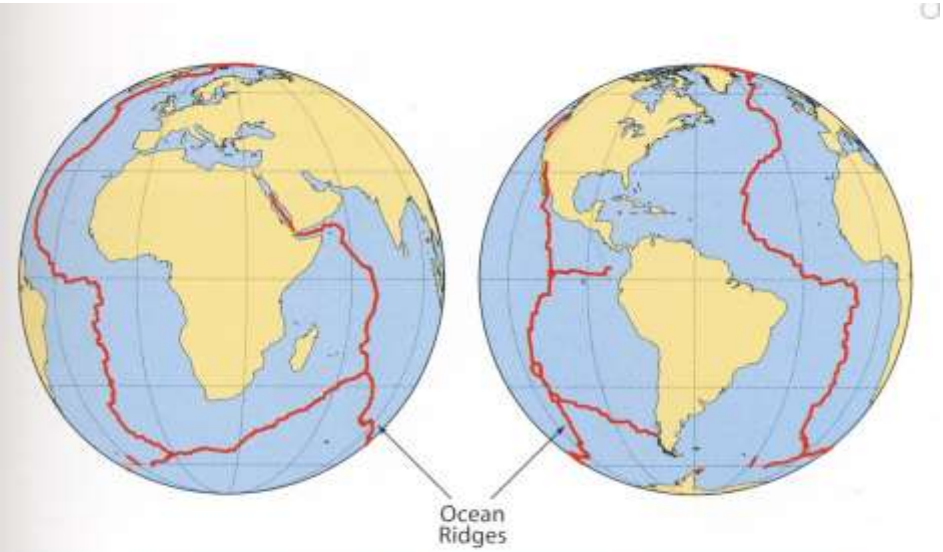
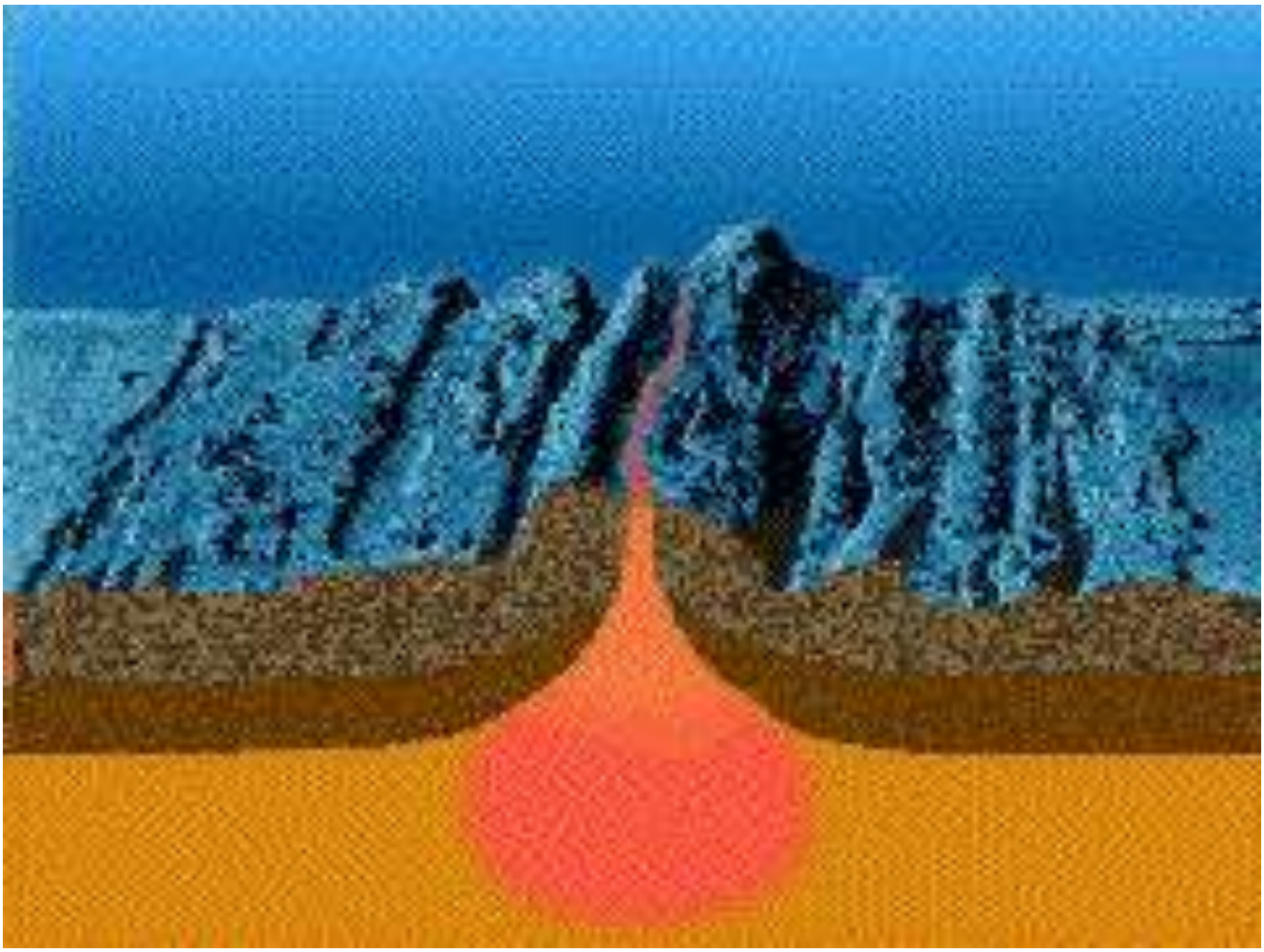
MID OCEANIC RIDGE

Along the boundries of the plates is The Mid-Ocean Ridge system that forms the most extensive chain of mountains on Earth, with more than 90 percent of the mountain range lying in the deep ocean. It runs about 40,390 miles and averages about 8,200 feet. However, some of the ridge appears above the water. Iceland is an example. Along the ridge boundaries, molten rock rises through the sea floor. These volcanic eruptions are very deep and often go unnoticed. In 1783 an eruption in Iceland was sufficiently bad that it destroyed crops, and killed more than 10.000 Icelanders – about a quarter of the population. NOAA says “Like the rest of the deep-ocean floor, we have explored less of the mountains of the Mid-Ocean Ridge system than the surface of Venus, Mars, or the dark side of the Moon. Use of submersible or remotely operated vehicles to explore the mid-ocean ridge has provided information on less than 0.1 percent of the ridge!”



Spreading sites between tectonic plates form an extensive system of ocean



The meeting of two plates sometimes makes it possible for water to enter the area as happens with the Red Sea, which was formed when the Arabian peninsula was split from the “Horn of Africa” but the Red Sea Rift – he space formed by the African and Arabian plates. This started in the Eocene and had greater movement in the Oligocene.

