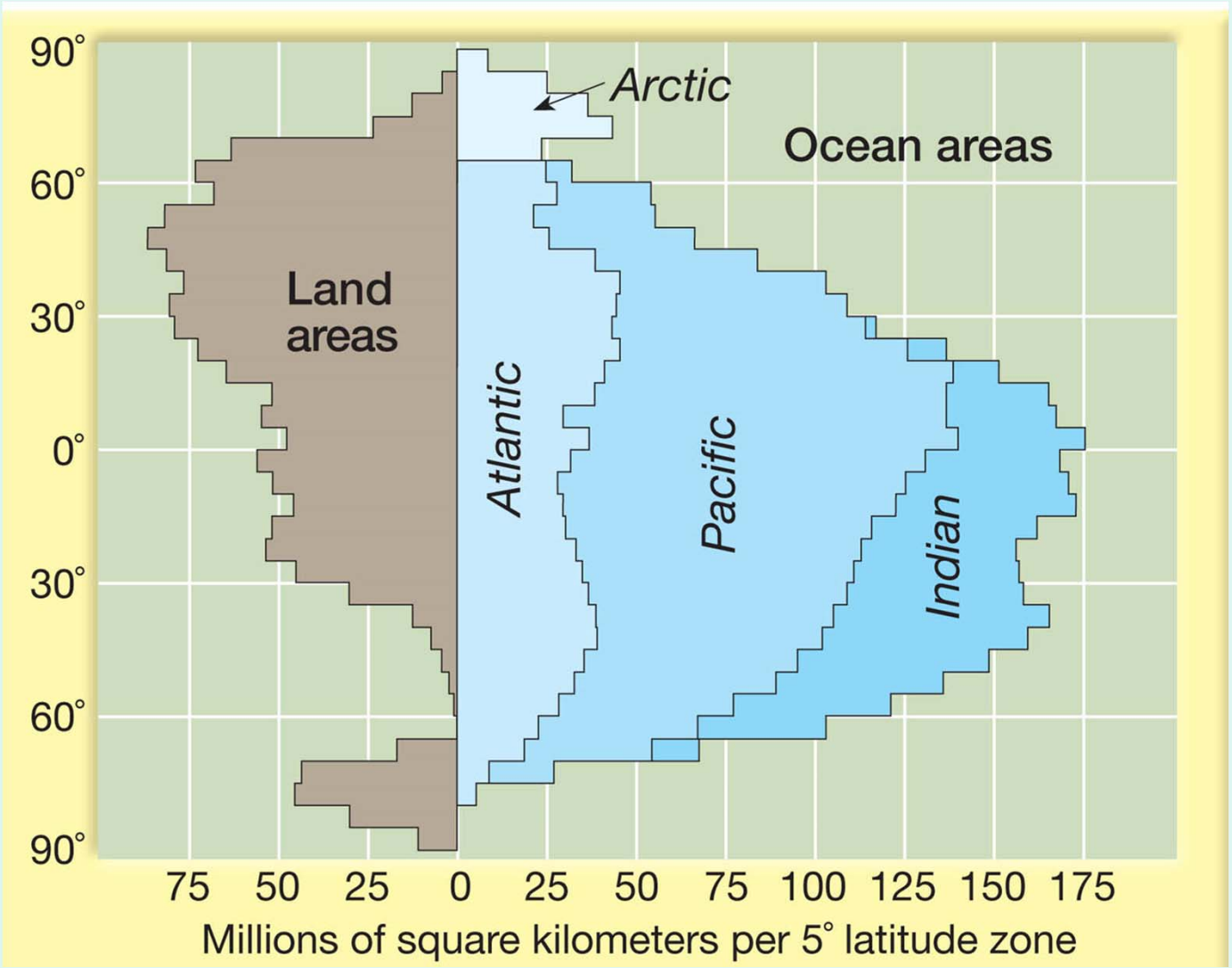
The Oceans of Earth



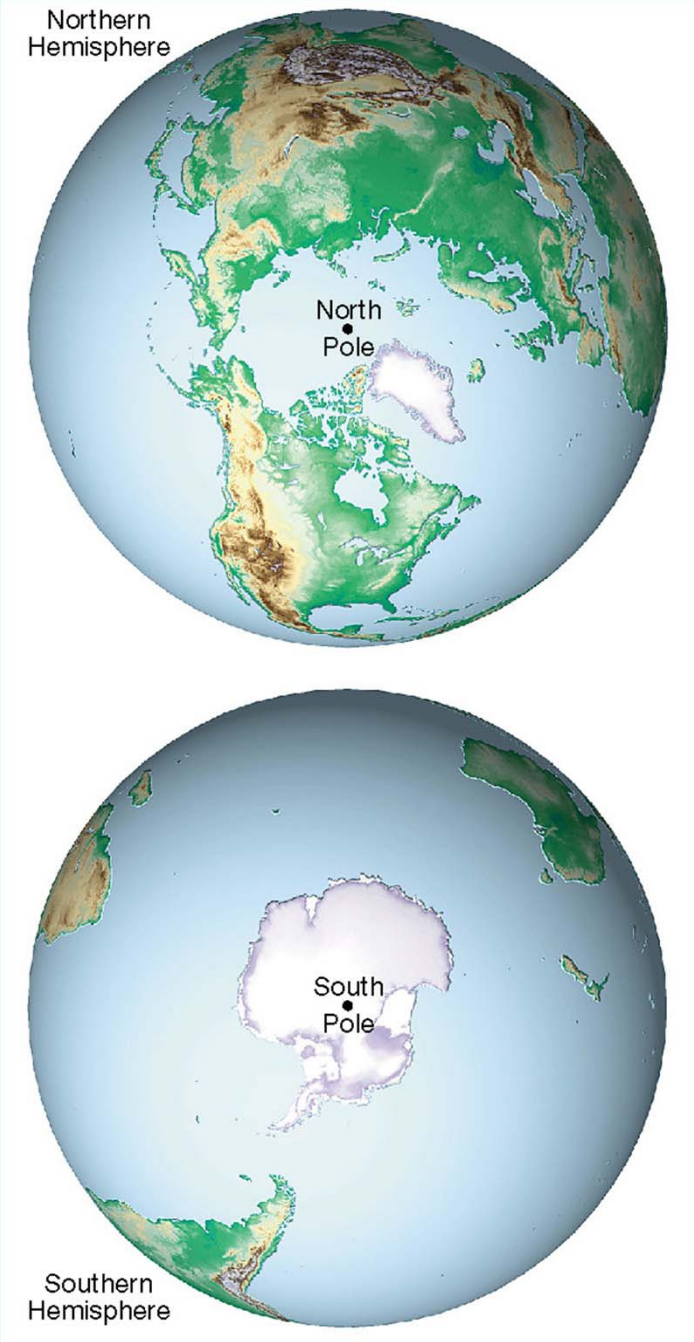
EARTH SCIENCE
QUIZ Chapter 10

Name KEY **Ed Meyers**

Match the following words with their definition and/or description:

1.	F	Baymouth Bar
2.	I	Fetch
3.	D	Longshore Current
4.	A	Neap Tide
5.	J	Spring Tide
6.	B	Thermohaline Circulation
7.	H	Tidal Current
8.	E	Wave Length
9.	C	Tombolo
10.	G	Upwelling

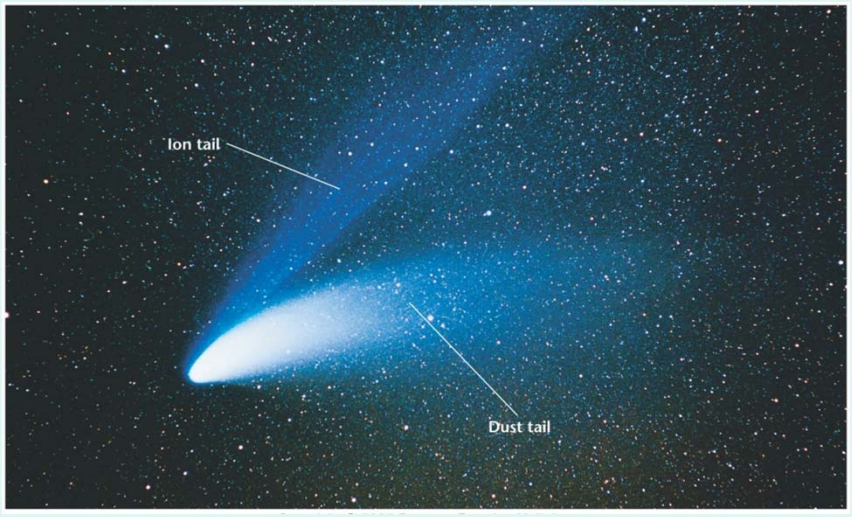
A. The lowest tidal ranges, occurring during the 1st and 3rd quarters of the moon



Views of the Northern and Southern Hemispheres

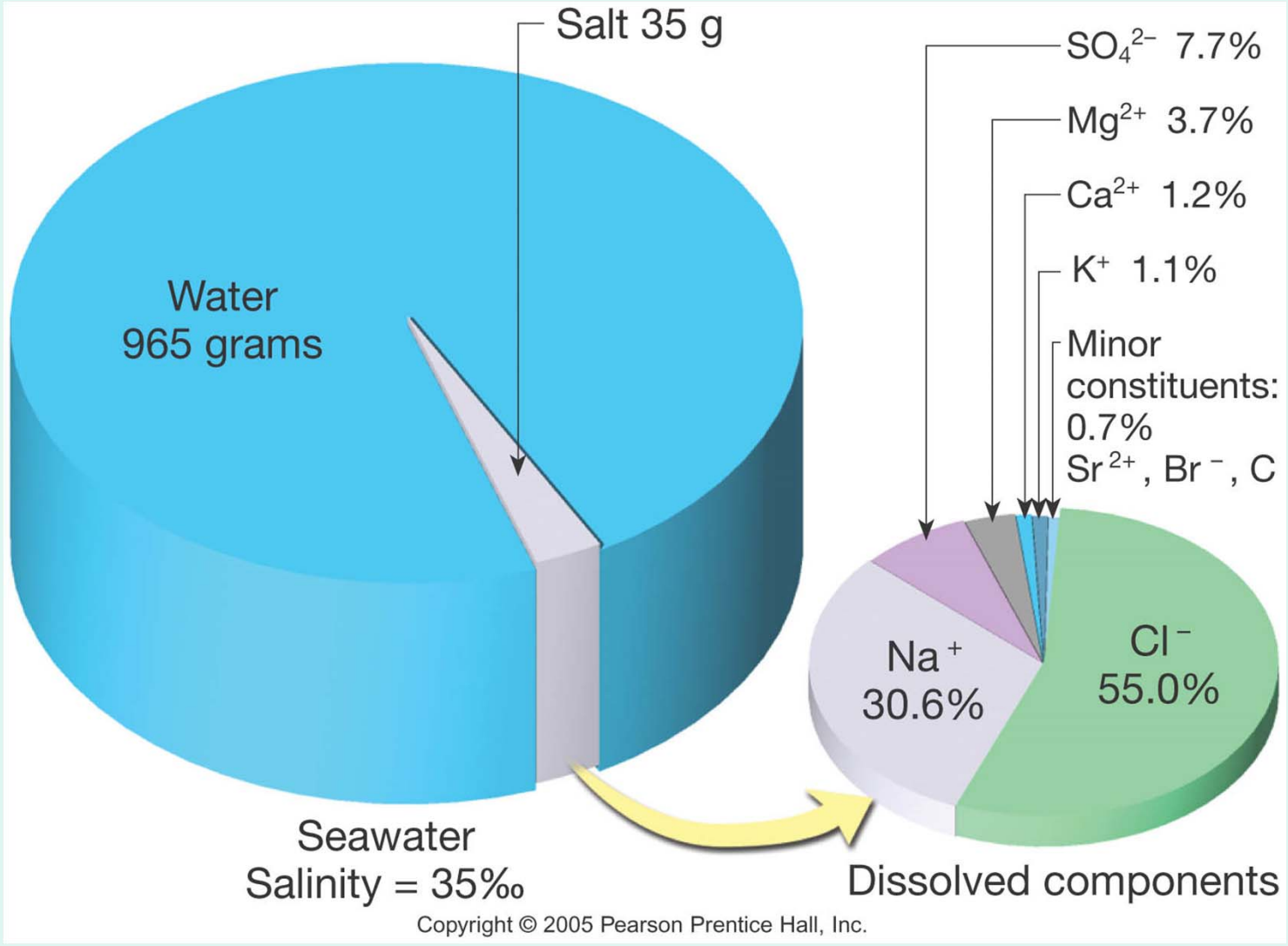
Origin of Seawater

Volcanoes

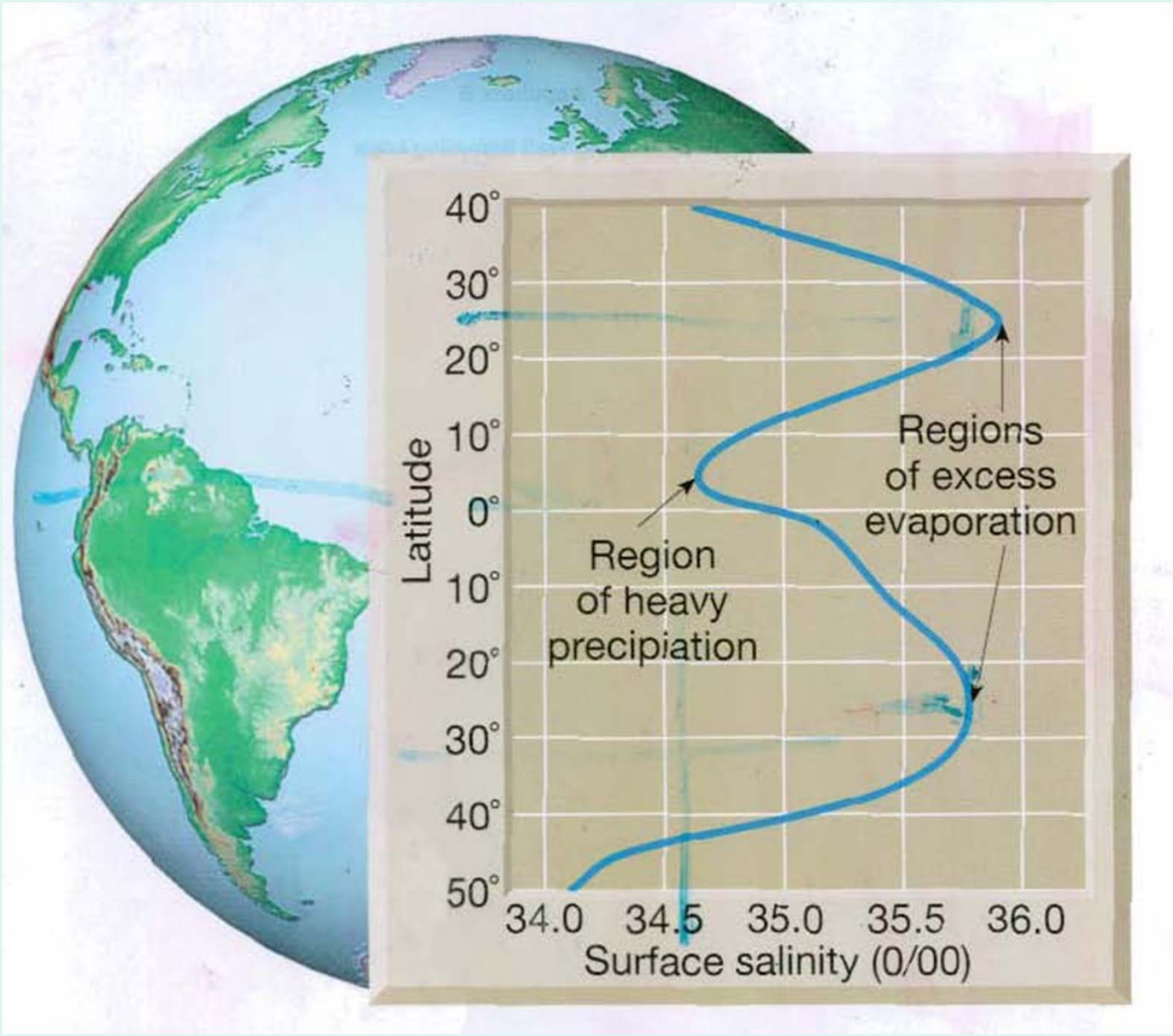


Comets

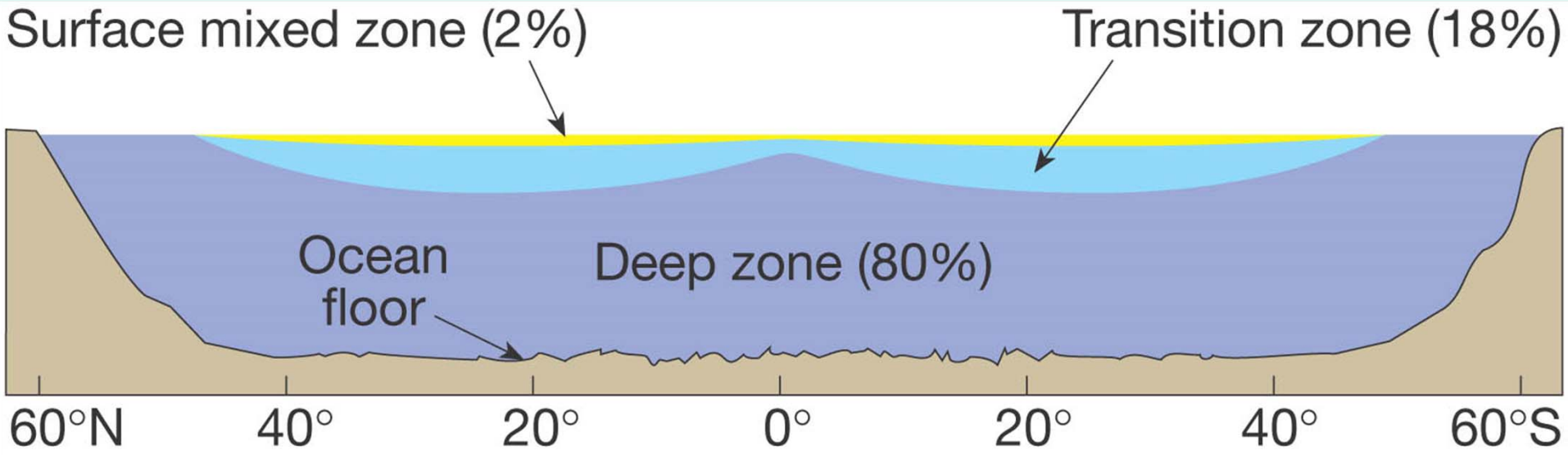
Dissolved Components in Seawater



Precipitation



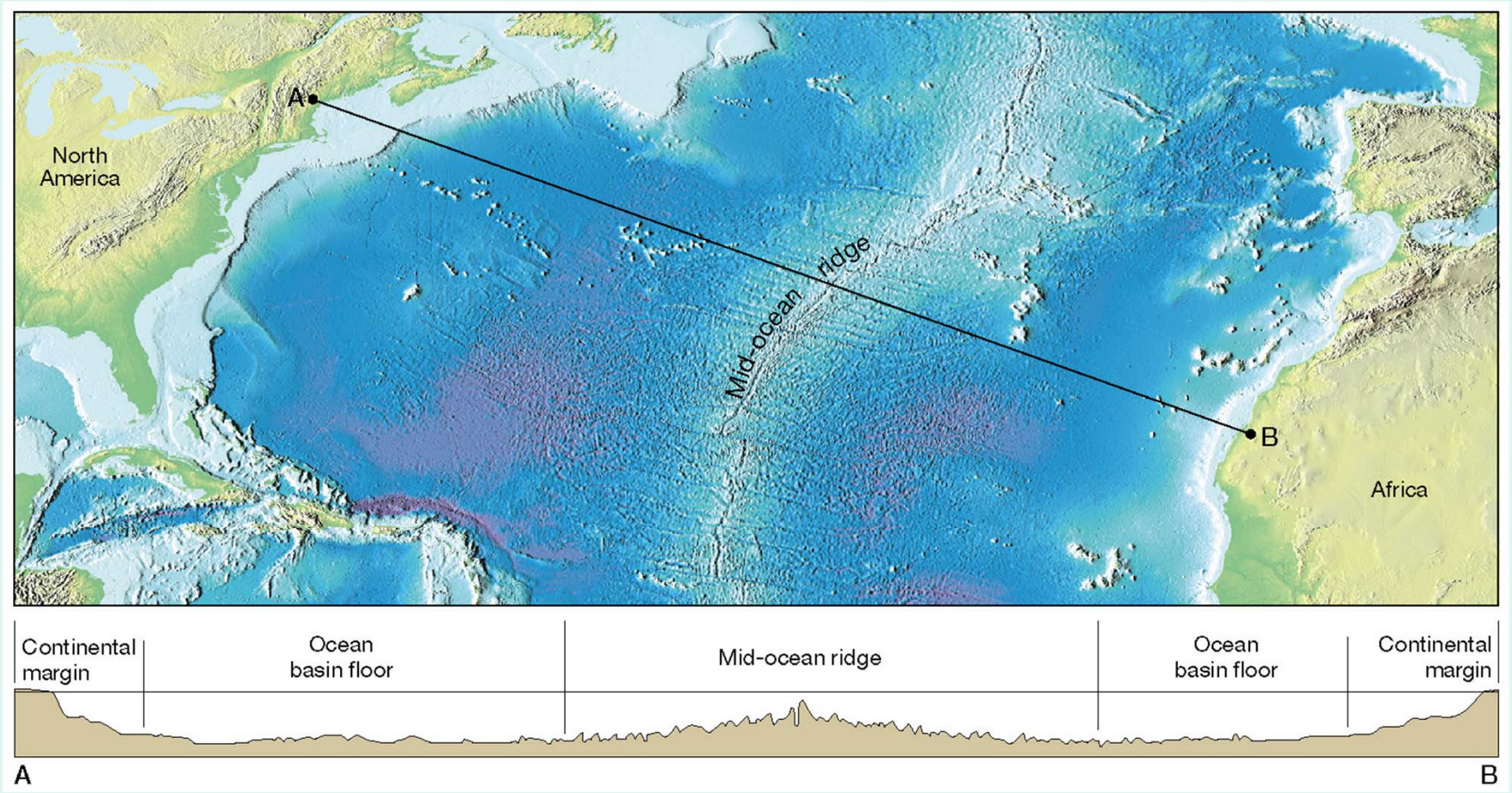
The Oceans Layered Structure



The Ocean's Layered Structure

- **Temperature and salinity change with depth in the oceans**
  - **Salinity variations with depth correspond to the general three-layered structure described for temperature**
  - **A zone of rapidly changing salinity, called the *halocline,* corresponds to the thermocline**

