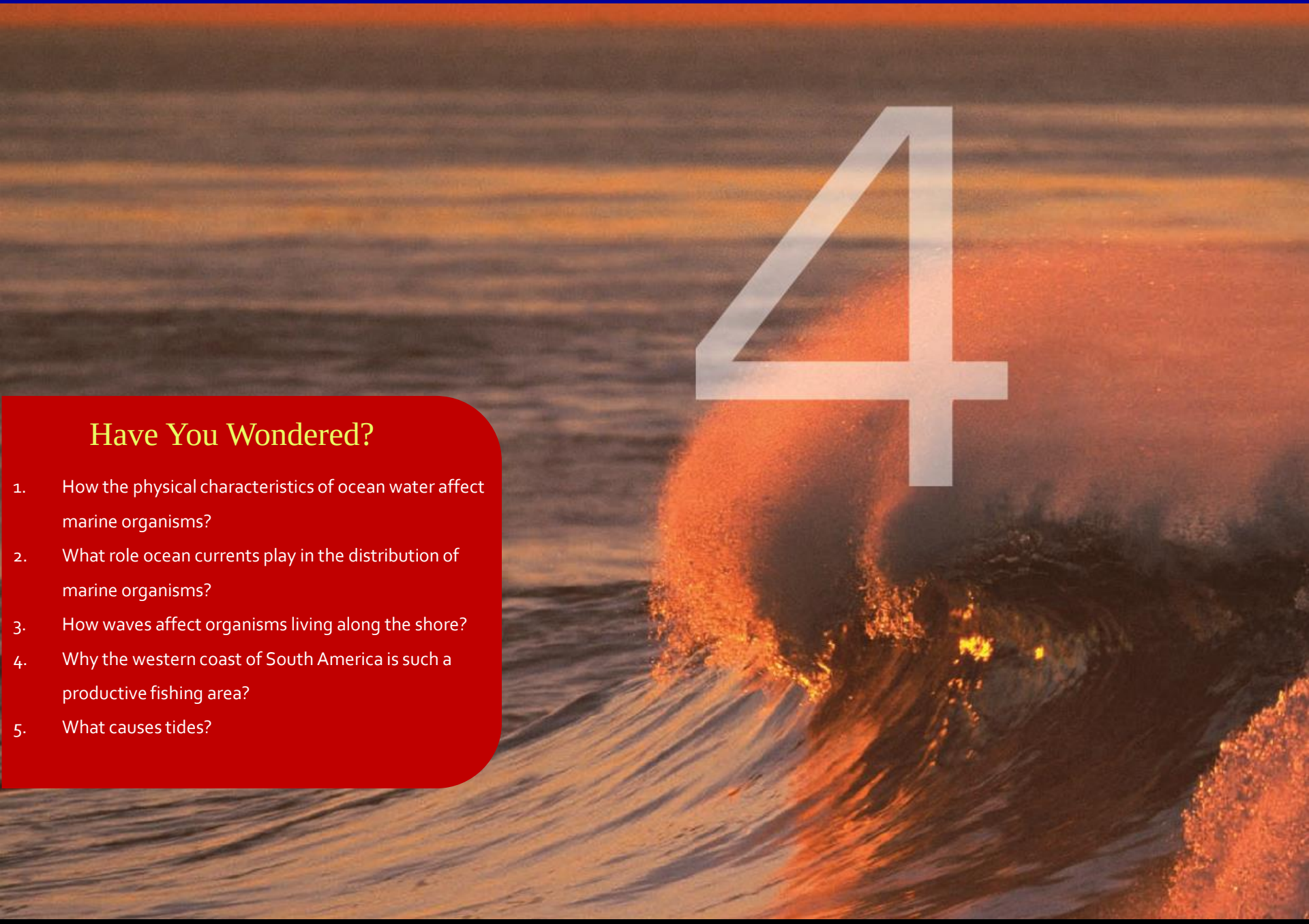
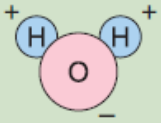


4

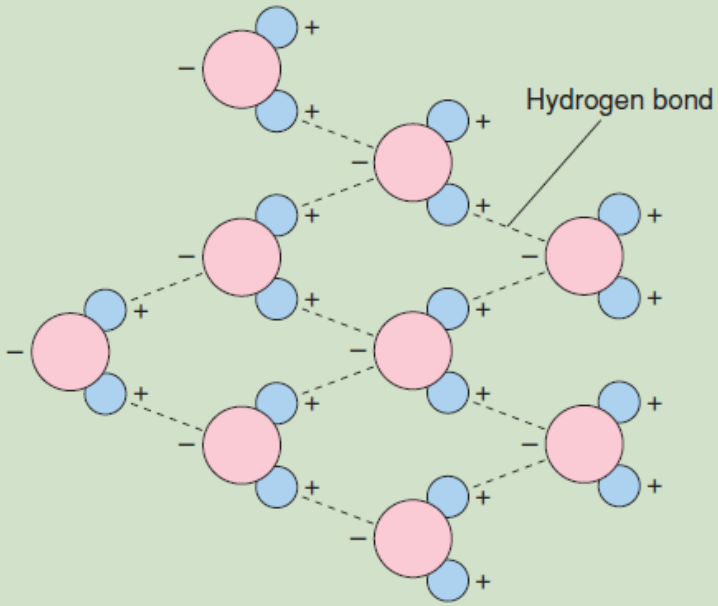
Have You Wondered?

1. How the physical characteristics of ocean water affect marine organisms?
2. What role ocean currents play in the distribution of marine organisms?
3. How waves affect organisms living along the shore?
4. Why the western coast of South America is such a productive fishing area?
5. What causes tides?