On the other hand, water may overrun the land as a result of the increasing amounts of water from a warming trend as happens with the Persian or Arabian Gulf

LECTURE THREE

THE OCEAN IS ALWAYS IN MOTION. WHY IS THIS IMPORTANT?

First we need to know what kinds of movement there are in the ocean.

Three Kinds of Water Movement

I. Tides
II. Waves
III. Currents

TIDES

Tides are regular movement of the ocean, most noticeable at the shore line as the water moves further and further up the shore and then recedes.
Much of the world has 2 a day but some places are somewhat different. Variation is caused by a number of factors, but the basic movement of the ocean's water in tides remains the same.

We have heard about them already, rather briefly when we mentioned the littoral or intertidal zones. The intertidal zone is the area that is covered and uncovered as the tides some in and out. But what causes that and what problems does it make?

Caesar and tides in Britain

When Caesar invaded Britain, his ships arrived at a high tide. The soldiers disembarked and when they wound up in a battle, they attempted to retreat onto the ships and leave. Unfortunately for them, the tide had "gone out" (ebbed) and the ships they had arrived in were now on the beach and not in the water. They had to continue fighting until the tide came in (flowed) and the ships were lifted back up and could sail away.
Caesar was of course, familiar with the tides, but in the Mediterranean where they behave somewhat differently!

Tides are classified in terms of whether they are high, low, spring or neap tides. The term “rip tide” is inaccurate in that what is being discussed there is a “rip current”. It isn’t a tide. What used to be called “tidal waves” have more recently been called “tsunami” (the Japanese for a “harbor wave”) since tsunami have nothing to do with tides (although as we will see they tend to look like a tide).
When the tide is coming in – that is the water is moving further and further up the shore, it is said to “flow”. When the water is moving down and away from the shore it is said to “ebb”. High tide is when the water comes in and low tide is when it goes out. Spring tides are exceptionally high tides and neap tides are exceptionally lower tides. What causes the tides?

The tides are caused by the gravitational pull of the sun and the moon on the Earth. The moon circles the earth and the Earth circles the sun. Now the moon is MUCH smaller than the Sun and smaller than the Earth. Here are the dimensions. Like geological time astronomical distance is difficult so there is a figure

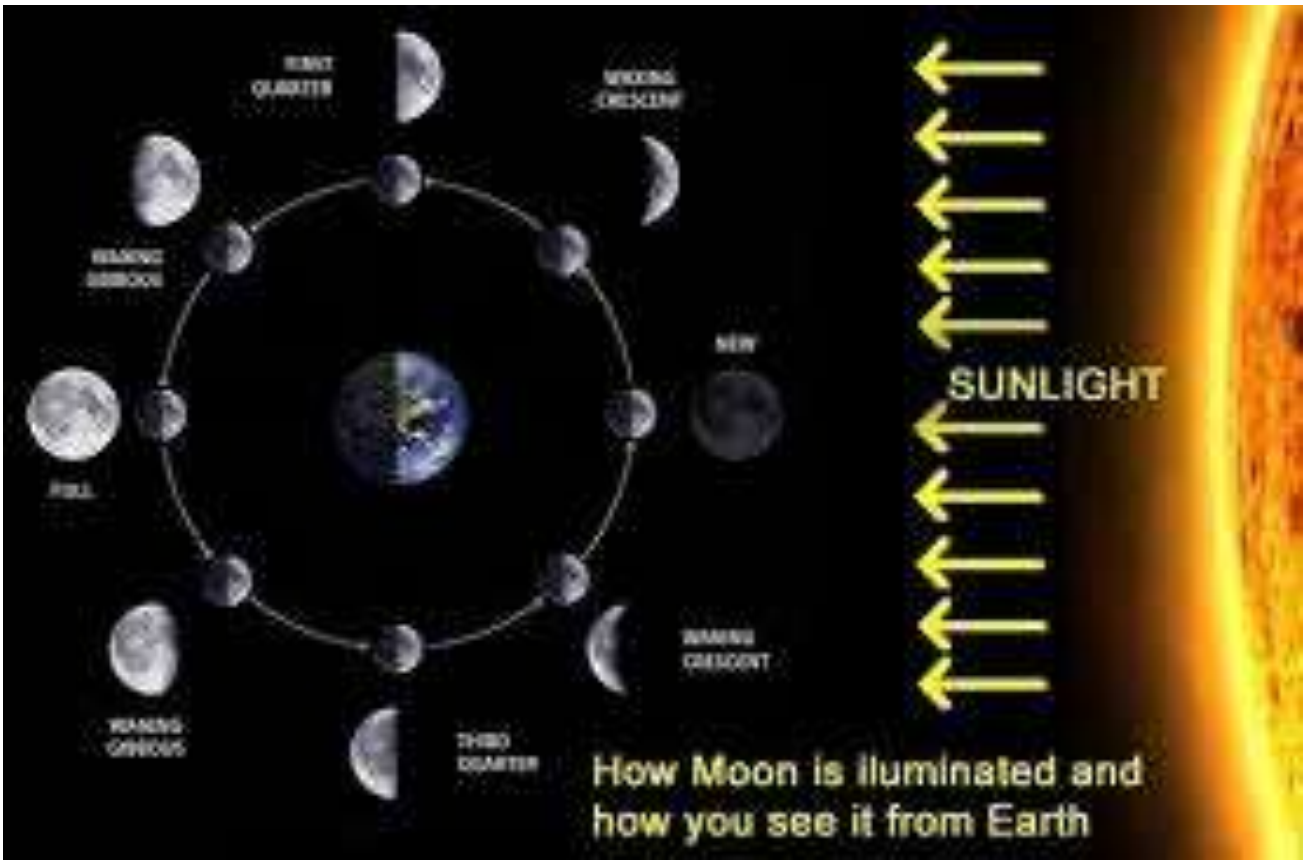
	Diameter		Circumference
Moon	3,476 km		
	2,120 miles	(4 inches)	~6,786 miles
Earth	12,756 km		
	7926 miles	(16 inches)	~25,000 miles
Sun	1,392,000 km		
	865,000 miles	(145.5 feet)	~2,720,984miles

