Environmental Science, 15e

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7

Climate and Biodiversity

Core Case Study: Coral Reefs

- Coral reefs are an example of mutualism
  - Composed of tiny polyps and single-celled algae (zooxanthellae)
- Reefs grow slowly and are susceptible to:
  - Damage due to soil runoff that blocks sunlight needed by the algae for photosynthesis
  - Fluctuations in water temperatures
  - Acidic water that can dissolve the shells of the corals

Why Should We Care About Coral Reefs?

- Climate change can stimulate all three problems and kill coral reefs
- What are the two major long-term threats to coral reefs?
- Why are reefs important centers of biodiversity?

7.1 What Factors Influence Climate?

- Incoming solar energy
- The earth's rotation
- Global patterns of air and water circulation
- Gases in the atmosphere
- The earth's surface features (topography)

The Earth Has Many Different Climates

- Weather and climate are not the same
  - Weather: short range (daily) changes in precipitation, humidity, wind speed, cloud cover
  - Climate: long term pattern of atmospheric conditions over hundreds or thousands of years
- The earth has many climatic regions, often determined by ocean currents

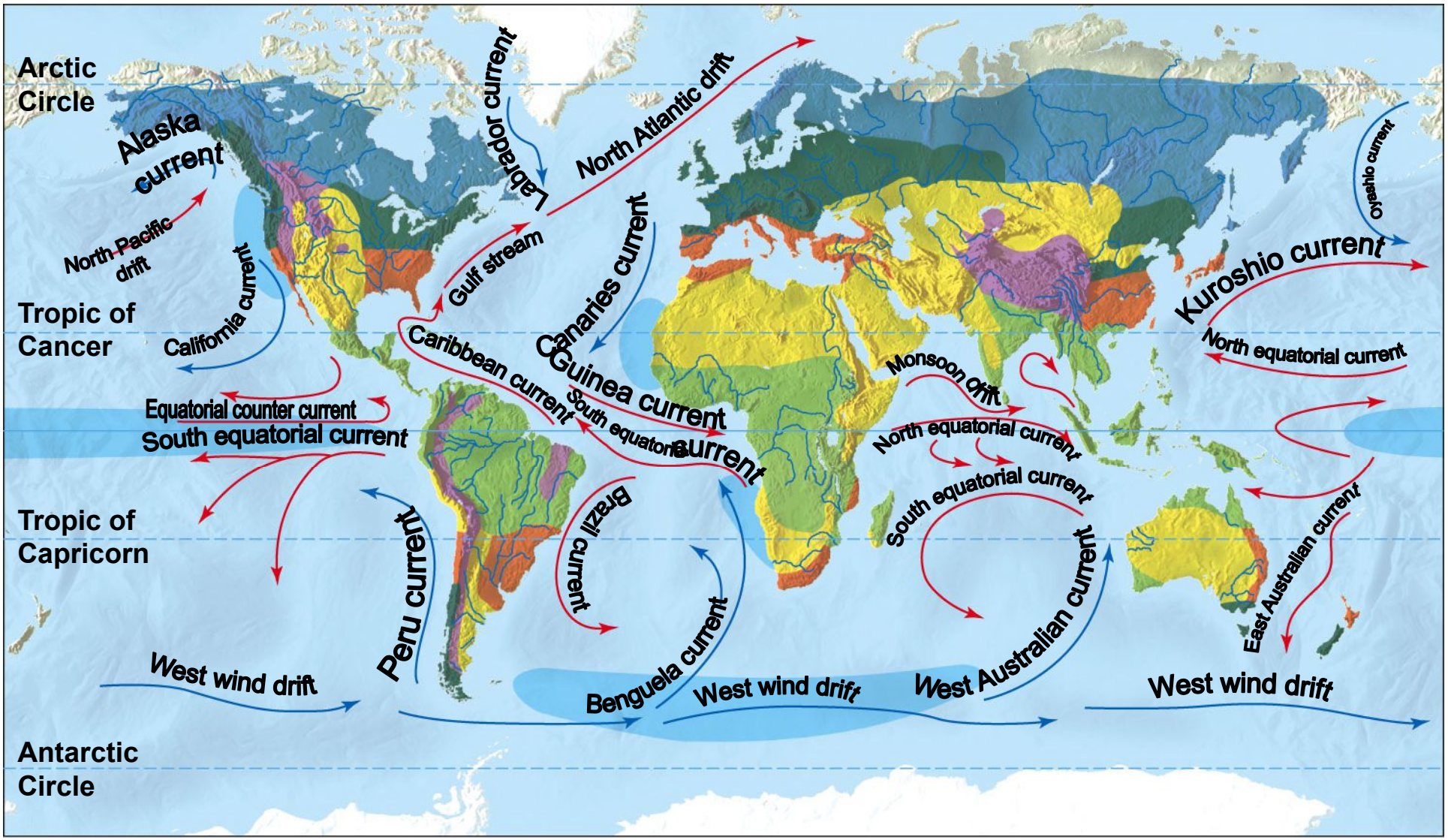
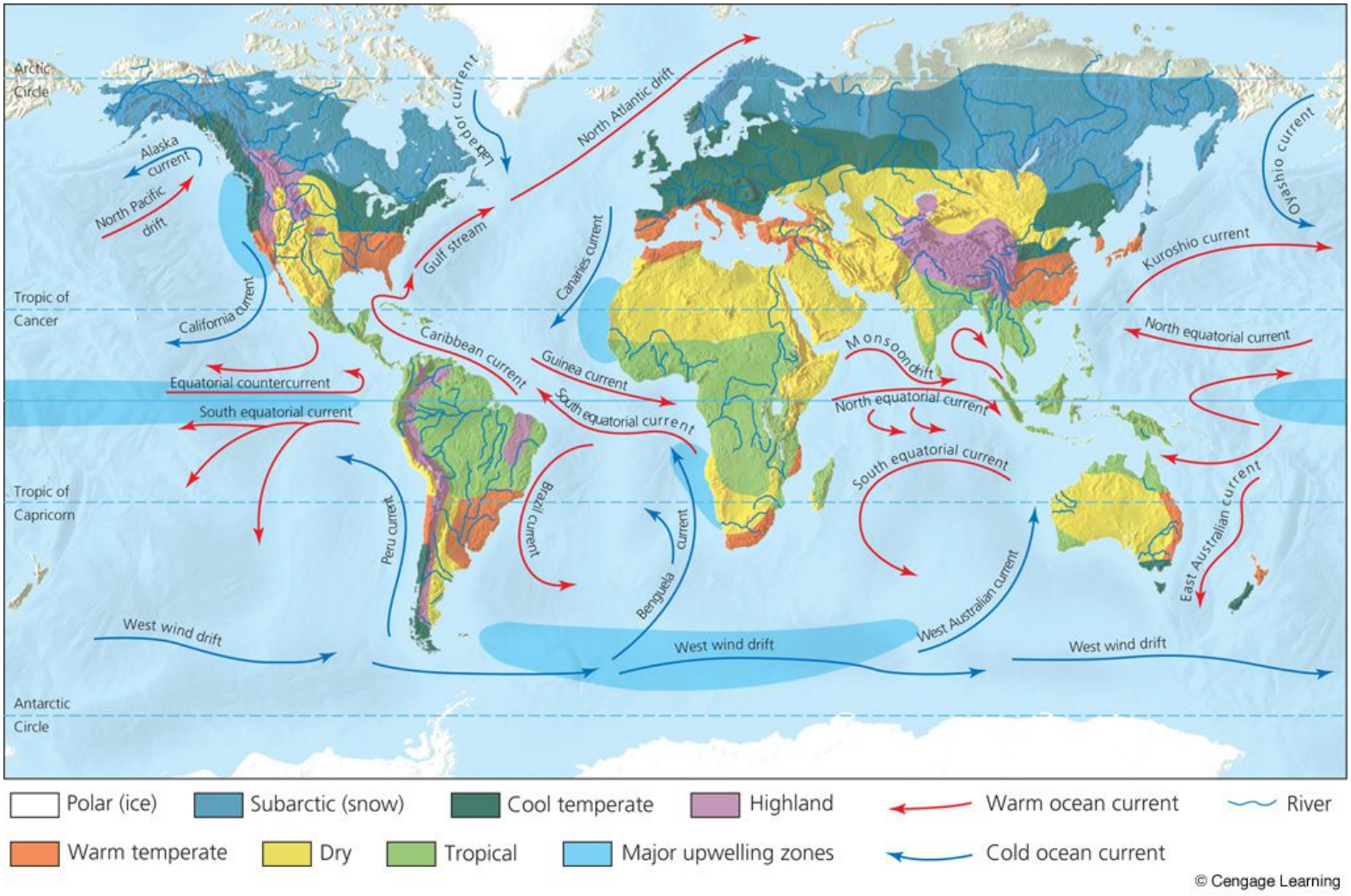