Nature of Water

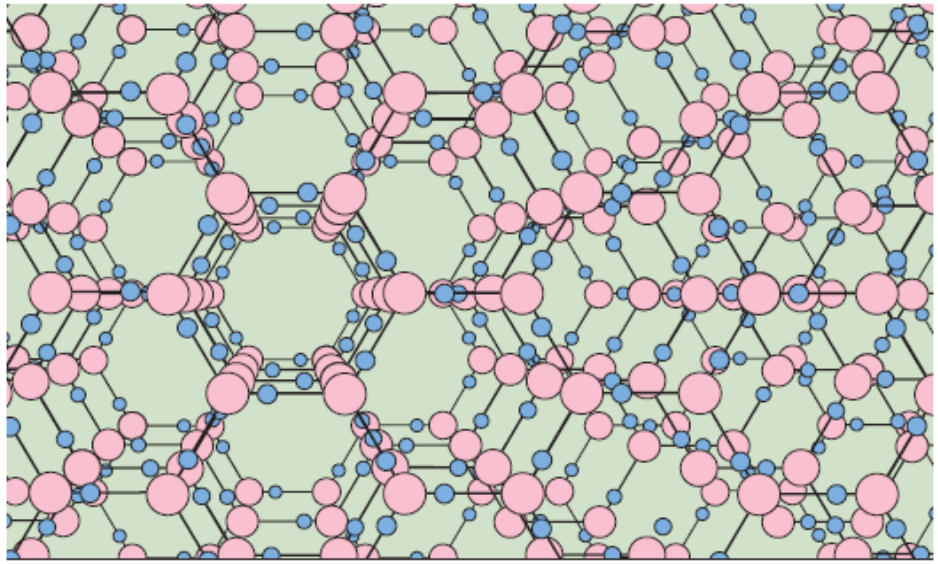


(a) Polar nature of water molecule



(b) Hydrogen bonding of water molecules due to its polarity

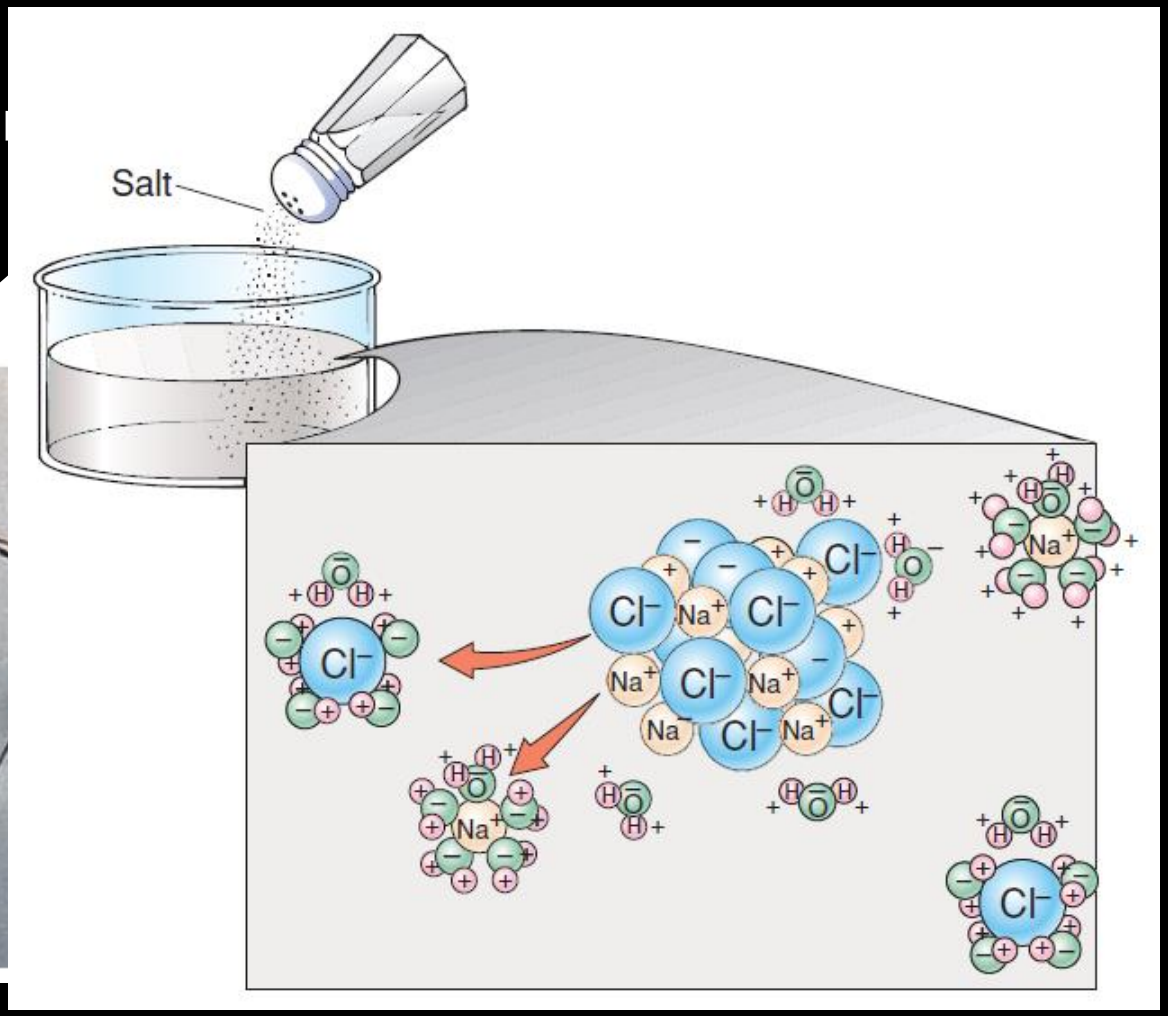
between 70% and 80% water by



(c) Structure of water molecules in a solid state (ice)

Physical and Chemical Property

- Water

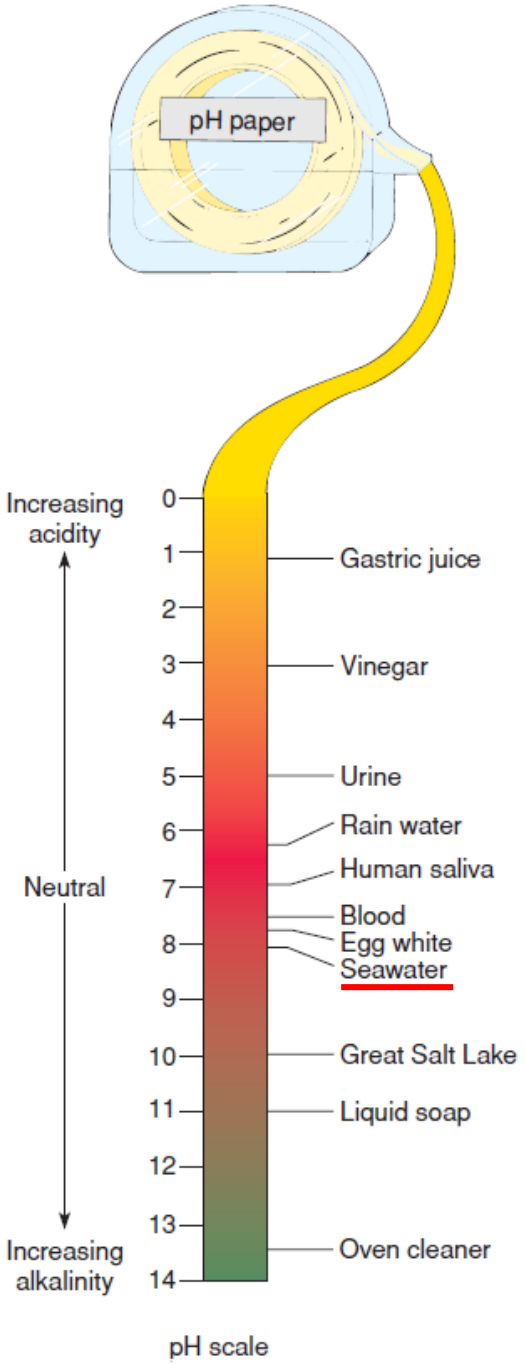


Ocean Water Summary

pH value

- Acids and Bases
- Acidic and Basic

- HCO^{3-} and $CO3^{2-}$



(pH=-log [H^+])