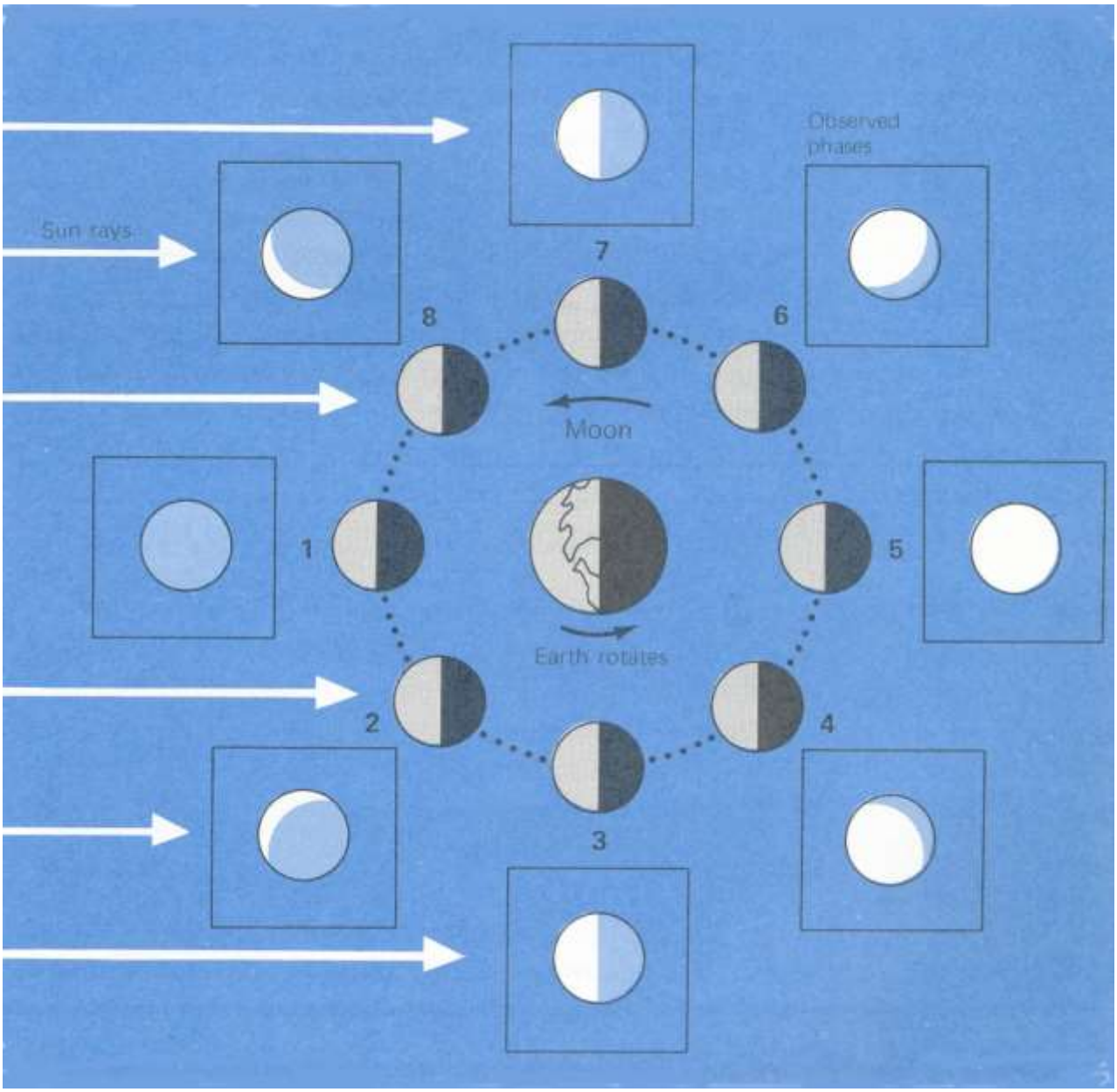
So while you might think the sun being much larger, would have a greater impact, the problem is it is much further away. The sun in about 93,000,000

miles from the Earth, the moon is only about 239,000 miles from the Earth. This is why during a total eclipse of the sun, the much, much smaller body (the moon) can completely cover the much larger body of the sun. Interestingly enough, the apparent size of the sun and the moon is the same! So the moon's influence on the tides is much greater. Both the sun and the moon have a gravitational force that pulls things on the earth toward them. The Earth in return pulls back enough that the material doesn't fly out into space. Water, being liquid in the ocean, tends to rise somewhat in the direction of the pull. This causes a kind of bulge in the ocean. Since the Earth is rotating faster than the moon is circling it, that bulge "moves" around the Earth.

Because the Moon revolves around the earth, each day it rising about 50 minutes later, so each day the tides will occur roughly 50 minutes later. You can get "tide charts" that will tell you each day when there will be high tides and when there will be low tides.

Also because the moon goes around the earth, it position relative to the sun changes and this causes the phases of the moon.


SUNLIGHT
How Moon is illuminated and
how you see it from Earth



So at sometimes, the moon and sun and Earth are in a straight line, with the moon either on the same side of the Earth as the sun, or on the opposite side of the Earth, from where the sun is.