Major Topographic Divisions of the North Atlantic Ocean



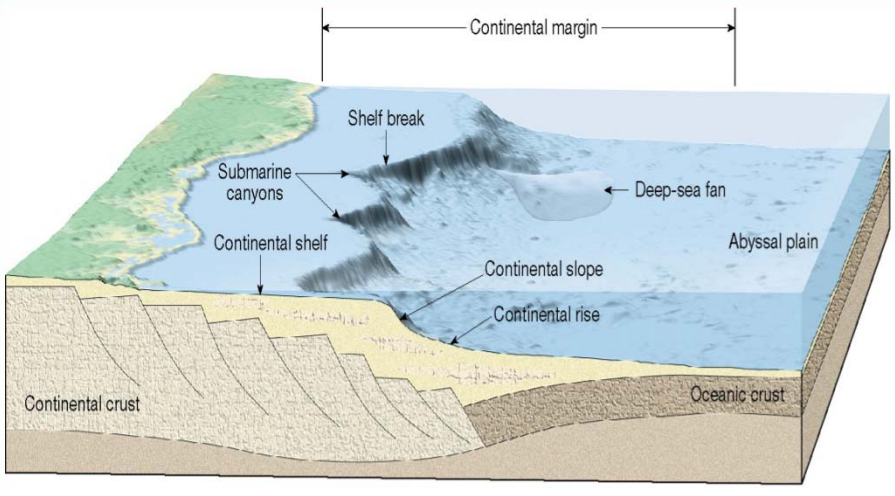
Continental Margins

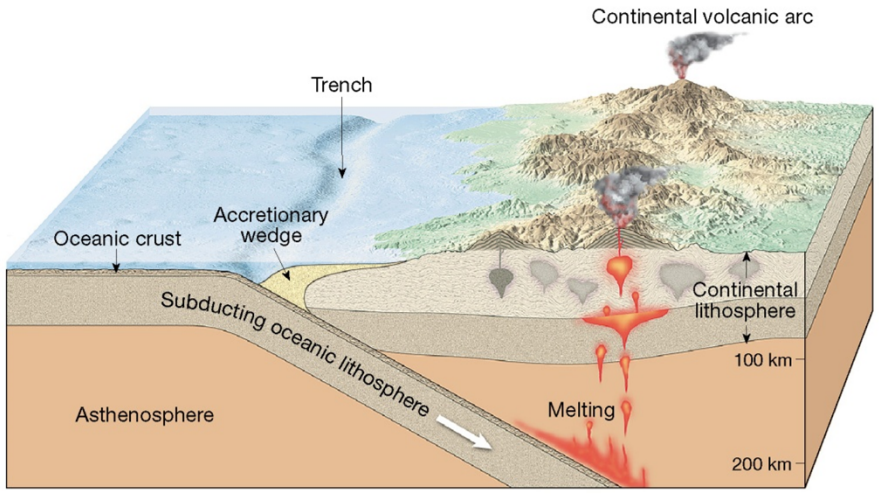
Passive

- Continental Shelf
- Continental Slope
- Continental Rise

Active

- Continental Shelf
- Continental Slope
- Trench





Chapter 10
The Restless Ocean

Ocean Water Movements

1) **Surface circulation**
2) **Upwelling and Downwelling**
3) **Deep Water Circulation**
4) **Tides**
5) **Wind Generated Waves**

Ocean Water Movements

- **Surface circulation – generated by the wind**
  - ***Ocean currents* are masses of water that flow from one place to another**
  - ***Surface currents* are generated from friction between the ocean and the wind that blows across the surface**
  - **Follow atmospheric circulation**
  - **Produce large slowly moving *gyres***

Average Ocean Surface Currents in February–March

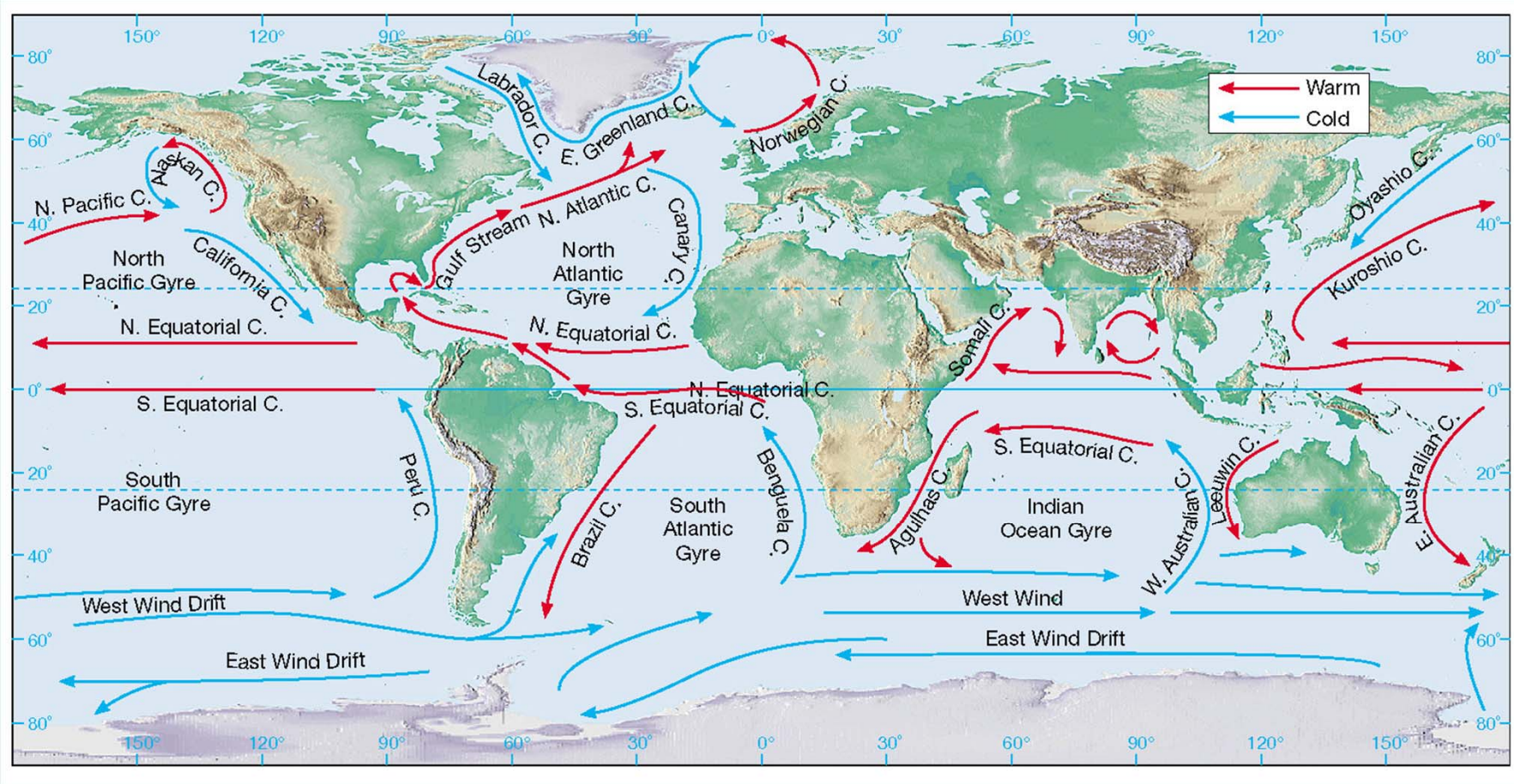
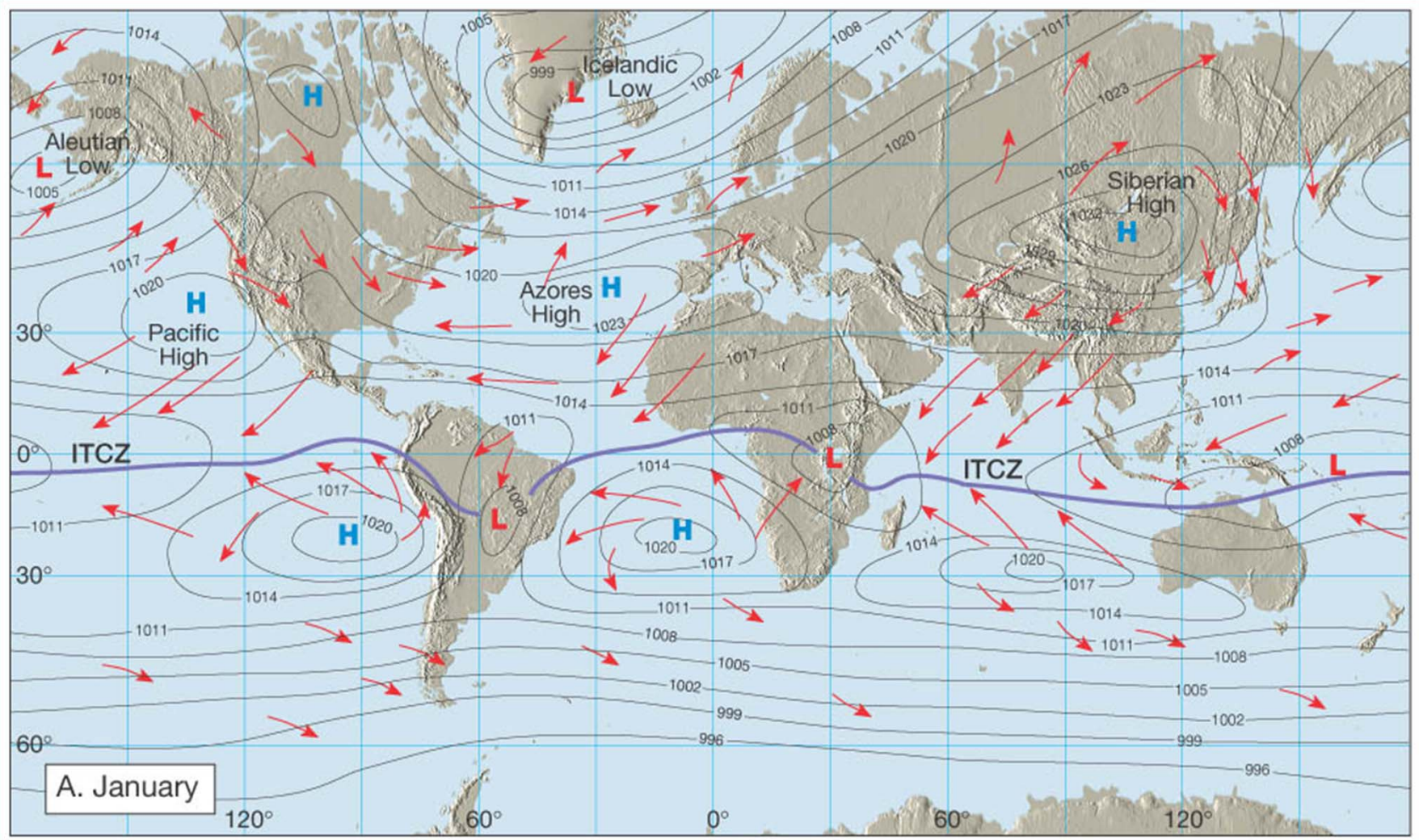
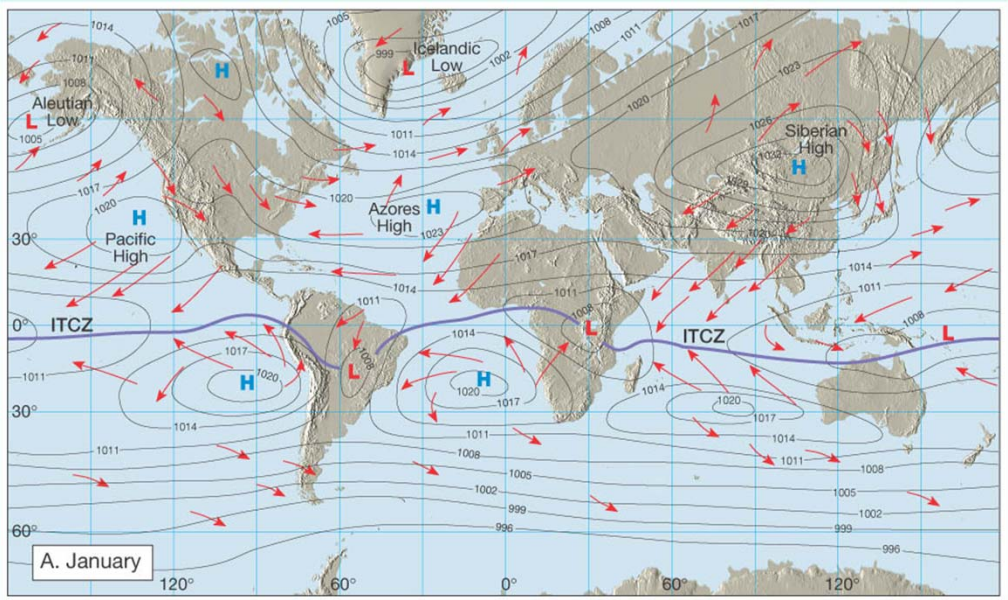


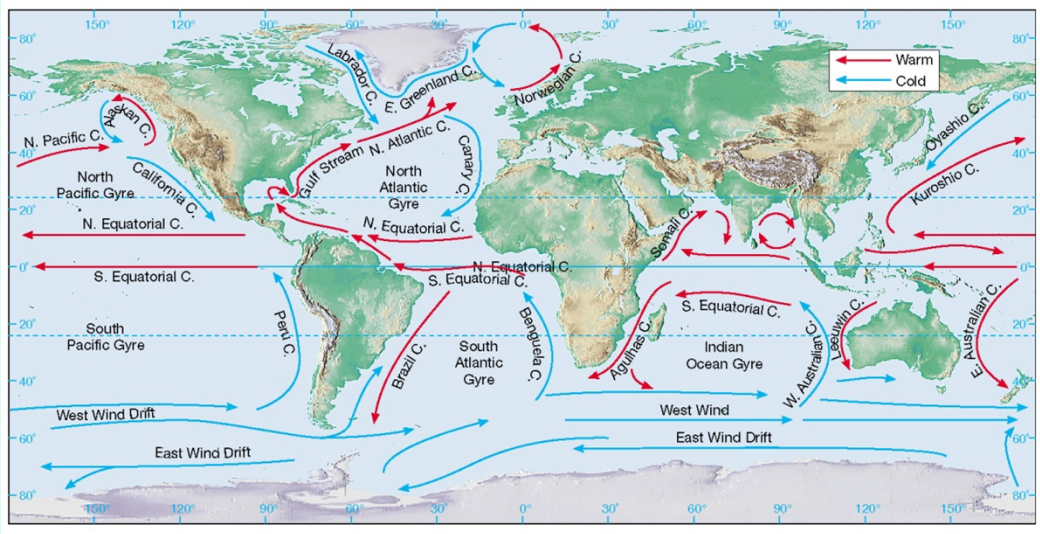
Figure 10.2

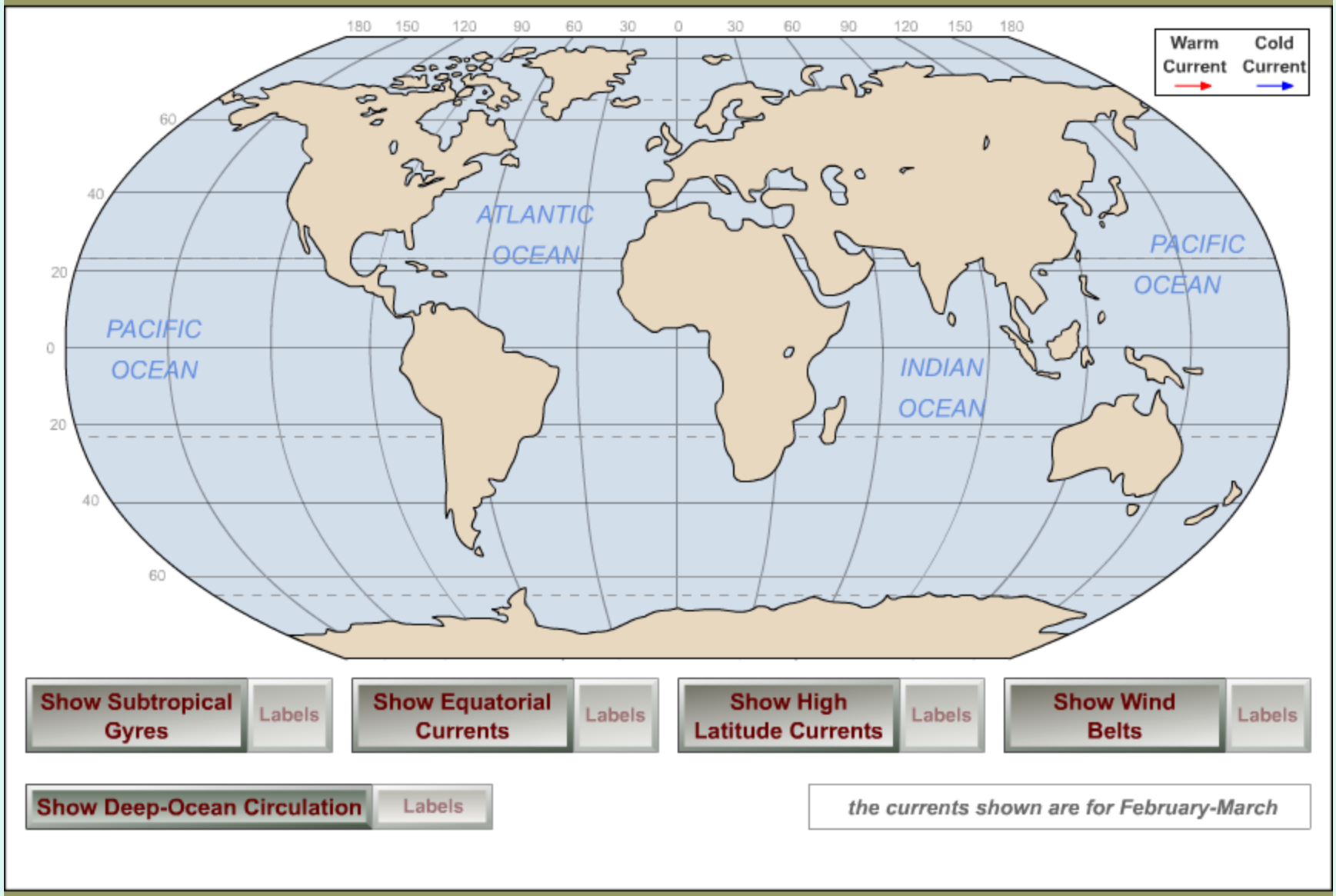
Atmospheric Circulation



Atmospheric and Surface Water Circulation






180 150 120 90 60 30 0 30 60 90 120 150 180
60
40
20
0
20
40
60
Warm Current
Cold Current
ATLANTIC OCEAN
PACIFIC OCEAN
PACIFIC OCEAN
INDIAN OCEAN
Show Subtropical Gyres
Labels
Show Equatorial Currents
Labels
Show High Latitude Currents
Labels
Show Wind Belts
Labels
Show Deep-Ocean Circulation
Labels
the currents shown are for February-March