CO_2 and Ocean pH

CO_2 and Ocean pH

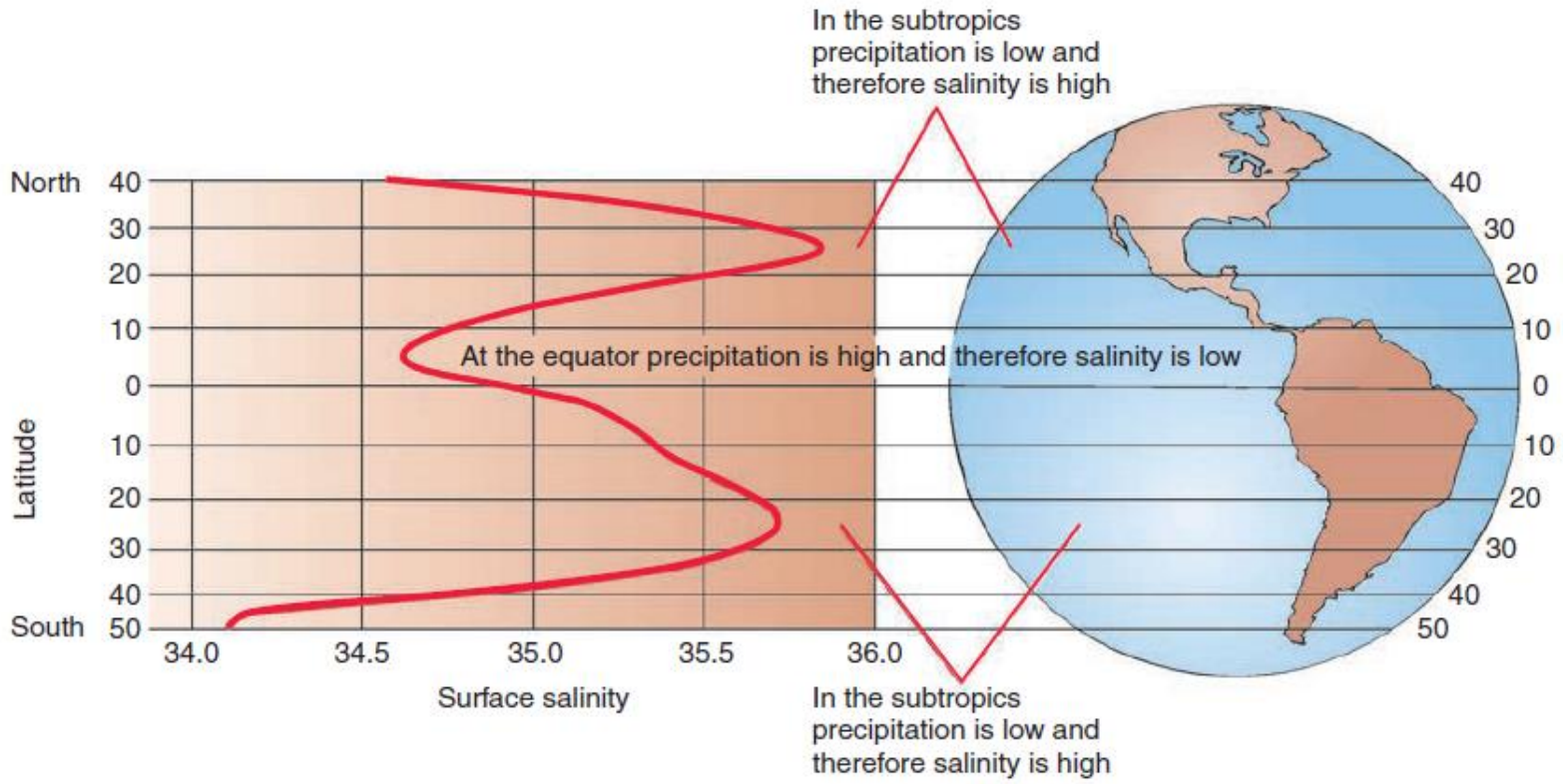
Salt water

- Composition of Seawater

Ion	g/kg Seawater	Percentage by Weight
Chloride (Cl^-)	19.35	55.07
Sodium (Na^+)	1076	30.62
Sulfate (SO_4^{2-})	2.71	7.72
Magnesium (Mg^{2+})	1.29	3.68
Calcium (Ca^{2+})	0.41	1.17
Potassium (K^+)	0.39	1.10
Bicarbonate (HCO^{3-})	0.14	0.40

Salinity

- 3.5 % salt and 96.5 % water by mass



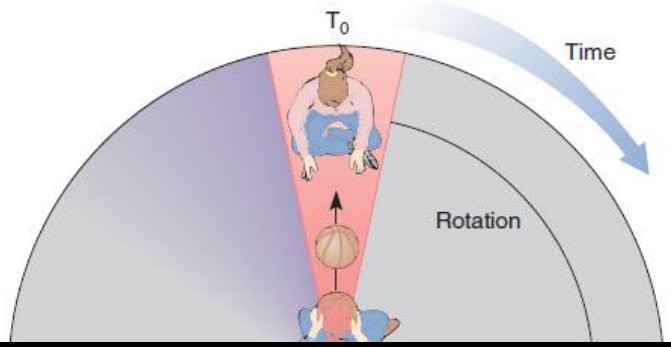
Gases in Seawater

Gas	Percentage by Volume in Atmosphere	Percentage by Volume in Surface Seawater	Percentage by Volume in Ocean Total
Nitrogen (N_2)	78.08	48	11
Oxygen (O_2)	20.99	36	6
Carbon dioxide (CO_2)	2.71	7.72	
Other Gases	1.29	3.68	