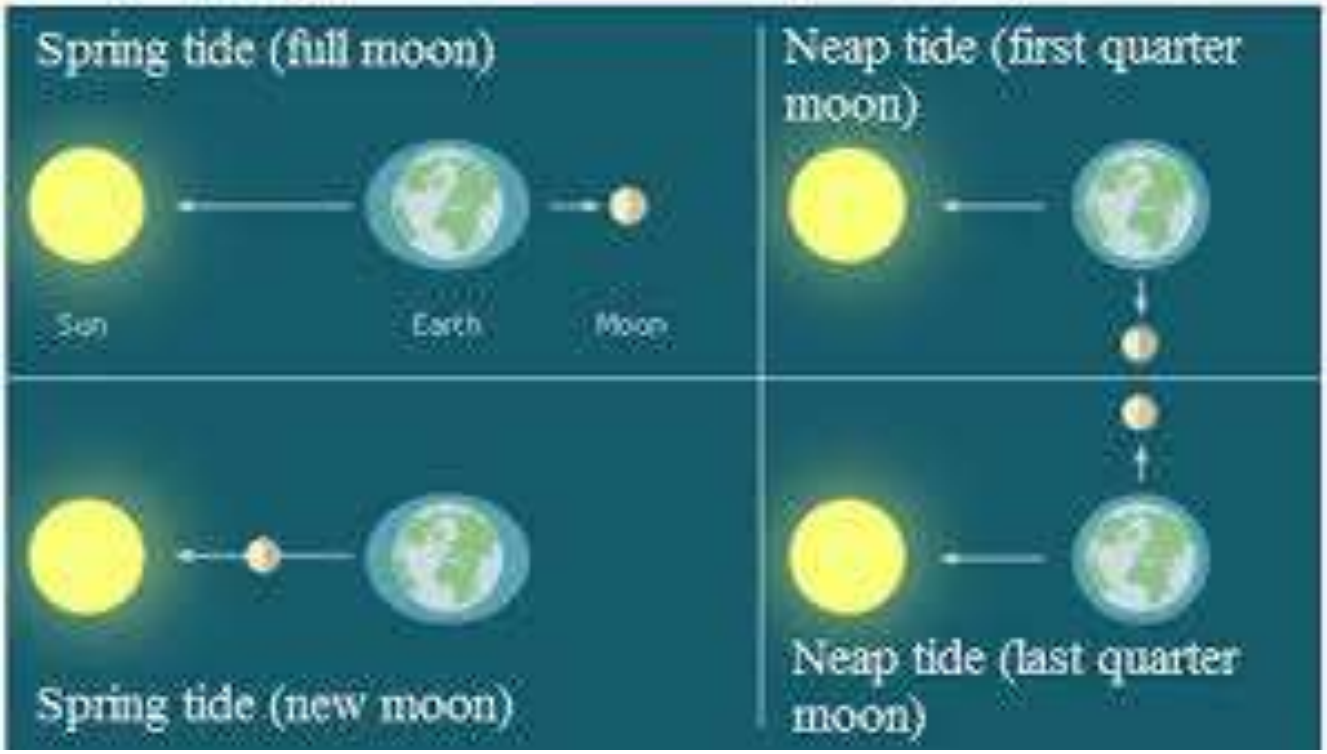
MOON--------EARTH----------SUN

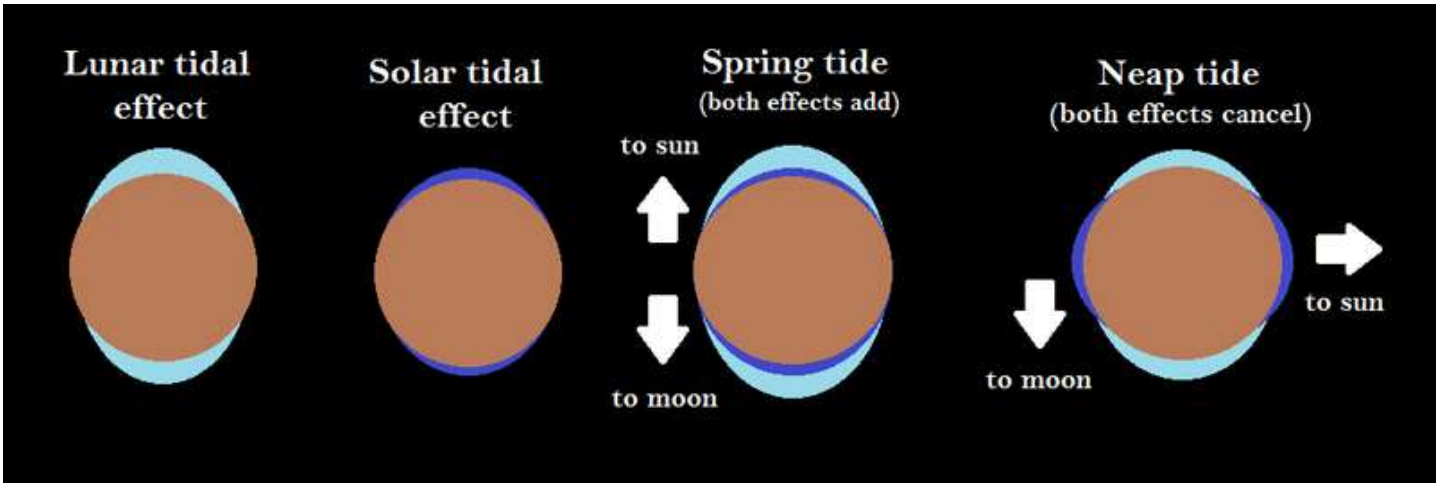
EARTH-----MOON--------SUN

At other times the moon and sun make a right angle with the Earth

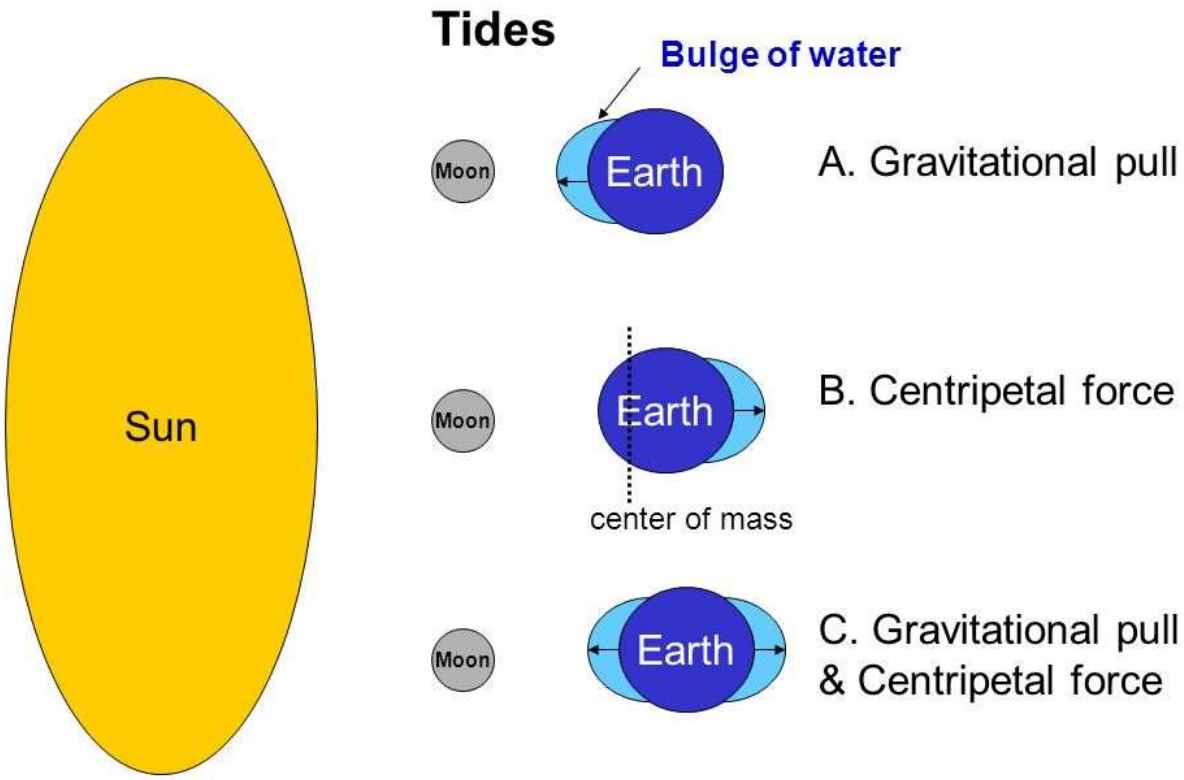
Or

So at some periods the moon and the sun are operating together, and at other times they are operating at cross purposes. When they operate together, the tide will be much higher and “spring up”. These are cleverly called “spring tides”. When they operate at cross purposes the tides, the tides will be much lower. These are called “neap tides”. So while every day there will be 2 high and 2 low tides, each month there will be 2 spring and 2 neap tides.





When the sun and moon are on the same side, why should there be a bulge on the opposite side? That bulge is caused by the Earth circling the sun which also causes the water to move away from the center of the Earth.



