2

Physical Processes and World Regions

Chapter Outline

2.1 Geologic Processes and Landforms
2.2 Patterns of Climate and Vegetation
2.3 Biodiversity
2.4 The World's Oceans
2.5 Global Climate Change

Objectives

This chapter will enable you to:

- Understand the tectonic forces behind some of the world's major landforms and natural hazards
- Recognize consistent global patterns in the distribution of vegetation types and climates
- Identify the natural areas most threatened by human activity and explain how natural habitat loss may endanger human welfare
- Appreciate the important roles of the world's oceans
- Describe the potential impacts of global climate change and international efforts to prevent them

Key Terms & Concepts

adaptation
Alliance of Small Island States
aquaculture
atmosphere
biodiversity
biodiversity hot spots
biological diversity
biomes
- boreal forest/taiga
- desert and xeric shrubland
- flooded grasslands and savannas
- Mediterranean forests, woodland, and scrub
- Montane grasslands and shrublands
- temperate grasslands,

savanna, and shrublands
- temperate mixed forest
- tropical coniferous forest
- tropical and subtropical dry broadleaf forest
- tropical and subtropical grasslands, savannas, and shrublands
- tropical and subtropical moist broadleaf forest

biosphere
cap-and-trade system
carbon sequestration
carbon sink
clean development mechanism
climate
- desert
- humid continental
- humid subtropical
- ice cap
- mangroves
- maritime or marine west coast Mediterranean
- oceanic
- polar climate
- semiarid
- subarctic
- tropical rain forest
- tropical savanna
- tundra
- undifferentiated highland

climate change refugees
coniferous trees
continental drift
cryosphere
emission-trading system
fault
faulting
fish farming
geologic hot spot
Green Revolution
geo-engineering
greenhouse effect
greenhouse gases
- carbon dioxide (CO_2)
- chlorofluorocarbons (CFCs)
- methane
- nitrous oxide

hydrologic cycle
hydrosphere
Intergovernmental Panel on Climate Change (IPCC)
International emissions trading
Joint implementation
Köppen climate classification system (KCC)
Kyoto Protocol
lithosphere
mitigation
monoculture
moment magnitude scale (MMS)
Montreal Protocol
plates
natural hazard
plates
plate tectonics
polar amplification
potential evaporation
precipitation
Reducing Emissions from Deforestation and Forest Degradation (REDD)
rifting
Ring of Fire
seafloor spreading
seismic activity
subduction
Subduction zone
tectonic forces
tipping point
trench
tsunami
United Nations Framework Convention on Climate Change
volcanism
weather

Chapter Summary

The Earth's three layers of habitable space are the hydrosphere, atmosphere, and lithosphere. The lithosphere is made up of separate plates that are in motion, a process known as plate tectonics. These movements result in mountain building, volcanic activity, earthquakes, and other consequences that represent natural hazards when they affect people.

Weather refers to atmospheric conditions prevailing at one time and place. Climate is a typical pattern recognizable in the weather of a region over a long period of time. Climatic patterns have a strong correlation with patterns of vegetation and in turn with human opportunities and activities in the environment.

Geographers group local climates into major climate types, each of which occurs in more than one part of the world and is associated with other natural features, particularly vegetation. Geographers recognize 10 to 20 major types of ecosystems or biomes, which are categorized by the type of natural vegetation. Vegetation and climate types are so sufficiently related that many climate types are named for the vegetation types.

Some biomes are particularly important because of their biological diversity—the number of plant and animal species and the variety of genetic materials these organisms contain. Regions where human activities are rapidly depleting a rich variety of plant and animal life are known as biodiversity hot spots, places scientists believe deserve immediate attention for study and conservation.

Oceans cover about 71 percent of the Earth's surface. They play the key role in the hydrologic cycle, sustain large numbers of people through the protein in fish and seafood, and contain valuable mineral resources. The bulk of the world's cargo trade is by sea.

Most of the sun's visible short-wave energy that reaches the Earth is absorbed, but some of it returns to the atmosphere in the form of infrared long-wave radiation, which generates heat and helps warm the atmosphere. This is the Earth's natural greenhouse effect.