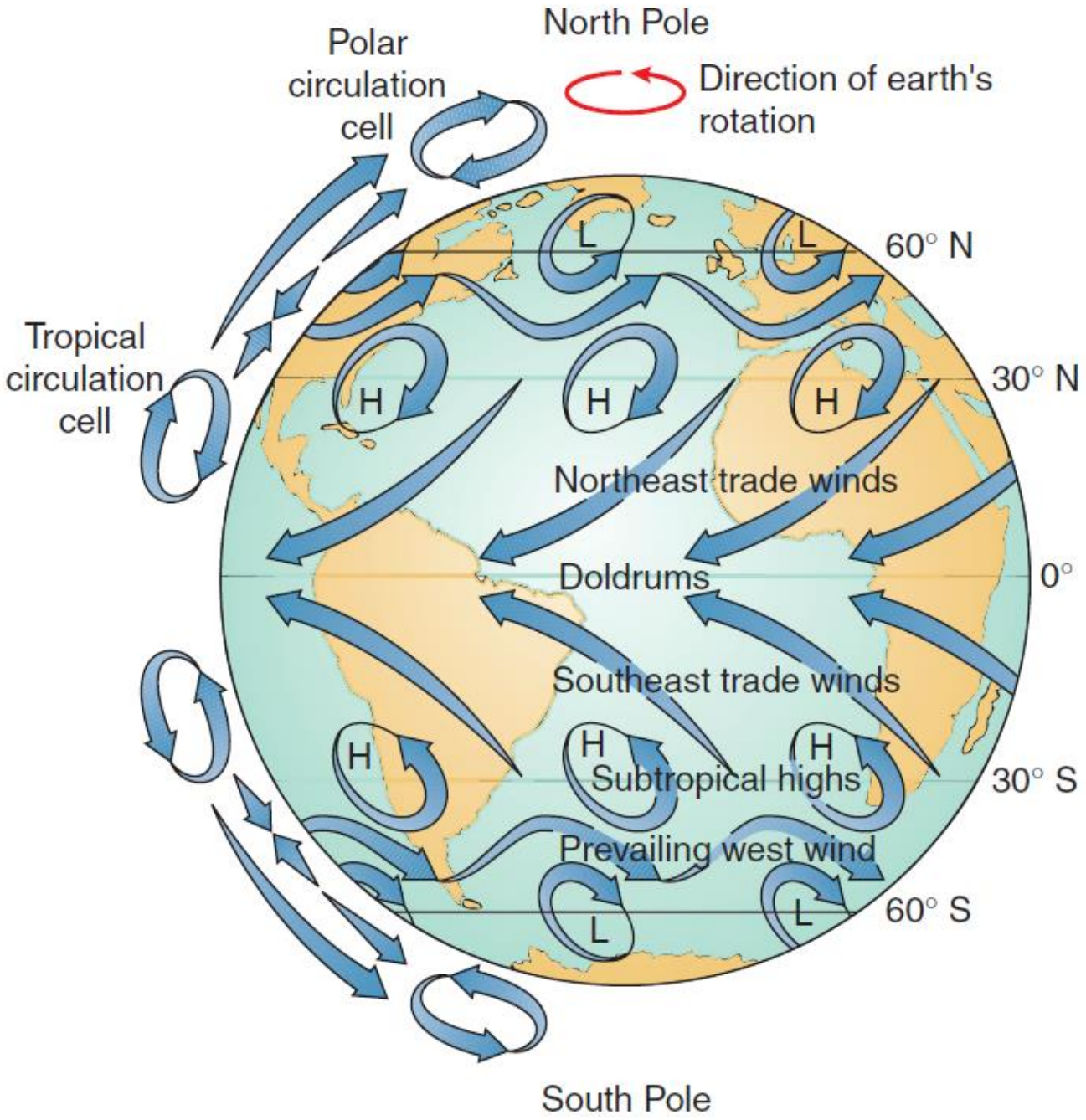
Wind and Currents

- Approximately 10% of ocean water is involved in surface currents. Driven by winds, the currents move water in the upper 400 meters (1,320 feet) of the ocean. These currents carry plankton in predictable paths through the surface waters, changing the distribution of planktonic food and dispersing planktonic larvae. Surface currents also influence the distribution of nekton, because predators follow the plankton and plankton feeders on which they prey.