Ocean Water Movements

Surface circulation

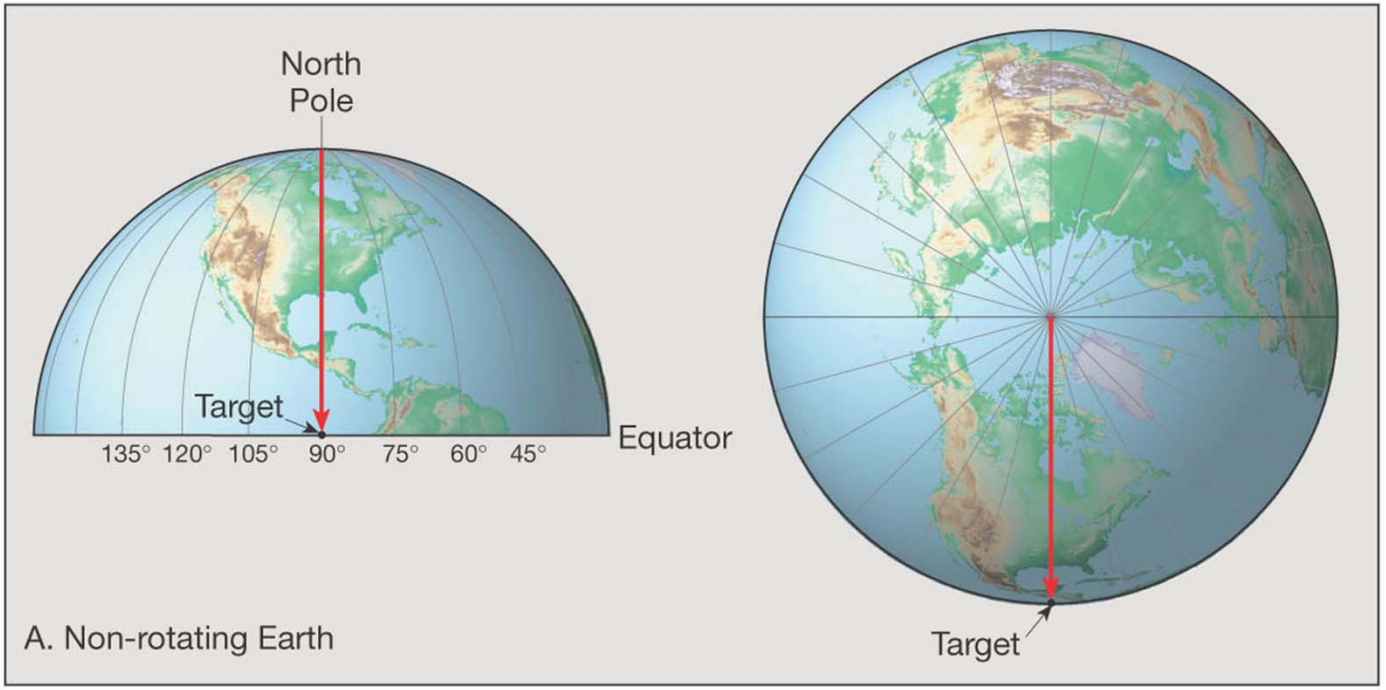
- **Climate**
  - **Currents from low latitudes into higher latitudes *(warm currents)* transfer heat from warmer to cooler areas**

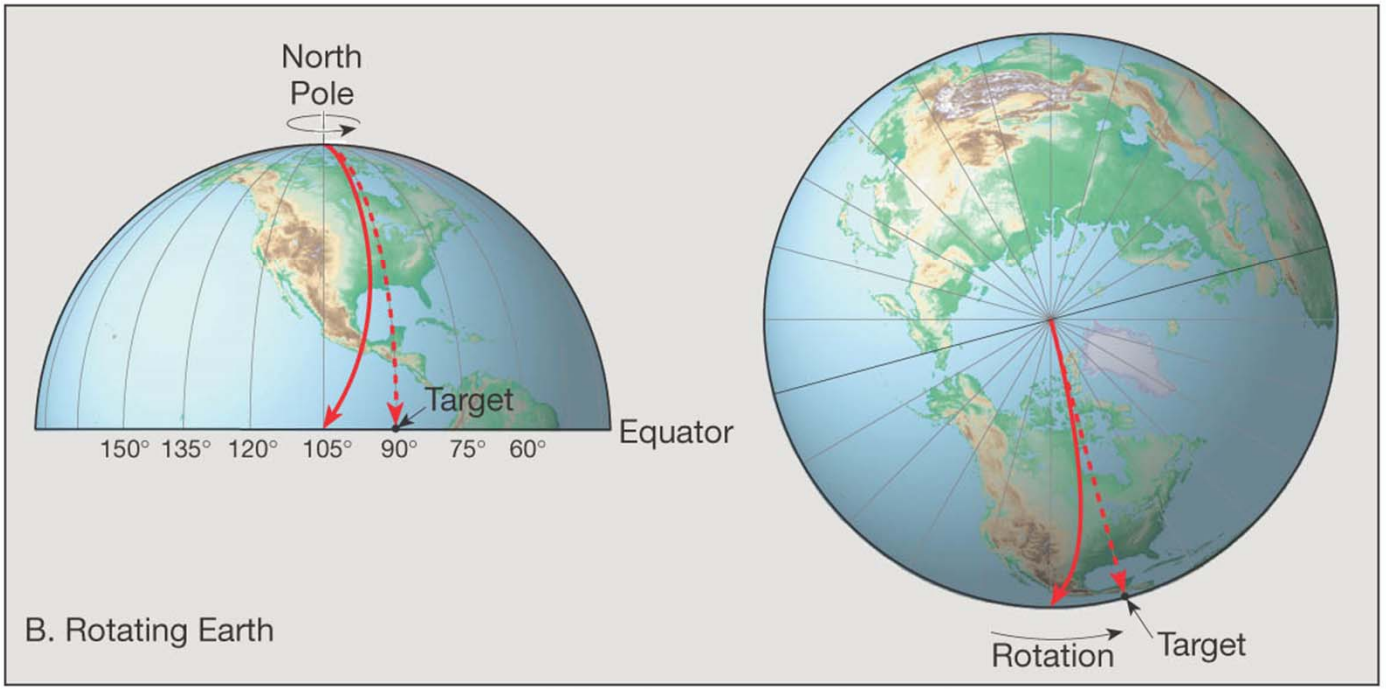
Corolis Effect

Surface circulation

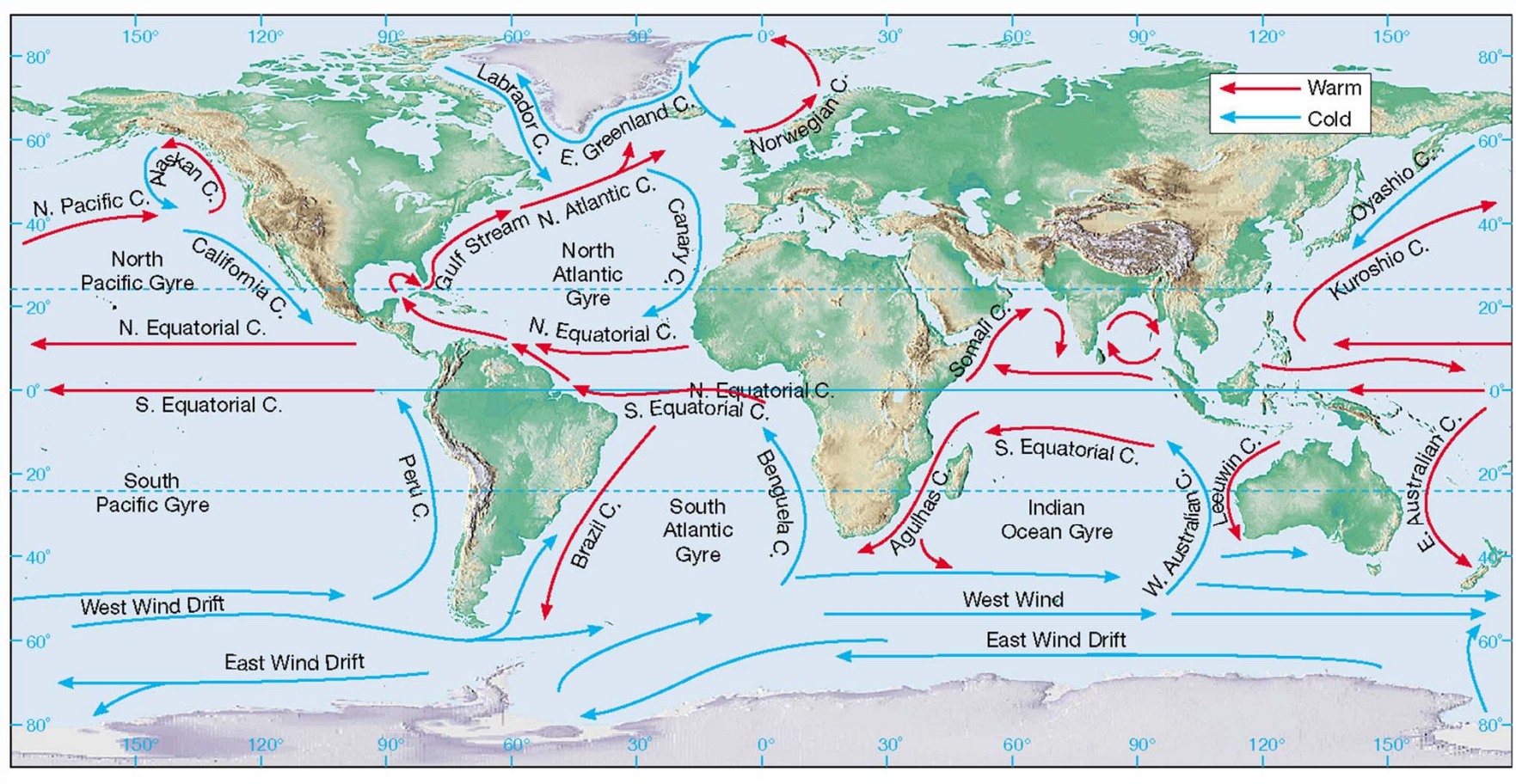
- **Deflected by the *Coriolis effect***
  - **To the right in the Northern Hemisphere**
  - **To the left in the Southern Hemisphere**

13_06





Continents and Ocean Circulation

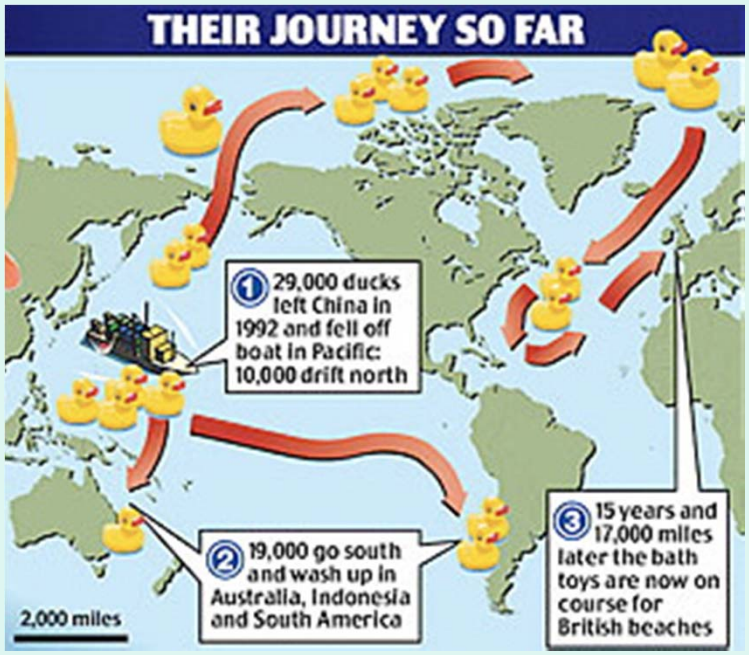


Ocean Water Movements

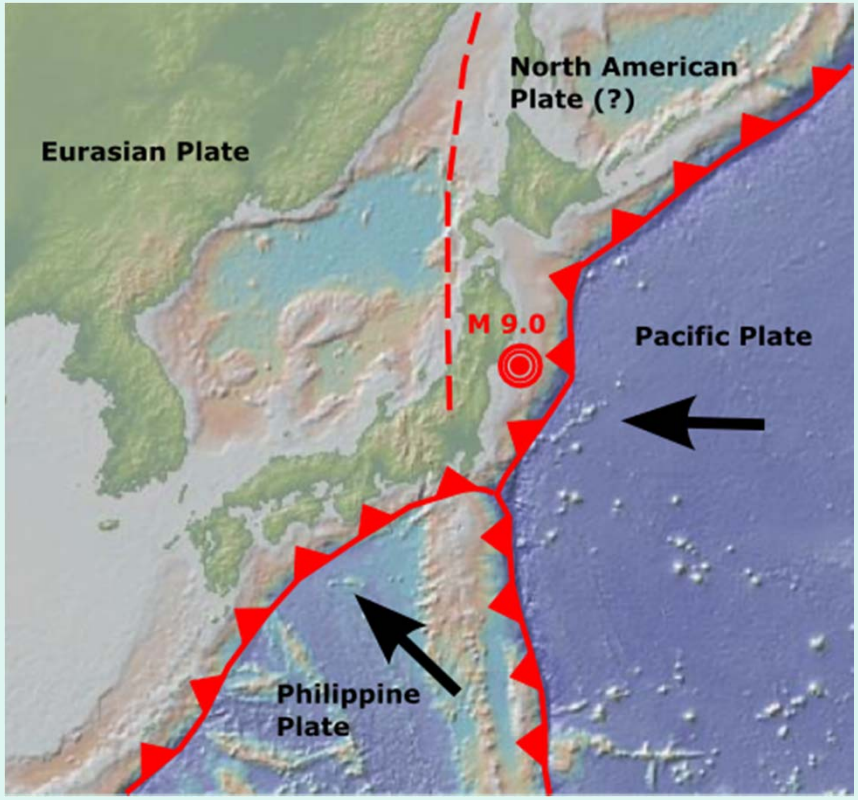
- **Surface circulation**
  - **Five main gyres**
    - **North Pacific gyre**
    - **South Pacific gyre**
    - **North Atlantic gyre**
    - **South Atlantic gyre**
    - **Indian Ocean gyre**
  - **Related to atmospheric circulation**

Continents and Ocean Circulation

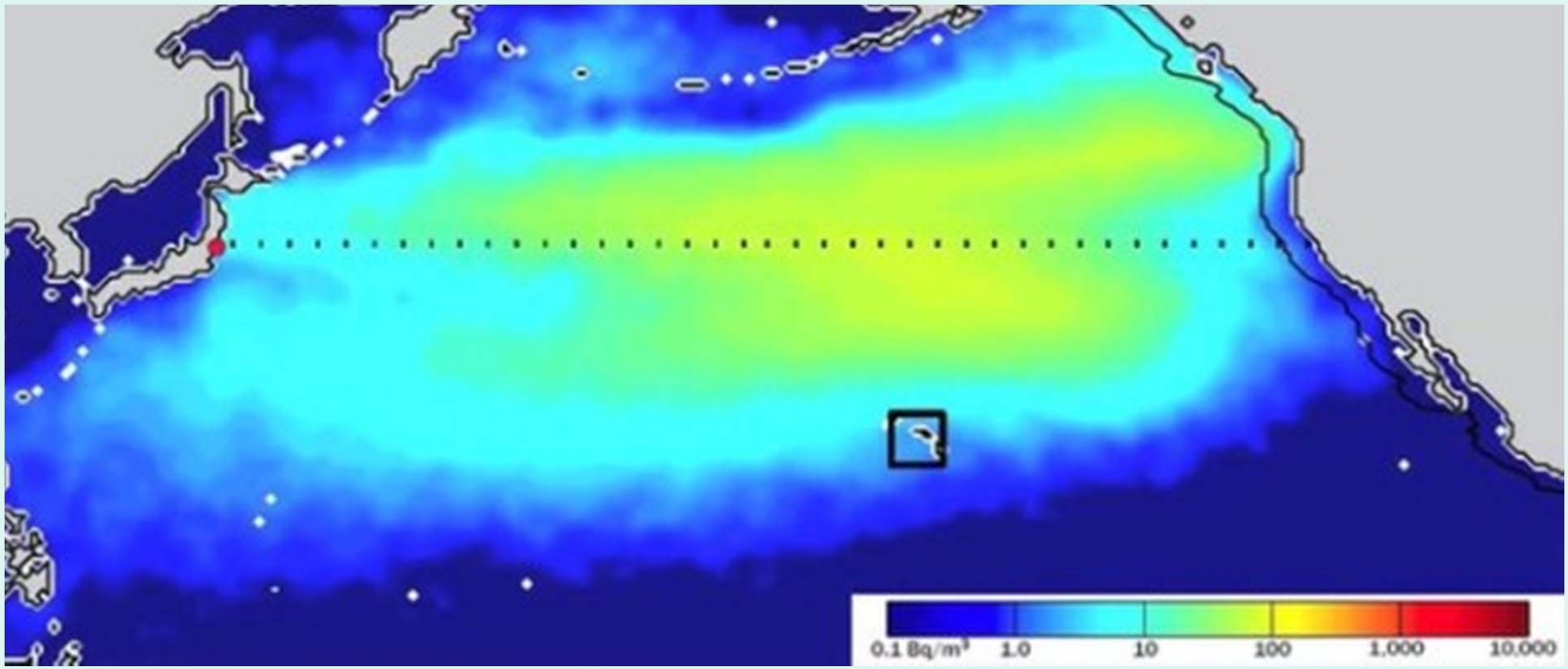
Continents and Ocean Circulation



Continents and Ocean Circulation

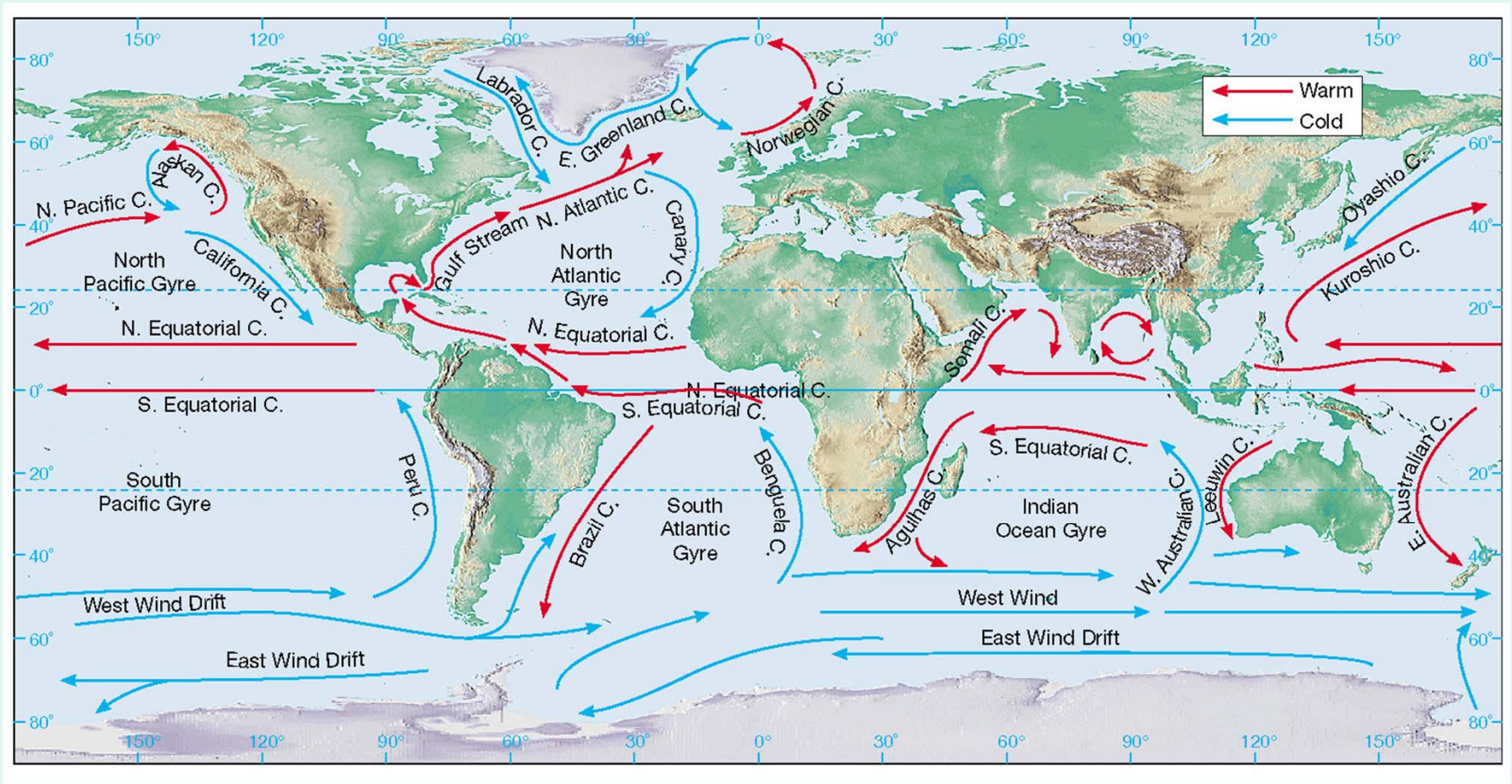


Continents and Ocean Circulation



March 2011 Nuclear Accident
2.1 years to travel across the Pacific
Sample byproducts of fission (Cesium -137)
Low levels of radiation – 1,000 times less than EPA standards
Radiation will peak in 2015/2016 but will remain below drinking water standards