Fig. 7-2, p. 123

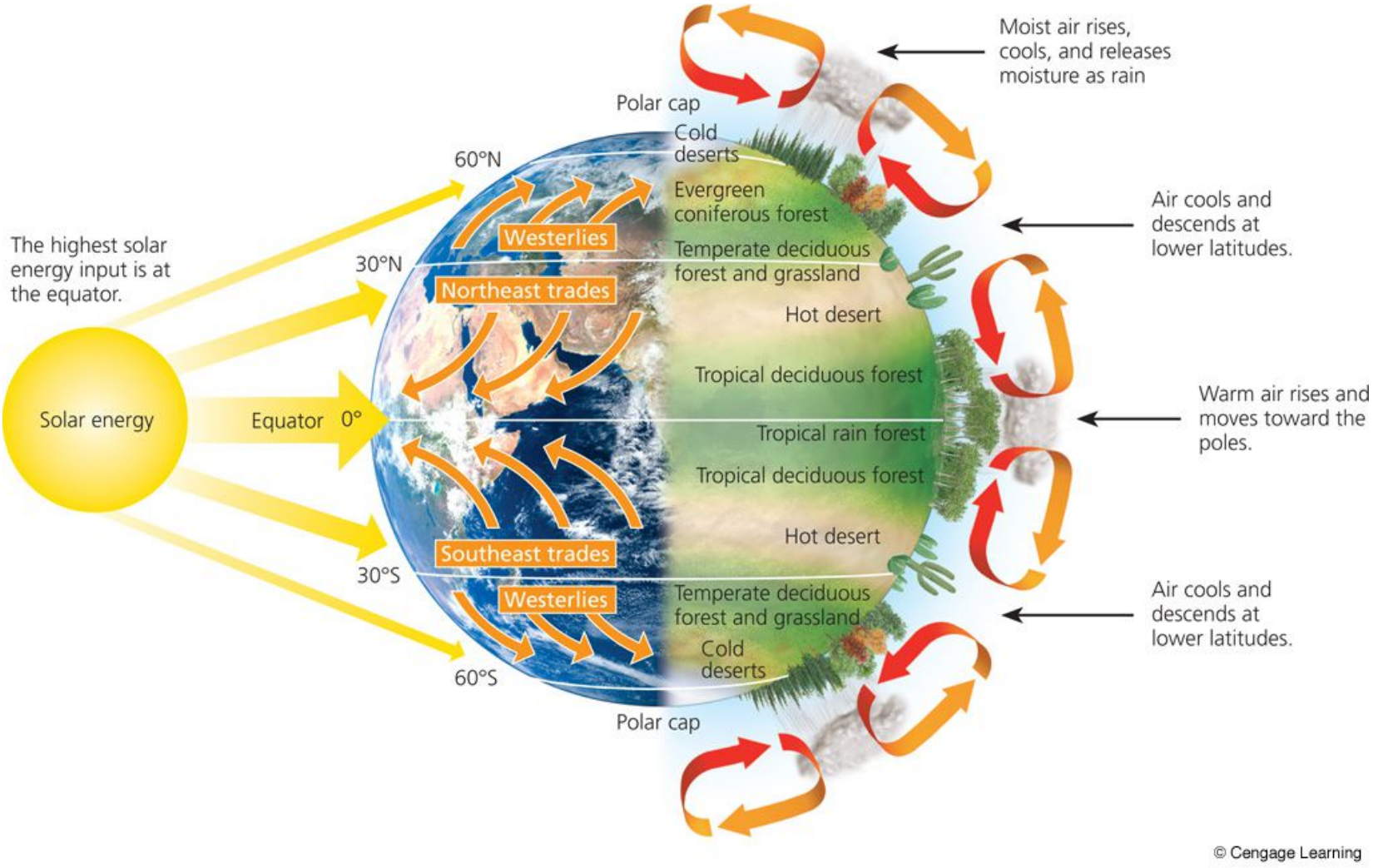
The Earth's Current Climate Zones



Air Circulation Patterns and Ocean Currents

- Both distribute heat and precipitation unevenly over the earth, causing climatic variation
- What factors affect air circulation in the lower atmosphere?
  - Uneven solar heating of the earth's surface
  - Rotation of the earth on its axis – the Coriolis effect
  - Properties of air, water, and land

Global Air Circulation



The Oceans and the Atmosphere are Strongly Linked

- Prevailing winds and the Coriolis effect drive ocean currents in circular patterns
- El Nino-Southern Oscillation or ENSO
  - When prevailing winds in the tropical Pacific Ocean weaken and change direction, altering large scale weather patterns for one or two years over at least two-thirds of the planet

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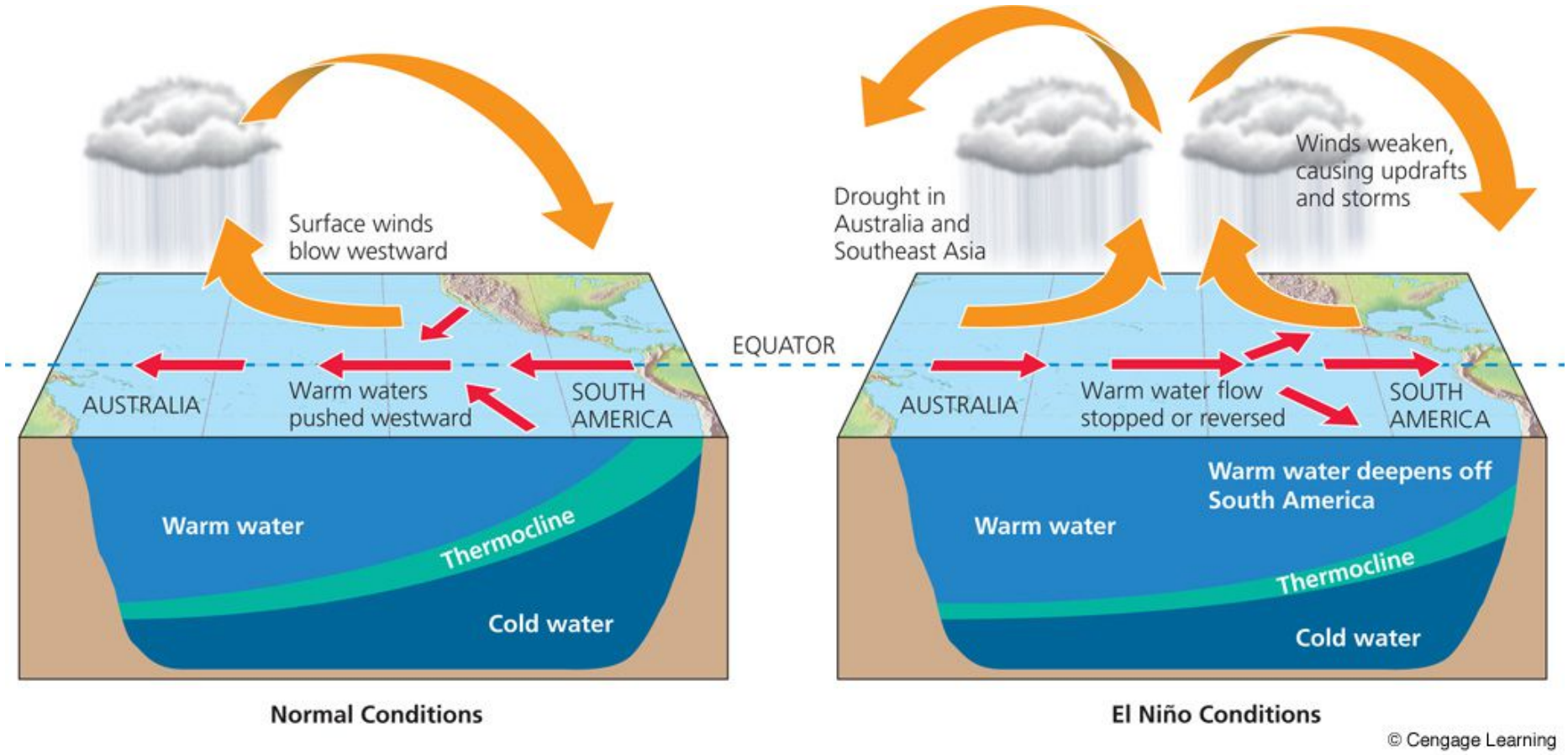