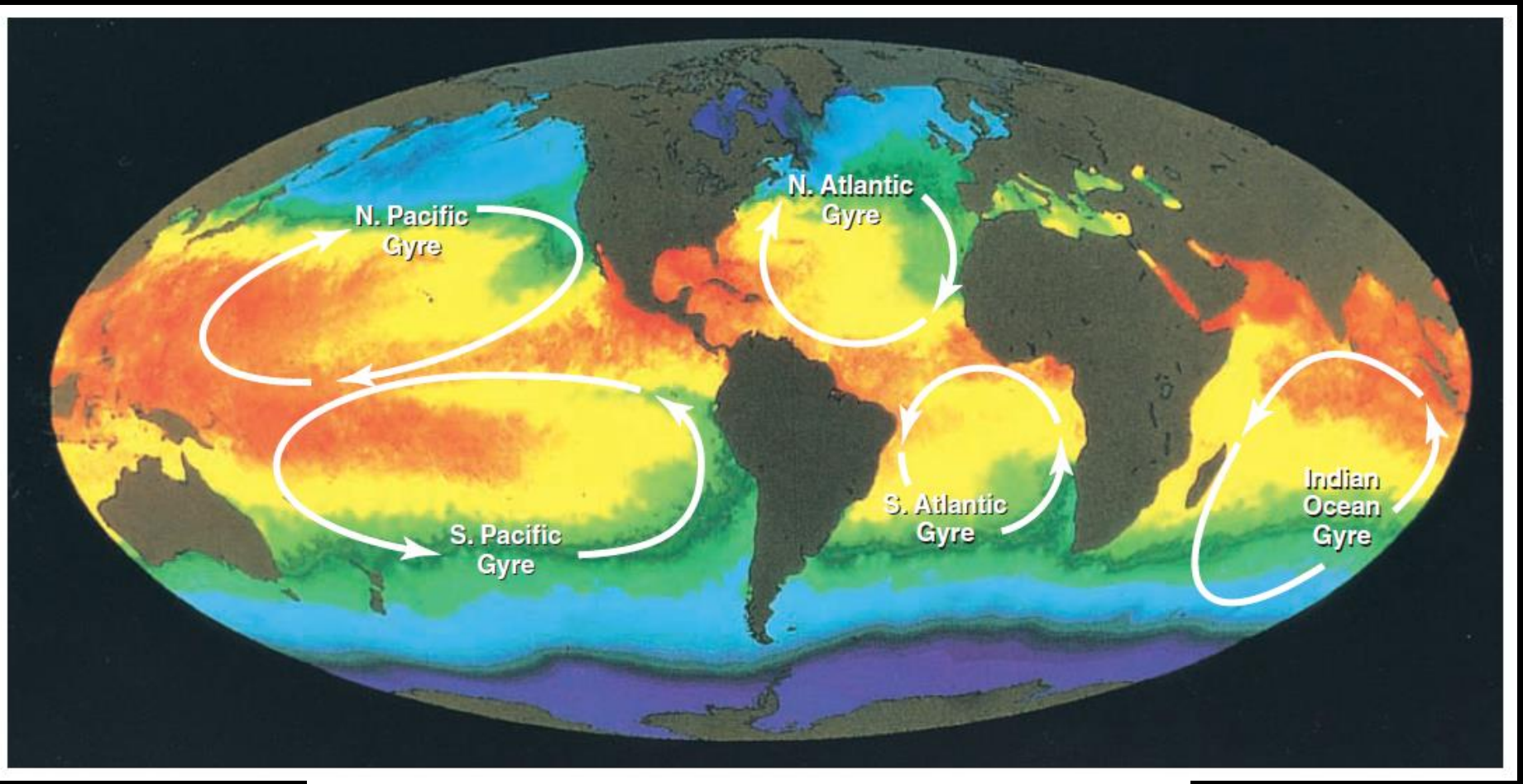
- *Coriolis Effect* and *Ekman spiral*

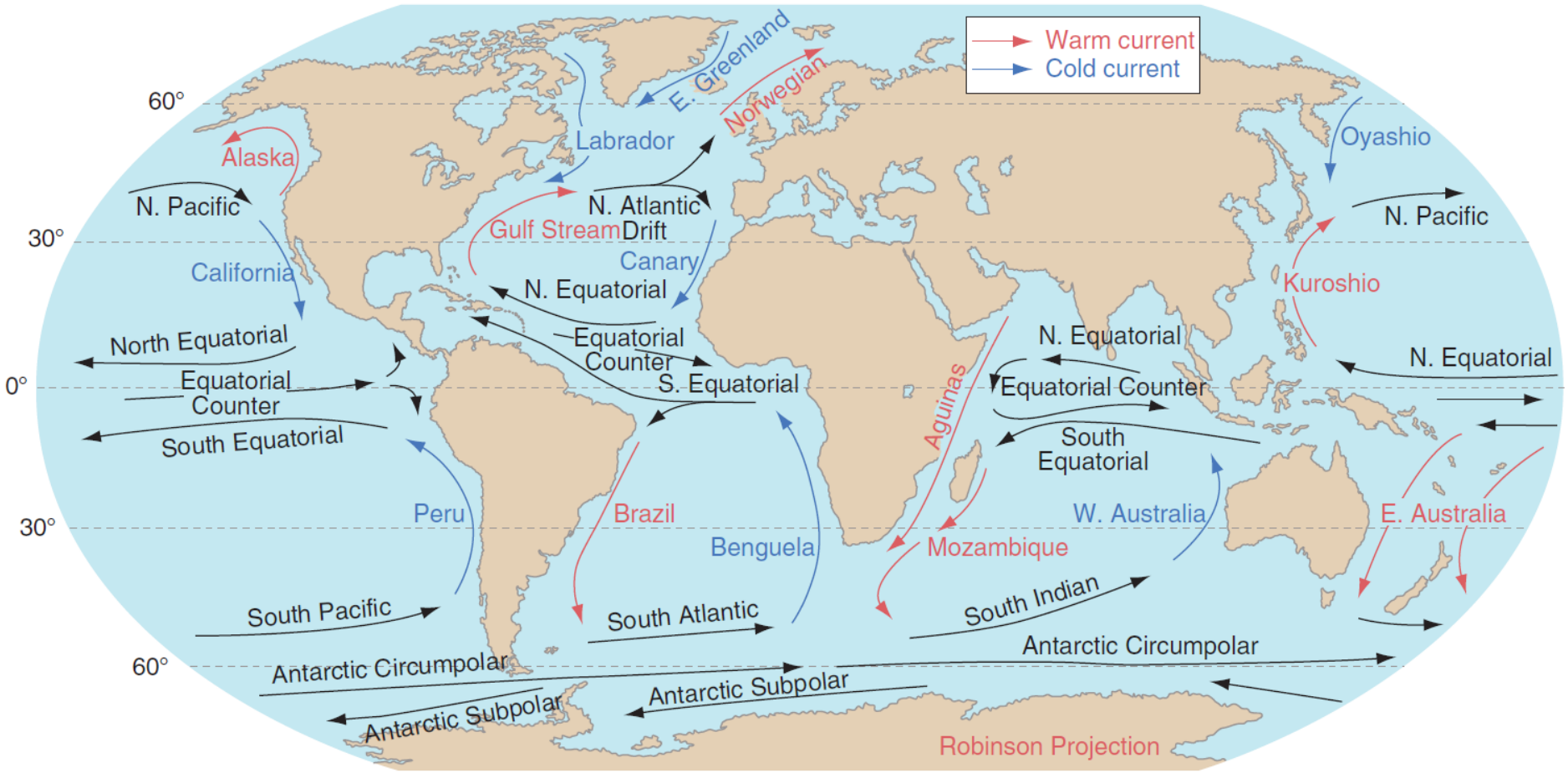


(b)

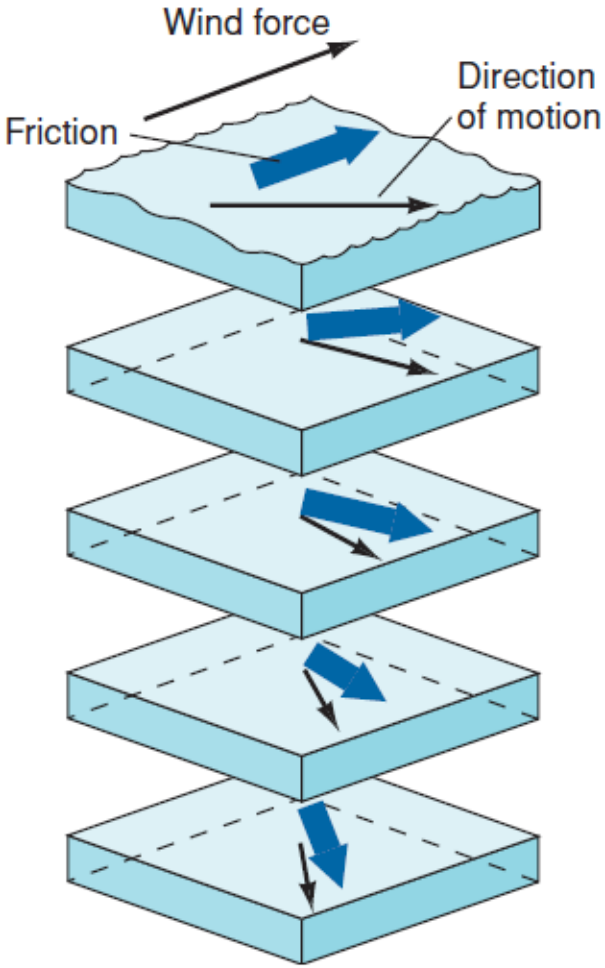

North Pole
Polar circulation cell
Direction of earth's rotation
60° N
Tropical circulation cell
30° N
Northeast trade winds
Doldrums
0°
Southeast trade winds
Subtropical highs
30° S
Prevailing west wind
60° S
South Pole
L
H

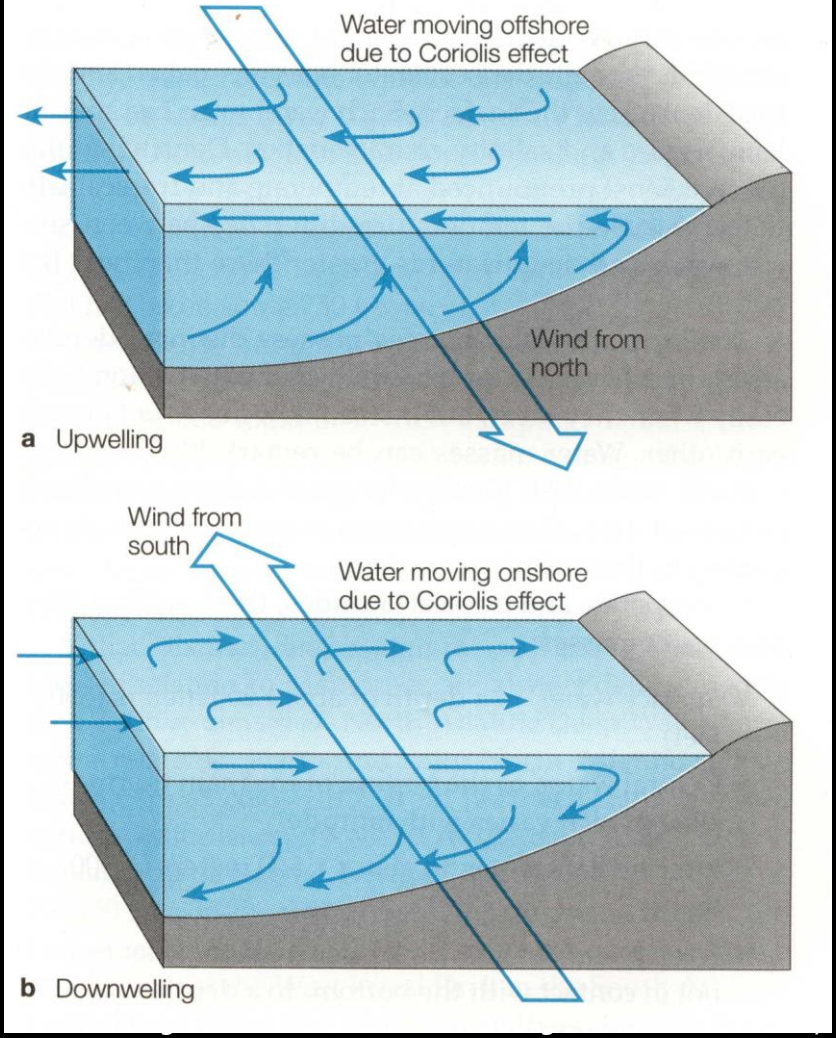
Current


N. Pacific Gyre
N. Atlantic Gyre
S. Pacific Gyre
S. Atlantic Gyre
Indian Ocean Gyre


Warm current
Cold current
60°
30°
0°
30°
60°
E. Greenland
Norwegian
Labrador
Alaska
N. Pacific
N. Atlantic Drift
Gulf Stream
California
Canary
N. Equatorial
North Equatorial
Equatorial Counter
South Equatorial
S. Equatorial
Peru
Brazil
Benguela
South Pacific
South Atlantic
Antarctic Circumpolar
Antarctic Subpolar
Agulnas
Mozambique
South Indian
W. Australia
E. Australia
Oyashio
N. Pacific
Kuroshio
N. Equatorial
Equatorial Counter
South Equatorial
N. Equatorial
Antarctic Circumpolar
Robinson Projection