Bay of Fundy video

The bay of Fundy in Canada has a rather narrow entrance so the tide pushes the water into the bay through a rather narrow channel with steep cliffs. The result is the water rises very quickly and it is possible for people and animals to be trapped in the beach with no way to avoid the rapidly rising waters.

In Cuxhaven in Germany, the shore is almost horizontal, so the tide comes in suddenly and with great speed.

Watt in Cuxhaven. Watt (pronounced Vaht) is a hard substance that even a horse drawn wagon can ride on with little if any “sinkage” as would happen if it were sane.

https://www.youtube.com/watch?v=yTpzaZa9vhs

WAVES

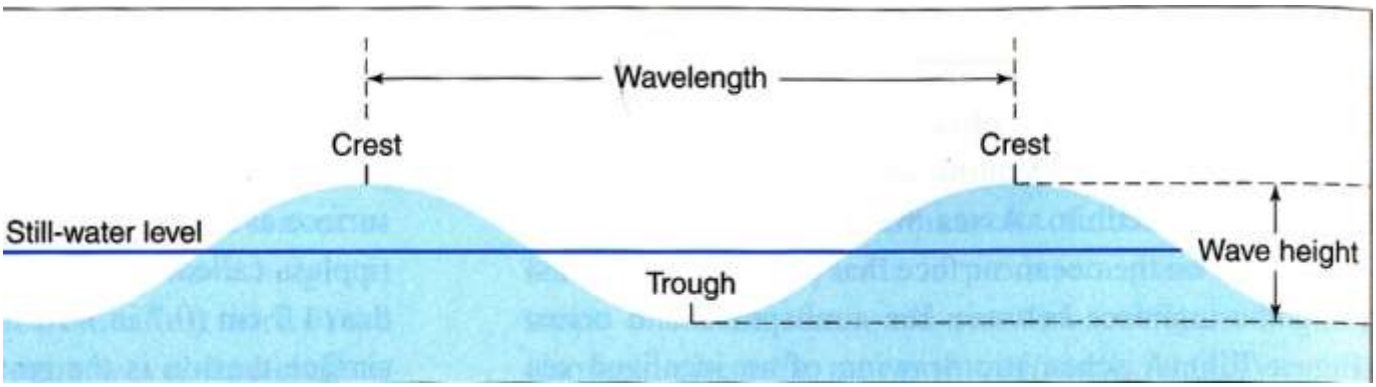
We will discuss 5 different kinds of waves:
1. Wind driven
2. Rogue
3. Tsunami
4.Tidal
5. Underwater or undersea

Waves are important to people since the have an impact on life in the ocean, travel on the ocean and land near the ocean. So we need to look at some of the different types of waves and how they have an impact on things.

WIND DRIVEN WAVES

While there are many kinds of motions in the ocean, probably the most obvious are the waves. We need a way to discuss waves, so first we need to see how they are measured

Waves are measured in specific ways



There are many kinds of waves as well. Most of the waves are called “wind driven waves”. These waves are caused by two fluids of different densities moving across one another. In this case one is air the other is water.
(You can notice this on a small scale if you blow across a cup of water, or coffee. When you try to cool the liquid and blow across the surface you will notice small “ripples” forming. It is the same principle.)
As the wind blows across the water, it sets small “capillary” waves in motion. These are often called “ripples”. (The surface tension of the water, works to end them) These ripples give greater surface area for the wind to blow against and the waves become larger. (These are called “gravity waves” because the force of gravity works to pull them back down to a level ocean.)

The area where wind driven waves are created are called

“seas”. When waves continue to move outside the area in which they are generated they are called “swells”. Since they move out of the area where the wind produced them it is possible for them to move faster than the wind!

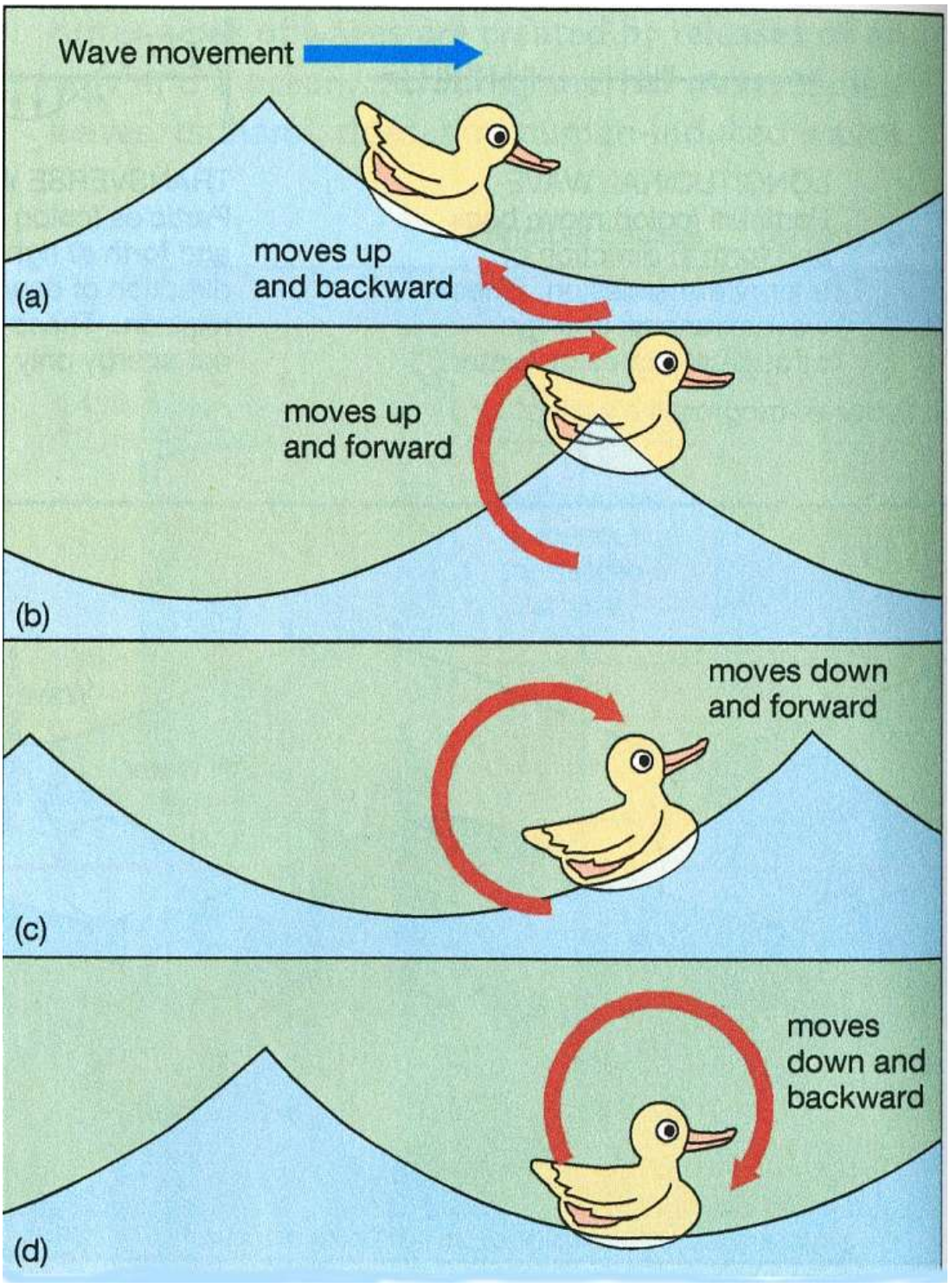
Ocean waves during storms can become very high and very dangerous. Even large ships can be in danger.