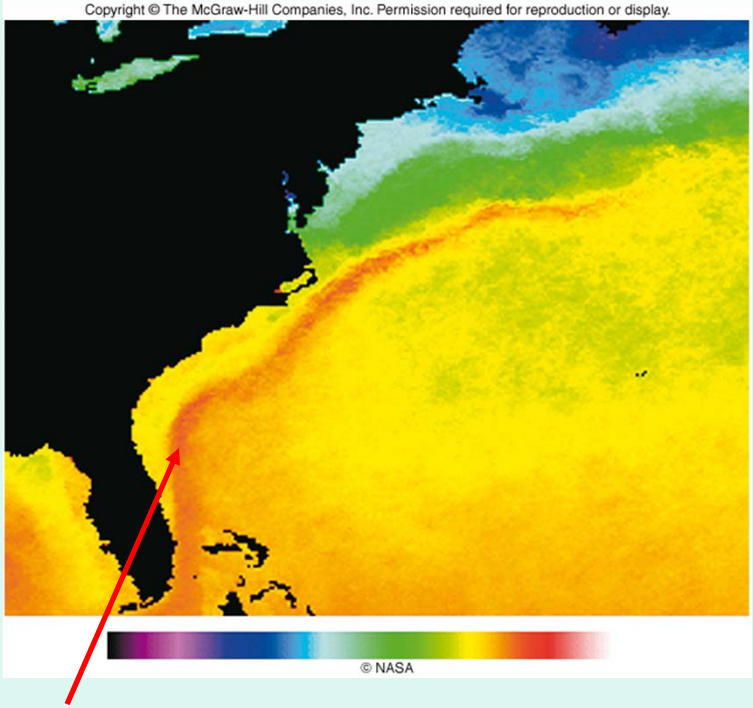
Important to Climate



Oceanic Circulation

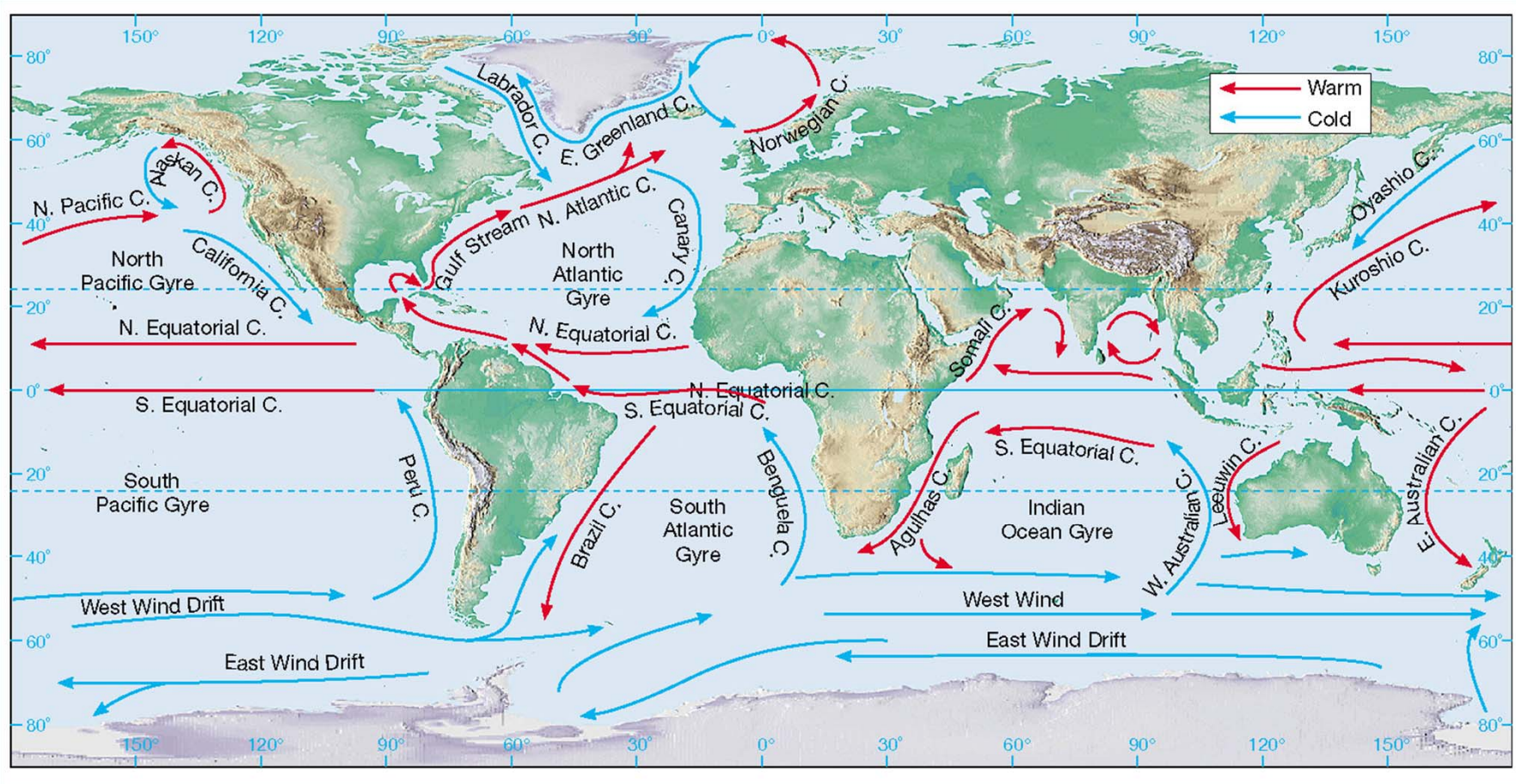
- **Winds move ocean water**
  - Friction between wind and surface water
  - ***Ocean currents follow prevailing wind direction except where the current encounters a barrier (e.g. landmass)***
  - Only about 10% of world's ocean water is moving in surface currents

- **Circulation patterns in atmosphere generate gyres**
  - Clockwise in N Hemisphere, counterclockwise in S Hemisphere
  - Water takes months to years to complete a gyre circuit
  - Fast-flowing boundary currents at western extents of gyres redistribute warm tropical water toward the poles (e.g. Gulf Stream, Kuroshio)
  - Eastern portions of gyres carry colder water from high latitudes toward equator

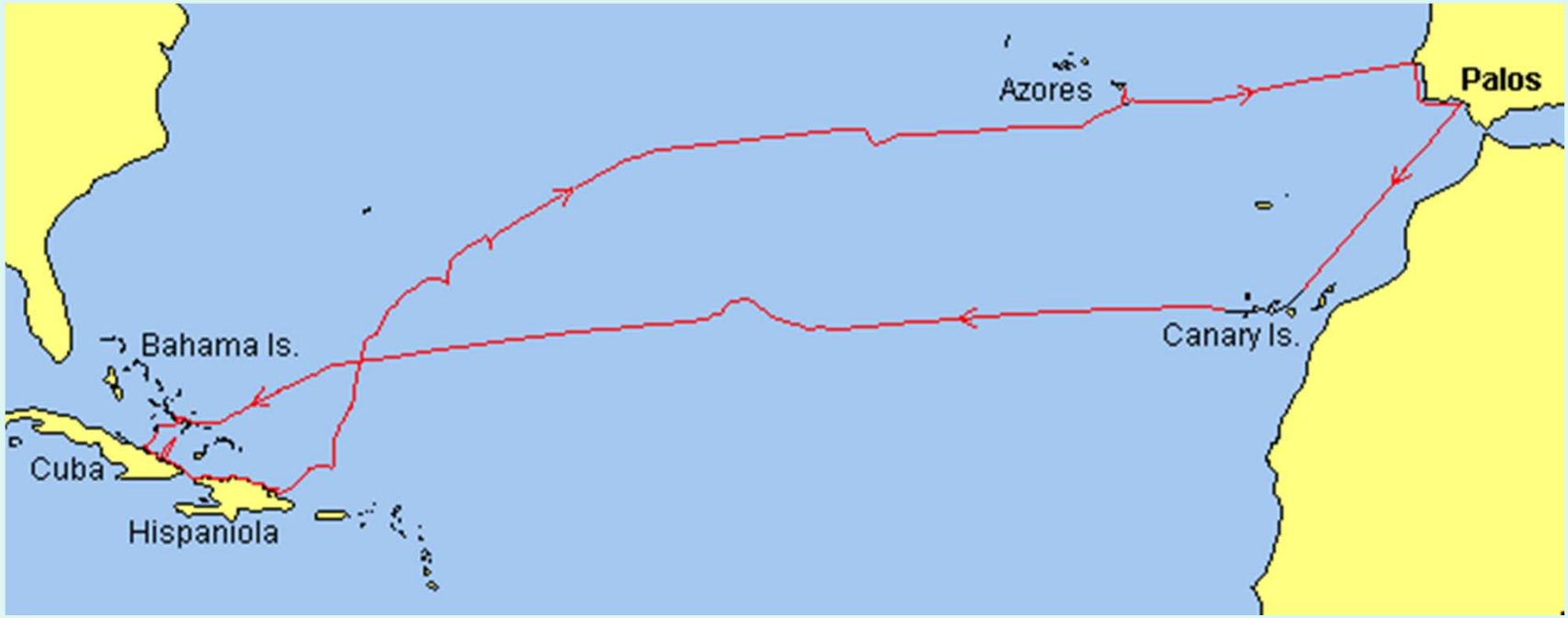


Narrow, high temperature Gulf Stream

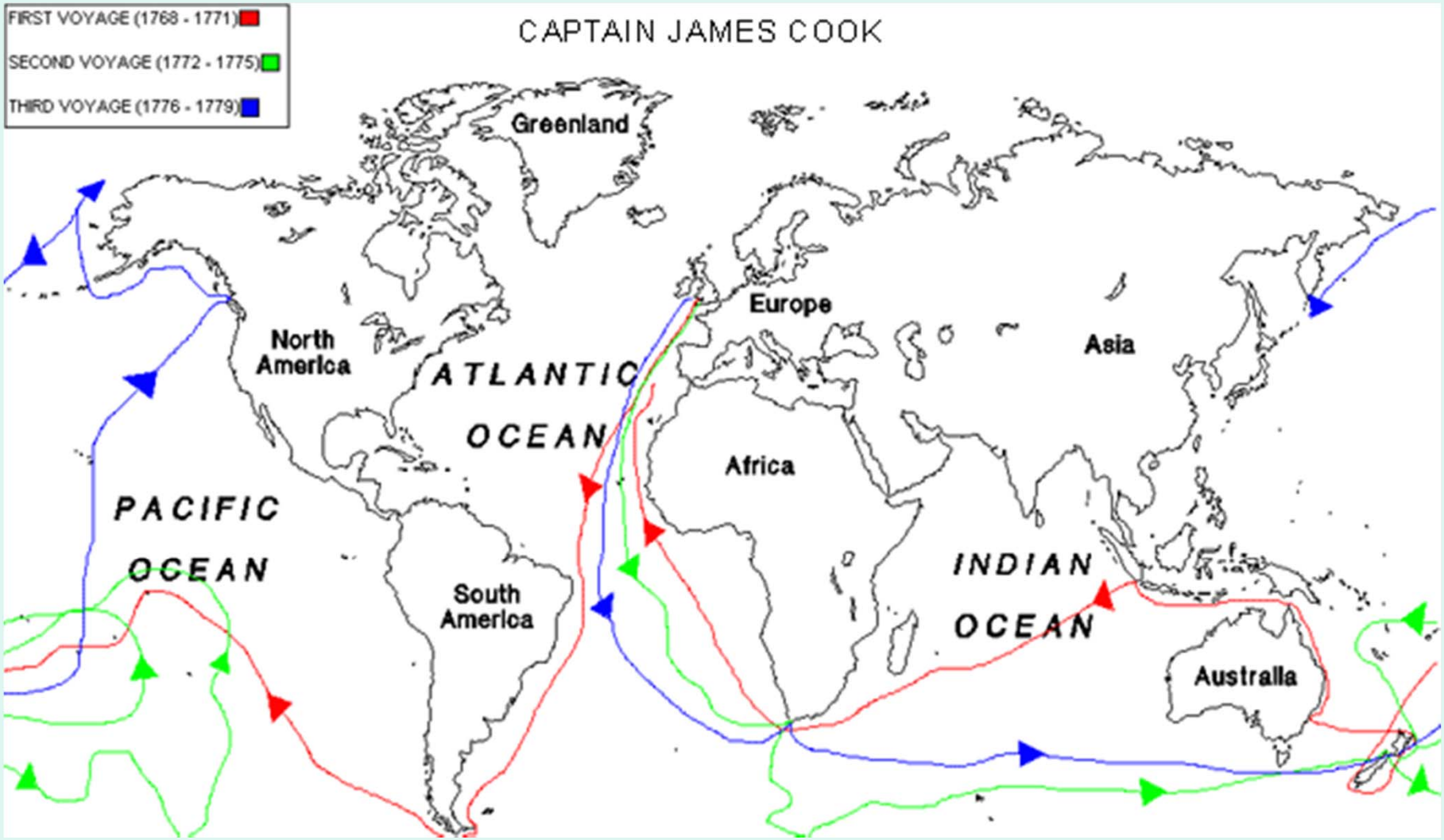
Important to Navigation



Columbus - 1492



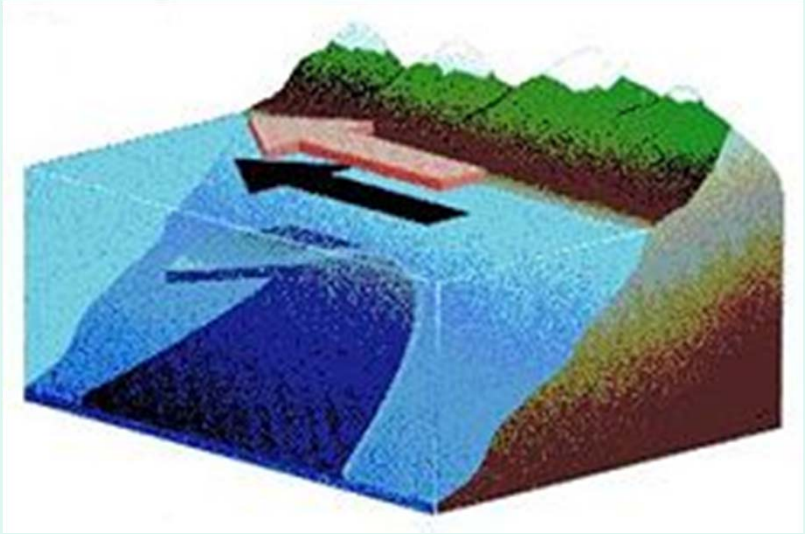
Cook – 1770s


FIRST VOYAGE (1768 - 1771)
SECOND VOYAGE (1772 - 1775)
THIRD VOYAGE (1776 - 1779)
CAPTAIN JAMES COOK
Greenland
North America
ATLANTIC OCEAN
Europe
Asia
Africa
PACIFIC OCEAN
South America
INDIAN OCEAN
Australia

Upwelling and Downwelling

Upwelling

- **The replacement of warm surface water by rising cold water from deeper layers**
- **Most characteristic along west coasts of continents**
- **Results in some the richest fishing grounds in the world**



Upwelling and Downwelling

Downwelling

- **The sinking of dense water**
- **Most characteristic in polar regions**

Formation of Sea Ice

Deep-ocean circulation

- A response to density differences
- Factors creating a dense mass of water
  - Temperature—Cold water is dense
  - Salinity—Density increases with increasing salinity
- Called *thermohaline circulation*

Idealized "Conveyor Belt" Model of Ocean Circulation

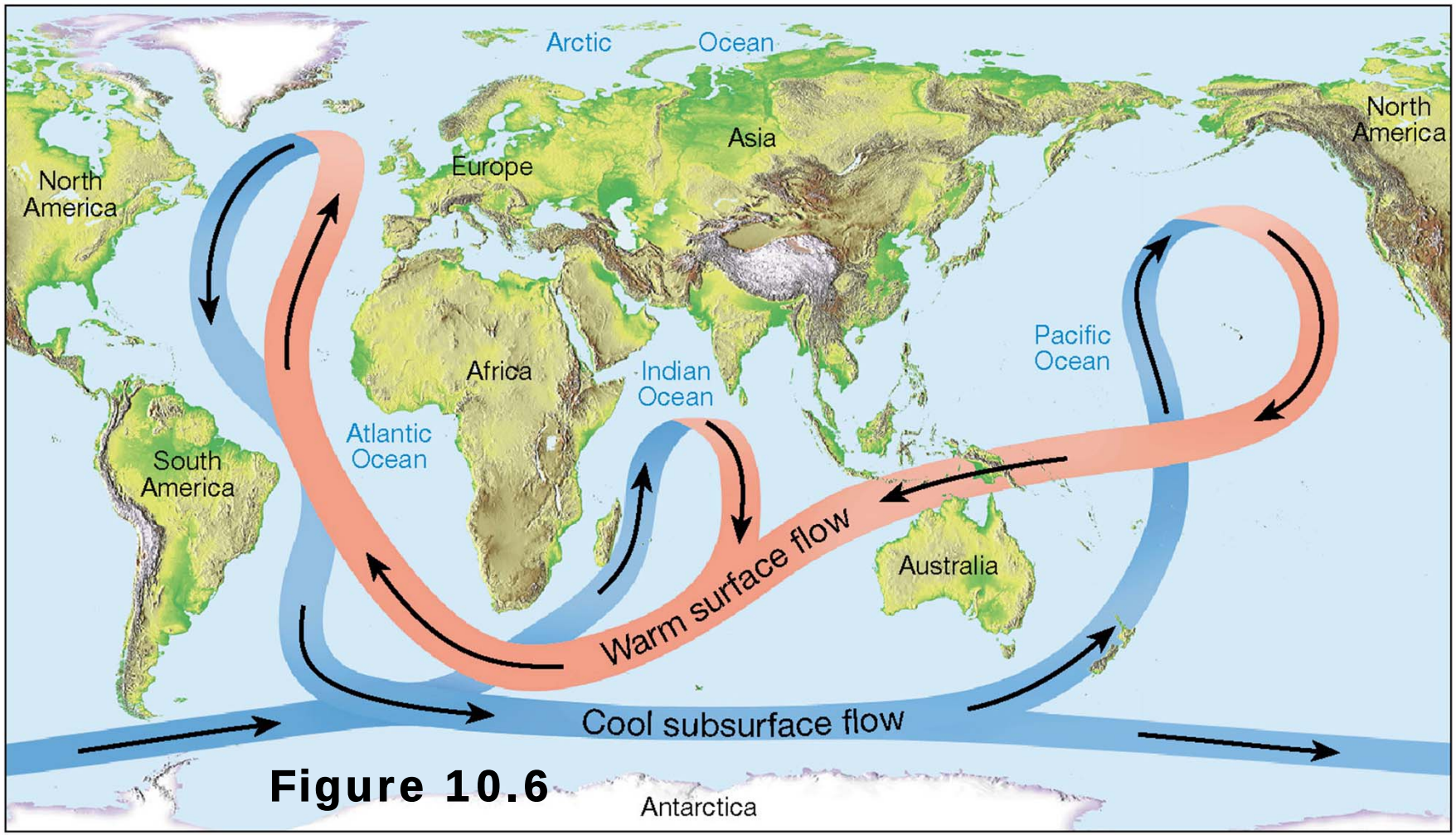


Figure 10.6

Ocean Water Movements

- **Deep-ocean circulation**
  - **A response to density differences**
  - **Factors creating a dense mass of water**
    - **Temperature—Cold water is dense**
    - **Salinity—Density increases with increasing salinity**
  - **Called *thermohaline circulation***