The scientific community represented by the United Nations-sponsored Intergovernmental Panel on Climate Change (IPCC) is convinced with 95 percent or greater certainty that human activities, particularly the production of carbon dioxide and other greenhouse gases, are responsible for global warming. Computer-based climate change models use various emissions scenarios for atmospheric carbon dioxide and indicate that the mean global temperature might warm up by an additional 2.7°F to 7°C (1.0°C to 3.7°C). The scientific consensus is that with global warming, the distribution of climatic conditions typical of biomes will shift poleward and upward in elevation, sea levels will rise, and mean global precipitation will increase (but with drought intensified in some areas). According to the IPCC, these trends are already observable.

Polar amplification with melting of ice that opens up more blue water and melts more ice, represents a positive feedback loop that could become irreversible. The point at which an impact becomes irreversible is a tipping point.

There are two approaches to confronting climate change. Mitigation measures aim to avoid the adverse impacts of climate change in the long term, and are usually associated with more-developed countries (MDCs). Adaptation measures are designed to cope with and reduce the

unavoidable impacts of climate change in the short and medium terms, and are usually associated with less-developed countries (LDCs).

In the policy arena, the European Union countries tend to exert the strongest leadership in fighting climate change. The United States has often been slow or unwilling to take strong, specific actions. China has tried to be exempted from mandatory steps but, along with the United States, has recently pledged to do more.

The Kyoto Protocol was an international agreement requiring the industrialized countries that ratified it to make substantial cuts in their carbon dioxide emissions to reduce global warming. Mechanisms to make cuts include the Clean Development Mechanisms, Joint Implementation, and Cap and Trade. The United States dropped its support for the treaty. It went into effect for the ratifying countries after Russia ratified it in 2004. Set to expire in 2012., the treaty was extended to 2020. Efforts continued to reduce carbon dioxide emissions, especially in the MDCs and China, and to maximize ways to reduce deforestation, especially in the LDCs. The goal is to keep the mean global temperature below 3.6°F (2°C) increase.

Lecture Outline

2.1 Geologic Processes and Landforms

- Plate tectonics – continental drift
    - Volcanoes
    - Earthquakes
    - Tsunamis
    - Richter scale
    - Faults

2.2 Patterns of Climate and Vegetation

- Weather
- Climate
- Precipitation
- Climates / biomes

2.3 Biodiversity

- The Importance of Biodiversity
- Biodiversity hotspots

2.4 The World's Oceans

- Why Should We Care About Oceans?
- Hydrosphere
- Hydrologic cycle

2.5 Global Climate Change

- The Greenhouse Effect
    - Greenhouse gases
        - Carbon dioxide
    - Kyoto Protocol
- The Effects of Global Warming
    - A warmer climate overall, but not warmer everywhere
    - Rising sea levels
    - More precipitation overall, but also more drought
    - Shifting biomes, with impacts on plant and animal species
    - Shifting biomes, with impacts on agriculture
    - More climate-related extreme events with significant impacts on people
    - Geopolitical instability and other impacts on human systems
- What Can We Do About Global Climate Change?
    - International panel on climate change (IPCC)
    - Chlorofluorocarbons (CFCs)
    - Ozone layer
    - Montreal Protocol

Lecture Topics

- What is physical geography?
    - Subfields
- Discuss recent tectonic activity: earthquakes, volcanic eruptions, and tsunamis.
- Describe tsunamis and warning systems for them.
- Outline climates and vegetation around the world.
    - Biomes – location and characteristics
- What does the term biological diversity mean?
    - The pros and cons of the Green Revolution
    - Locate and discuss the importance of biodiversity hot spots.
- Why is water the Earth's priceless resource?
- What distinguishes weather from climate?
    - Severe weather
    - Extreme storms
    - Climate change and global warming
        - IPCC
        - Effects of global warming
        - Adaptation or mitigation

Review Questions

1. **What are the three "spheres" of habitable life on Earth?**

   To begin a study of physical processes, one must start with the four life spheres. Lithosphere or rock sphere is associated with tectonic forces. The hydrosphere or water sphere is made up of all the earth's waters. The atmosphere is the layer of gases that surrounds the earth with an emphasis on the first eleven miles up from the surface. The biosphere or ecosphere, which is the global ecological system including all living organisms and their relationships among the lithosphere, hydrosphere, and atmosphere. These four spheres are in a constant state of change, as they interact with each other.

2. **What is plate tectonics, and what are some of the main consequences of tectonic activity?**

   Around 1912, Alfred Wegener proposed an idea called continental drift. In short, it stated that all of the land areas of the world were at one time connected. These land areas broke apart about 225 million years ago and slowly drifted into their current location.