VIDEO of 100 ft high wave

https://www.youtube.com/watch?v=t8xNfMBoMMM

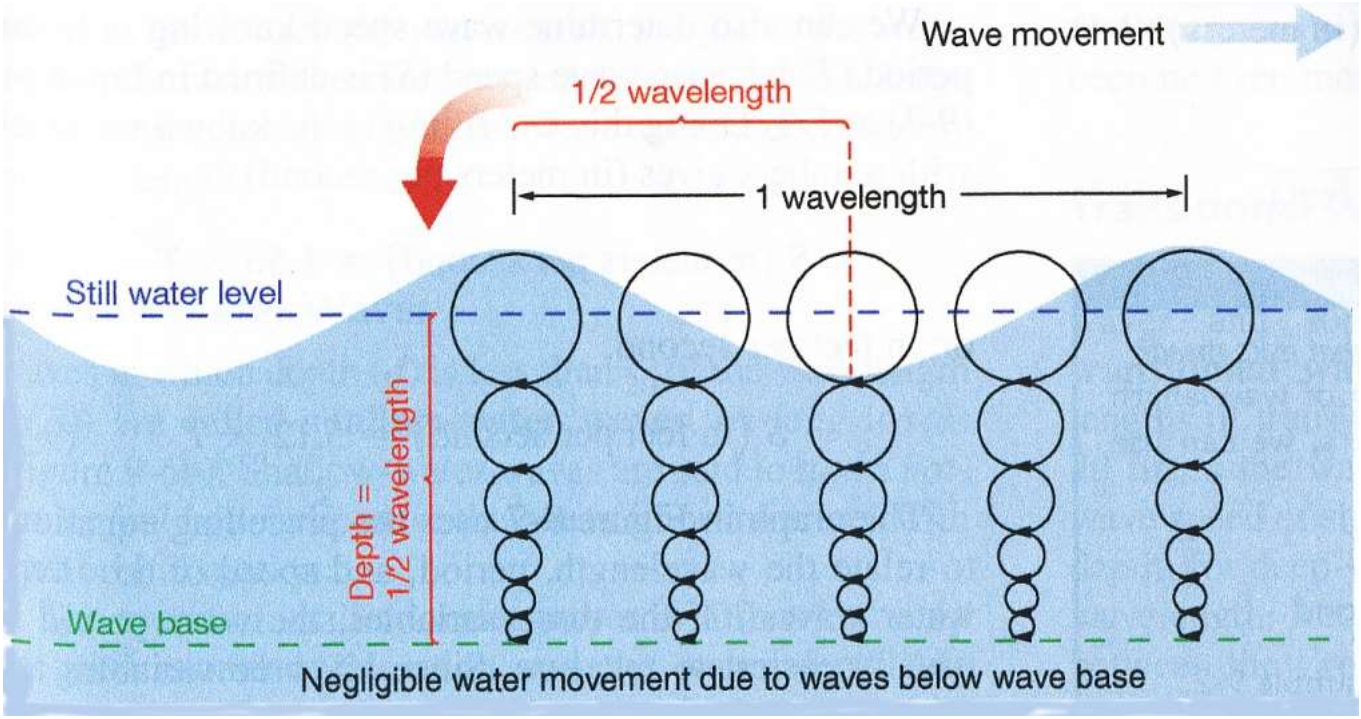
When the wind blows, it transmits energy to the water and the energy moves through the water. This energy is what causes the wave. The water in the wave does not move forward any more than wheat does when wind blows across it and causes the wheat to bend. The energy moves across the field, the wheat doesn’t. Similarly, the energy moves across the ocean and in the ocean and the water rises and falls as the energy passes by.

This can be seen by the movement of an object in the water when a wave comes by:



SEE VIDEO IN POWER POINT

https://www.youtube.com/watch?v=7yPTa8qi5X8



2 WAVE PHASE VIDEOS

As the top level starts to rotate, it presses against a lower level which also starts to rotate and so on down into the depths. At a certain level, the is negligible rotation and this is the wave “base” There are three factors that have an impact on the wave. One is how long the wind is blowing, the second is how hard the wind is blowing and the third is over what distance the wind is blowing. The distance over which the winds blows without interruption is called the “fetch’

.

Wind speed is measured in a scale called the Beaufort scale.

BEAUFORT WIND SCALE WITH CORRESPONDING SEA STATE CODES					
Beaufort Number	Wind Velocity (Knots)	Wind Description	Sea State Description	Sea State	
				Term and Height of Waves (Feet)	Condition Number
0	Less than1	Calm	Sea surface smooth and mirror-like	Calm, glassy 0	0
1	1-3	Light Air	Scaly ripples, no foam crests		
2	4-6	Light Breeze	Small wavelets, crests glassy, no breaking	Calm, rippled 0 – 0.3	1
3	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Smooth, wavelets 0.3-1	2
4	11-16	Moderate Breeze	Small waves, becoming longer, numerous whitecaps	Slight 1-4	3
5	17-21	Fresh Breeze	Moderate waves, taking longer form, many whitecaps, some spray	Moderate 4-8	4
6	22-27	Strong Breeze	Larger waves, whitecaps common, more spray	Rough 8-13	5
7	28-33	Near Gale	Sea heaps up, white foam streaks off breakers	Very rough 13-20	6
8	34-40	Gale	Moderately high, waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks		
9	41-47	Strong Gale	High waves, sea begins to roll, dense streaks of foam, spray may reduce visibility		
10	48-55	Storm	Very high waves, with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility	High 20-30	7
11	56-63	Violent Storm	Exceptionally high waves, foam patches cover sea, visibility more reduced	Very high 30-45	8
12	64 and over	Hurricane	Air filled with foam, sea completely white with driving spray, visibility greatly reduced	Phenomenal 45 and over	9

Figure 8-1. Beaufort wind scale.

When a wave approaches the shore, it ‘breaks”.