Greenhouse Gases Warm the Lower Atmosphere

- Solar energy flows to the earth
  - Some is reflected back to space and some is absorbed by greenhouse gases which warm the lower atmosphere (greenhouse effect)
- Human activities (production and burning of fossil fuels, clearing crops) emit greenhouse gases into the atmosphere that can eventually change the climate

Earth's Surface Features Affect Local Climates

- Mountains can interrupt the flow of winds and affect storms – the rain shadow effect
- Cities can also have microclimates as they absorb heat

7.2 What Are the World's Terrestrial Ecosystems? How Do We Affect Them?

- Biome and ecosystem formation is driven by long term differences in precipitation and temperature over time
- Human activities interfere with ecosystem and economic services provided by these biomes

Climate Helps To Determine Where Terrestrial Organisms Can Live

- The formation of specific ecosystems (deserts, grasslands, and forests) is due to:
  - Differences in average annual precipitation and temperature
  - Air circulation patterns and ocean currents
- Climate and vegetation vary both in latitude and elevation

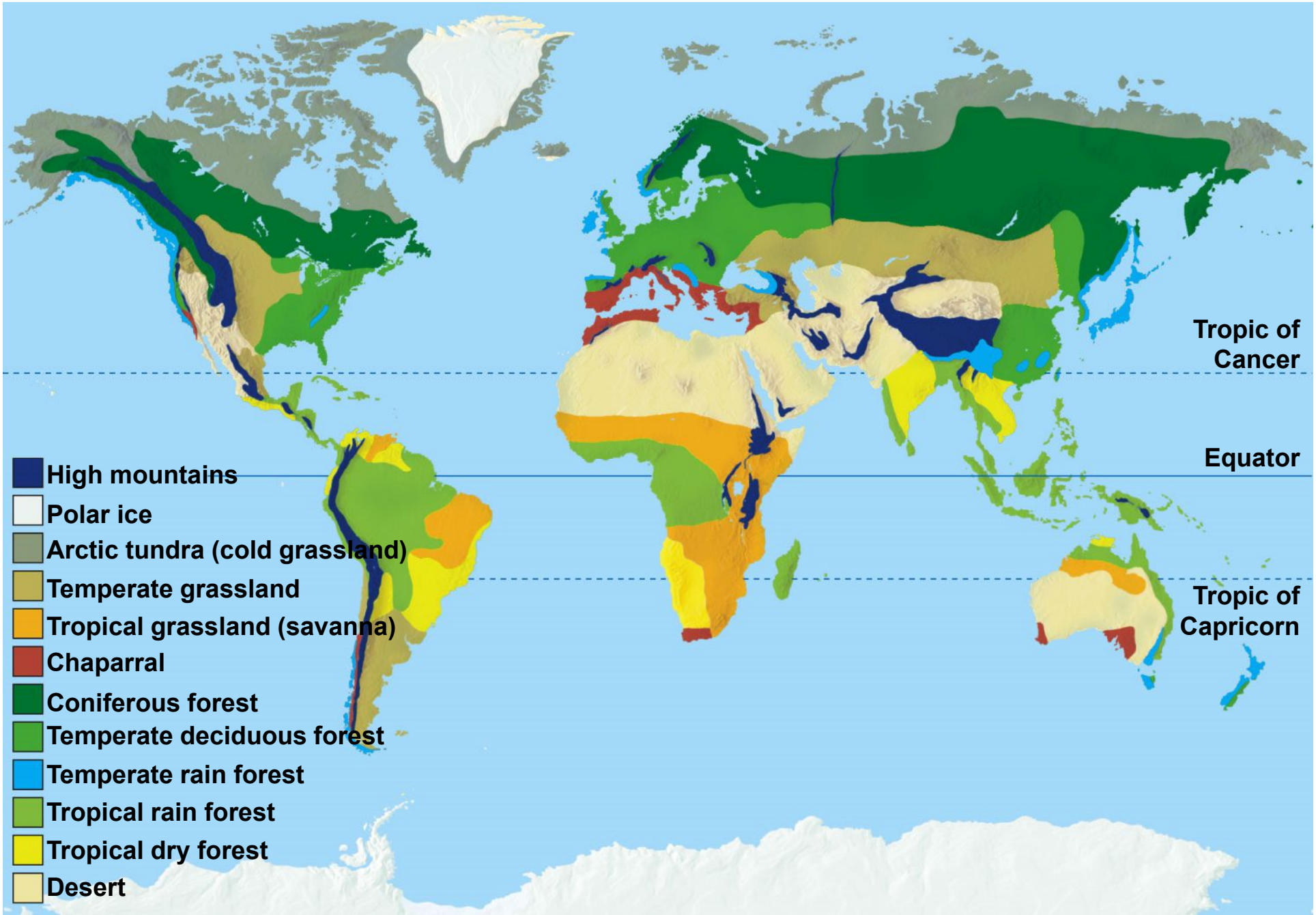
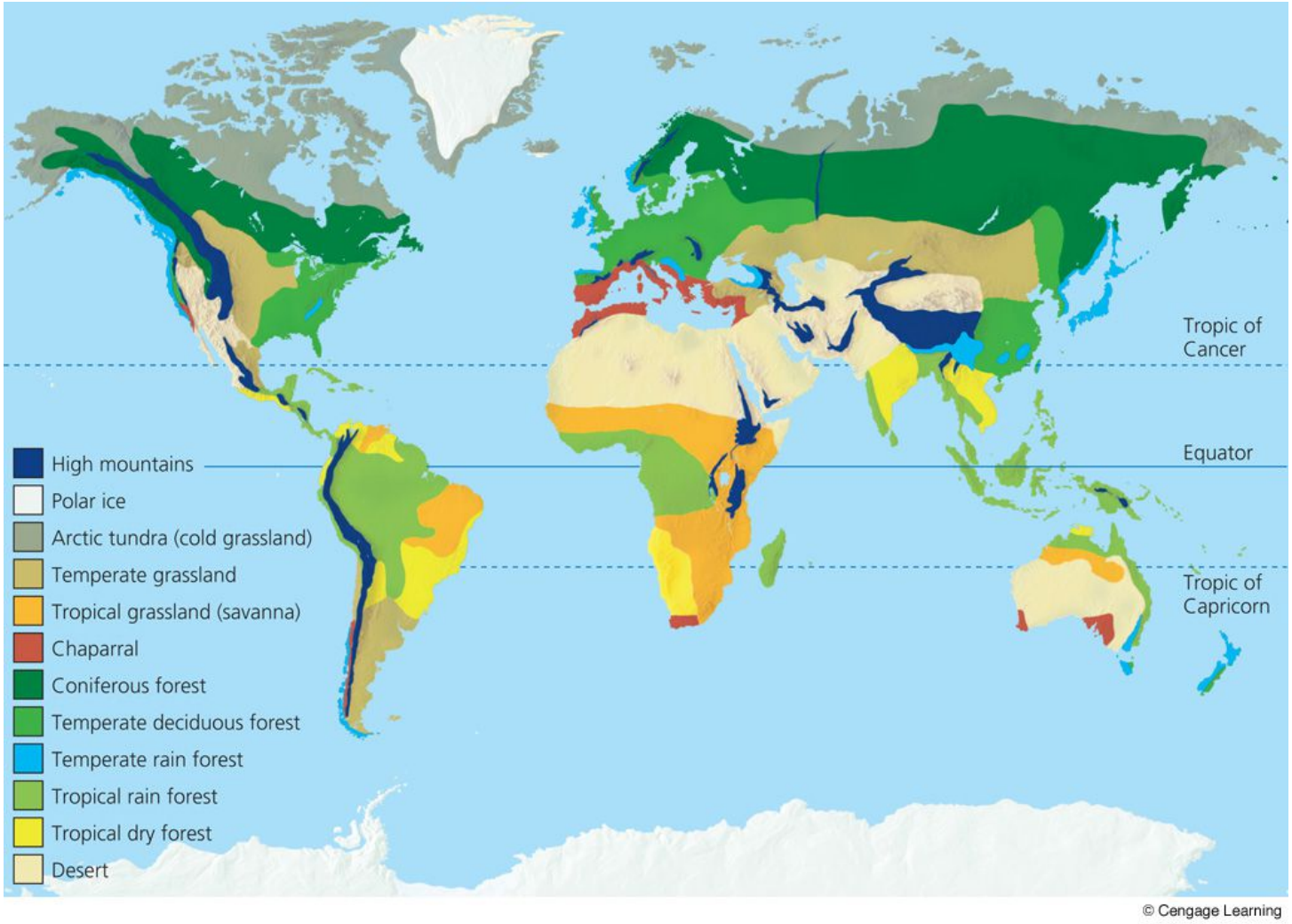