   The Earth's crust is made up of about twelve large plates and about six smaller plates and looks like a cracked eggshell. The movement of these pates is called plate tectonics.

   Two ocean plates moving away from each other (diverging), results in sea floor spreading. When plates collide, this often results in earthquakes and tsunamis. Volcanoes occur most frequently where two plates have collided. An example would be the Ring of Fire around the Pacific Ocean along the west coast of the Unites States. The Pacific Plate bent down as the North American Plates rides over it, resulting in a fault line and the possibility of earthquakes as the two plates grind past each other. When plates collide, the ocean plate usually sinks under a continental plate.

3. **What is the difference between weather and climate?**

   Weather is immediate daily conditions, such as a daily weather forecast. However, climate refers to the long term average of weather conditions for a place over a long period of time.

   a. **What are the main forces that produce precipitation and aridity?**

      Precipitation is the result of air rising and cooling. As warm moist air rises, it cools at the environmental laps rate (-3.6°F per 1,000 feet) stationary or slow rate. For faster moving air, the cooling rate is -5.5°Fper 1,000 feet.

As the temperature drops, the relative humidity increases to the dew point where the air is saturated. Further cooling results in moisture collecting around dust particles (hydroscopic nuclei) to form droplets. These droplets join to produce larger droplets which ultimately fall as rain.

Aridity or deserts are caused by:

- A cold ocean current next to a land mass
- Descending cold dry air around 30° Latitude North or South
- A mountain range that blocks the air and forces it to rise over the mountains; on the leeward side cool dry air descends

4. What are the major climate types and their associated biomes?

Ice cap climates are found at the north and south poles and on the top of tall mountains. In the ice cap biome, vegetation is virtually nonexistent, except in some areas where the ice or snow melts and allows some tundra vegetation to grow.

Subarctic climates have long cold winters. However, the summers in this climate type are short and cool. Coniferous Forests, often called boreal forests or taiga covers much of Northern Russia and thrive in subarctic climates such as the Siberian region. In this type of biome, needle leaf evergreen coniferous trees are present, since this type of plant life can withstand long periods of time when the ground is frozen.

Tundra climates have long cold winters and short cool summers. Vegetation is predominantly mosses, lichens, some shrubs, dwarfed trees, and a few types of grasses.

In a desert climate, dry conditions prevail. Receiving less than ten inches of precipitation annually is the standard criteria to be classified as a desert climate. Thus, vegetation in this type of climate is sparse and if present, usually consists of desert shrubs and cactus.

Areas next to deserts, which get more rain and are more humid, are referred to as transitional zones and called semiarid or steppe areas, grasslands, or temperate grasslands. The vegetation in steppe areas is grass. In a savanna, the grass is tall often three feet high, but in prairies it is much shorter.

In tropical rain forests and tropical savanna climates there are distinct differences. In tropical rain forests, the conditions are hot, with high rainfall, and high humidity; these ideal conditions produce vegetation that is growing every day. Tropical rain forests are generally located near the equator, and have the greatest diversity of plant and animal life on the planet. Although mostly dominated by broadleaf evergreen trees, the major rain forest has four layers:

1. Floor
2. Understory
3. Canopy
4. Emergent

In comparison to tropical rain forests, tropical savannas have a more prolonged dry season

In a tropical deciduous forest, the trees lose their leaves during the drier months, which seems fitting since the name deciduous means seasonal shedding of leaves.

Marine west coast climates are found on the western side of continents. In the United States, they are present in Washington, Oregon, and Northern California. Conifers, redwoods, and sequoia are some examples of vegetation which usually thrives in these humid middle-latitude regions which have mild to hot summers and winters ranging from mild to cold.

Mediterranean climates are most typically found between a marine west coast climate and lower-latitude steppe or desert climate, such as southern Europe and some parts of California. This type of climate usually has a dry summer with the majority of the rain in the winter months. Vegetation in this climate is referred to as a Mediterranean scrub forest or chaparral, with many of the shrubs containing fragrant oils.

The humid subtropical climate is usually found between 20° and 40° latitudes. This type of climate is characterized by hot summers and cool winters with mixed broadleaf and pine trees.

The humid continental climate is farther north and has hot summers and cold winters. Temperatures in this climate are more extreme. Vegetation in this climate type is mostly conifers.

