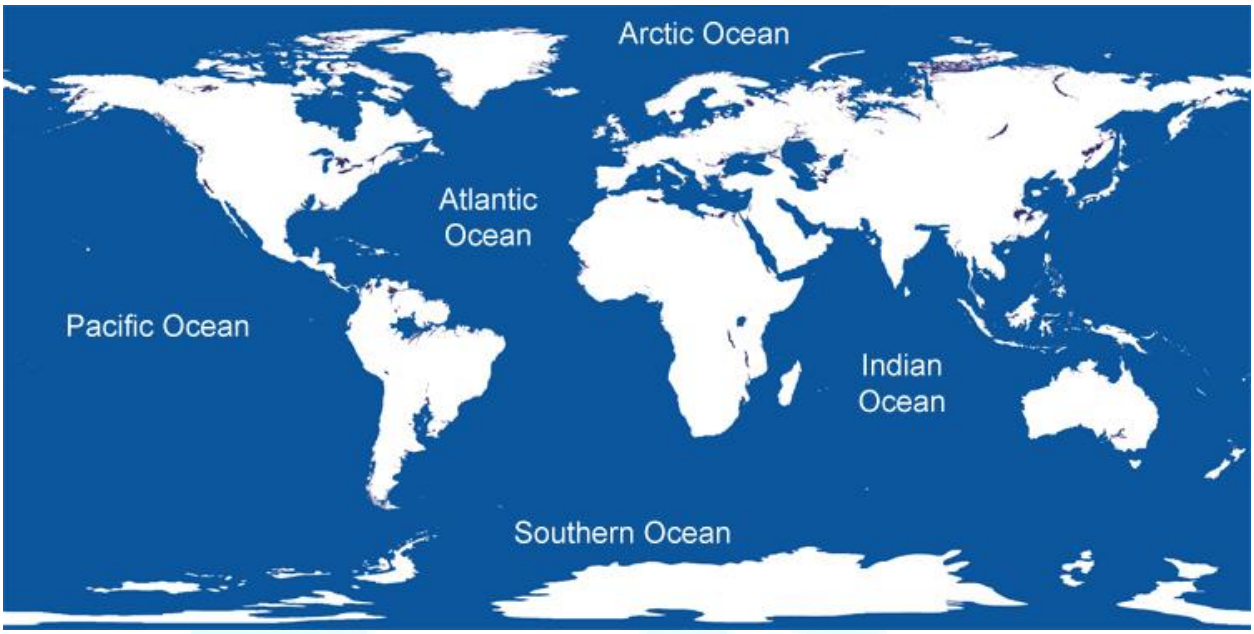
Module II: Physical Geography

3. Oceans in the world



- The Pacific Ocean
  - ❖ **Largest and deepest ocean.**
  - ❖ Covers about **one-third of the earth's surface**.
  - ❖ Average depth is generally around 7,300 meters.
  - ❖ Its shape is roughly triangular with its apex in the north at the Bering Strait.
  - ❖ Many marginal seas, bays and gulfs occur along its boundaries.
  - ❖ Nearly 20,000 islands dot this vast ocean.
  - ❖ **North and Central Pacific**
    - ➢ Characterized by maximum depth and a large number of deeps, trenches and islands.
    - ➢ Some well-known trenches are **Aleutian and Kuril.**
    - ➢ There are also a large number of seamounts and guyots. **[Hawaiian Hotspot]**
  - ❖ **West and South-West Pacific**

- ➢ Average **depth is about 4,000 m.**
- ➢ It is marked by a variety of islands, marginal seas, continental shelves and submarine trenches.
- ➢ **The Mariana Trench** and **Mindanao Trench** are very deep with a depth of more than **10,000 meters.**

❖ **South-East Pacific**

- ➢ This part is conspicuous for the absence of marginal seas, and has submarine ridges and plateaus.
- ➢ The **Tonga and Atacama trenches** are prominent.

Sea	Surrounding Countries
Bering sea	Alaska Peninsula of US, East Russia, Kamchatka peninsula of Russia
Bismarck sea	Papua New Guinea
Bohol sea	Philippines
Celebes sea	Indonesia, Malaysia, Philippines
Coral sea	Australia, Papua New Guinea, Solomon Islands, Vanuatu, New Caledonia (France)
East China sea	South Korea, Japan, Taiwan, China
South China sea	China, Taiwan, Vietnam, Cambodia, Philippines, Brunei, Malaysia, Indonesia, Singapore
Sea of Japan	Japan, North Korea, South Korea, Mainland Russia, Sakhalin island of Russia

Sea of Okhotsk	Kuril and Sakhalin islands of Russia, Kamchatka peninsula, mainland Russia
Java sea	Java, Sumatra, Borneo, Sulawesi islands of Indonesia, Malaysia, Singapore
Philippine sea	Philippines, Taiwan, Indonesia
Sulu sea	Philippines, Palawan islands of Philippines, Malaysia
Tasman sea	mainland Australia, Tasmania Islands, New Zealand
Yellow sea	North Korea, South Korea, China

- The Atlantic Ocean
  - ❖ The Atlantic is the second largest ocean after the Pacific.
  - ❖ It is roughly **half the size of the Pacific Ocean.**
  - ❖ Its shape resembles the letter **'S'**.
  - ❖ In terms of trade, it is the most significant of all oceans.
  - ❖ **Continental Shelf**
    - ➢ It has a prominent continental shelf with varying widths.
    - ➢ The length of the **continental shelf is maximum in the Northern Atlantic coasts.**
    - ➢ The largest width occurs off north-east America and north-west Europe.
    - ➢ The Grand Banks continental shelf is the most productive continental shelf in the world. [Recall fishing industry in Laurentian Climate]
    - ➢ The Atlantic Ocean has numerous marginal seas occurring on the shelves, like the Hudson Bay, the Baltic Sea, and the North

Sea, and beyond the shelves like the **Gulf of Florida (Mexican Gulf).**

❖ **Mid-Atlantic Ridge**

➢ The most remarkable feature of the **Atlantic Ocean** is the Mid-Atlantic Ridge which runs from north to the south paralleling the **'S' shape of the ocean.**

➢ The ridge has an average height of **4 km** and is about **14,000 km** long.

❖ **Seamounts and guyots**

➢ They are present in significant numbers but not as significant as in the pacific ocean.

➢ Several seamounts form islands of the mid-Atlantic. Examples include Pico Island of **Azores, Cape Verde Islands, Canary Islands etc..**

➢ Also, there are coral islands like **Bermuda and volcanic islands like St Helena etc..**

❖ **Trenches**

➢ The Atlantic Ocean lacks significant troughs and trenches, which are most characteristic to the **Pacific Ocean.**

➢ **North Cayman and Puerto Rico** are the two troughs and **Romanche and South Sandwich** are the two trenches in the Atlantic Ocean.