0 %
Loading

Ocean Water Movements

- **Deep-ocean circulation**
  - **Most water involved in deep-ocean currents begins in high latitudes at the surface**
  - **A simplified model of ocean circulation is similar to a conveyor belt that travels from the Atlantic Ocean, through the Indian and Pacific Oceans, and back again**

Idealized "Conveyor Belt" Model of Ocean Circulation

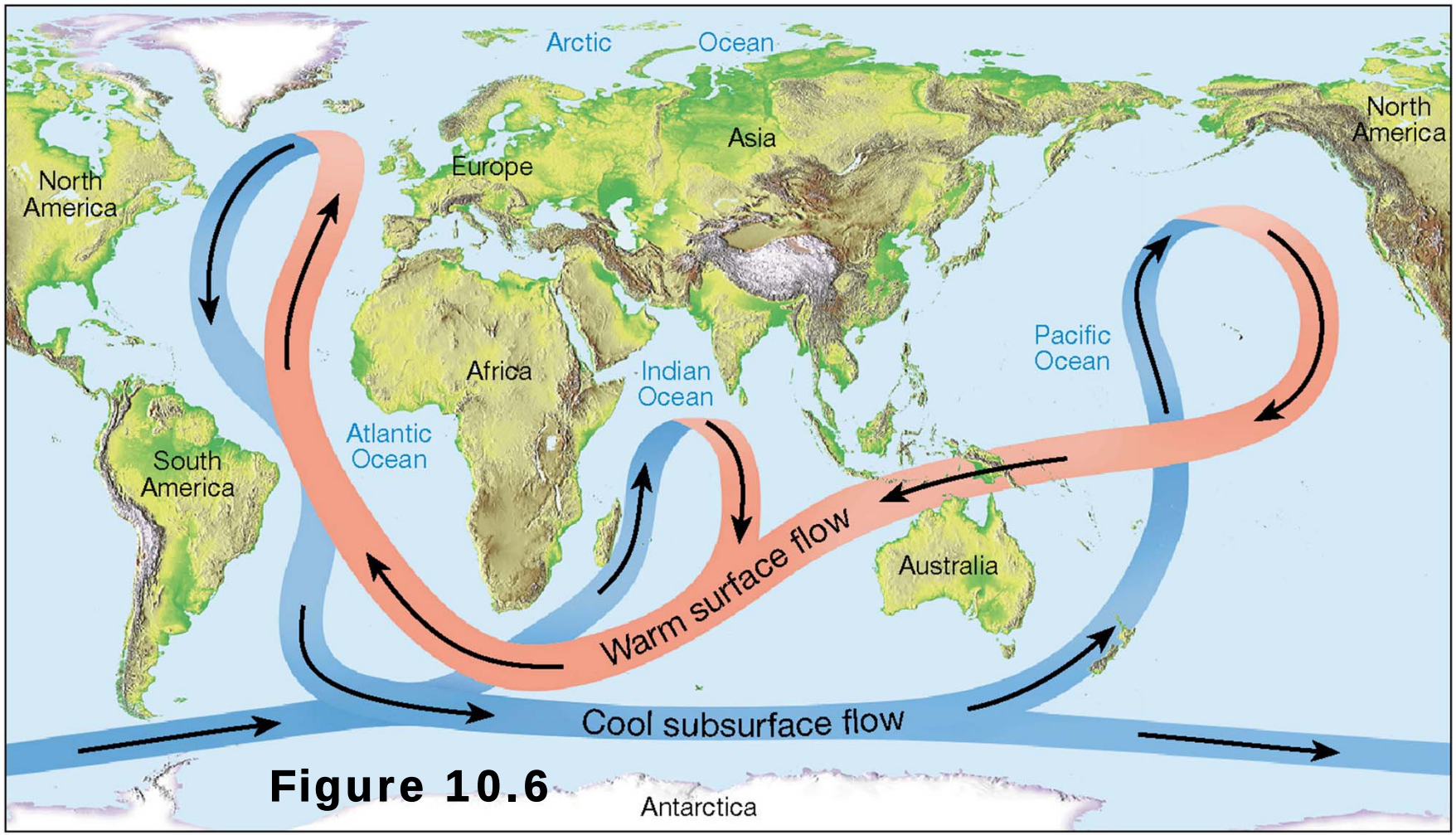


Figure 10.6

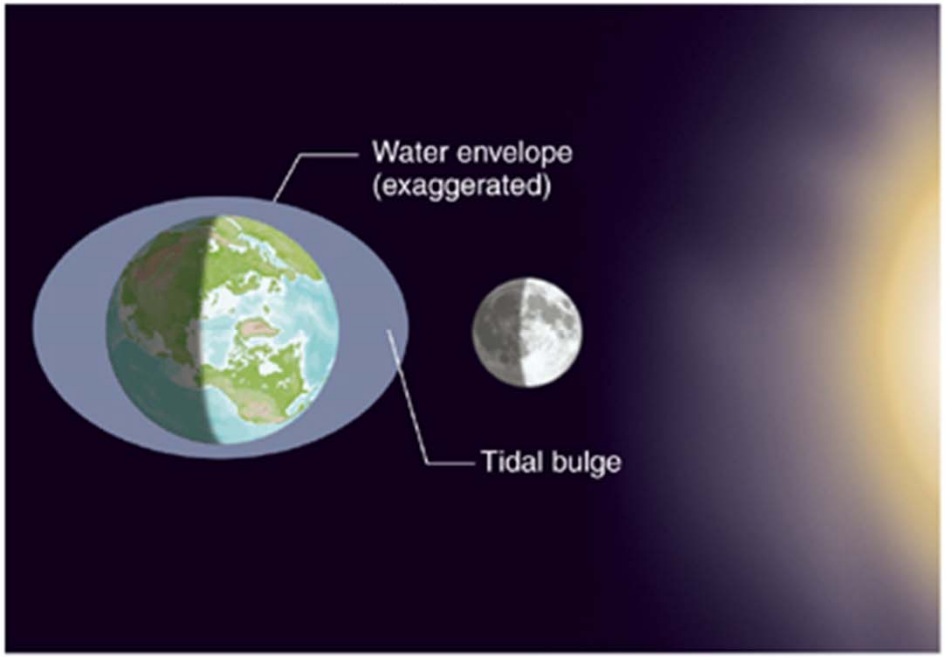
Tides

- **Changes in elevation of the ocean surface**
- **Caused by the gravitational forces exerted upon the Earth by the Moon, and to a lesser extent by the Sun**

Tides

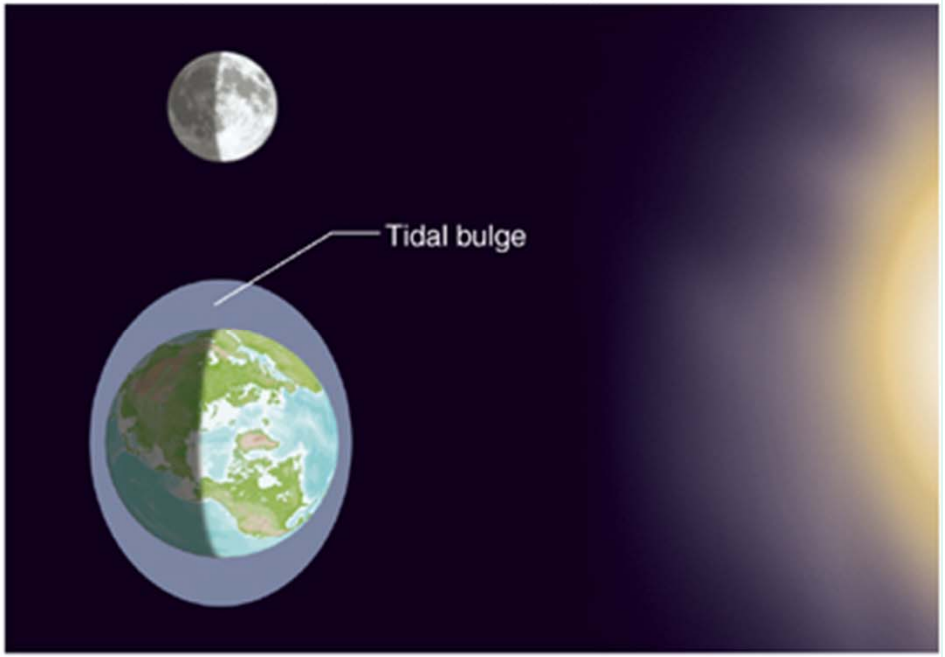
***Tides* = changes in the sea surface height caused by the gravitational attraction of the moon (and a bit by the sun)**

- a) Spring tides – largest tidal bulges, highest tides
- b) Neap tides – smallest tidal bulges, lowest tides



a.

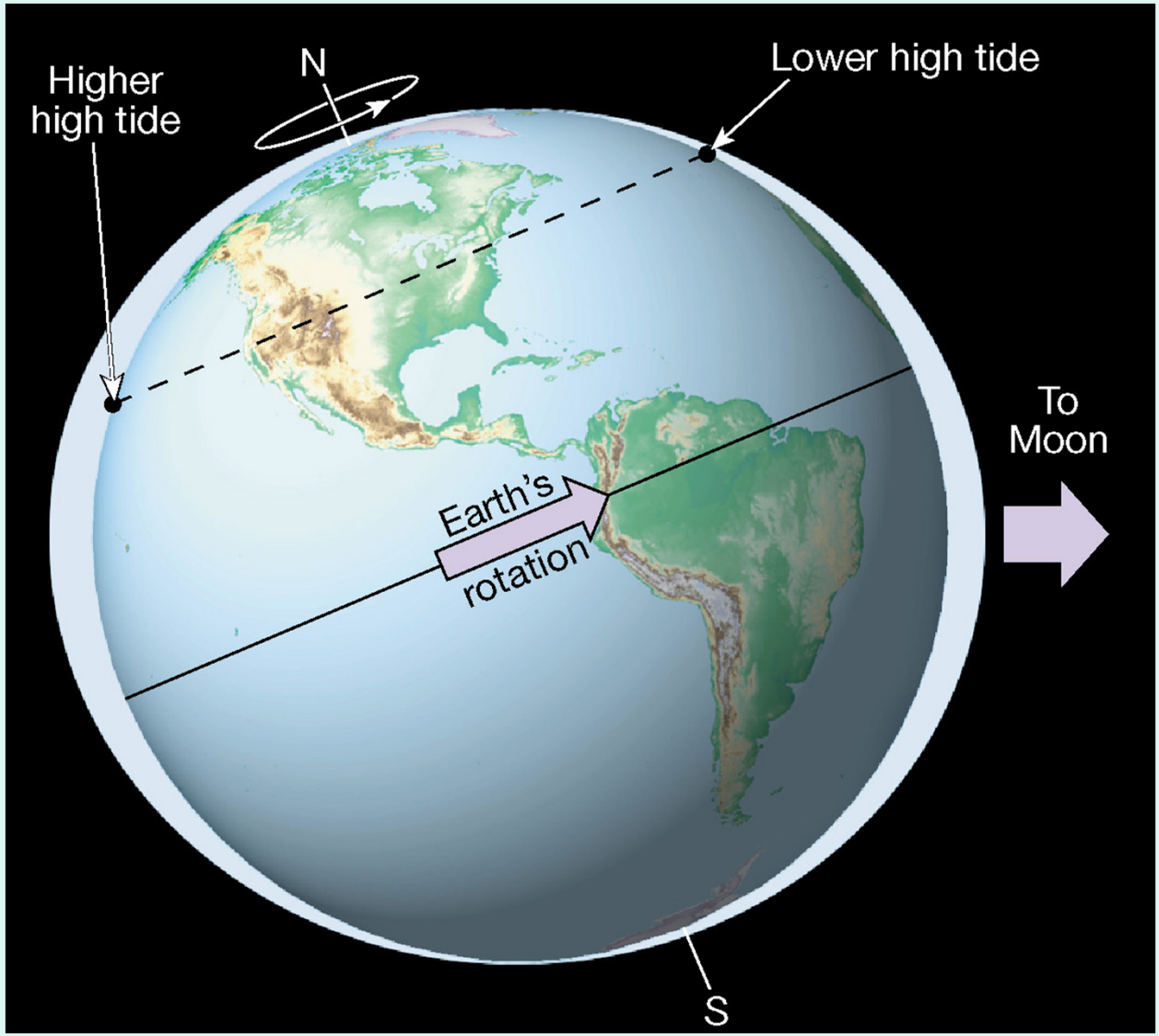
Sun and moon exerting pull on the Earth in same direction. Occur during New Moon.



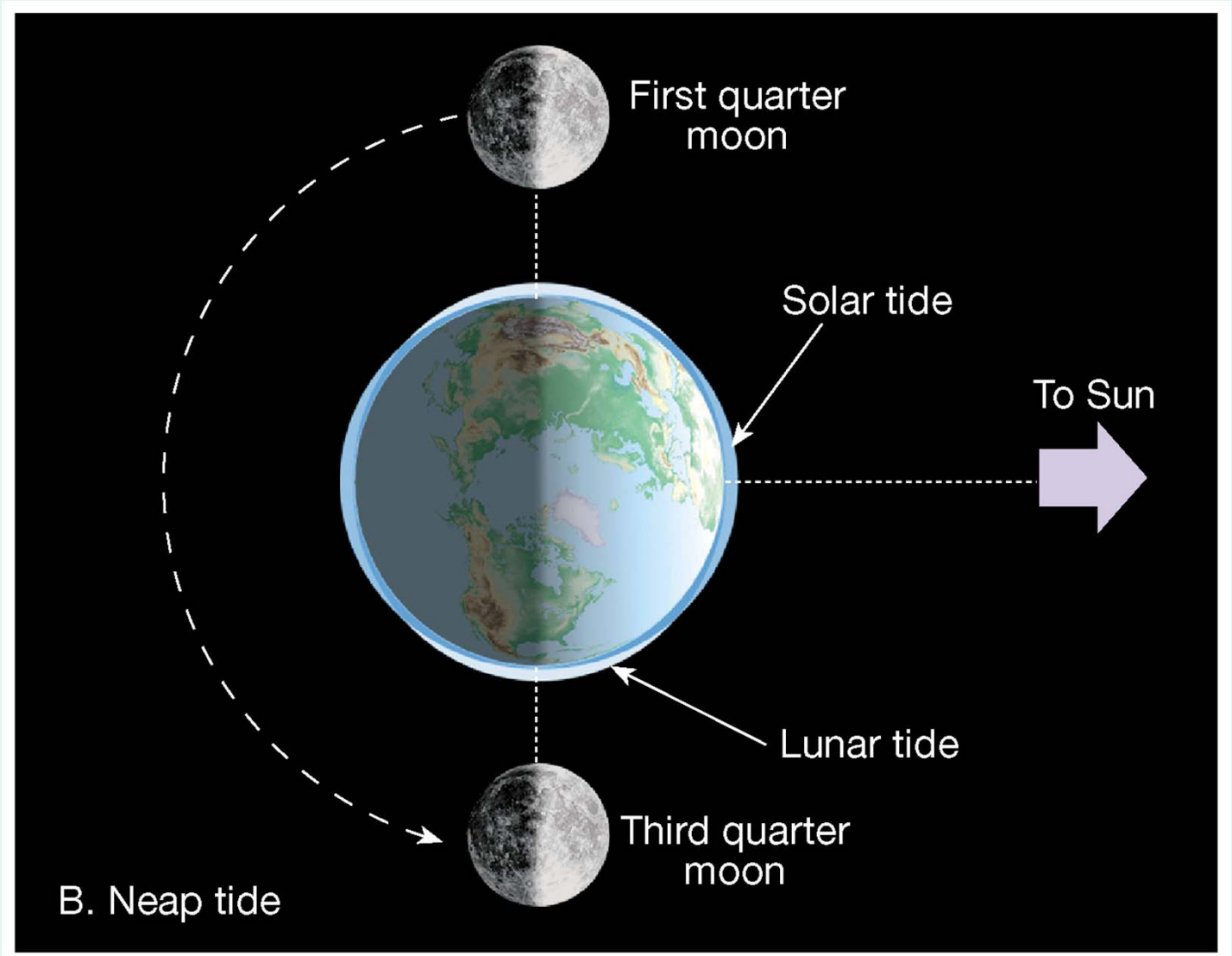
b.

Sun and moon exerting pull on the Earth in different directions.