Tropic of Cancer
Equator
Tropic of Capricorn
High mountains
Polar ice
Arctic tundra (cold grassland)
Temperate grassland
Tropical grassland (savanna)
Chaparral
Coniferous forest
Temperate deciduous forest
Temperate rain forest
Tropical rain forest
Tropical dry forest
Desert

Fig. 7-9, p. 128

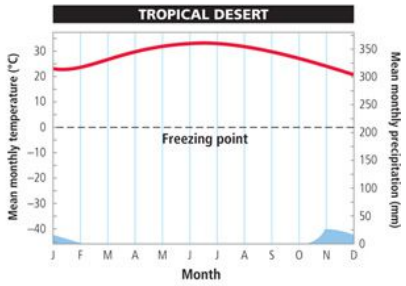
The Earth's Major Biomes

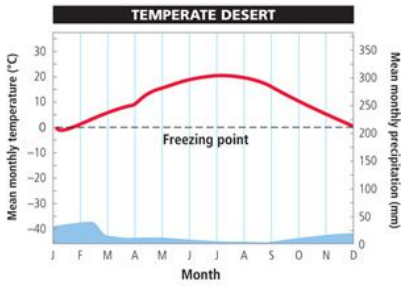


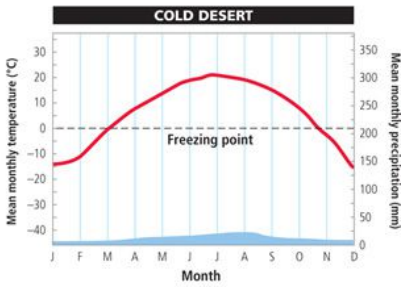
Deserts and Grasslands

- The three major types of deserts
  - Tropical, temperate, and cold
- Desert ecosystems are fragile because they have low rainfall and slow plant growth
- The three major types of grasslands
  - Tropic, temperate, and cold