Sea	Bordering Countries/Lands
Argentine sea	Argentina, Uruguay, Antarctica
Baltic sea	Sweden, Denmark, Germany, Poland, Lithuania, Latvia, Estonia, Russia, Finland
Black sea	Bulgaria, Romania, Ukraine, Russia, Georgia, Turkey

Caribbean Sea	Cuba, Jamaica, Dominican Rep, Puerto Rico, Costa Rica, Nicaragua, Guatemala, Honduras Belize, Venezuela, Columbia, Panama
Gulf of Mexico	US, Mexico, Cuba
Greenland sea	Greenland, Iceland, Svalbard (Norway)
Hudson Bay	Quebec, Ontario, Manitoba, Nunavut provinces of Canada
Irminger sea	Iceland, Greenland, Canada
James Bay	Quebec and Antario provinces of Canada
Labrador sea	Labrador peninsula of Canada, Greenland

- The Indian Ocean
  - ❖ The Indian Ocean is the **third largest of the world's oceanic divisions.**
  - ❖ Smaller and less deep than the Atlantic Ocean.
  - ❖ **Submarine ridges**
    - ➢ Submarine ridges in this ocean include the Lakshadweep-**Chagos Ridge** [Reunion Hotspot], the **Socotra-Chagos Ridge**, the **Seychelles Ridge**, the South **Madagascar Ridge, Carlsberg Ridge** etc..
    - ➢ These ridges divide the ocean bottom into many basins. Chief among these are the **Central Basin, Arabian Basin, South Indian Basin, Mascarene Basin, West Australian and South Australian Basins.**
  - ❖ **Islands**

- ➢ Most of the islands in the Indian Ocean are continental islands and are present in the north and west.
- ➢ These include the **Andaman and Nicobar, Sri Lanka, Madagascar and Zanzibar.** The Lakshadweep and Maldives are coral islands and Mauritius and the Reunion Islands are of volcanic origin. The eastern section of the Indian Ocean is almost free from islands

❖ **Continental Shelf**

- ➢ The ocean's continental shelves are narrow, averaging 200 kilometers **(120 mi)** in width.
- ➢ An exception is found off **Australia's** northern coast, where the shelf width exceeds **1,000 kilometers (620 mi).**
- ➢ The average depth of the ocean is **3,890 m (12,762 ft).**

❖ **Trenches**

- ➢ Linear depths are almost absent. Few exceptions are **Sunda Trench, which lies to the south of the island of Java and Diamantina Trench, west of Australia.**
- ➢ Its deepest point is Diamantina Deep in Diamantina Trench, at 8,047 m. Sunda Trench off the coast of Java is also considerably deep.

❖ **Straits**

- ➢ Most of the straits in the Indian Ocean are important trade roots.
- ➢ The major choke points include **Bab el Mandeb, Strait of Hormuz, the Lombok Strait, the Strait of Malacca and the Palk Strait.**

Sea	Bordering Countries
Arabian sea	Somalia, Yemen, Oman, Iran, Pakistan, India
Andaman sea	India, Myanmar, Thailand,

	Indonesia, Malaysia
Persian Gulf	Iran, Iraq, Kuwait, Saudi Arabia, Qatar, Bahrain, UAE, Oman
Bay of Bengal	India, Bangladesh, Myanmar, Thailand, Indonesia, Malaysia, Sri Lanka
Gulf of Oman	Pakistan, Iran, UAE, Oman
Gulf of Aden	Yemen, Somalia
Gulf of Kutch	India
Gulf of Khambhat(Cambay)	India
Gulf of Mannar	India, Sri Lanka
Laccadive sea	India, Maldives, Sri Lanka

❖ ANTARCTIC OCEAN

Sea	Bordering Lands
Amundsen sea	West Antarctica, Cape Flying Fish, Cape Dart
Davis sea	East Antarctica, West Ice shelf, Shackleton ice shelf
Bellingshausen sea	West Antarctica, Alexander island in east, Peter Island in north
Cooperation sea	East Antarctica, Enderby land, west ice shelf
Cosmonauts sea	East Antarctica, Price Olav coast, Enderby land

Lazarev sea	Pricess Astrid Coast, Queen Maud Land in south
Mawson sea	East Antarctica, Shackleton ice shelf in west, Bowman island in east
Somov sea	Oates coast, Victoria land, George V coast in south
Ross sea	Victoria land, Maries Byrd land, Ross island in east, Roosevelt island in west
Weddell sea	Near western peninsular Antarctica, Coats land, Princess Martha coast

❖ ARCTIC OCEAN

Sea	Bordering Countries
Baffin bay	Baffin island of Canada, Greenland
Barents sea	Russia, Norway, Sweden, Finland
Beaufort sea	Canada, Alaska of US
Chukchi sea	Alaskan peninsula of US,east Russia
Kara sea	Russia
Lincoln sea	Greenland and Ellesmere island of Canada
Pechora sea	Kola peninsula, Russia

Wandel sea	Greenland
White sea	Enclosed between Kola peninsula and mainland Russia

- Relief of ocean floor
  - ❖ The oceans, unlike the continents, merge so naturally into one another that it is hard to demarcate them.
  - ❖ The geographers have divided the oceanic part of the earth into five oceans, namely the Pacific, the Atlantic, the Indian, Southern, and the Arctic.
  - ❖ The various seas, bays, gulfs, and other inlets are parts of these four large oceans.
  - ❖ A major portion of the ocean floor is found between 3-6 km below the sea level.
  - ❖ The floors of the oceans are rugged with the world's largest mountain ranges, deepest trenches, and the largest plains. These features are formed, like those of the continents, by the factors of tectonic, volcanic, and depositional processes
  - ❖ Major Ocean Relief Features

    The ocean floors can be divided into **four major divisions:**

    1. **The Continental Shelf**
       - ➢ Continental Shelf is the gently sloping seaward extension of continental plate.
       - ➢ These extended margins of each continent are occupied by relatively shallow seas and gulfs.
       - ➢ Continental Shelf of all oceans together covers **7.5%** of the total area of the oceans.
       - ➢ Gradient of continental is **1°** or even less.
       - ➢ The shelf typically ends at a very steep slope, called the **shelf break.**

- ➢ The continental shelves are covered with variable thicknesses of sediments brought down by rivers, glaciers etc..
- ➢ Massive sedimentary deposits received over a long time by the continental shelves, become the source of fossil fuels [Petroleum].
- ➢ Examples: **Continental Shelf of South-East Asia, Great Banks around Newfoundland, Submerged region between Australia and New Guinea.**
- ➢ The shelf is formed mainly due to
  - ➔ **submergence of a part of a continent**
  - ➔ **relative rise in sea level**
  - ➔ **Sedimentary deposits brought down by rivers**
- ➢ There are various types of shelves based on different sediments of terrestrial origin
  - ➔ glaciated shelf (Surrounding Greenland),
  - ➔ coral reef shelf **(Queensland, Australia),**
  - ➔ shelf of a large river **(Around Nile Delta),**
  - ➔ shelf with dendritic valleys **(At the Mouth of Hudson River)**
  - ➔ shelf along young mountain ranges **(Shelves between Hawaiian Islands).**

2. The Continental Slope

- ➢ A continental slope is the slope between the outer edge of the continental shelf and the deep ocean floor.
- ➢ The continental slope is cut by submarine canyons in many locations.
- ➢ The continental slope marks the seaward edge of the continental shelf.
- ➢ The gradient of the slope region varies between **2-5°**.
- ➢ It extends between the depth of **180 to 3600 meters**.

