

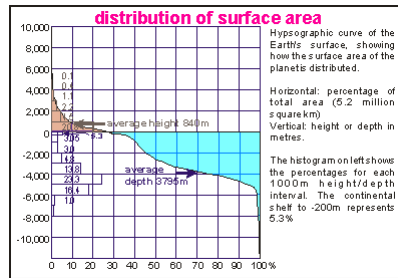
Hydrosphere - Oceanography

Ocean Waters

80% of Southern Hemisphere
 60% of Northern Hemisphere
 70% of Earth's surface



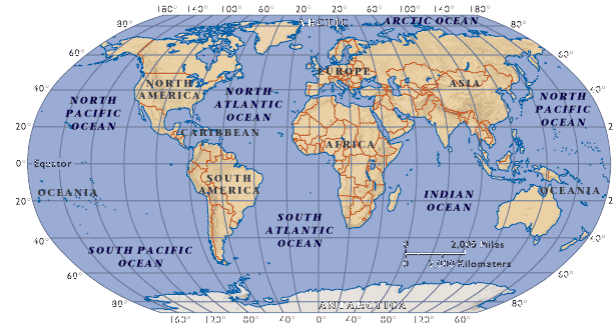
1350 million km³ water
 average depth ~4 km
 deepest 11.5 km



subdivided

Oceans

Pacific largest
 1/3 Earth's surface
 Atlantic most coastline
 Indian
 Arctic
 Southern
 Antarctic



Seas, Gulf, Bay, ...
 Baltic, Mediterranean,
 Red, Black, Bering ...

Source of Water (and atmosphere)

Degassing release of gaseous and volatile substances from solids and liquids during crystallization and pressure or heating.

Water Vapor originally caught in gaseous atmosphere condensed when cooled

SALT dissolved from land deposited in sea

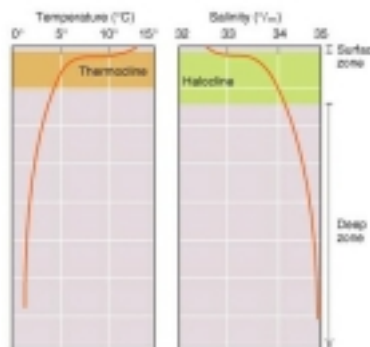
highly soluble

100 gm seawater ⇒ 3.5 gm NaCl

if oceans evaporate ⇒ 70 m salt

major ions (by weight)

Cl⁻ 55% Na⁺ 31%
 SO₄⁼ 8% Mg⁺⁺ 4%



Temperature of Oceans

reacts slowly to air temperature changes

Surface: -2°C near Poles 30°C near Equator

Deep Ocean: > 2km 1-3°C worldwide

reservoir of cold water

Thermocline - region 1.2 - 1.4 km depth, T changes quickly

Ocean Floor

continental

shelf

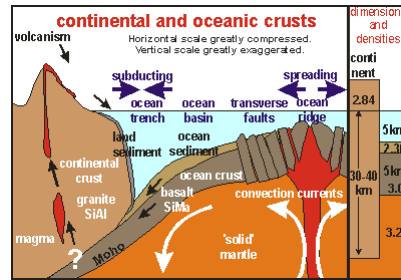
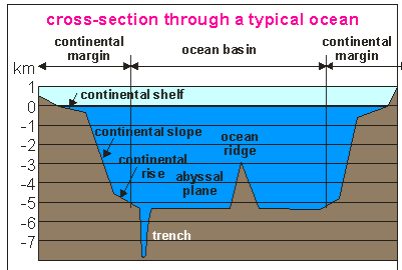
slope

rise

abyssal plane

trenches

deepest parts



Tides caused by Moon (and Sun) gravitational forces on Earth

Force of gravity between two objects is mutual

Newton's 3rd Law of Motion:

for every action, there is an equal and opposite reaction

Forces always come in pairs!

Earth and Moon attract

(pull on) each other

Gravity is an

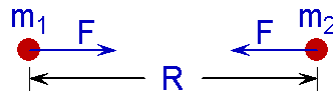
inverse square law

it gets weaker

as the distance R

between objects increases

$$F = G \frac{m_1 m_2}{R^2}$$



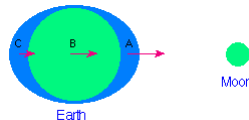
Moon *pulls* on Earth's near side (A)

more than on Earth's center (B)

AND

Moon *pulls* on Earth's far side (C)

less than on Earth's center (B)



Earth's surface bulges toward and away from Moon

Earth's oceans bulge more than the crust.

Earth rotates beneath Moon

continents pass through ocean bulges.

Ocean level rises every 12 hrs, falls 6 hrs later - **Tides**

2 high tides and 2 low tides each day.

Sun also pulls on Earth

less difference between opposite sides than Moon

Size of tides related to Earth-Moon-Sun position: Moon's phase

At New Moon and Full Moon

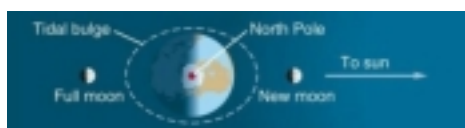
Solar and Lunar - same direction

Spring tides: large tidal bulges

do not only occur in spring!

At 1st and 3rd Quarter Moons

Solar and Lunar - perpendicular



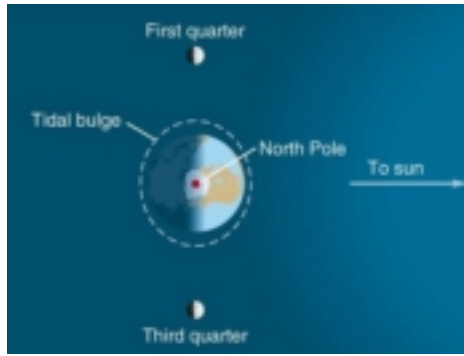
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Neap tides: small tidal bulges

play

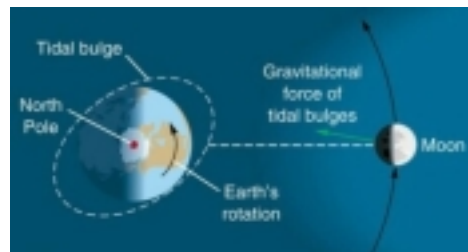
Surprising consequences of tides:

- 1) Earth's gravity causes tidal bulges in Moon
friction in flexing Moon rock slowed Moon's rotation
rotation period = orbital period
explains why Moon always keeps same face toward Earth
- 2) As Earth rotates, it pulls oceans against Moon's gravity
friction between oceans and crust slowed Earth's rotation by 0.0023 sec/century
900 million years ago the day was 18 hours long!
tidal bulges are *out of phase*



01-18b

- 3) Earth rotation drags ocean bulge ahead of Moon's direction
Gravity between ocean bulge and Moon is mutual
Ocean bulge pulls Moon forward in its orbit
causes Moon to recede from Earth by 4 cm/year



01-18c