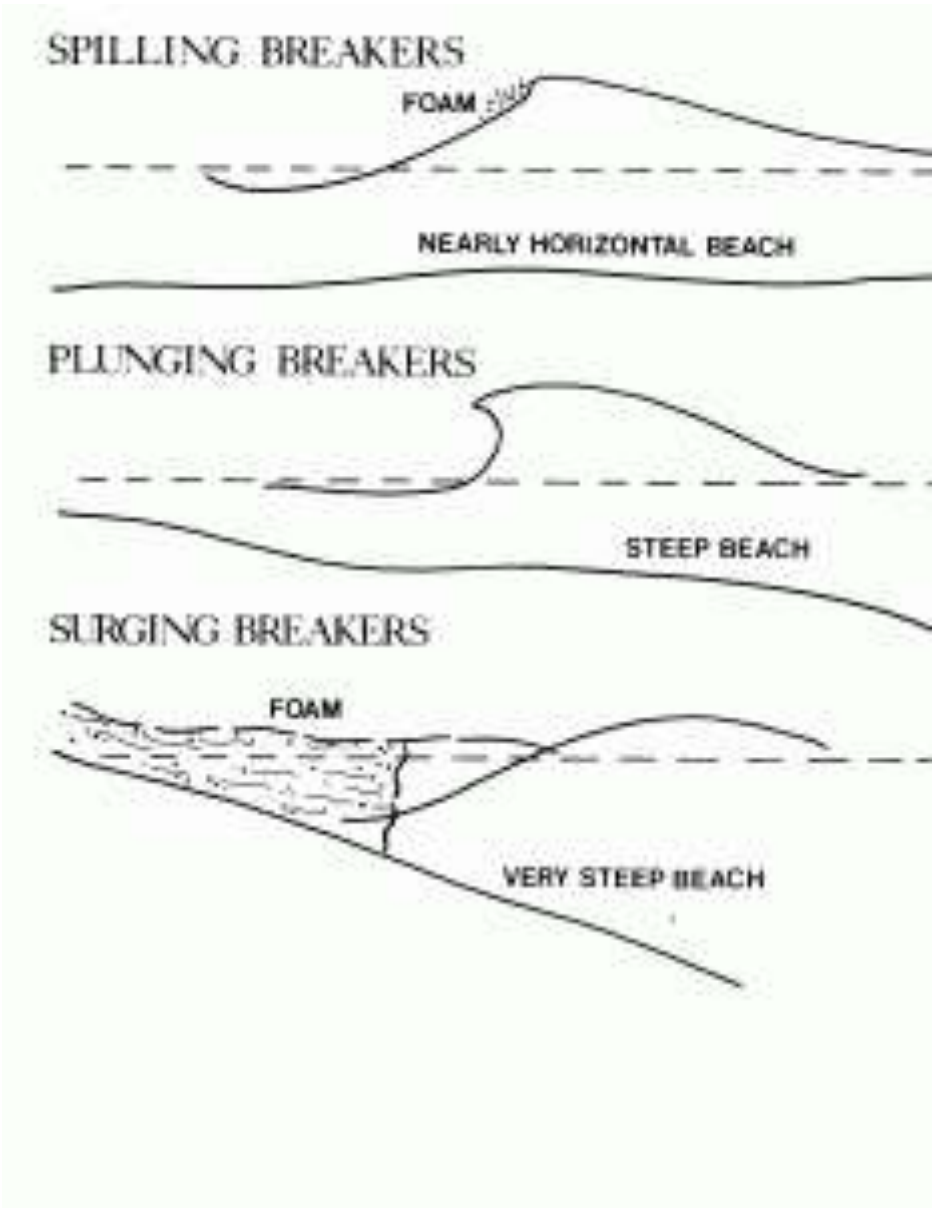
When the water depth decreases to one half of a wave’s wavelength, the wave starts to “feel the bottom”. That means that the deepest water molecules set into circular motion by the wave’s energy run into the seafloor. This forces the wave to grow upwards, so wave height increases. The base of the wave is slowed down by friction against the sea bottom, while the top of the wave rushes ahead, so the wave crest begins to

lean more and more forward until it topples over, and breaks on the shore.

Waves begin to break when the ratio of wave height/wavelength exceeds 1/7. Example: when a 14-foot wave length reaches a height of two feet, the wave breaks.

WHY IS THIS IMPORTANT?

The way the wave breaks is both caused by the shoreline and has an effect on the shore line. The way the waves break are classified as spilling, plunging or surging and are the result of different kinds of sea bottoms. The different kinds of breakers are significant because of the way they impact the coast. Generally there are 3 basic kinds of beakers (although they can be subdivided) (Notice here the definition of the kind of breaker is based on specific criteria –technical definitions. The definition is made for specific reasons)
If a beach is nearly horizontal (little slope) it will produce “spilling breakers”. If the beach is steep, it will cause the breaker sot be of the “plunging” type. Extremely steep beaches will produce “surging” breakers.