- In some places, for example, off the shore of the Philippines, the continental slope extends to a great depth.
- Continental slopes, mainly due to their steepness and increasing distance from the land, have very little deposits of sediments on them.
- **Sea life is also far less here than on the shelf.**
- Along the base of the continental slope is a deposit of sediments. This belt of sedimentary deposits form the continental rise.
- In some regions the rise is very narrow but in others it may extend up to **600 km** in width.

3. The Deep Sea Plain

- Deep sea planes are gently sloping areas of the ocean basins.
- These are the flattest and smoothest regions of the world because of terrigenous [denoting marine sediment eroded from the land] and shallow water sediments that buries the irregular topography.
- It covers nearly 40% of the ocean floor.
- The depths vary between 3,000 and 6,000 m.
- These plains are covered with fine-grained sediments like clay and silt.
- It has extensive submarine plateaus, ridges, trenches, beams, and oceanic islands that rise above sea level in the midst of oceans.
- E.g. the Azores, Ascension Island

4. The Oceanic Deeps

- The trenches are relatively steep-sided, narrow basins (Depressions). These areas are the deepest parts of the oceans.

- ➢ They are of tectonic origin and are formed during ocean – ocean convergence and ocean-continent convergence.
- ➢ They are some **3-5 km** deeper than the surrounding ocean floor.
- ➢ The trenches lie along the fringes of the deep-sea plain at the bases of continental slopes and along island arcs.
- ➢ The trenches run parallel to the bordering-fold mountains or the island chains.
- ➢ The trenches are very common in the Pacific Ocean and form an almost continuous ring along the western and eastern margins of the Pacific.
- ➢ The **Mariana Trench off the Guam Islands** in the Pacific Ocean is the deepest trench with a depth of more than **11 kilometers.**
- ➢ Other ocean deeps
  1. **Mindanao deep (35000 feet)**
  2. **Tonga trench (31000 feet)**
  3. **Japanese trench (28000 feet) (all 3 in the Pacific Ocean)**
- ➢ They are associated with active volcanoes and strong earthquakes **(Deep Focus Earthquakes like in Japan)**. This makes them very significant in the study of plate movements.
- ➢ As many as **57 deeps** have been explored so far; of which 32 are in the Pacific Ocean; 19 in the Atlantic Ocean and 6 in the Indian Ocean.

❖ Minor Ocean Relief Features

- ➢ Apart from the above mentioned major relief features of the ocean floor, some minor but significant features predominate in different parts of the oceans.
  1. **Ridges,**
  2. **Hills,**
  3. **Seamounts,**

4. **Guyots,**
5. **Trenches,**
6. **Canyons,**
7. **Fracture zones,**
8. **Island arcs,**
9. **Atolls,**
10. **Coral reefs,**
11. **Submerged volcanoes and**
12. **Sea-scarps.**

➢ **Mid-Oceanic Ridges**

➔ A mid-ocean ridge is a seafloor mountain system formed by plate tectonics.

➔ It typically has a depth of about **2,600 meters** and rises about **2,000 meters** above the deepest portion of an ocean basin.

➔ This feature is where seafloor spreading takes place along a divergent plate boundary.

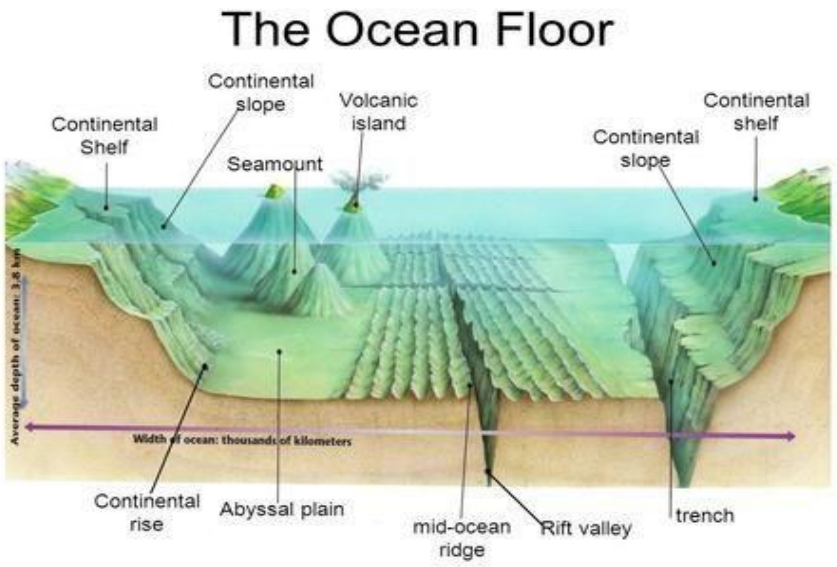
➢ **Seamount**

➔ A seamount is an underwater mountain formed by volcanic activity.

➔ seamount does not reach the surface of the ocean.

➔ These can be **3,000-4,500 m tall.**

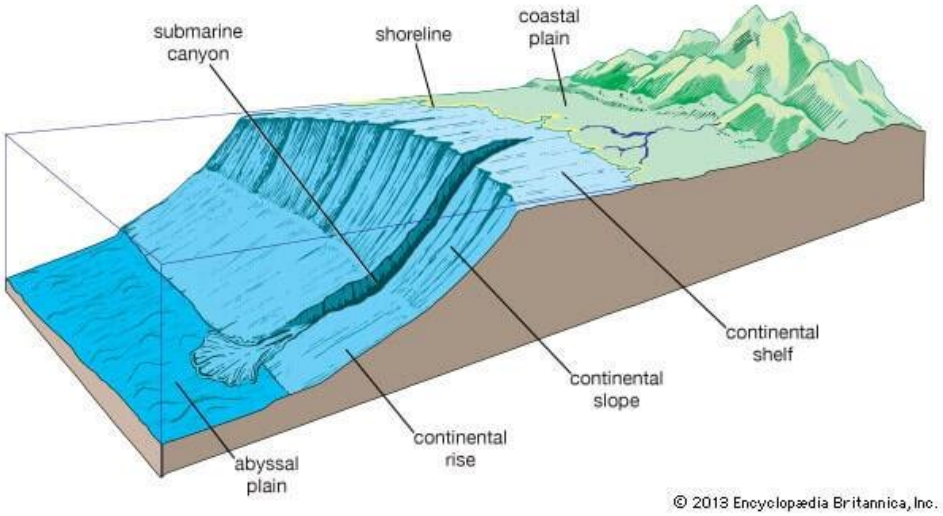
➔ Emperor seamount, an extension of the **Hawaiian Islands in the Pacific Ocean, is a good example.**



➢ Submarine Canyons

➔ A submarine canyon is a steep-sided valley cut into the seabed of the continental slope, sometimes extending well onto the continental shelf, having nearly vertical walls, and occasionally having canyon wall heights of up to **5 km,** from canyon floor to canyon rim, as with the **Great Bahama Canyon.**

➔ The **Hudson Canyon** is the best-known submarine canyon in the world.