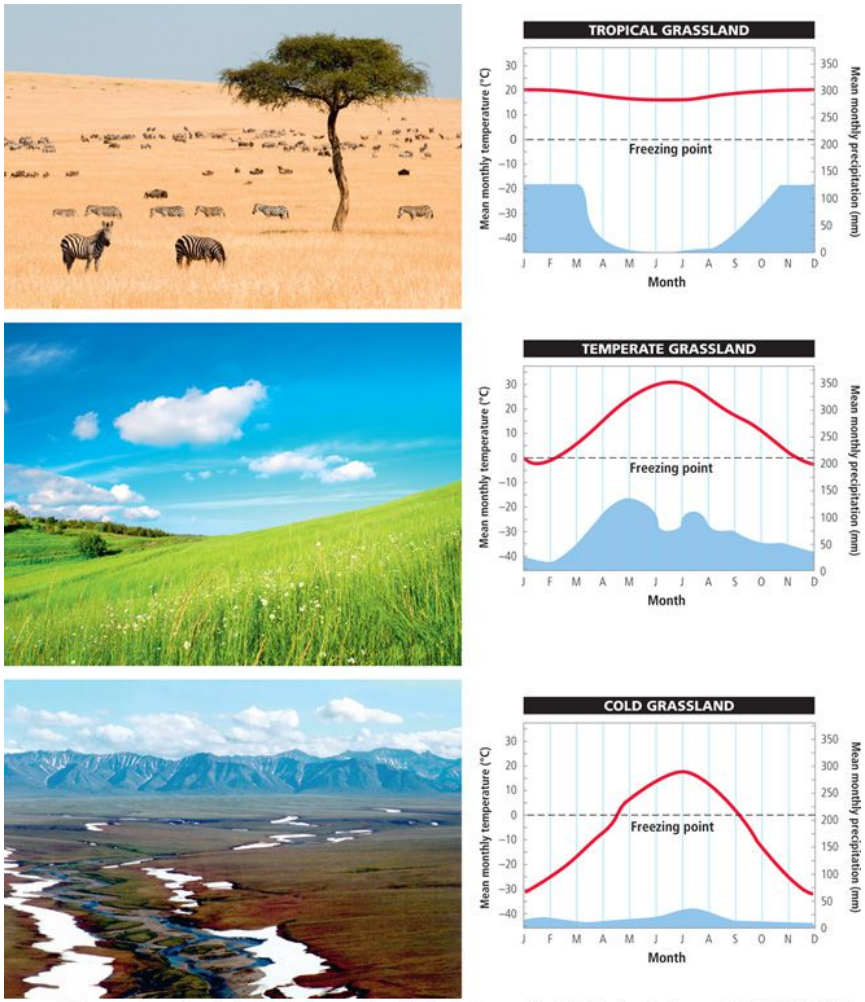
Tropical, Temperate, and Cold Deserts







Tropical, Temperate, and Cold (Arctic Tundra) Grasslands



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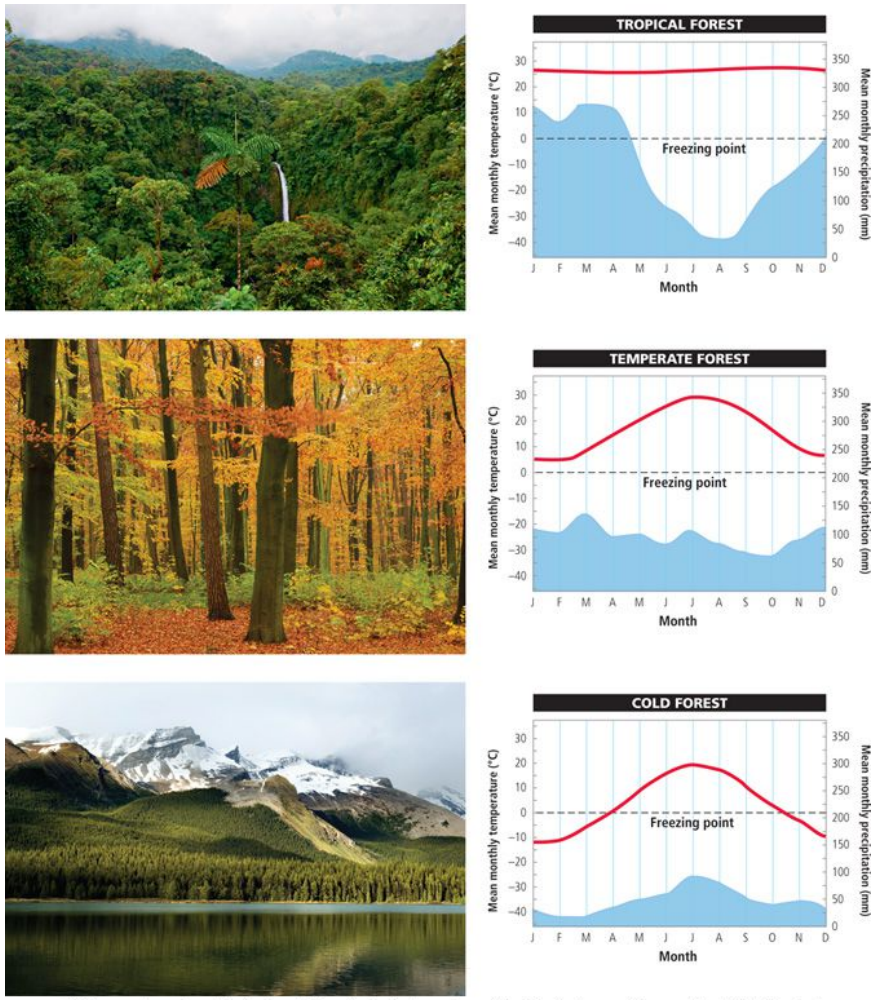
Forests

- The three major types of forests:
  - Tropical (near the equator)
  - Temperate (deciduous and coastal coniferous forests)
  - Cold forests (northern coniferous forests in the higher latitudes

Tropical, Temperate, and Cold (Northern Coniferous, or Boreal) Forests



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Forest Covered Mountains Play Important Ecological Roles

- Much of the world's population depends on mountains for fresh water
- Mountains can be islands of biodiversity that are surrounded by areas of less diversity
  - They often have endemic species found nowhere else on the earth

Humans Have Disturbed Much of the Earth's Land

- About 60% of terrestrial ecosystems are degraded or used unsustainably
- How long can we degrade these terrestrial forms of natural capital without permanently altering ecosystems and the world's economies?