SPILLING BREAKERS
FOAM
NEARLY HORIZONTAL BEACH
PLUNGING BREAKERS
STEEP BEACH
SURGING BREAKERS
FOAM
VERY STEEP BEACH

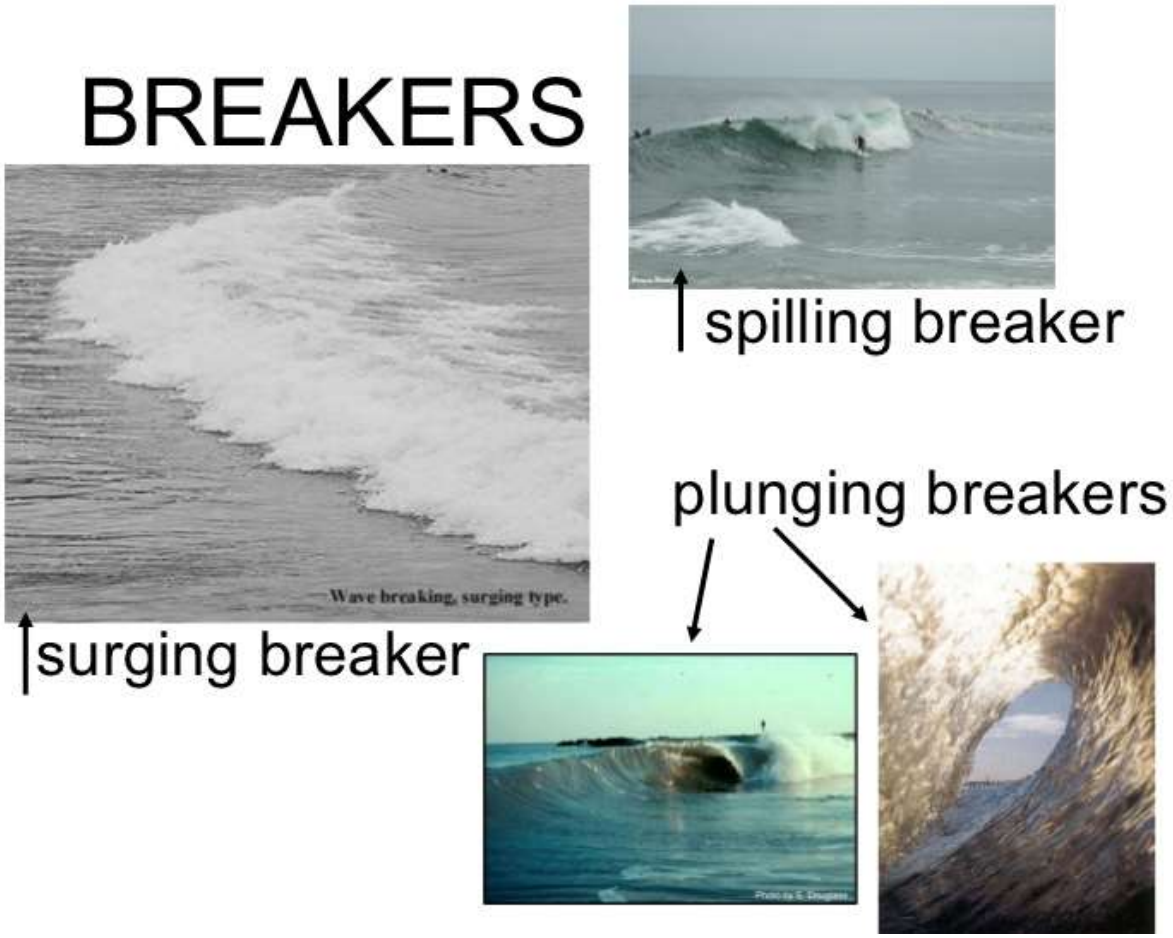
3 Main Types of Breakers

1. Surging:
   - Steep slope beach; wave rolls instead of breaks right onto beach

2. Plunging:
   - Moderate slope; wave curls; surfing!

Manos, Northern Indonesia

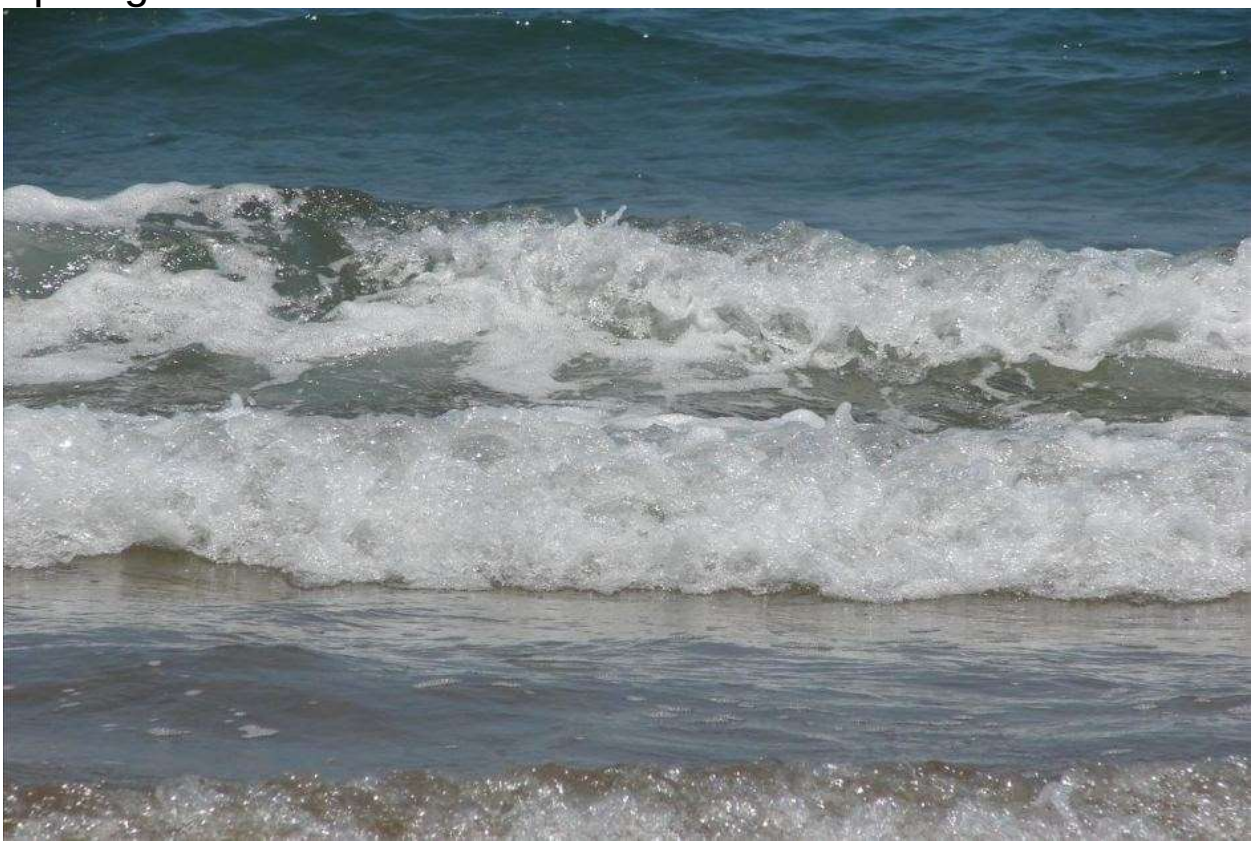
3. Spilling:
   - Gentle slope; break far from shore over long distance; crest spills down face of wave



SURGING WAVE (Never breaks)

Plunging
These are the kinds most surfers like.

Spilling Wave



A NOAA site (http://oceanexplorer.noaa.gov/edu/learning/9_ocean_waves/activities/breaking_waves.html) asks these questions and gives these answers.

Surging waves cause the most coastal erosion.

Which type of breaker - spilling, plunging, or surging – will cause the most coastal erosion? Explain.

A surging breaker will cause the most erosion because it slams into the beach at full speed. Spilling and plunging breakers slow down as they drag across the seafloor, so their energy is dissipated over a wider zone.

Spilling waves deposit more sand on shore and expand Beaches

Which type of breaker - spilling, plunging, or surging – will deposit sand onshore and expand beaches? Explain.

Waves can move sand when their energy is in contact with the bottom. Spilling breakers spend the most time and energy dragging across the seabed, so they should be able to push more sand onto the beach. Surging waves hardly interact with the bottom at all, so they will have little effect on offshore sand.

So wave types is important not only to surfers, but to people who worry about coastal erosion –especially to those who build houses, highways, and other edifices on the shoreline.

It became necessary to move the Cape Hatteras Lighthouse that was built on Cape Hatteras Barrier Island in 1870 1500 feet (457 meters) from the shore. By 1970 the water was a mere 120 feet from the base of the lighthouse because of erosion. In 1999 it was moved 2900 feet (884 meters) from its original location!

Cape Hatteras Light House (2) Dangerously near the water