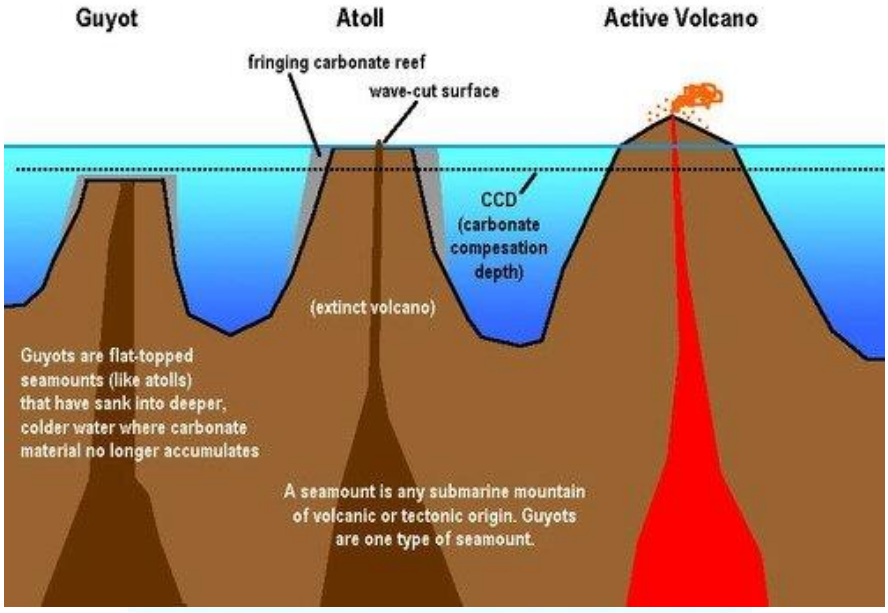


➢ Guyots

➔ **Guyot,** also known as a **tablemount,** is an isolated underwater volcanic mountain with a flat top more than 200 m below the surface of the sea.

➔ They show evidence of gradual subsidence through stages to become flat-topped submerged mountains.

➔ It is estimated that more than **10,000 seamounts** and **guyots** exist in the **Pacific Ocean alone.**



➢ Atoll

➔ An atoll, sometimes known as a coral atoll, is a ring-shaped coral reef, including a coral rim that encircles a lagoon partially or completely.

➔ There may be coral islands or cays on the rim. **Atolls** are located in warm tropical or subtropical oceans and seas where corals can grow.

➢ Bank

➔ These marine features are formed as a result of the erosional and depositional activity.

➔ A bank is a flat-topped elevation located in the continental margins.

➔ The depth of water here is shallow but enough for navigational purposes.

➔ The **Dogger Bank in the North Sea and Grand Bank** in the north-western **Atlantic**, Newfoundland are famous examples.

➔ The banks are sites of some of the most productive fisheries of the world.

➢ Shoal

➔ A **shoal** is a detached elevation with shallow depths. Since they project out of water with moderate heights, they are dangerous for navigation.

➢ Reef

➔ A reef is a predominantly organic deposit made by living or dead organisms that form a mound or rocky elevation like a ridge.

➔ Coral reefs are a characteristic feature of the Pacific Ocean where they are associated with **seamounts and guyots**.

➔ The largest reef in the world is found off the Queensland coast of Australia. [We will study coral reefs in future posts]

➔ **Since the reefs may extend above the surface, they are generally dangerous for navigation.**

❖ Significance of Study of Oceanic Relief

➢ **Ocean relief controls the motion of sea-water.**

➢ The oceanic movement in the form of currents, in turn, causes many variations in both oceans and in the atmosphere.

➢ **The bottom relief of oceans also influences navigation and fishing.**

- Distribution of temperature and salinity of ocean water

❖ The world ocean means the combined oceans of the earth, occupying about **71%** of the earth's surface & has a mean depth of about **3800m** including shallow seas in addition to the main basins.

❖ The round figure of **4000m** applies quite well to the average depth of the main portions of the **Atlantic, Pacific 7 Indian Oceans.**

- Volume of the world ocean is about **1.4 billion** cubic kilometers (**1.37×10** to the power of **9 cu km**) which constitutes **97.2 %** of the world's free water most of the remaining **2.8%** is locked up in glaciers.
- Physical characteristics of sea water
  - Water is the sole natural compound which exists in **3 statuses in the conditions of temperature & pressure which are found on earth. The liquid state being the most common.**
  - Water has high specific heat, linked on the one hand, to the fact that one its constituents hydrogen has the highest specific heat of all the elements & on the other hand to the presence of hydrogen bonds.
  - The freezing of water is accompanied by an increase in volume of about **105** & because of this ice floats on water, freezing splits the partitions of cells in animal or plant & porous.
  - The surface tension of water is the highest of all liquids. This characteristic influences the formation of drops of water as well as waves.
  - **The surface water in a liquid state reflects only a small part of luminous radiation & absorbs much solar heat.**
  - The transmission of light is unaffected by salinity temperature or pressure. However suspended particles may scatter the light. Is more penetrating & they are subjected to molecular scattering & hence the blue color of the ocean. Different colors of the ocean like green or brownish particularly along coast due to green planktonic species & due to detritus suspended the water.
  - Sound waves propagation is easily affected by factors like salinity, temperature or pressure.
  - **The speed of waves increases with increase in salinity, temperature or pressure.**
- The chemical composition of sea-water

- ➢ Ocean water contains a variety of substances dissolved in water & as suspended particles.
- ➢ The composition of seawater varies from place to place 7 primarily depending on the abundance of life forms, presence of rivers & other geological & meteorological conditions.
- ➢ Thus different substances are dissolved in seawater. **The dissolved substances of seawater is therefore can be into 2 categories namely**
- ➢ Dissolved gasses in sea-water
  - ➔ The major gasses found in sea water in the order of their relative abundances are **Nitrogen, Oxygen & Carbon dioxide.**
  - ➔ Apart from these the presence of hydrogen sulfide gas is significant as it indicate bacterial activity, decay of organic material & stagnation of water
- ➢ The mineral constituents of water
  - ➔ The sea contains a large number of dissolved compounds & elements. The seawater contains about **10 major elements** & at least about **49 minor & trace elements.**

Elements	%
Cl	19.35
Na	10.79
Mg	1.29
S	0.88
Ca	0.41
K	0.38
Br	0.06

C	0.03
Sr	0.01
B	0.005

➢ Salinity of Ocean water:

➔ Salinity is the total amount of solid material in a kilogram of sea water expressed in parts per thousand.

➔ **The average salinity of seawater is 3.5% 7 is generally expressed as 35 parts per thousands.**

➢ Change in salinity distribution

➔ Salinity changes due to winds resulting from differing in atmospheric pressure.

➔ **The strong wind blowing throughout the year carry much of the warm & saline water from the western shore of the land in the**

➔ lower middle latitudes & from the eastern shore in the higher latitudes resulting in changes in salinity distribution.