Temperate mixed forests have broadleaf and conifers trees as the main vegetation types. This type of climate is seen in middle-latitude areas with humid subtropical and humid continental climate types. Pine forests on the coastal plains of the southern United States are an example of this climate type.

Undifferentiated highland climates have a range of conditions according to elevation, wind, and sun exposure. The vegetation in an undifferentiated highland climate differs greatly depending upon elevation, degree and direction of slope, and other factors. This type of biome can be seen near mountain ranges in places such as Colorado.

a. Where do they tend to occur on Earth?

Ice Cap Climate – High latitudes; polar; predominantly Antarctica and Greenland

Subarctic Climate – High latitudes; polar; predominantly northern hemisphere; predominantly northern Canada and Russia
Tundra Climate – High latitudes; polar; predominantly northern hemisphere; predominantly northern Canada and Russia
Desert Climate – Low and Middle latitudes; equatorial of Mediterranean climates
Steppe Climate – Low and Middle latitudes; typically borders Desert and Mediterranean climates
Tropical Rain Forest Climate – equatorial and island; typically borders Mediterranean and Desert climates
Tropical Savanna Climate – Low and middle latitudes; typically borders Tropical Rain Forest climates; central and southern Africa, central South America
Marine West Coast Climate – Mid to high latitudes; northwestern United Sates, Northwestern Europe
Mediterranean Climate – Mid latitudes; often found pole ward of Desert climates; southwestern United States, around the Mediterranean Sea, southern Australia
Humid Subtropical Climate – Mid latitudes; southeastern United States, southeastern Asia
Humid Continental Climate – Mid latitudes; central and eastern United States, northeastern Asia
Undifferentiated Highland Climate - Mid latitudes

5. Where are the biodiversity hot spots?

Biodiversity hot spots are regions where human activities are rapidly depleting the rich variety of plant and animal life.

a. In what kinds of locations and biomes do many of them occur?

Conservation International has identified thirty-four priority sites for biodiversity hot spots. Most of these areas are in tropical rainforest and are islands that tend to have high biodiversity and often endemic species because species on them have evolved in isolation to fulfill special roles in these ecosystems and because human pressures on island ecosystems are particularly intense.

6. What important roles do the world's oceans play, and what are their major resources?

With about 70% of the earth being covered by water, the hydrosphere (oceans and freshwater sources) plays a large and critical role in the hydrologic cycle, in many of the Earth's physical processes, and sustains many people. Simply put, the oceans are invaluable.

One of the most important roles played by the ocean is the hydrologic cycle, which happens as evaporation over the oceans increases the humidity in the air. As this warm moist air blows over land, the air rises, and cools, resulting in rain. Part of this rain runs off and makes its way back to the ocean.

Another vital role of the oceans is serving as a food source. About a billion people in the world rely mainly on fish for their protein. Thus, in order to sustain life for many, humans rely on the oceans.

Oceans also provide energy and raw materials that people use. Oceans provide an avenue for transportation. Oceans are also responsible for a large tourist industry.

a. In what ways are these resources threatened?

About 15 percent of the world's population is fed by the oceans. In the last thirty years, there has been 40% growth worldwide in demand for seafood. Although seafood could be a renewable resource, some countries refuse to agree to set and enforce limits. Countries like Japan have refused to follow the United Nations list of endangered Species. Thus, some scientists predict a collapse of all commercial fish species by 2050.

7. What are the most prominent changes that are anticipated or underway in the warming world? apparent long-term effects on the Earth's atmosphere can be attributed to modern technology?

A warmer climate overall, but not warmer everywhere.
Geographically, the impacts of climate change are expected to be greatest at the higher latitudes, especially in the polar realms. Permafrost, the frozen ground typical of the Polar Regions, has been melting at an alarming rate. Impacts on marine environments are also profound in these high latitudes. The IPCC estimates that the average coverage of Arctic sea ice has shrunk about 3 percent per decade since 1978.

Rising sea levels.
As global temperatures rise, so do sea levels, for two reasons: melting glacial ice on land is pouring more water into the sea, and as seawater warms, it occupies more volume, known as "thermal expansion".

More precipitation overall, but also more drought.
Higher temperatures will cause more evaporation from the world's oceans, resulting in more precipitation, but it will be unevenly distributed. The IPCC forecasts more precipitation in the higher latitudes, but less precipitation, with intense and longer

droughts, and with serious implications for supplies of drinking water, in the lower latitudes.

