes and earthquakes , and of the effects of the carnivorous 'Crown of thorns' startfish (Acanthaster)on the Great Barrier Reef.

FUTURE REEFS

THANK YOU