➔ The variations in salinity are according to the nature of the atmosphere i.e. the difference between **precipitation 7 evaporation.**

- Movements of ocean water: The classification

❖ Movements of ocean water are also affected by external forces like the sun, moon and the winds.

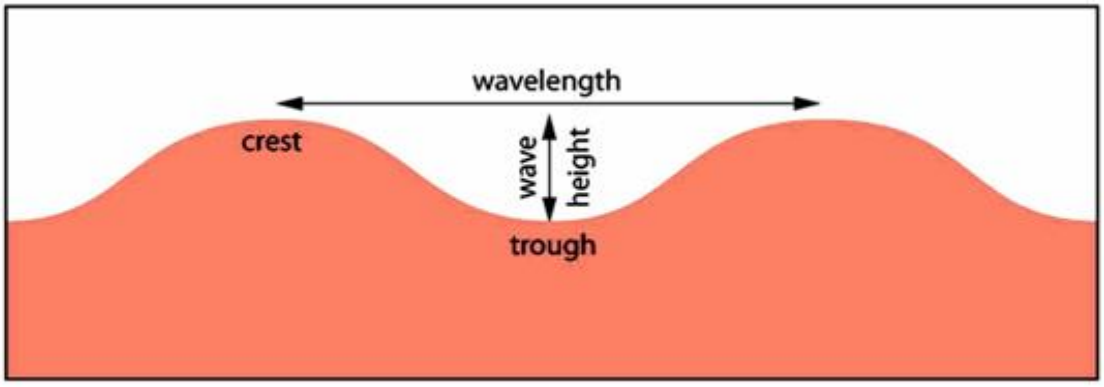
1. Waves

➢ Waves are nothing but the oscillatory movements that result in the rise and fall of the water surface.

➢ Waves are a kind of horizontal movement of the ocean water.

➢ They are actually the energy, not the water as such, which moves across the ocean surface.

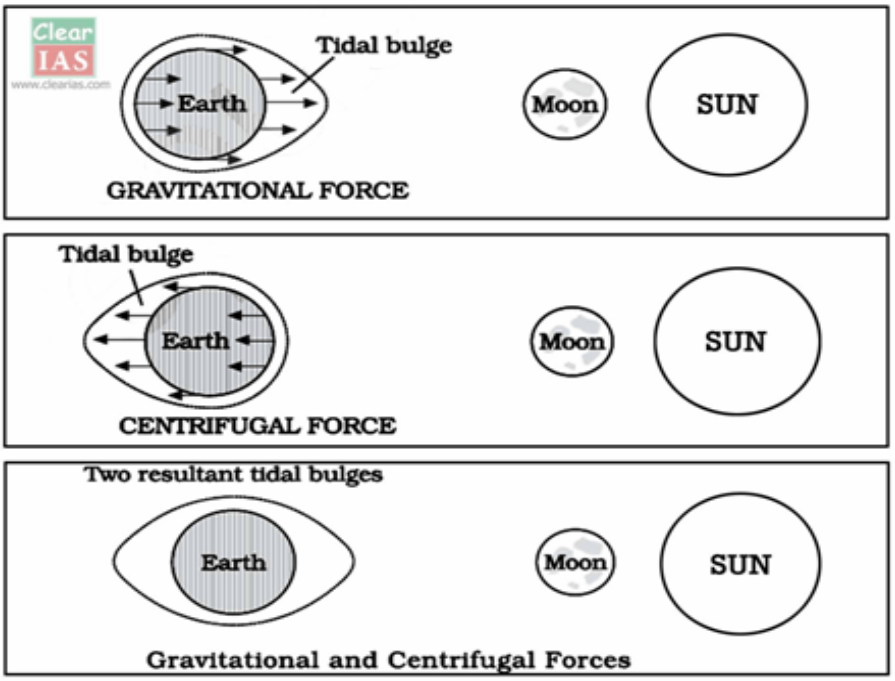
- ➢ This energy for the waves is provided by the wind.
- ➢ In a wave, the movement of **each water particle is in a circular manner.**
- ➢ A wave has two major parts: the **raised part is called as the crest while the low-point is called the trough**.



2. Tides

- ➢ Tides are the periodical rise and fall of the sea levels, once or twice a day, caused by the combined effects of the gravitational forces exerted by the **sun, the moon and the rotation of the earth.**
- ➢ They are a vertical movement of waters and are different from movements of ocean water caused by meteorological effects like the winds and atmospheric pressure changes.
- ➢ Note: The water movements which are caused by the meteorological effects like the above are called surges and they are not regular like tides.
- ➢ The moon's gravitational pull to a great extent is the major cause of the occurrence of tides **(the moon's gravitational attraction is more effective on the earth than that of the sun).**
- ➢ The Sun's gravitational pull and the centrifugal force due to the rotation of earth are the other forces which act along with the moon's gravitational pull.

- The highest tides in the world occur in the **Bay of Fundy in Canada.**
- When the tide is channeled between islands or into bays and estuaries, they are termed as **Tidal Currents.**
- The regular interval between two high or **two low tides is 12 hours 25 minutes.**



- Types of Tides

A. TIDES BASED ON THE FREQUENCY

- **Semi-diurnal Tide:** They are the most common tidal pattern, featuring two high tides and two low tides each day.
- **Diurnal Tides:** Only one high tide and one low tide each day.
- **Mixed Tide:** Tides having variations in heights are known as mixed tides. They generally occur along the west coast of North America.

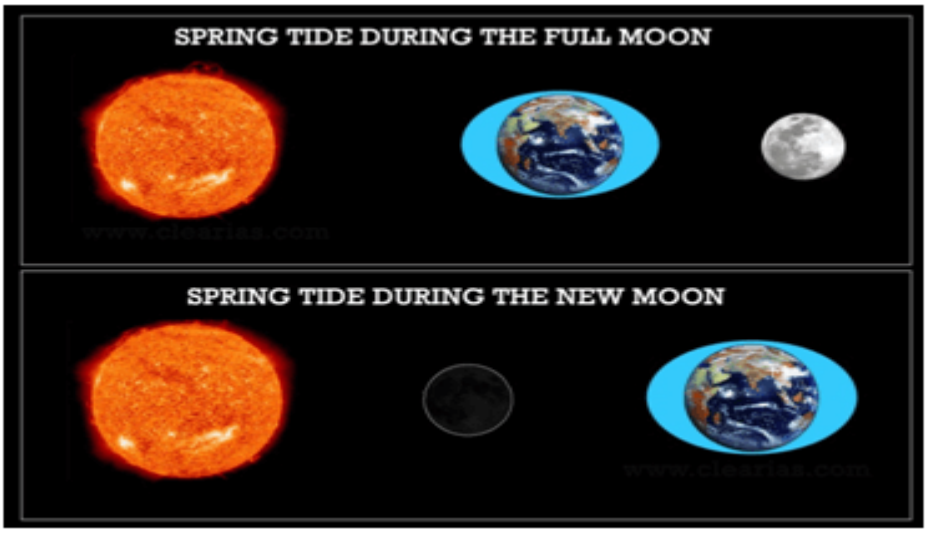
B. TIDES BASED ON THE SUN, THE MOON, AND THE EARTH'S POSITIONS

➔ **Spring Tides:**

★ When the sun, the moon, and the earth are in a straight line, the height of the tide will be higher than normal.