Shifting biomes, with impacts on plant and animal species.
With warming, the distribution of climatic conditions typical of biomes is shifting poleward around the world and upward in mountainous regions. Many animal species will be able to migrate to keep pace with changing temperatures, but plants, being stationary, will not.

Shifting biomes, with impacts on agriculture.
Agriculture will also be affected as growing zones move poleward. And although the right temperature and rainfall combinations for productive agriculture might emerge new areas, the right soil conditions may not be there (the hard rock of the Canadian Shield will never make good farmland, for example). The IPCC reports on agriculture impacts so far that many studies have had negative impacts on crop yields have been more common than positive.

More climate-related extreme events, with significant impacts on people.
These impacts are material and psychological. According to the IPCC, "impacts from recent climate-related extremes, such as heat waves, droughts, floods, cyclones, and wildfires… include alteration of ecosystems, disruption of food production and water supply, damage to infrastructure and settlements, morbidity and mortality, and consequences for mental health and human well-being."

Geopolitical instability and other impacts on human systems.
The IPCC reports that "climate-related hazards exacerbate other stressors, often with negative outcomes for livelihoods, especially for people living in poverty." Climate-related hazards affect poor people's lives directly through impacts on livelihoods, reductions in crop yields, or destruction of homes and indirectly through, for example, increased food prices and food insecurity.

a. What steps are being taken or considered to avert these changes through mitigation and through adaptation?

Mitigation measures are trying to avoid, reduce, and reverse the cause and effects of climate change. The Montreal Protocol has 37 countries agreeing to reduce emissions of CFC's. Another way is to decrease industrial and automotive emissions by providing incentives to industry.

The Kyoto Protocol in 1997 had 84 countries out of about 160 in the world in attendance. Some of the policies that came from that conference:

1. Reduced dependence on oil
2. Industries and homes becoming more energy efficient
3. Tax incentives for going more energy efficient
4. Research on solar power
5. Reduce greenhouse gases and CFC's

Adaptation measures attempt to reduce the impacts of climate change. Some of these measures:

1. Sea walls to prevent flooding
2. Zoning land that is flood prone
3. Soil conservation techniques
4. Better utilization of land
5. More hybrid crops
6. More fish farms
7. More efficient use of trash and agricultural waste

These measures and many other types of changes are needed to get the Earth back to an ecologically balanced system.

8. Why are China and the United States particularly important in issues related to climate change, and how do they characterize their abilities to modify greenhouse gas emissions?

Generally, mitigation is seen as a problem that the world's richer countries plus China should deal with because they are the main producers of greenhouse gases. China and the United States together account for roughly 40 percent of the entire global emissions output. In 2014, the two 'great powers of climate change' came to an agreement (but not a treaty): In the United States would cut net greenhouse gas emissions to 26-28 percent below 2005 levels by 2025. China would reach its peak CO2 emissions around 2030 and increase the non-fossil field share of all energy sources to round 20 percent by 2030.

9. According to the IPCC, what specific cap on greenhouse gas emissions would prevent the worst consequences of global warming?

The IPCC advocated a "carbon budget" for humanity—a limit on the amount of carbon dioxide that can be produced by industrial activities and the clearing of forests. No more than 1 trillion metric tons of carbon could be burned and the resulting gases released into the atmosphere, the panel found, for planetary warming to be kept below that 3.6°F (2°C) above the level of preindustrial times. Over half-trillion tons have already been burned since the beginning of the Industrial Revolution, and unless there is a reduction in the rate at which energy consumption is growing, the trillionth ton will be burned to sometime around 2040. Keep your eyes on what world powers do or don't do to keep the planet below that critical threshold of a 3.6°F (2°C) increase.

10. What are the market-based incentives that could help treaty members meet their emissions reduction targets?

With the **clean development mechanism (CDM)**, a wealthier Annex I country can earn emissions units by investing in emission-reduction projects in a poorer country, and use those certified emission reduction (CER) credits to meet part of its overall emission reduction target.

Joint Implementation (JI) allows an Annex I country to earn emission reduction units (ERUs) by investing in emission reduction in another Annex I country.

There is the mechanism of the marketplace where emissions credits are bought and sold. The **international emissions trading** (also called **cap and trade**) mechanism lets countries that have an excess of emission units (emissions permitted to them, but not used) to sell this excess capacity to countries that are over their targets.

Answers to MindTap Exercises

Global Geoscience Watch

1. b

2. c

3. larger than