EKMAN SPIRAL





Upwelling and downwelling

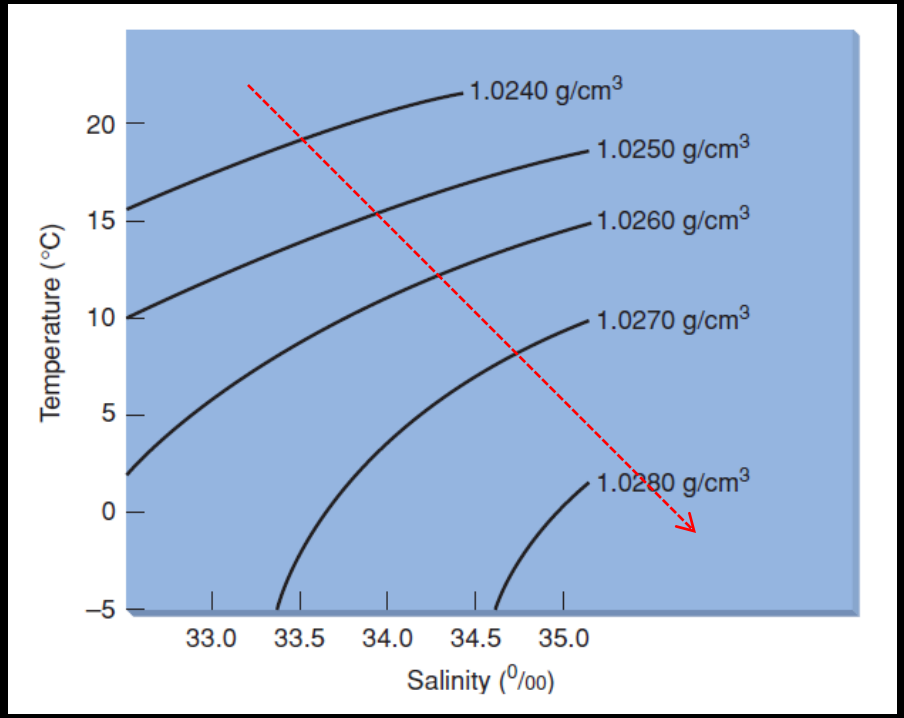
- *Upwelling* is the process by which a combination of wind and ocean currents brings nutrient-laden water from the ocean bottom to the surface.
- *Downwelling* is the vertical movement of water in the downward direction.

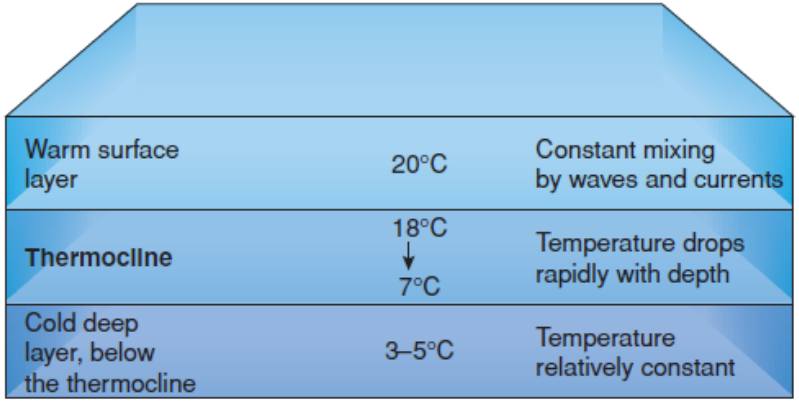
In Summary

- Winds are produced by differences in the density of air. Warmer air at the equator rises and moves toward the poles, whereas colder air at the poles sinks and returns to the equator. Air masses in the Northern Hemisphere move to the right, and air masses in the Southern Hemisphere move to the left. This apparent deflection of air masses is called the *Coriolis effect*. Wind patterns are responsible for driving ocean currents. Like air masses, ocean currents are affected by the Coriolis effect, causing them to deflect. The combination of wind, gravity, and the Coriolis effect produces gyres, circular patterns of water flow at the ocean's surface.
- Water also flows from the surface to a depth of about 100 meters, a process known as *Ekman transport*.

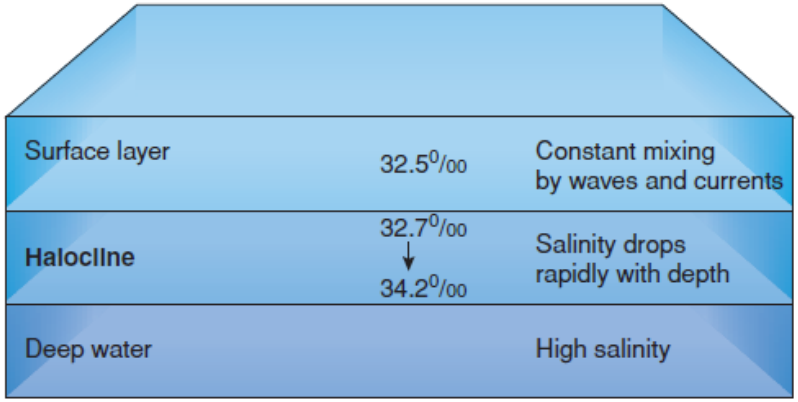
Ocean layers and Ocean mixing

- Density of seawater is 1.0270 g/m^3.
- In the open ocean, surface temperature is more decisive than salinity in determining the water's density.
- Salinity becomes a more important factor in determining the density of water close to shore.





(a)



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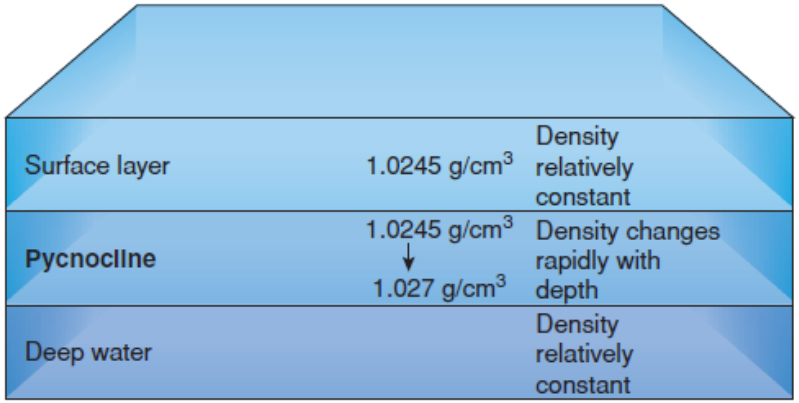