★ These are called **spring tides.**

★ They occur twice in a month-one on the full moon **(Poornima)** and the other on the new moon **(Amavasya).**



➔ **Neap Tides**

★ Normally after seven days of a spring tide, the sun and the moon become at a right angle to each other with respect to the earth.

★ Thus, the gravitational forces of the sun and the moon tend to counteract one another.

★ The tides during this period will be lower than the normal which are called the neap tides.

★ They also occur twice in a **month- during the first quarter moon and the last quarter moon.**

➢ Magnitude of Tides

➔ **Perigee:** When the moon's orbit is closest to the earth, it is called perigee. During this period, unusually high and low tides occur.

➔ **Apogee:** When the moon's orbit is farthest from the earth, it is called apogee. Tidal ranges will be much less than the average during this period.

➔ **Perihelion:** It is the position where the earth is closest to the sun **(around January 3rd)**. Unusual high and low tides occur during this time.

➔ **Aphelion:** It is the position where the earth is farthest from the sun **(around July 4th)**. Tidal ranges are much less than the average during this period.

➢ TIDAL BORE

➔ When the leading edge of the incoming tide forms a wave/ waves of water that travel up a river or a narrow bay against the direction of the river or bay's current, it is called a **tidal bore**.

➔ The Indian rivers like the **Ganges, Brahmaputra, Indus, etc exhibit tidal bores.**

➢ INTERTIDAL ZONE

➔ The intertidal zone, also known as the foreshore and seashore and sometimes referred to as the littoral zone, is the area that is above water at low tide and under

water at high tide **(i.e., the area between the tide-marks).**

- ➢ EFFECTS OF TIDES
  - ➔ Tides act as a link between the port and the open sea. Some of the major ports of the world, such as London port on the river **Thames and Kolkata** port on river **Hugli are located on the rivers away from the sea coast.**
  - ➔ The tidal current clears away the river sediments and slows down the growth of delta.
  - ➔ It increases the depth of water which helps ships to move safely to the ports.
  - ➔ **It also acts as a source for producing electricity.**

3. Ocean Currents

- ➢ The ocean currents are the horizontal flow of a mass of water in a fairly defined direction over great distances.
- ➢ They are just like a **river flowing in an ocean.**
- ➢ Ocean currents can be formed by the winds, density differences in ocean waters due to differences in temperature and salinity, gravity and events such as earthquakes.
- ➢ The direction of movement of an ocean current is mainly influenced by the rotation of the earth (**due to Coriolis force, most ocean currents in the northern hemisphere move in a clockwise manner and ocean currents in the southern hemisphere move in an anti-clockwise manner).**
- ➢ **GYRE, DRIFT, AND STREAM**
  - ➔ Any large system of rotating ocean current, particularly those involved with large wind movements is called a **Gyre**. They are caused by the Coriolis force.

- ➔ When the ocean water moves forward under the influence of prevailing wind, it is called **Drift** (The term 'drift' is also used to refer to the speed of an ocean current which is measured in knots). E.g. **North Atlantic Drift.**
- ➔ When a large mass of ocean water moves in a definite path just like a large river on the continent, it is called a **Stream**. They will have greater speed than drifts. E.g. **Gulf Stream.**

Types of Ocean Currents

- ➢ WARM OCEAN CURRENTS
  - ➔ Those currents which flow from equatorial regions towards poles which have a higher surface temperature and are called warm current.
  - ➔ **They bring warm waters to the cold regions.**
  - ➔ They are usually observed on the east coast of the continents in the lower and middle latitudes of both hemispheres.
  - ➔ In the northern hemisphere, they are also found on the west coast of the continents in the higher latitudes **(E.g. Alaska and Norwegian Currents).**
- ➢ COLD OCEAN CURRENTS
  - ➔ Those currents which flow from **polar regions towards the equator** have a lower surface temperature and are called cold currents.
  - ➔ **They bring cold waters into warm areas.**
  - ➔ These currents are usually found on the west coast of the continents in low and middle latitudes of both hemispheres.

➔ In the northern hemisphere, they are also found on the east coast in the higher latitudes **(E.g. Labrador, East Greenland and Oyashio currents)**

➢ Factors influencing the origin and nature of ocean currents

1. Difference in density

➔ As we all know, the density of seawater varies from place to place according to its temperature and proportion of salinity.

➔ **The density increases with an increase in salinity and decreases with a decrease in salinity.**

➔ But when the temperature increases, density decreases and when the temperature decreases density increases.

➔ This increase and decrease in density due to the differences in temperature and salinity causes the water to move from one place to another.

➔ Such a movement of water due to the differences in density as a function of water temperature and salinity is called the **Thermohaline Circulation**.

➔ In polar regions, due to a lower temperature, the waters will be of high density. This causes the waters to sink to the bottom and then to move towards the less dense middle and lower latitudes (or towards the equatorial regions).

➔ **They rise (upwelling) at the warm region and push the already existing less dense, warm water towards the poles**.

2. The earth's rotation

➔ Earth's rotation causes Coriolis force which deflects the air to its right in the northern hemisphere and to its left in the southern hemisphere-**Ferrel's Law.**

➔ Similarly, ocean water is also affected by the Coriolis force and follows **Ferrel's Law.**

➔ Hence, ocean currents in the northern hemisphere move in a clockwise (towards right) direction and ocean currents in southern hemisphere moves in an anti-clockwise (towards left) direction **(In the Indian Ocean due to the impact of the Asian monsoon, the currents in the northern hemisphere do not follow this pattern of movements all time).**

3. The winds

➔ The winds like trade winds and westerlies drive the ocean water in a steady flow in front of them.

➔ When the direction of the winds changes, the direction of the current also gets changed.

- Coral reefs

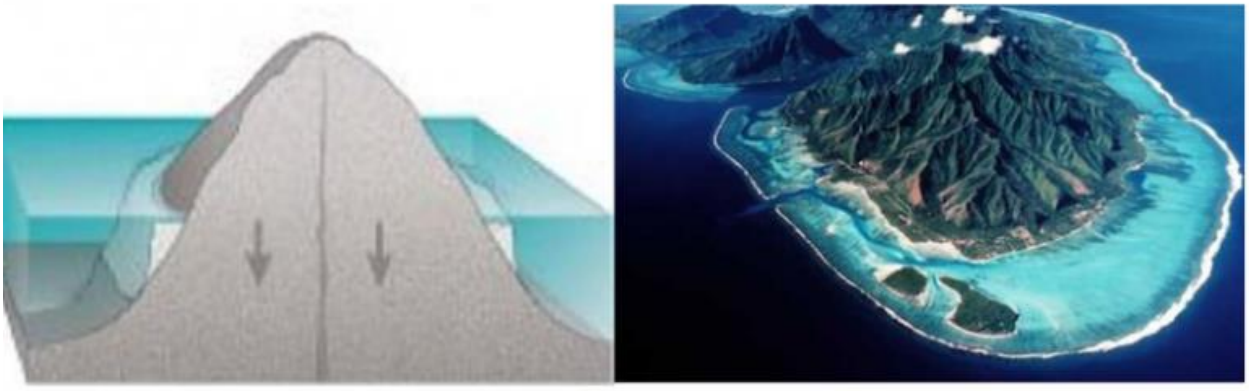
❖ Corals are nothing but **calcareous rocks, formed from the skeletons of minute sea animals, called polyps.**