Idealized Tidal Bulges on Earth



High Tides Follow Moon




0 %
Loading

Tides

- **Monthly tidal cycle**
  - ***Spring tide***
    - **During new and full moons**
    - **Gravitational forces added together**
    - **Especially high and low tides**
    - **Large daily tidal range**

Earth-Moon-Sun Positions During the Spring Tide

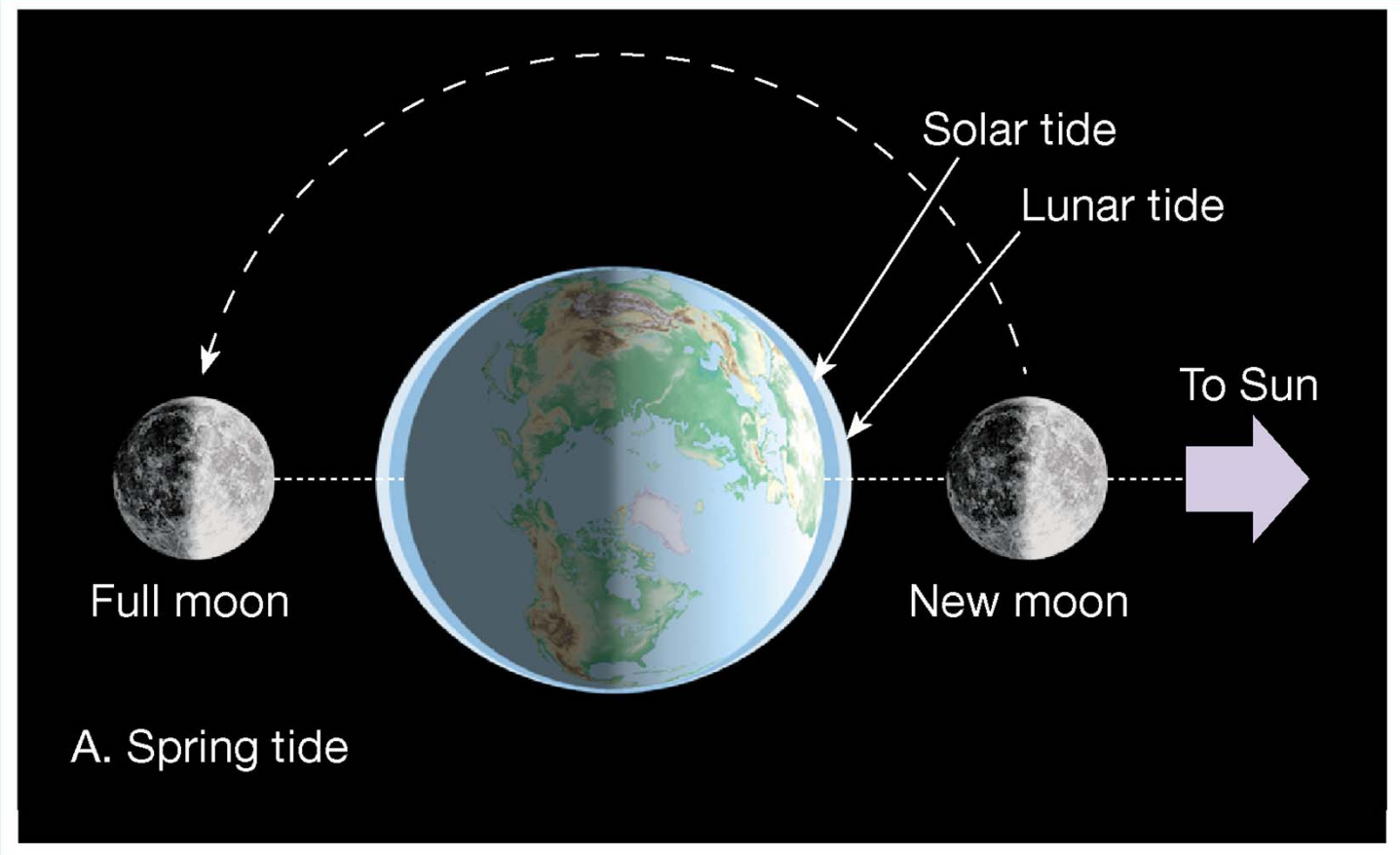


Figure 10.26 A

Tides

- **Monthly tidal cycle**
  - ***Neap tide***
    - **First and third quarters of the Moon**
    - **Gravitational forces are offset**
    - **Daily tidal range is least**
- **Tidal patterns**
  - **Many factors influence the tides**
    - **Shape of the coastline**
    - **Configuration of the ocean basin**
    - **Water depth**

Earth-Moon-Sun Positions During the Neap Tide

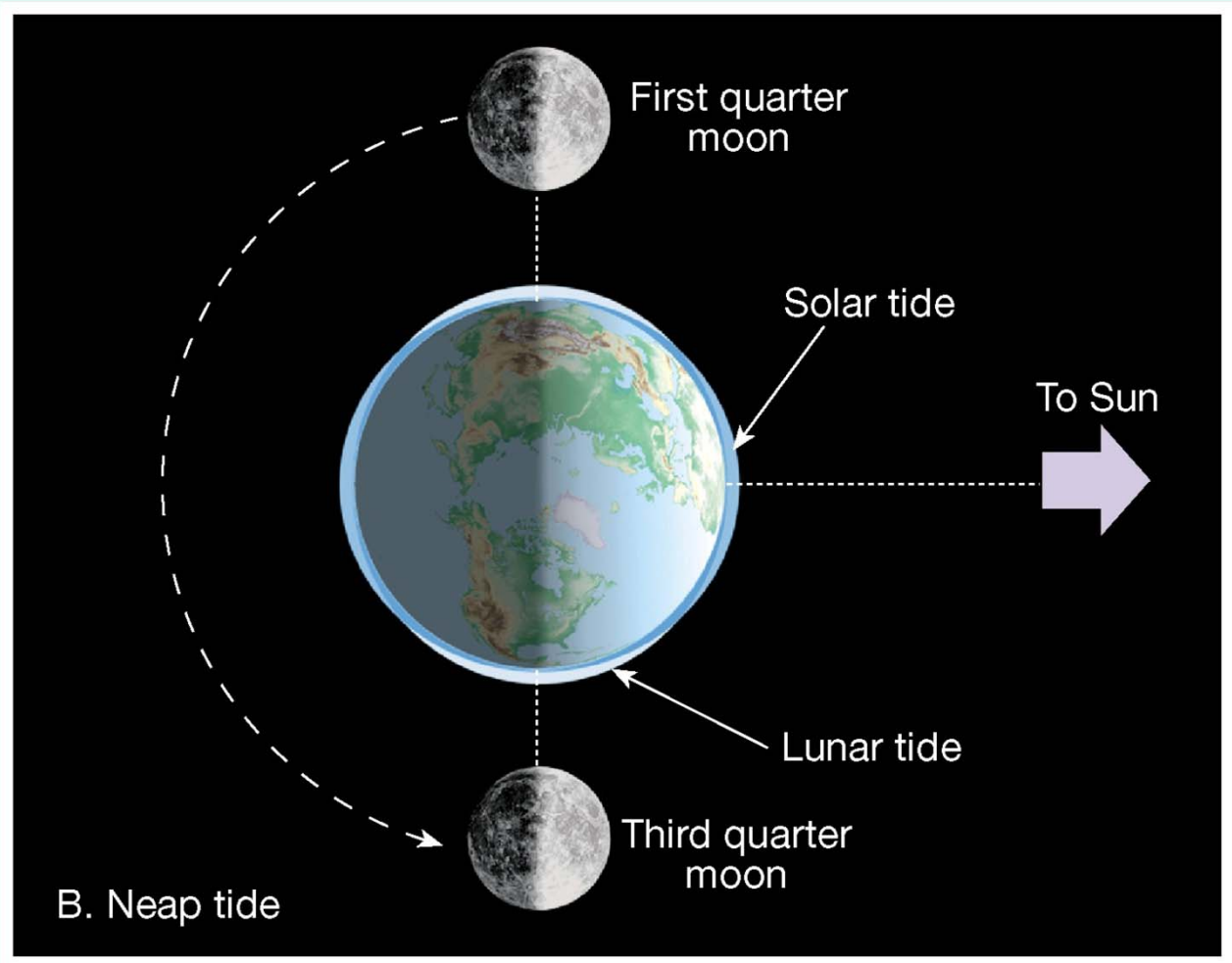


Figure 10.26 B

Tides

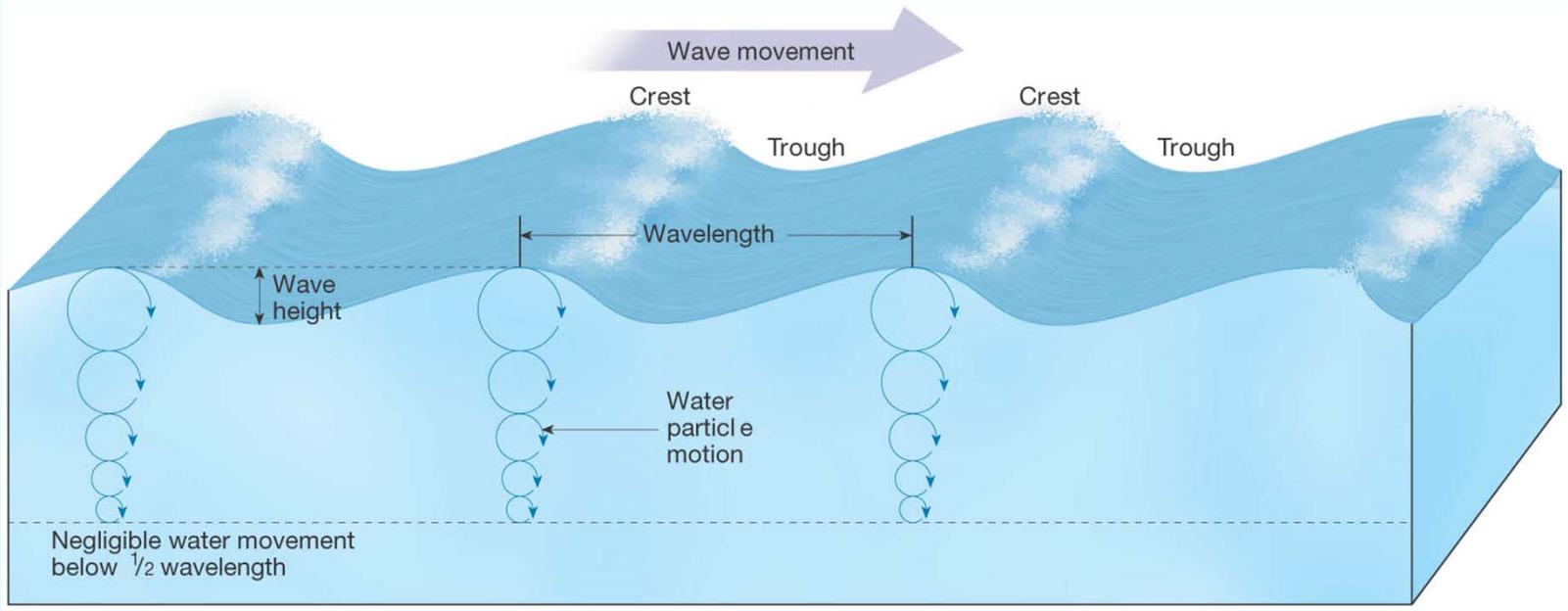
- **Tidal currents**
  - **Horizontal flow accompanying the rise and fall of tides**
  - **Types of tidal currents**
    - ***Flood current*—Advances into the coastal zone**
    - ***Ebb current*—Seaward moving water**
  - **Sometimes *tidal deltas* are created by tidal currents**

Configuration of Shoreline

Waves

Waves

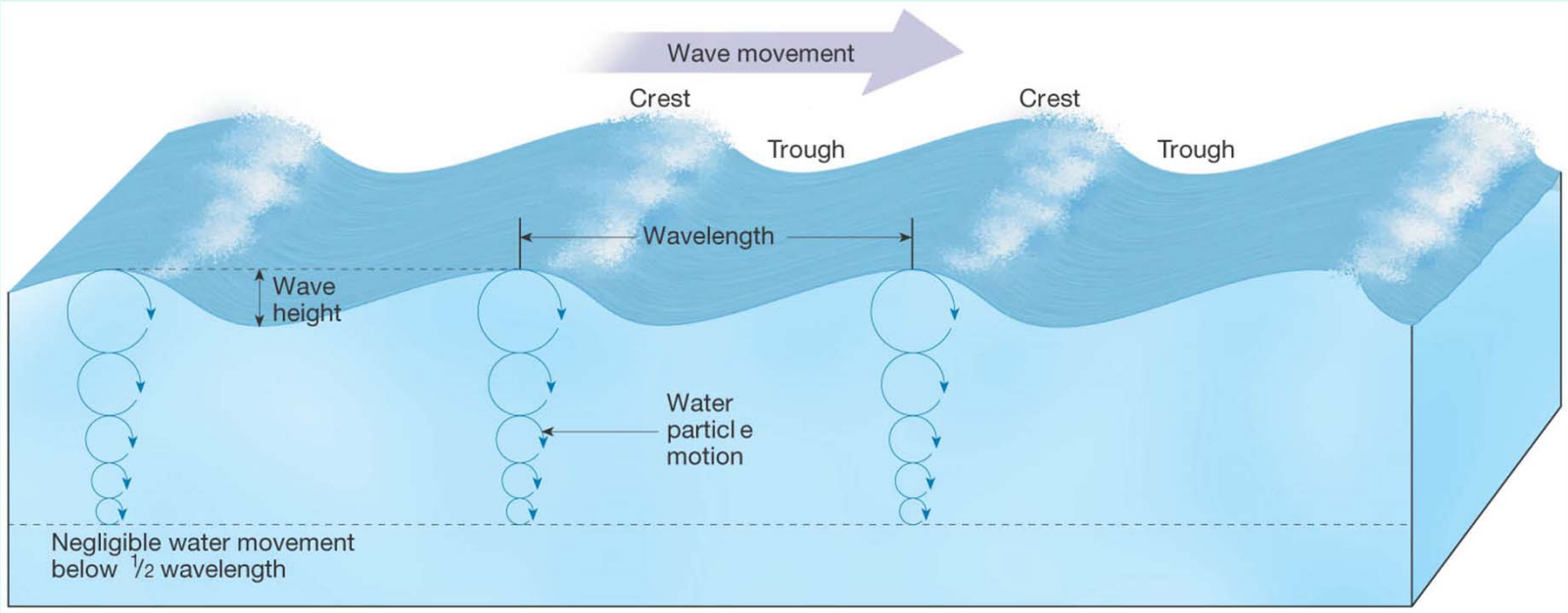
- **Energy traveling along the interface between ocean and atmosphere**
- **Derive their energy and motion from wind**
- **Parts : *Crest, Trough, Wavelength, height***



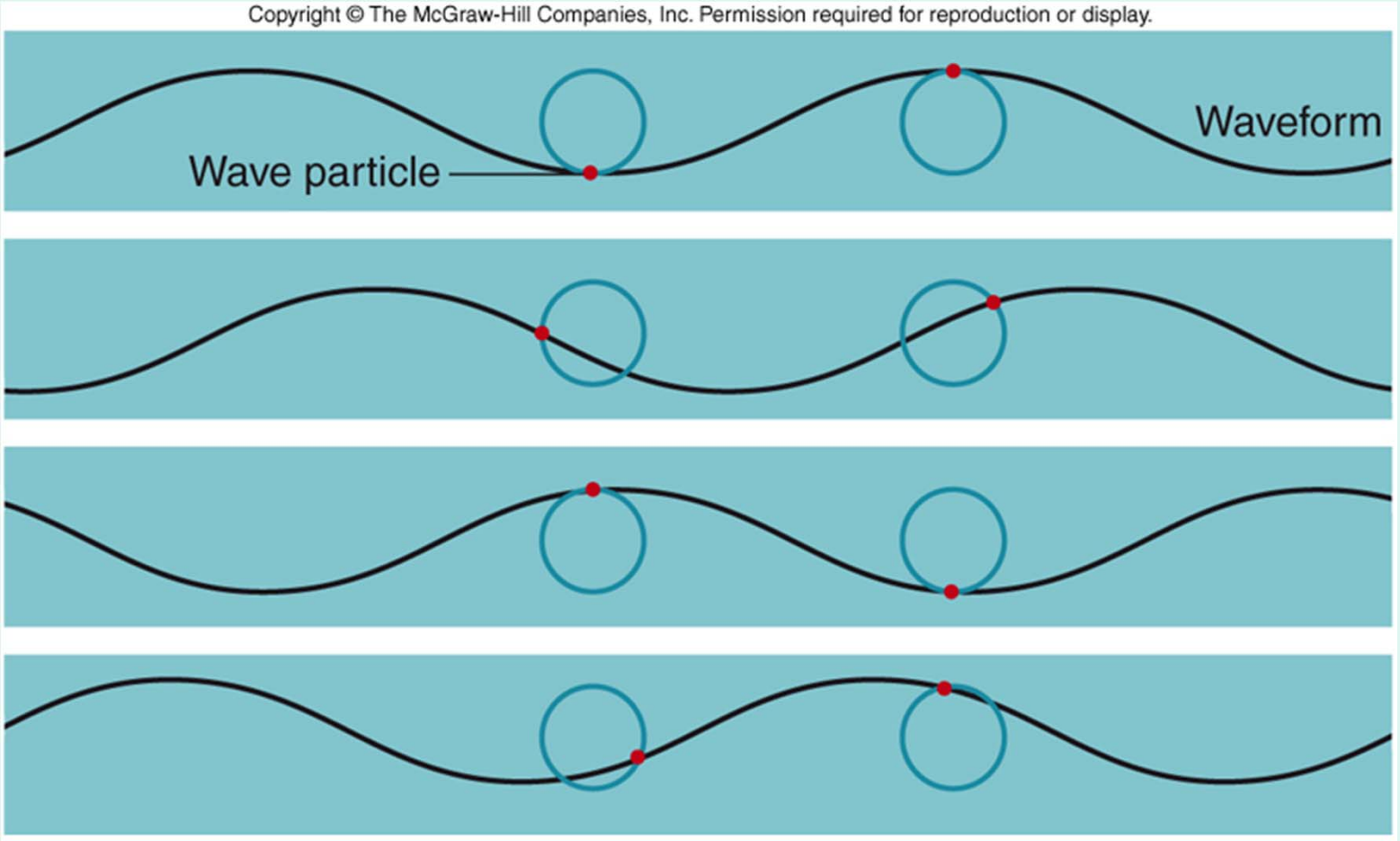
Waves

Characteristics

- **Wave height—The distance between a trough and a crest**
- **Wavelength—The horizontal distance between successive crests (or troughs)**
- **Wave period—The time interval for one full wave to pass a fixed position**



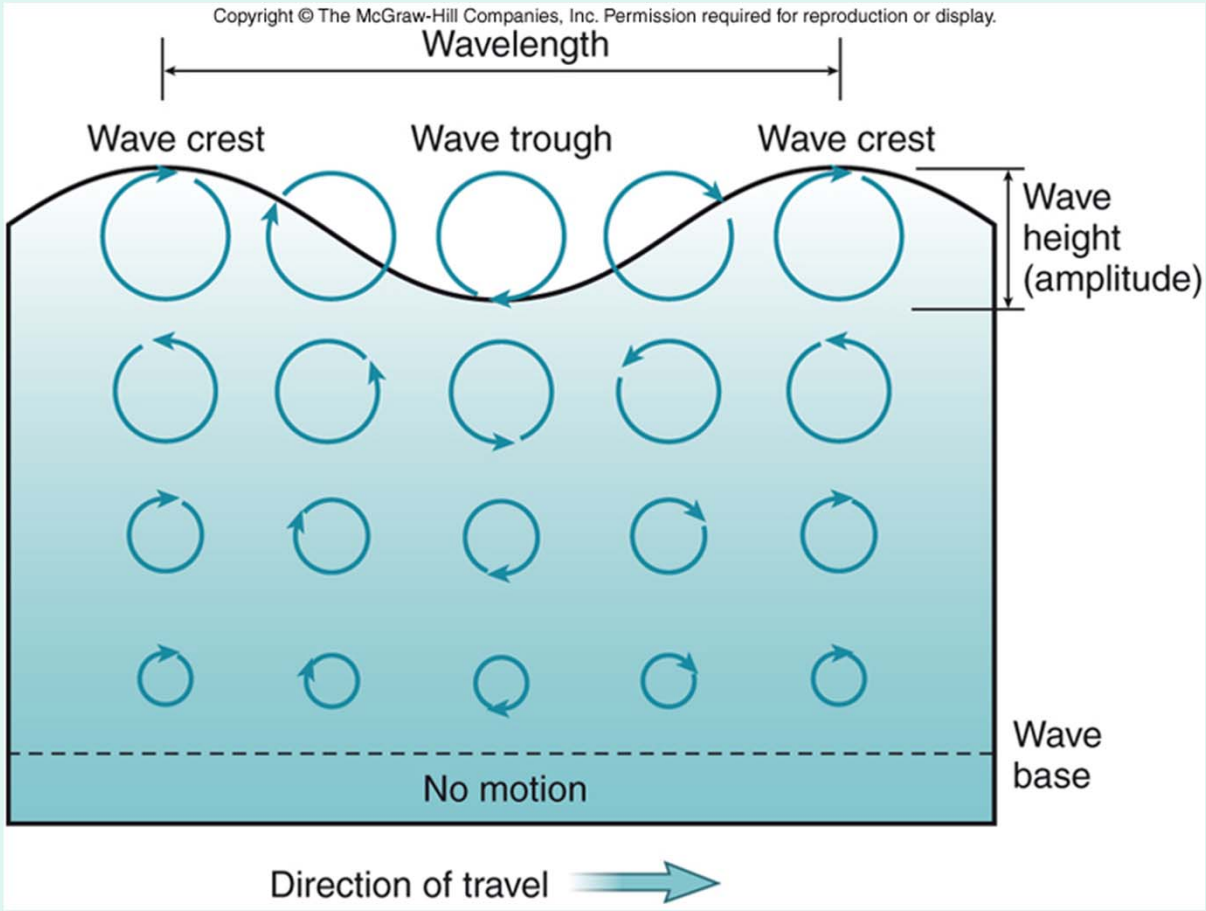
Wave Action



In the open ocean water simply bobs up and down. The wave shape (waveform) moves while the water particles follow a circular path and remain in place.

Wave Action

- **Wave size, speed, and direction are controlled by winds**
- **The waves we see in the ocean are the result of wind energy transferred to surface water**



Wave action affects only surface waters.