The Impact of Human Activities

Natural Capital Degradation

Major Human Impacts on Terrestrial Ecosystems

Deserts	Grasslands	Forests	Mountains
Large desert cities	Conversion to cropland	Clearing for agriculture, livestock grazing, timber, and urban development	Agriculture
Destruction of soil and underground habitat by off-road vehicles	Release of CO_2 to atmosphere from burning grassland	Conversion of diverse forests to tree plantations	Timber and mineral extraction
Depletion of groundwater	Overgrazing by livestock	Damage from off-road vehicles	Hydroelectric dams and reservoirs
Land disturbance and pollution from mineral extraction	Oil production and off-road vehicles in arctic tundra	Pollution of forest streams	Air pollution blowing in from urban areas and power plants
			Soil damage from off-road vehicles

7.3 What Are the World's Marine Aquatic Ecosystems? How Do We Affect Them?

- Humans are disrupting the vital ecosystem and economic services provided by oceans

Water Covers Most of the Planet

- Marine biomes, called aquatic life zones, are either salt or fresh water in nature
- Biodiversity in aquatic biomes is determined largely by salinity
  - Marine life zones (oceans, estuaries, coastal wetlands, and coral reefs)
  - Freshwater life zones (lakes, rivers, streams and wetlands)

Oceans Provide Vital Ecosystem and Economic Services

- Water temperature, dissolved oxygen, and the availability of food, light and nutrients determine the abundance and location (water depth) marine organisms
- The three major marine life zones
  - Coastal zones (estuary and coastal wetlands)
  - The open ocean
  - The ocean bottom

Marine Systems

Natural Capital

Marine Ecosystems

Ecosystem Services

Oxygen supplied through photosynthesis

Water purification

Climate moderation

CO_2 absorption

Nutrient cycling

Reduced storm damage (mangroves, barrier islands, coastal wetlands)

Biodiversity: species and habitats

Economic Services

Food

Energy from waves and tides

Pharmaceuticals

Harbors and transportation routes

Recreation and tourism

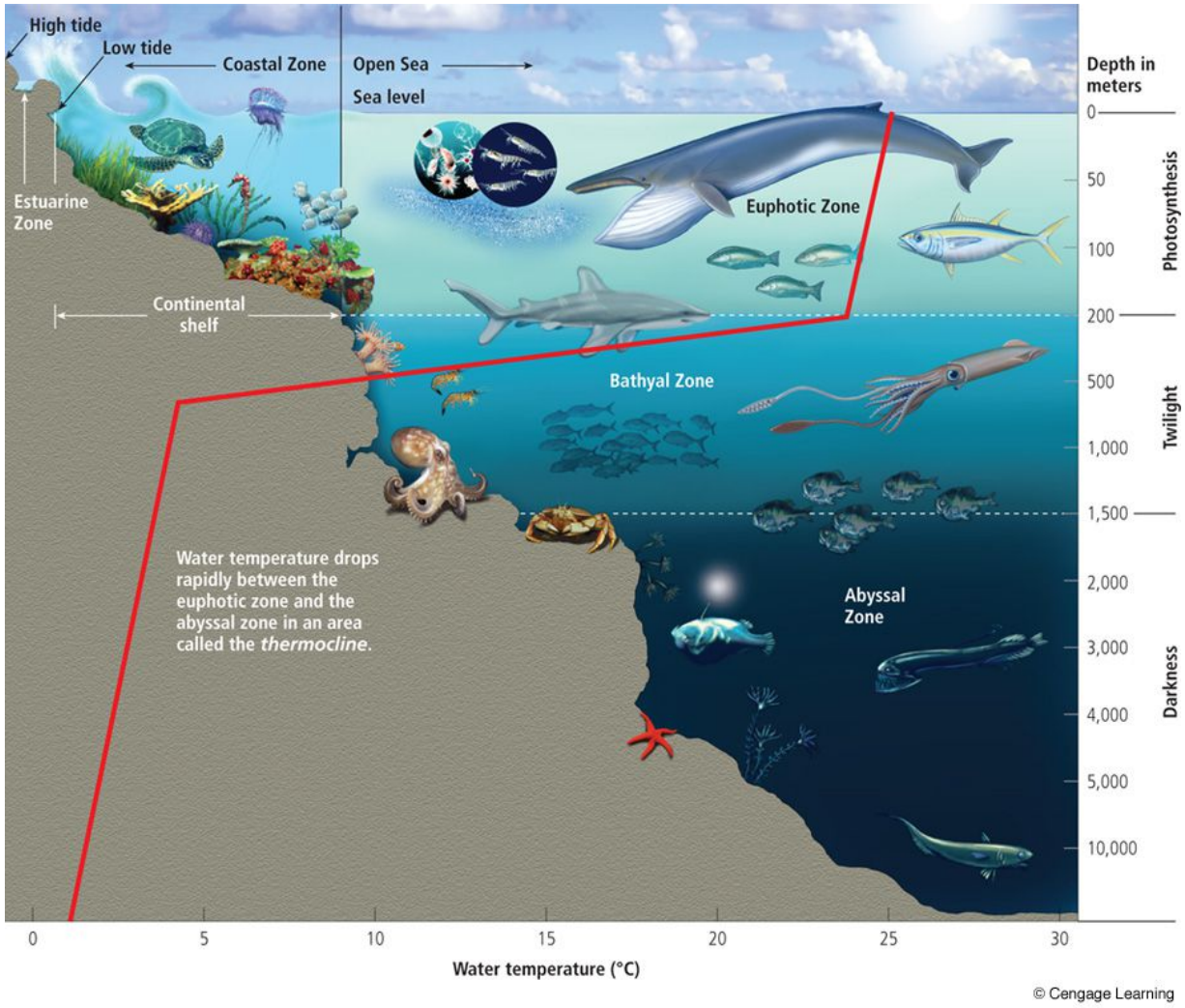
Employment

Minerals

What Services Do Coastal Aquatic Ecosystem and Economic Provide?