- The polyps extract calcium salts from seawater to form hard skeletons which protect their soft bodies. **These skeletons give rise to corals.**
- The corals live in colonies fastened to the rocky seafloor. New generations develop on skeletons of dead polyps. The tubular skeletons grow upwards and outwards as a cemented calcareous rocky mass collectively called corals.
- The shallow rock created by these depositions is called a **reef**. These **reefs, later on, evolve into islands.**
- The corals Occur in different forms and colors, depending upon the nature of salts or constituents they are made of.
- The progressive development of corals appears over the sea surface in different forms over a period of time.
- Small marine plants (algae) also deposit calcium carbonate, thus contributing to coral growth.
- Ideal conditions for coral growth
  - Corals thrive in tropical waters-between **30°N and 30°S l**atitudes.
  - The ideal depths for coral growth are **45 m to 55 m below sea surface,** where there is abundant sunlight available.
  - The temperature of water should be around **20°C.**
  - Clear salt water is suitable for coral growth, while both freshwater and highly saline water are harmful for polyp growth.
  - Adequate supply of oxygen and microscopic marine food, **called plankton, is essential for growth and existence.**
  - As the food supply is more abundant on the seaward side, corals grow more rapidly on the seaward side.
- Types of Coral Reefs
  - Coral reefs can be classified on the basis of large-scale reef morphology; the size and shape of a reef, and its relation to nearby land (if any).

- ➢ This is usually (but not always) sufficient to clearly distinguish one type from the others.
- ➢ There is often a great deal of overlap among the major reef types (within a given biogeographic region) in terms of the dominant groups of animals and plants, as well as their ecological interactions.
- ➢ There are three major types of coral reefs: **Fringing Reef, Barrier Reef, and Atoll**

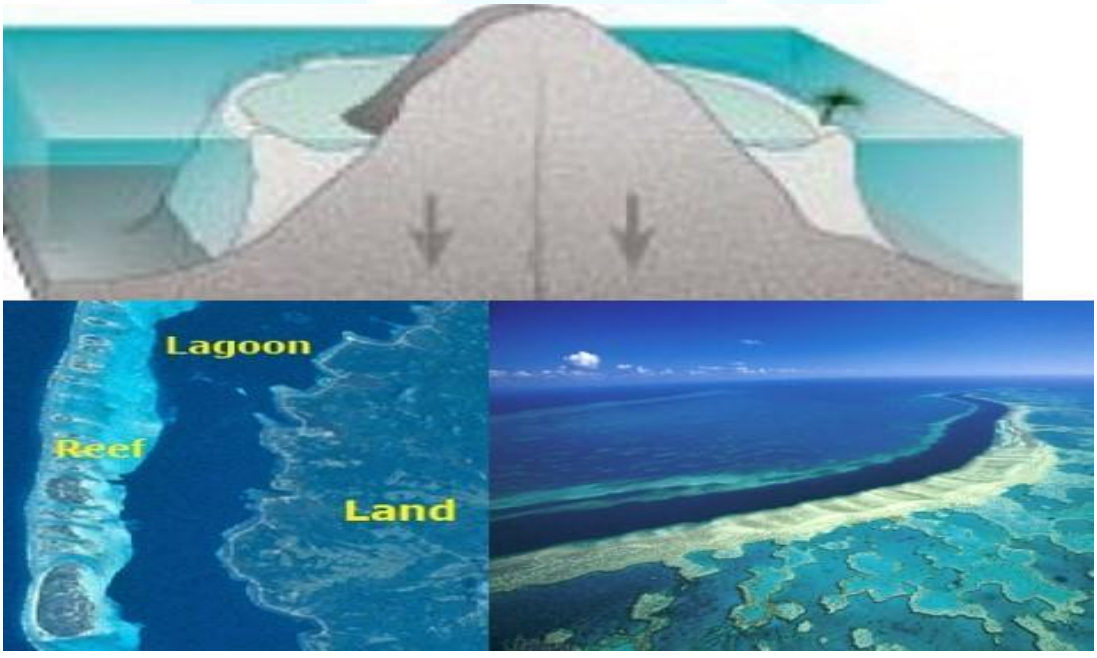
➢ **Fringing Reef**

- ➔ **It is by far the most common of the three major types of coral reefs.**
- ➔ It is a coral platform attached to a continental coast or an island, sometimes separated by a narrow, shallow lagoon or channel.
- ➔ A fringing reef runs as a narrow belt, **0.5 km to 2.5 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 increases in depth.
- ➔ The surface of a fringing reef is rough, as it is covered with coral remains forming a boulder zone or reef flat.



➢ **Barrier Reef**

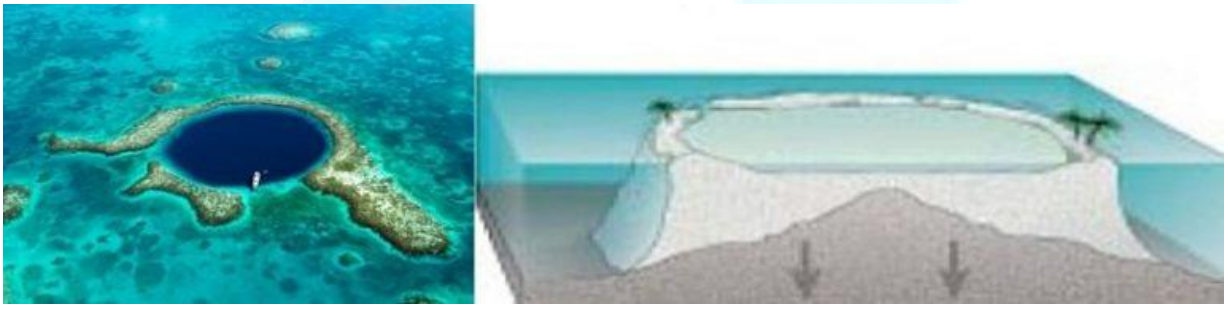
- ➔ This is the largest of the three reefs, runs for hundreds of kilometers and is several kilometers wide.
- ➔ It extends as a broken, irregular ring around the coast, or an island, running almost parallel to it.
- ➔ A barrier reef is characterized by the distant location of the reef from the coast with a broader and deeper lagoon, which is sometimes joined with the seawater through one or more channels cutting across the barrier reef.
- ➔ A barrier reef is very thick, going even below **180 meters** from the surface with the seaward side sloping steeply into the deep sea. The surface of a barrier reef is covered with coral debris, boulders, and sand.
- ➔ The most famous example of this type of reef is the Great Barrier Reef off the coast of northeastern **Australia, which is 1900 km long and 160 km wide.**



➢ **Atolls**

- ➔ It is a ring-like reef, which, partly or completely, encloses a lagoon. The lagoon may have a level surface, but the seaward side of the reef slopes steeply into the deep sea.