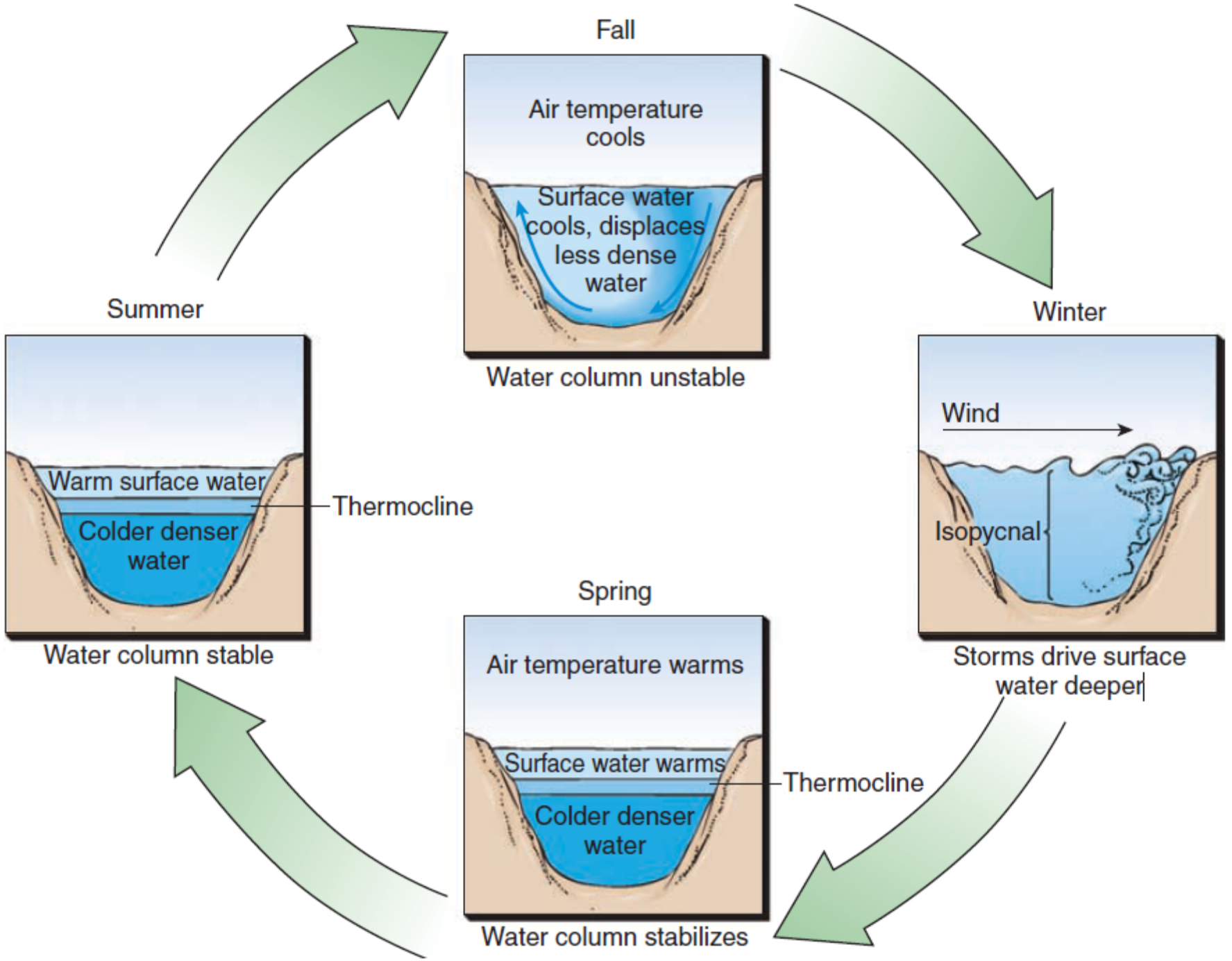
(c)

The *thermocline* is a zone in the ocean characterized by a rapid change in temperature with increasing depth.
(温跃层)

The *halocline* is a zone in the ocean that is characterized by a rapid change in salinity with depth.
(盐度跃层)

The *pycnocline* is a zone in the ocean that is characterized by a rapid change in density with depth.
(密度跃层)

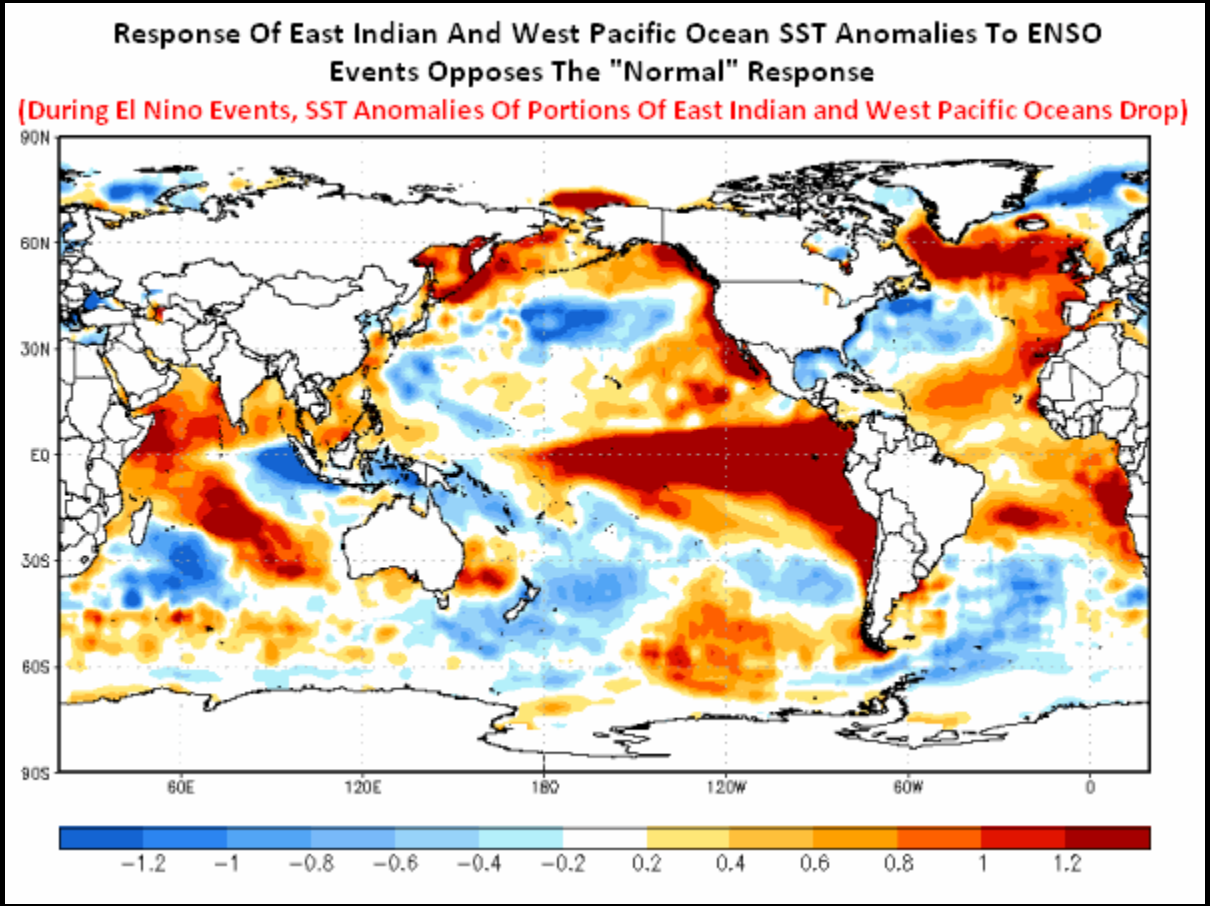
GLOSSARY


Fall
Air temperature cools
Surface water cools, displaces less dense water
Water column unstable
Winter
Wind
Isopycnal
Storms drive surface water deeper
Spring
Air temperature warms
Surface water warms
Thermocline
Colder denser water
Water column stabilizes
Summer
Warm surface water
Thermocline
Colder denser water
Water column stable