- Filter out toxic pollutants, excess plant nutrients, and sediments, and absorbs other pollutants
- Provide food habitats, and nursery sites
- Reduce storm damage and coastal erosion by:
  - Absorbing waves
  - Storing excess water produce by storms and tsunamis

Major Life and Vertical Zones in an Ocean



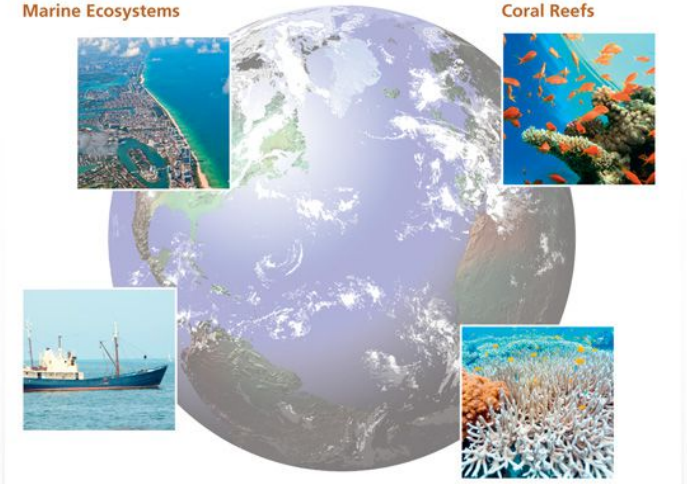
The Open Sea and the Ocean Floor Host a Variety of Species

- Open sea, beyond the continental shelves, is divided into three vertical zones
  - Euphotic zone (brightly lit with photoplankton that carry out photosynthesis, large fish)
  - Bathyal zone (dimly lit, no photosynthesis producers, smaller animals)
  - Abyssal zone (dark and very cold)

Human Impacts on Coral Reefs

Natural Capital Degradation

Major Human Impacts on Marine Ecosystems and Coral Reefs



Half of coastal wetlands lost to agriculture and urban development	Ocean warming
Over one-fifth of mangrove forests lost to agriculture, aquaculture, and development	Rising ocean acidity
Beaches eroding due to development and rising sea levels	Rising sea levels
Ocean-bottom habitats degraded by dredging and trawler fishing	Soil erosion
At least 20% of coral reefs severely damaged and 25–33% more threatened	Algae growth from fertilizer runoff
	Bleaching
	Increased UV exposure
	Damage from anchors and from fishing and diving

7.4 What Are the World's Freshwater Ecosystems? How Do We Affect Them?

- Human activities are disrupting the freshwater environments (lakes, rivers and wetlands), just as they are disrupting the oceans

Water Stands in Some Freshwater Systems and Flows in Others

- Freshwater aquatic zones have both
  - Standing bodies of water (lakes, ponds, and inland wetlands) and flowing systems (streams and rivers)
    - Runoff: water that flows into surface waters
  - Surface water: freshwater that flows on or is stored in bodies of water on the surface
    - Watersheds: geographic areas that supply runoff, sediments, and dissolved substances to freshwater systems

Freshwater Systems Provide Ecosystem and Economic Services

Natural Capital

Freshwater Systems

Ecosystem Services		Economic Services
Climate moderation		Food
Nutrient cycling		Drinking water
Waste treatment		Irrigation water
Flood control		Hydroelectricity
Groundwater recharge		Transportation corridors
Habitats for many species		Recreation
Genetic resources and biodiversity		Employment
Scientific information		

Water Stands in Some Freshwater Systems and Flows in Others

- Lakes:
  - Oligotrophic lakes: typically deep and steep sided with a small nutrient supply
  - Eutrophic lakes: typically shallow and murky with a large supply of nutrients
- Cultural eutrophication
  - Process that adds human generated pollution and agricultural runoff (excess nutrients and sediments) to these water systems

Freshwater Streams and Rivers Carry Large Volumes of Water

- Streams flow through source, transition, and floodplain zones
- Streams that flow downhill shape the land by erosion
  - Cutting valleys, creating sand, gravel, and soil
- Deltas
  - Form at the mouth of the river from sediment the river has carried from upstream, from which wetlands form

Freshwater Inland Wetlands

- Vital sponges that provide free ecosystem and economic services
  - Filter/degrade waste and pollution
  - Limit flooding and erosion
  - Sustain stream flow during droughts
  - Help to recharge ground water aquifers
  - Maintain biodiversity
  - Provide recreation for humans

Human Activities are Disrupting and Degrading Freshwater Systems

- Water flow is restricted by dams and canals
- Water flow is disrupted by flood control levies and dikes
- Agricultural and urban pollution is added to freshwater systems
- Wetlands have been drained or filled in to grow crops or for construction of buildings

Additional Case Study: Reef Balls

- Coral reefs are some of the world's oldest, most diverse, and productive ecosystems
  - These centers of aquatic biodiversity are being damaged at an alarming rate by both human activity and natural phenomena (hurricanes, tsunamis, etc.).
- The invention of the reef ball provides one solution to coral reef degradation through habitat loss

Additional Case Study: Reef Balls

- Why build reefs with reef balls?
- Do they have an application beyond coral reefs?
- Who can get involved in reef restoration with reef balls?

Reef Balls and the Three Big Ideas

- Reef balls are useful worldwide, independent of climate
  - Even though climatic differences determine the type and location of the earth's biomes
- Reef ball usage is increasing globally in a large variety of ocean environments
- Reef balls restore and increase important ecosystem and economic services