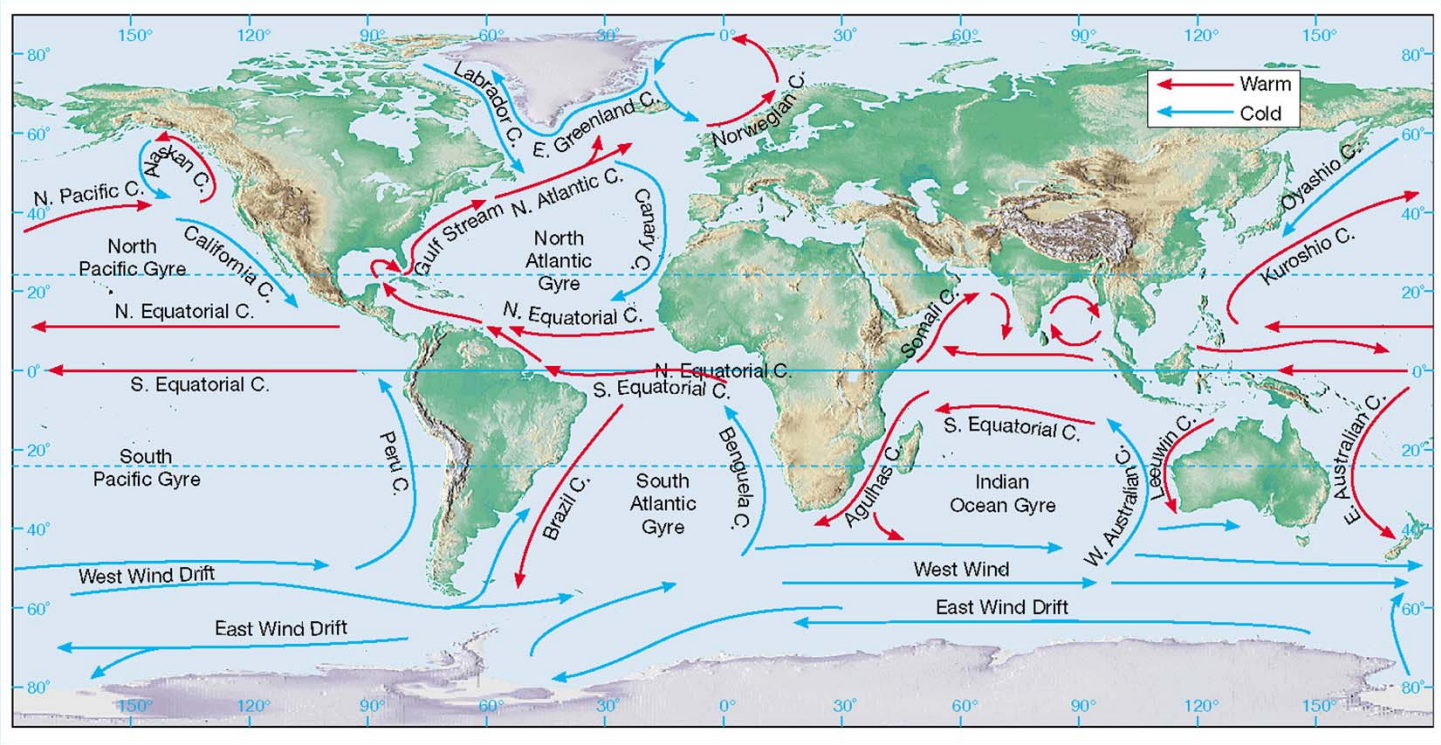
Motion decreases downward to a depth equal to about ½ of the wavelength called the *wave base*.

The deeper the wave base, the more volume of water involved in the wave.

Ocean Water Movements

Wave height, length, and period depend on

- **Wind speed**
- **Length of time the wind blows**
- ***Fetch*—The distance that the wind travels**

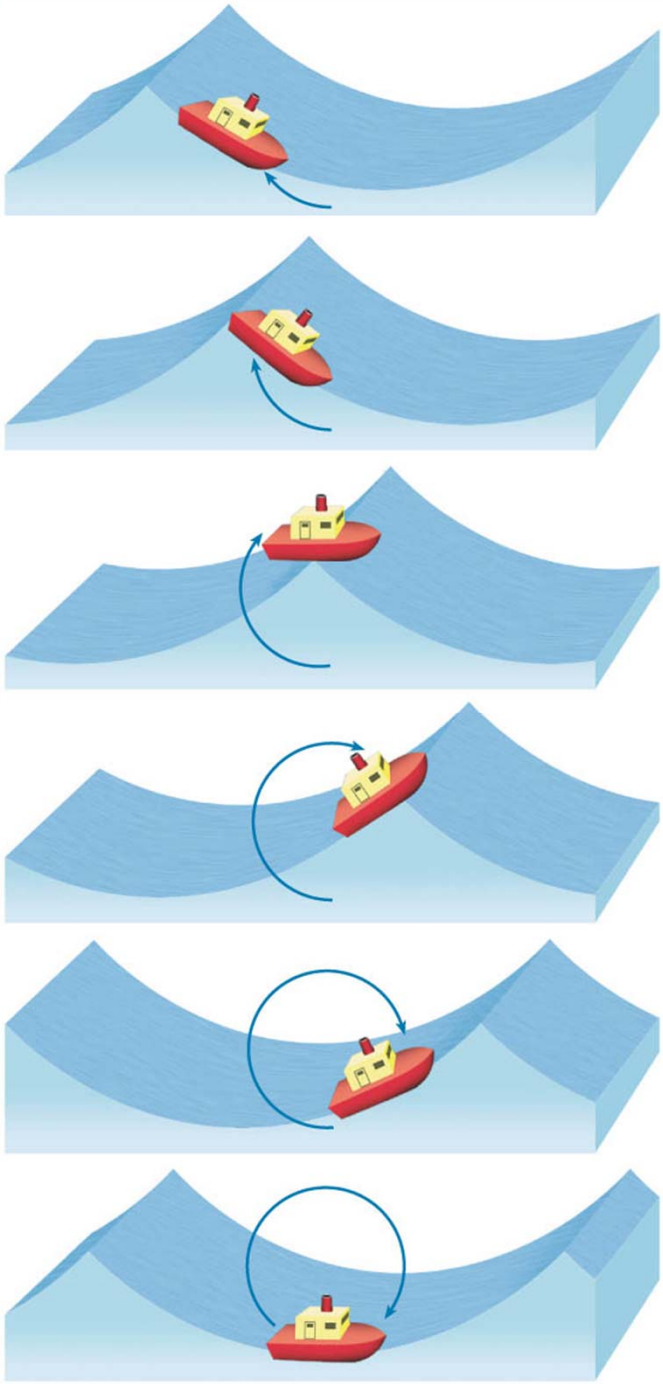


Ocean Water Movements

Types of Waves

- **Oscillation Waves**
  - **Located in open ocean**
  - **Water stays in one location – wave energy moves forward- the water passes energy along by moving in a circle**
  - **Swells are generated in windy areas**

10_08



Ocean Water Movements

Types of Waves

- **Transition Waves (Breakers)**
  - **Waves near shore – at a depth of less than ½ of wavelength**
  - **As wave interfaces with shore bottom it begins to slow down – wave length shortens and wave height increase**
  - **Water moves forward onto shore**

Changes That Occur When a Wave Moves onto Shore

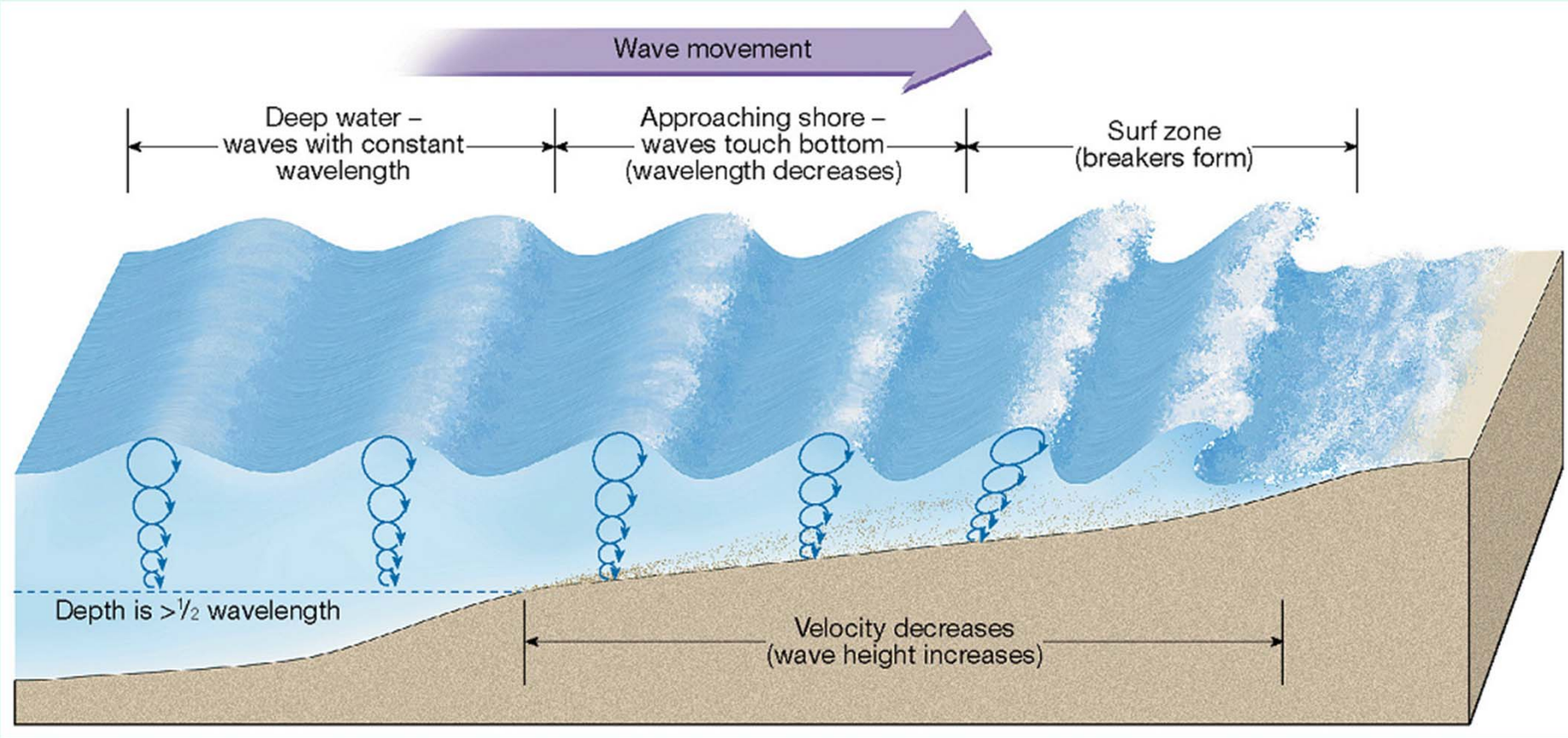


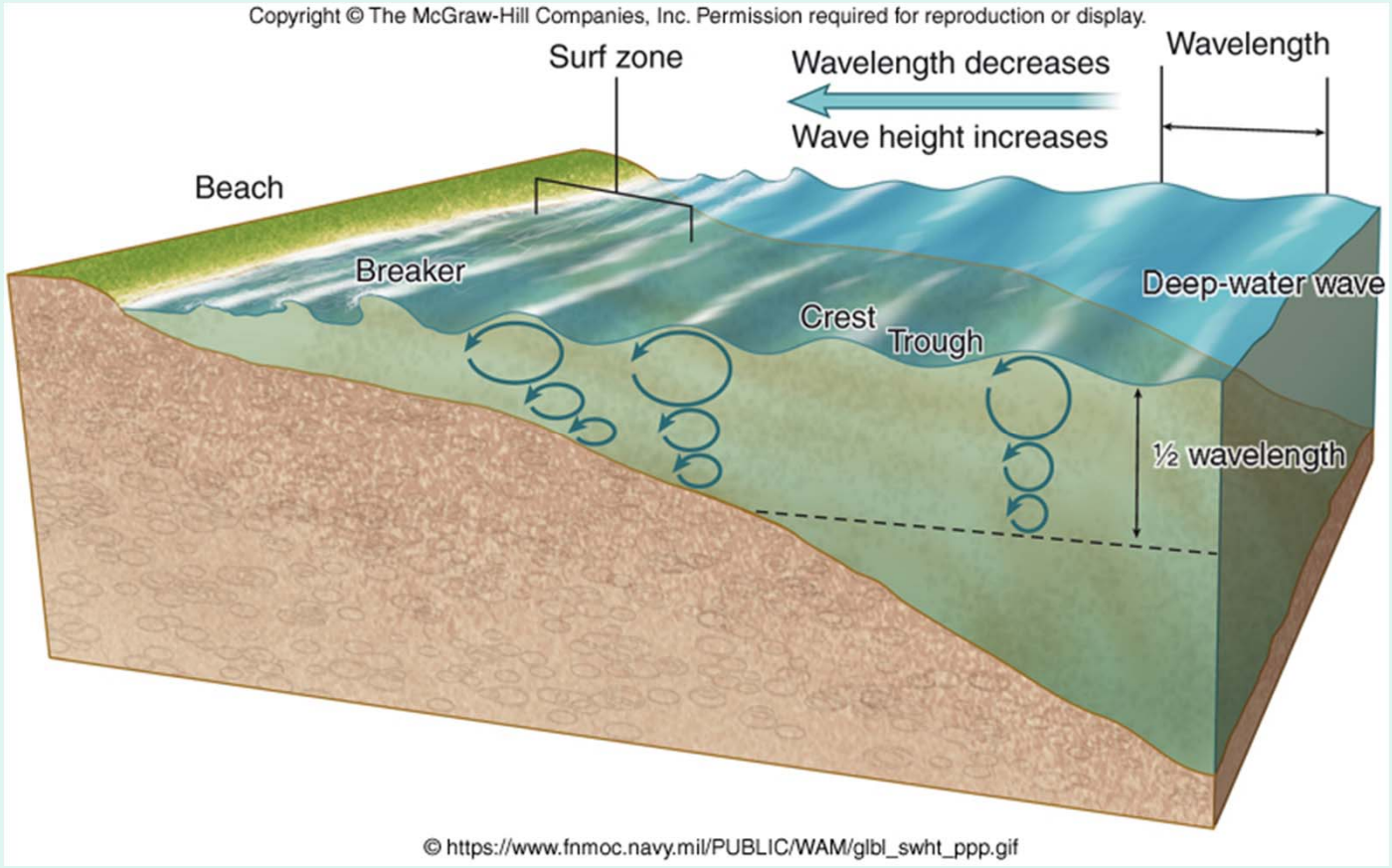
Figure 10.9

Wave Action

As a wave approaches shore and shallower water it is slowed by friction, its length decreases, and it becomes taller and steeper.

Wave eventually collapses due to over-steepening (breaker).

Water actually moves forward here.

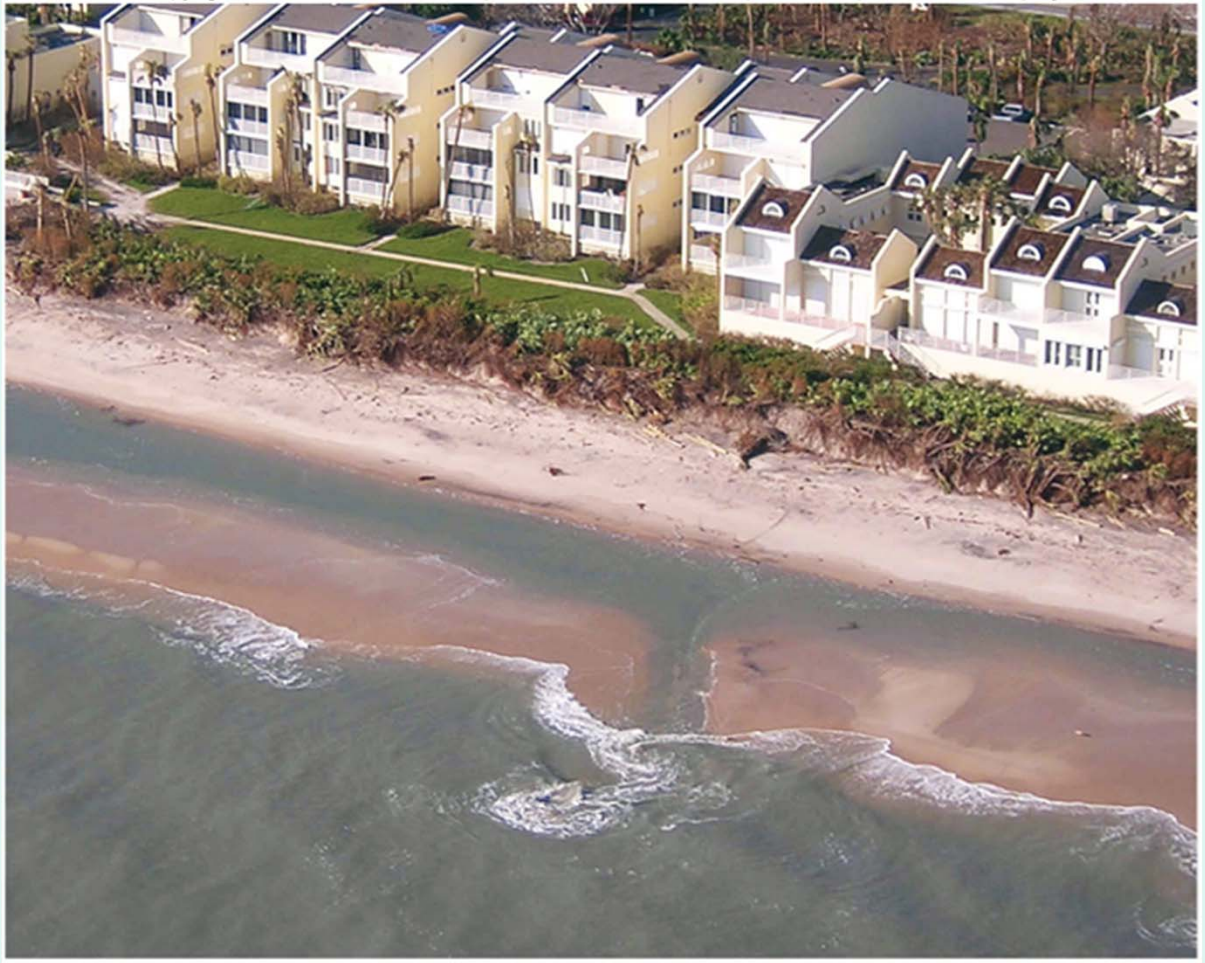



0 %
Loading

Big Waves

Wave Action

Rip Currents – Narrow currents of water flowing through gaps in sandbars lying just offshore.



b.