El Niño Southern Oscillation

El Niño and La Niña

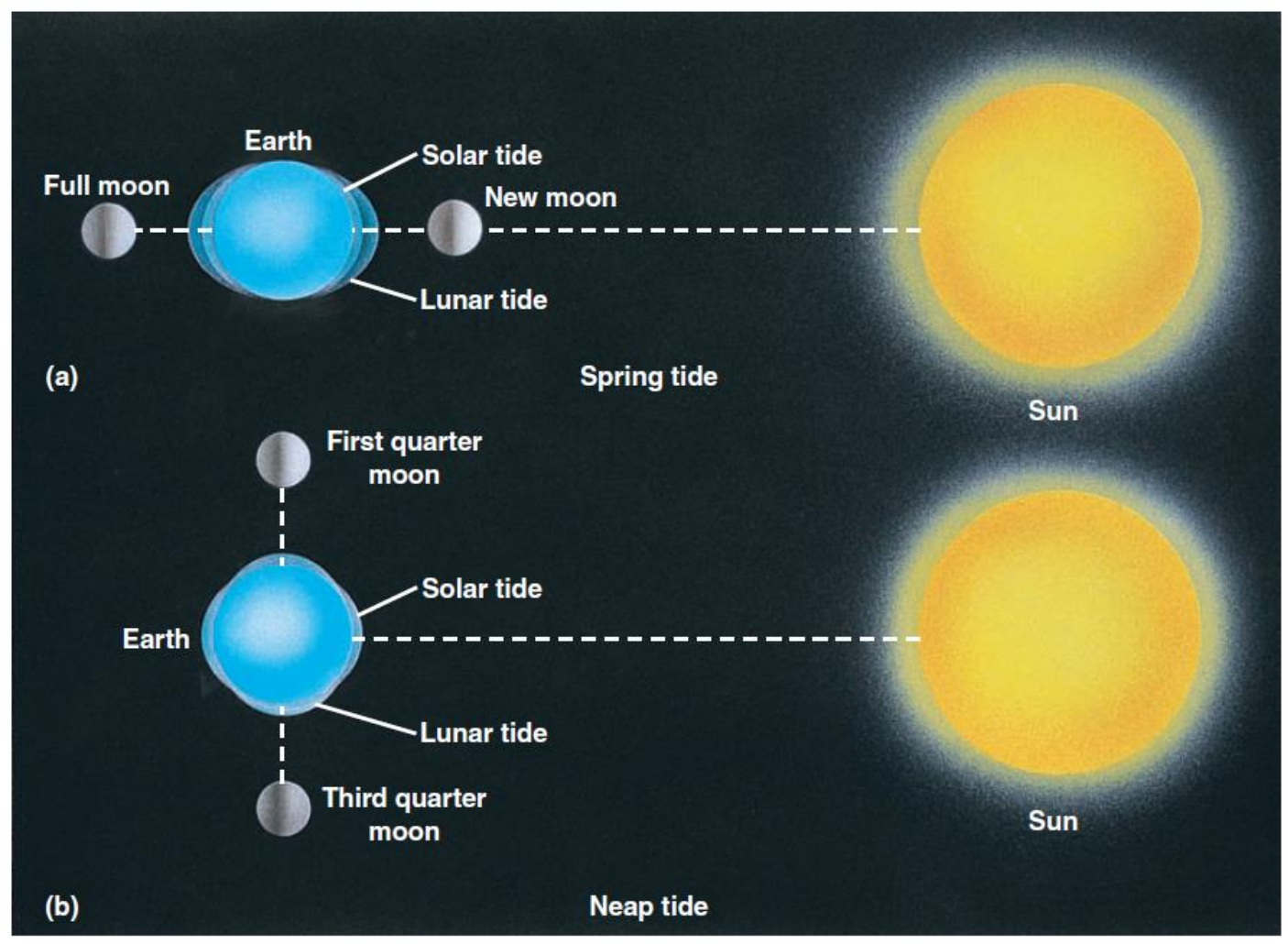
El Niño and La Niña

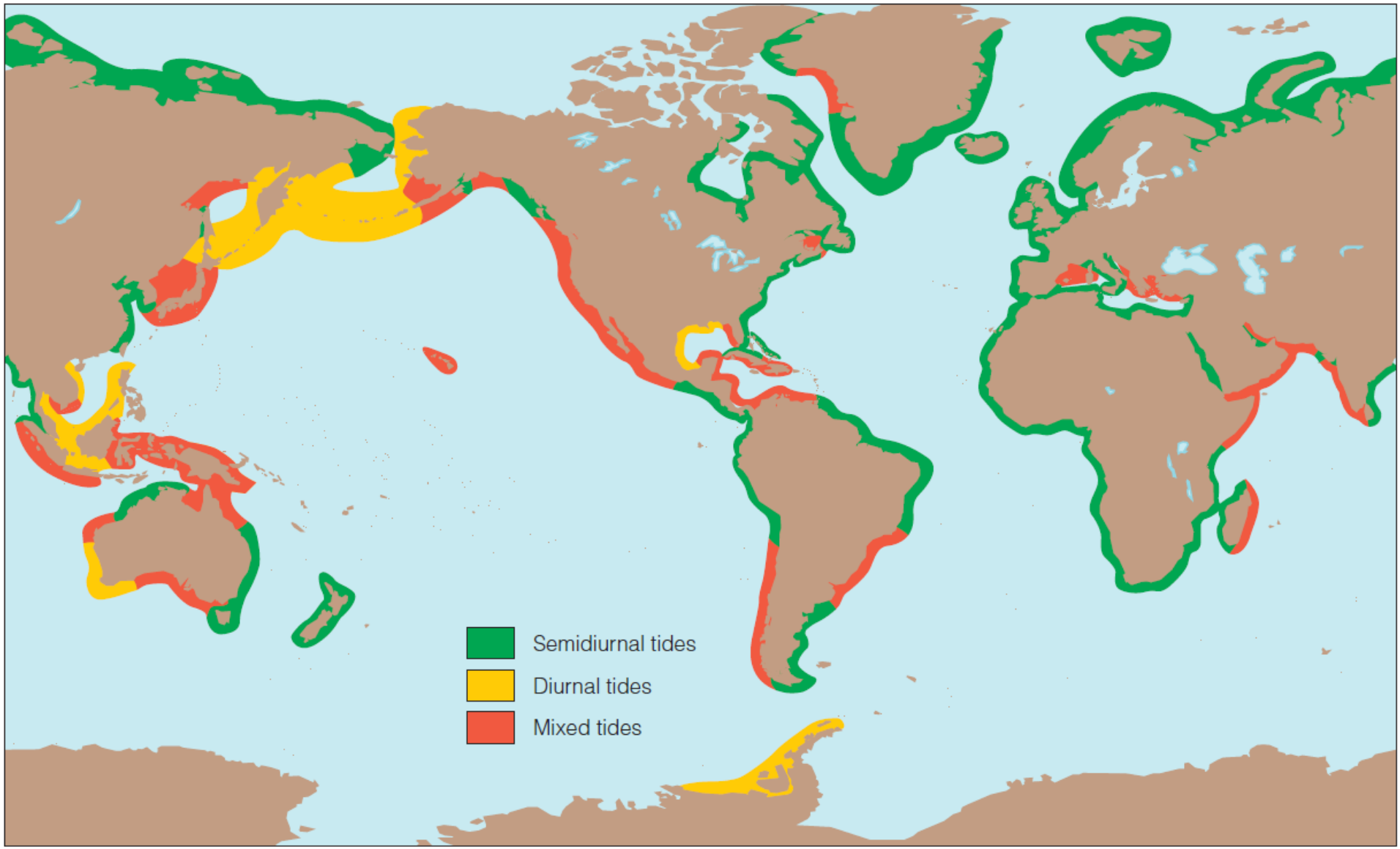


Tides

- *Tides* are the *changes in sea level* that occur as a result of the gravitational pull of the moon and the sun on the water of the oceans.
- Tides play a considerable role in the life of many marine organisms, especially those that live in the area exposed at low tide and covered by high tide (the intertidal zone).

Why tides occur?





(d)