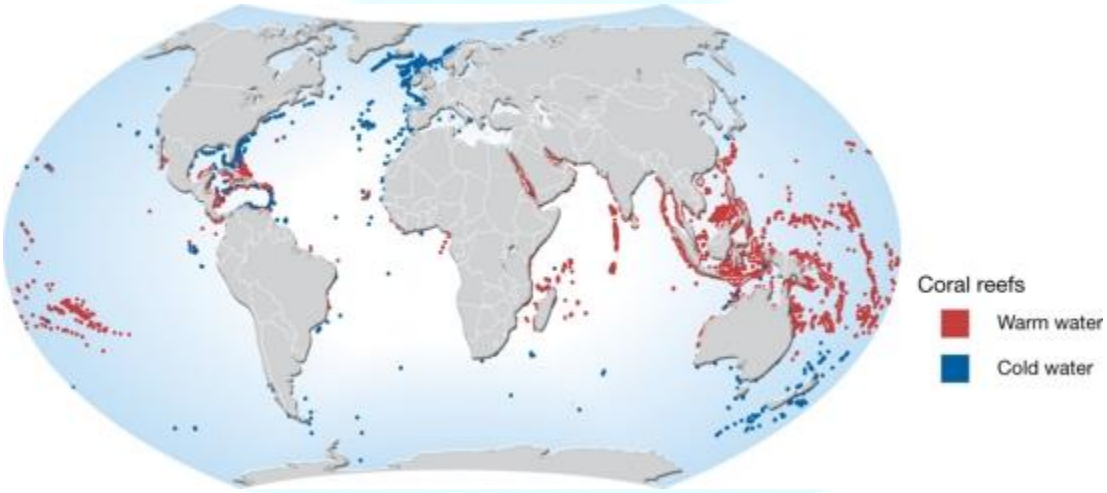
- ➔ The lagoon has a depth of **80-150 meters** and may be joined with seawater through a number of channels cutting across the reef.
- ➔ Atolls are located at great distances from deep-sea platforms, where the submarine features may help in formation of atolls, such as a submerged island or a volcanic cone which may reach a level suitable for coral growth.
- ➔ 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**



❖ Distribution of Coral Reefs

- ➢ The majority of reef-building corals are found within tropical and subtropical waters. **These typically occur between 30° north and 30° south latitudes.**
- ➢ The **Indonesian/Philippines archipelago has the world's greatest concentration of reefs and the greatest coral diversity.**

- ➢ Other areas of reef concentration are the **Great Barrier Reef of Australia, the Red Sea, and the Caribbean**, the latter having a much lower diversity than all major **Indo-Pacific regions.**
- ➢ World's major coral reef regions:
  - **➔ Caribbean/ western Atlantic**
  - **➔ Eastern Pacific**
  - **➔ Central and western Pacific**
  - **➔ Indian Ocean**
  - **➔ Arabian Gulf**
  - **➔ Red Sea**



❖ Coral Reefs Bleaching

- ➢ Coral reef ecosystems worldwide have been subject to unprecedented degradation over the past few decades. Disturbances affecting coral reefs include anthropogenic and natural events.
- ➢ Recent accelerated coral reef decline seems to be 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, etc.**

- Coral bleaching occurs when the relationship between the coral host and marine algae, which give coral much of their color, breaks down. Without the marine algae, the tissue of the coral animal appears transparent and the coral's bright white skeleton is revealed. **Coral reef bleaching is a common stress response of corals to many of the various disturbances mentioned above.**
- **Corals begin to starve once they bleach**. While some corals are able to feed themselves, most corals struggle to survive without their algae. If conditions return to normal, corals can regain their algae, return to their normal color and survive. However, this stress is likely to cause decreased coral growth and reproduction, and increased susceptibility to disease.
- **Bleached corals often die if the stress persists.**
- **Coral reefs that have high rates of coral death following bleaching can take many years or decades to recover.**

❖ Causes of Coral Bleaching

➢ **Temperature**

➔ Coral species live within a relatively narrow temperature margin and therefore, low and high sea temperatures can induce coral bleaching.

➔ Bleaching events occur during sudden temperature drops accompanying intense upwelling episodes, seasonal cold-air outbreaks etc.

➢ **Solar Irradiance**

➔ Bleaching during the summer months, during seasonal temperature and irradiance maxima often occurs disproportionately in shallow-living corals and on the exposed summits of colonies.

➢ **Subaerial 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.

➢ **Fresh Water Dilution**

➔ Rapid dilution of reef waters from storm-generated precipitation and runoff has been demonstrated to cause coral reef bleaching.

- Deposits of ocean floors
  - ❖ Ocean deposits are sediments that come from different sources by different means and it settles down on the ocean floor.
  - ❖ The following are the sources of Ocean deposits:
  - ❖ **Terrestrial sediments**
    - ➢ Both biotic and abiotic sediments from continents get accumulated on the continental shelf and slope via river, winds, and wave erosion.
  - ❖ **Volcanic sediments**
    - ➢ Some oceanic sediments are of volcanic origin that deposit in the ocean directly or indirectly from the air.
  - ❖ **Marine Organism**
    - ➢ The main sources of Ooze deposits in the deep ocean are dead marine organisms that derive from Zooplankton and Phytoplankton.
  - ❖ **Extraterrestrial**
    - ➢ Sediments from meteorites.
  - ❖ Classification of Ocean Deposits
    1. Terrigenous deposits
       - ➢ he Deposits which are mainly found on the **Continental shelf are called Terrigenous deposits.**
       - ➢ main sources of Terrigenous deposits are terrestrial sediments.

➔ Boulders, sand, gravel, rocks, and mud are major components of these deposits.

➔ Marine Fossil fuel is also present in the ocean deposit on the continental shelf

2. Pelagic Deposits

➢ Pelagic deposits are composed of both organic and inorganic sediments and are generally found in the deep oceans in the continental slope, continental rise, trenches, and abyssal plains.

➢ Pelagic Deposits are generally two types:

➢ **Mud**

➔ Muds are very finer sediments and clay. It is largely found in continental slopes and Abyssal plains.

➔ Muds are classified into the following types:

➔ **Red Mud**

★ Red mud or clay are generally originated from Volcanos activities. It contains Iron oxide.

➔ **Blue Mud**

★ It contains Iron sulfite.

➔ **Green Mud**

★ It contains Potassium silicate.

➔ **Coral Mud**

★ It contains a coral reef.

➢ **Ooze**

➔ Ooze contains both organic sediments from marine remains and inorganic sediments from mud.

➔ The ooze can be further classified into the following types:

➔ **Calcareous Ooze**

★ Calcareous Ooze is present mainly on the Atlantic and Indian ocean bottom.

- ★ It is made up of Calcium carbonate made up of marine Mollusca and single-cell Protozoans.

➔ **Siliceous Ooze**

- ★ It is also of organic origin made up of silica; mostly found in **Phytoplankton and diatom.**
- ★ Siliceous Ooze is largely present in the **pacific ocean and the Southern Ocean.**