© NOAA

Beaches and Shoreline Processes

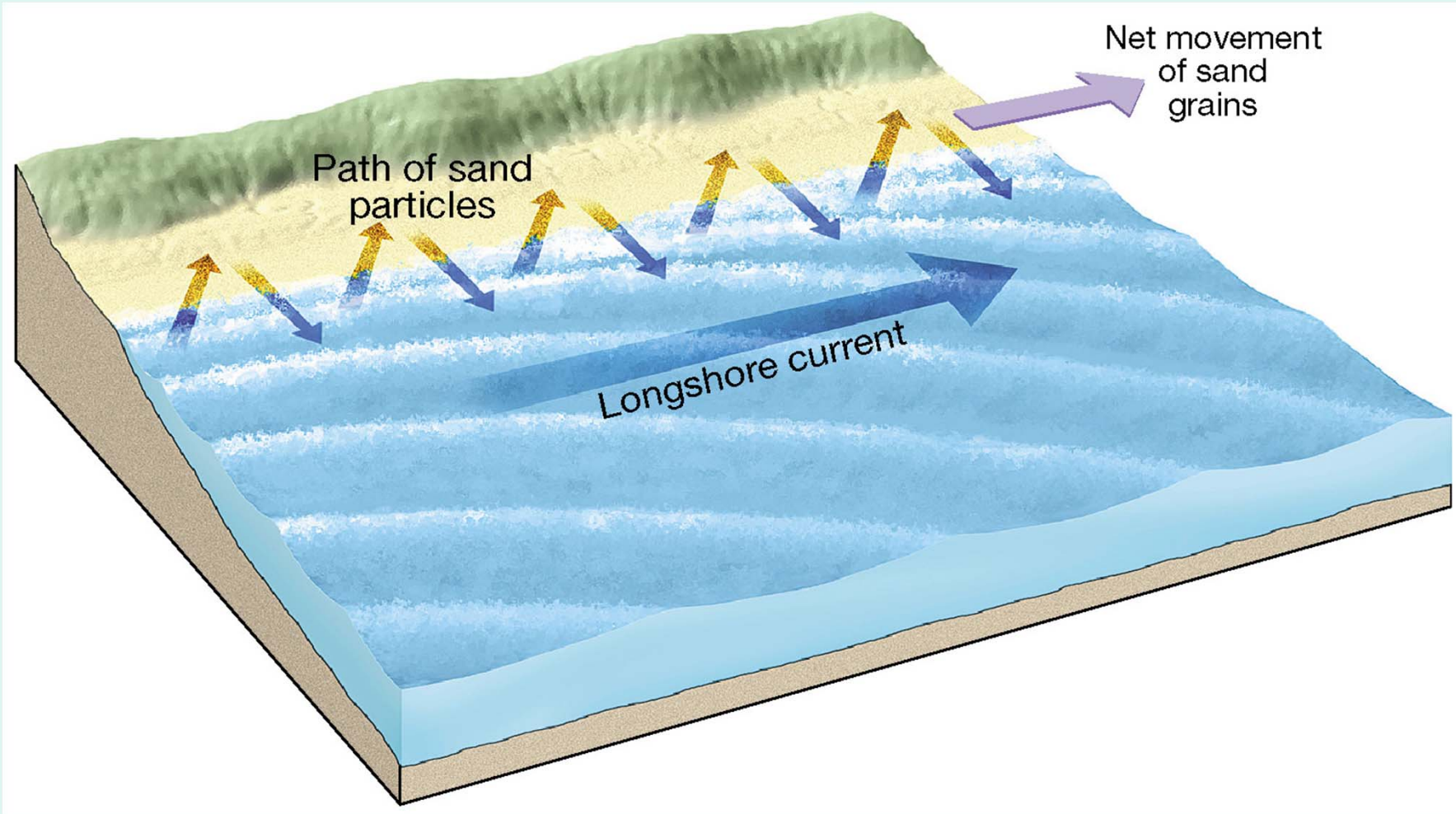
- **Beaches are composed of whatever material is available**
  - **Some beaches have a significant biological component**
  - **Material does not stay in one place**
- **Wave erosion**
  - **Caused by**
    - **Wave impact and pressure**
    - **Breaks down rock material and supplies sand to beaches**

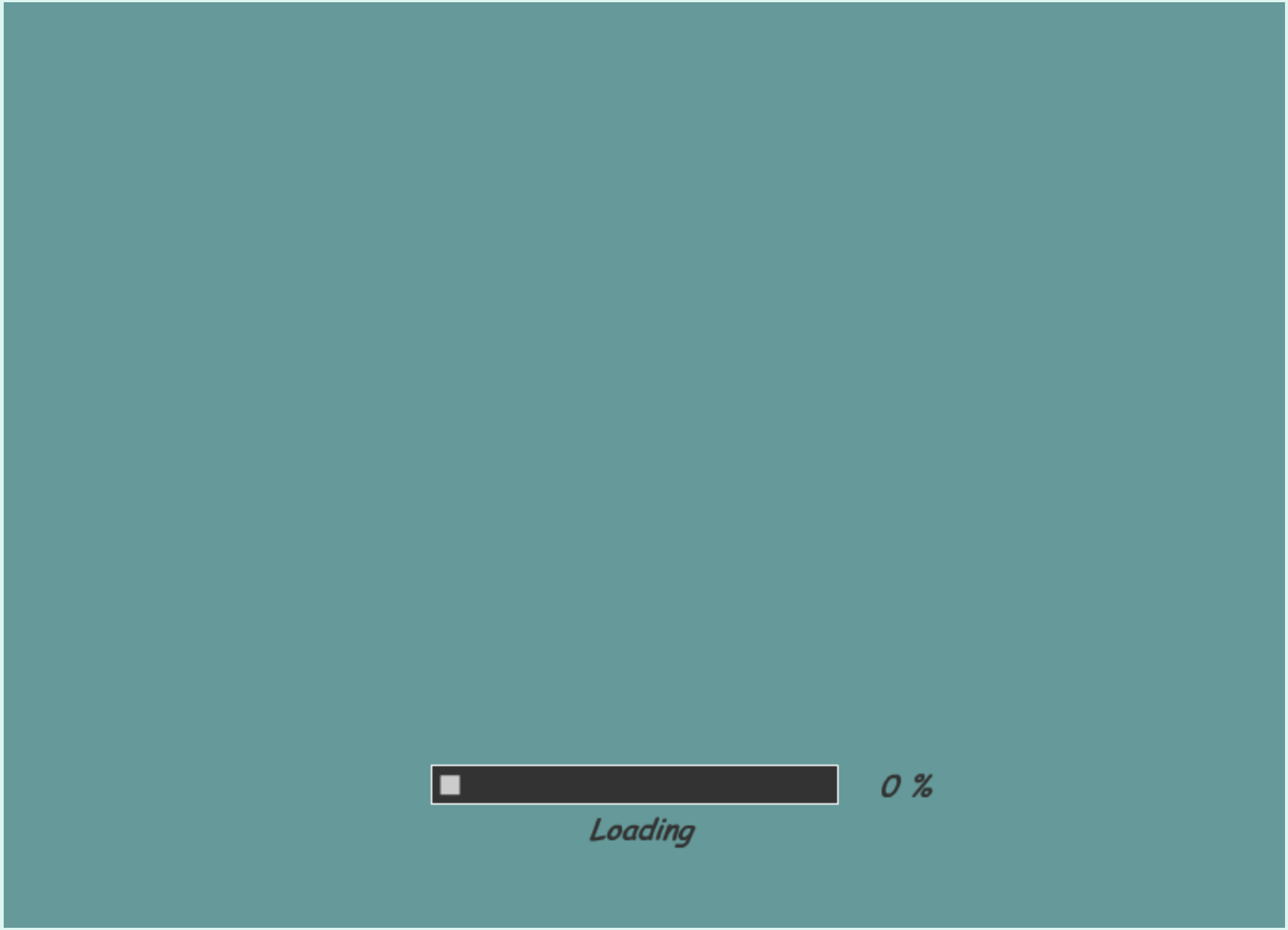
Beaches and Shoreline Processes

Beaches and Shoreline Processes

- **Longshore transport**
  - ***Beach drift*—Sediment moves in a zigzag pattern along the beach face**
  - **Longshore current**
    - **Current in surf zone**
    - **Flows parallel to the shore**
    - **Moves substantially more sediment than beach drift**

Beach Drift and Longshore Currents




0 %
Loading

Beaches and Shoreline Processes

- **Wave refraction**
  - **Bending of a waves**
  - **Wave arrives parallel to shore**
  - **Results**
    - **Wave energy is concentrated against the sides and ends of the headland**
    - **Wave erosion straightens an irregular shoreline**

Wave Refraction Along an Irregular Coastline

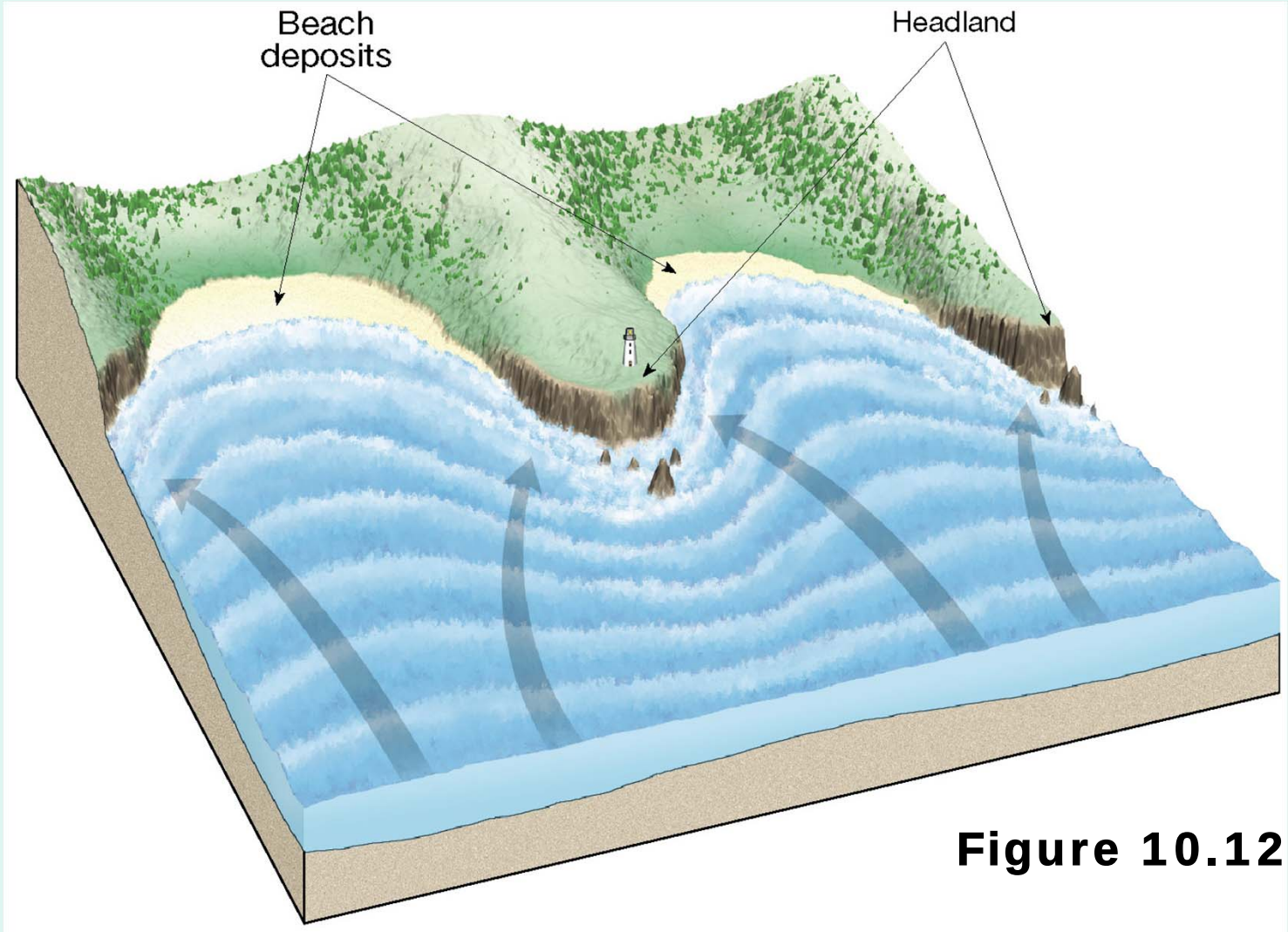


Figure 10.12


0 %
Loading

Wave Refraction Along an Irregular Coastline

Shoreline Features

Erosional features

- ***Wave-cut cliff***
- ***Wave-cut platform***
- ***Marine terraces***
- **Associated with headlands**
  - **Sea arch**
  - **Sea stack**

Shoreline Features

Erosional features

Sea Arch

Figure 10.18 Sea arch

Sea Stack

Sea stack

Shoreline Features

- **Depositional features**
  - ***Spit* —A ridge of sand extending from the land into the mouth of an adjacent bay with an end that often hooks landward**
  - ***Baymouth bar* —A sand bar that completely crosses a bay**
  - ***Tombolo*—A ridge of sand that connects an island to the mainland**

SPIT

a.

© D.A. Rahm/Easterbrook Photo/ Image Center

- *Spit* – sand bar partially blocking a landform
- *Baymouth Bar* – sand bar that completely blocks a channel

The bay at Puget Sound, Washington. This narrow spit may become a baymouth bar.

Baymouth Bar

Aerial View of a Spit and Baymouth Bar Along the Massachusetts Coastline

Tombolo

Shoreline Features

- **Depositional features**
  - **Barrier islands**
    - **Mainly along the Atlantic and Gulf Coastal Plains**
    - **Parallel the coast**
    - **Originate in several ways**

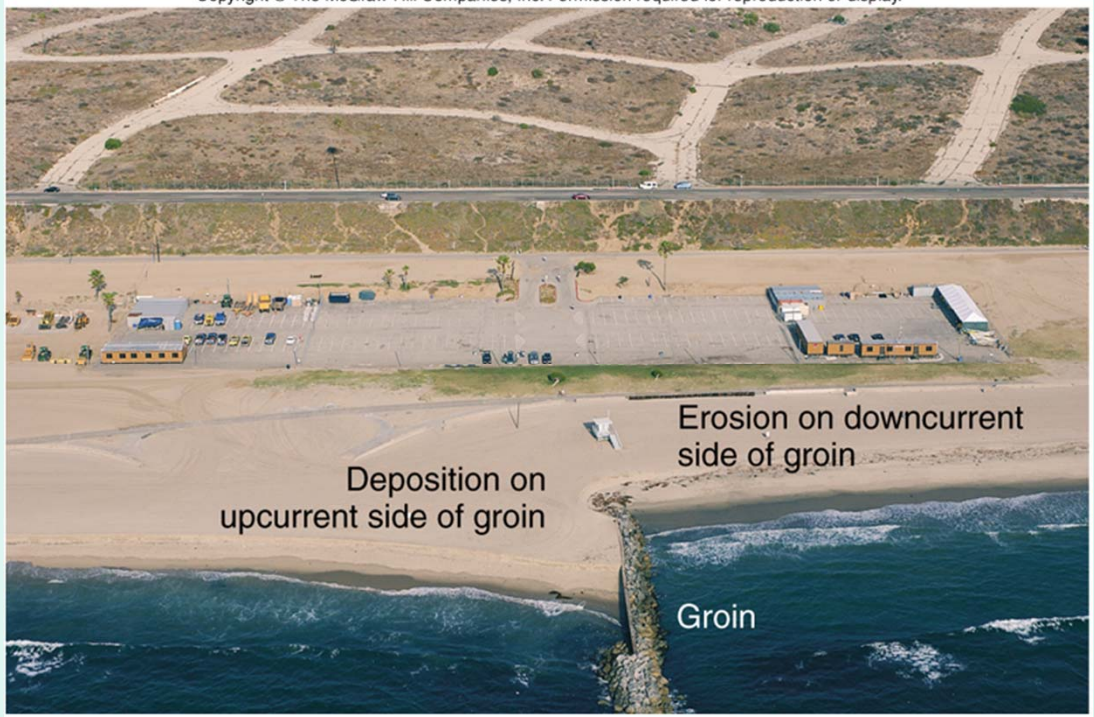
Stabilizing the Shore

- **Responses to erosion problems**
  - ***Stabilization*—Building structures**
    - ***Groins* —Barriers built at a right angle to the beach that are designed to trap sand**
    - ***Breakwaters*—Barriers built offshore and parallel to the coast to protect boats from breaking waves**
    - ***Seawalls*—Armors the coast against the force of breaking waves**

Shoreline Protection

Groins – wall-like structures built perpendicular to the shoreline as barriers to longshore currents

- Causes deposition on upcurrent side, but erosion on downcurrent side

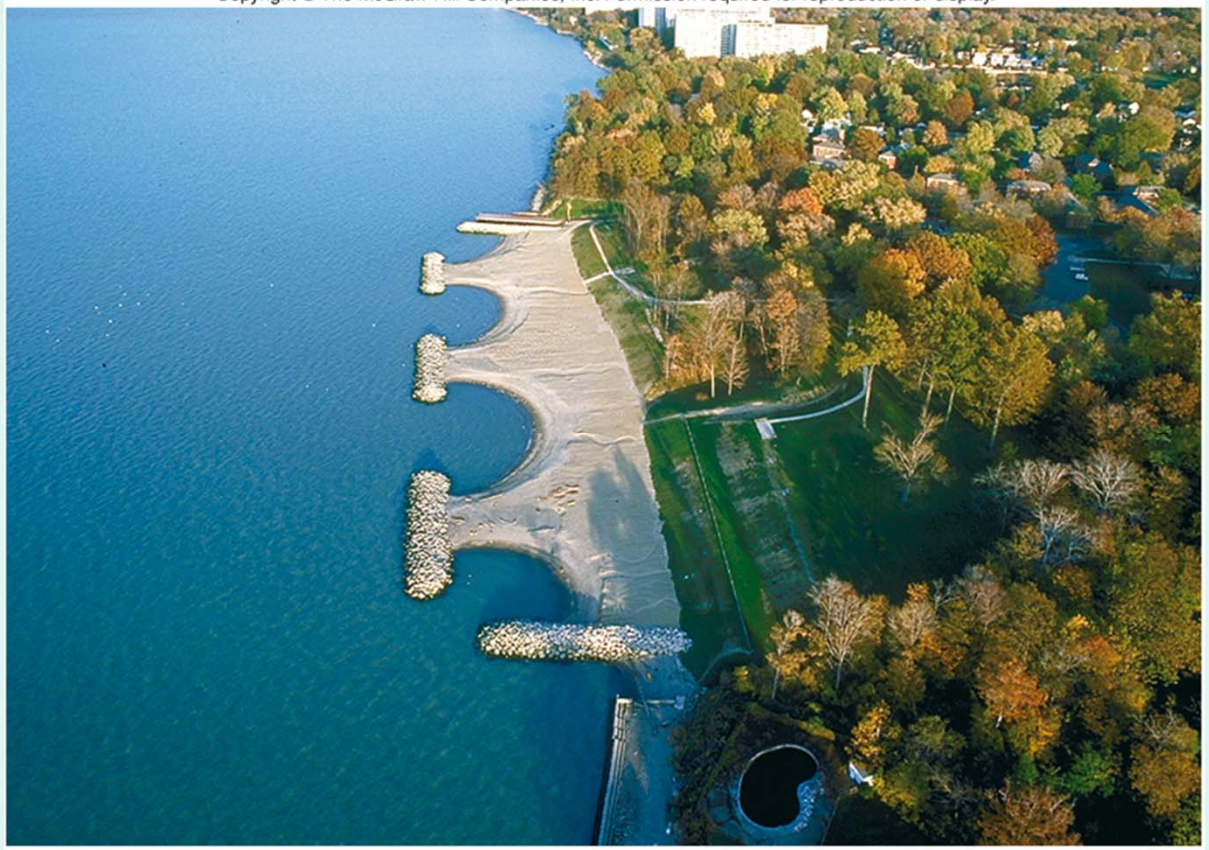


Shoreline Protection

Breakwaters – barriers built offshore to protect part of the shoreline

- Slow the waves and allow the beach to grow behind them

Unprotected parts of the shoreline often erode more quickly.



© US Army Corps of Engineers


0 %
Loading

Stabilizing the Shore

- **Responses to erosion problems**
  - **Alternatives to hard stabilization**
    - ***Beach nourishment*** **by adding sand to the beach system**
    - **Relocating buildings away from beach**

Miami Beach
Beach Nourishment

Before

After

Stabilizing the Shore

- **Erosion problems along U.S. Coasts**
  - **Atlantic and Gulf Coasts**
    - **Development occurs mainly on *barrier islands***
      - **Face open ocean**
      - **Receive full force of storms**
    - **Development has taken place more rapidly than our understanding of barrier island dynamics**

Stabilizing the Shore

- **Erosion problems along U.S. Coasts**
  - **Pacific Coast**
    - **Characterized by relatively narrow beaches backed by steep cliffs and mountain ranges**
    - **Major problem is the narrowing of the beaches**
      - **Sediment for beaches is interrupted by dams and reservoirs**
      - **Rapid erosion occurs along the beaches**

Coastal Classification

- **Shoreline classification is difficult**
- **Classification based on changes with respect to sea level**
  - ***Emergent coast***
    - **Caused by**
      - **Uplift of the land, or**
      - **A drop in sea level**

Emergent coast

- ***Wave-cut cliff***
- ***Wave-cut platform***
- ***Marine terraces***

Coastal Classification

- **Classification based on changes with respect to sea level**
  - ***Submergent coast***
    - **Caused by**
      - **Land adjacent to sea subsides, or**
      - **Sea level rises**
    - **Features of a submergent coast**
      - **Highly irregular shoreline**
      - ***Estuaries* —Drowned river mouths**

Major Estuaries Along the East Coast of the United States