

1  **Global Climate Change**

Earth 9th Edition – Chapter 21

2  **Climate Change: summary in haiku form**

Veep Al Gore was right:
the truth is inconvenient,
but do something now.

3  **Key Concepts**

- Earth's climate system.
- The atmosphere and the greenhouse effect.
- Natural causes of climate change.
- Human impact on global climate.
- Possible consequences of global warming.

4  **Figure 21.2**

5  **The climate system**

- The climate system includes the
 - Atmosphere
 - Hydrosphere
 - Geosphere
 - Biosphere
 - Cryosphere (ice and snow)

6  **How is climate change detected?**

- Techniques for analyzing Earth's climate history
 - Seafloor sediments – numbers and types of organic remains are indicative of past sea-surface temperatures
 - Oxygen isotope analysis – ratio of ¹⁸O/ ¹⁶O in shells of microorganisms reflect past temperatures

7  **Figure 21.3**

8  **Aboard JOIDES Resolution**

9  **National Ice Core Lab**

10  **Figure 21.5B**

11  **How is climate change detected?**

- Techniques for analyzing Earth's climate history
 - Other sources of data for studying past climates include
 - Growth of tree rings
 - Pollen contained in sediment and coral reefs
 - Information found in historical documents

12  **Dendrochronology...**

13  **Extending the range of info:**

14  **Extending the range of info:**

15  **Extending the range of info:**

16  **Corals**

17  **Some atmospheric basics**

- Composition of the atmosphere
 - ☒ Air is a mixture of many discrete gases
 - Composition varies over time and distances
 - ☒ After water vapor, dust, and other variable components are removed, nitrogen and oxygen make up 99% of the clean dry air
 - ☒ CO₂, although present in minute amounts (0.0338%), greatly influences the heating of the atmosphere

18  **Composition of Earth's atmosphere**

- 19 **Some atmospheric basics**
- Composition of the atmosphere
 - ☒ Two important variable components of air are water vapor and aerosols
 - ◆ Water vapor absorbs ultraviolet radiation given off by Earth similar to CO₂
 - ◆ Aerosols (tiny solid and liquid particles) are important because they act as surfaces for condensation and also are good absorbers and reflectors
- 20 **Some atmospheric basics**
- Energy from the Sun
 - ☒ Electromagnetic radiation is energy emitted in the form of rays, or waves
 - ◆ Key difference among electromagnetic waves is their wavelength
 - ☒ Some basic laws governing radiation
 - ◆ All objects emit radiant energy
 - ◆ Hotter objects radiate more total energy than do colder objects
- 21 **The Electromagnetic Spectrum**
- 22 **Some atmospheric basics**
- Energy from the Sun
 - ☒ Some basic laws governing radiation
 - ◆ The hotter the radiating body, the shorter the wavelengths of maximum radiation
 - ◆ Objects that are good absorbers of radiation are good emitters as well
- 23 **Some atmospheric basics**
- The fate of incoming solar energy
 - ☒ Approximately 50% of the solar energy that strikes the atmosphere reaches Earth's surface
 - ◆ 30% is reflected back to space
 - ◆ 20% is absorbed by clouds and the atmosphere's gases
- 24 **Incoming solar radiation**
- 25 **The greenhouse effect**
- ☒ Radiant energy that is absorbed heats Earth and eventually is reradiated skyward
 - ◆ Radiation is in the form of longwave infrared radiation
 - ◆ Atmospheric gases, primarily H₂O and CO₂, are more efficient absorbers of longwave radiation
 - ◆ This selective absorption, called the greenhouse effect, results in warming of the atmosphere
- 26 **The greenhouse effect**
- 27 **Figure 21.12 (left)**
- 28 **Figure 21.12 (middle)**
- 29 **Figure 21.12 (right)**
- 30 **Global Warming**
- 31 **Natural causes of climate change**
- Several explanations have been formulated to explain climate change including
 - ☒ Plate tectonics
 - ☒ Variations in Earth orbit – eccentricity, obliquity, and precession
 - ☒ Volcanic activity
 - ☒ Changes in the Sun's output associated with sunspots
- 32 **SO₂ plume from Mt. Etna**
- 33 **Figure 21.13B**
- 34 **Sulfuric Acid Haze**
- 35 **"Geology Guy" Sunspot Image**
- 36 **Sunspot Close-up:**
- 37 **Mean Annual Sunspot Numbers**
- 38 **Human impact on global climate**
- Humans have been modifying the environment for thousands of years

- ☒ Ground cover has been altered by
 - ◆ Fire
 - ◆ Overgrazing
- ☒ Results in modification of climatological factors such as reflectivity, evaporation rates, and surface winds
 - ◆

39  **Human impact on global climate**

- Humans have been modifying the environment for thousands of years
 - ☒ Addition of carbon dioxide and other trace gases to the atmosphere are likely contributing to global climate change
 - ◆ Trace gases include methane, nitrous oxide, and chlorofluorocarbons

40  **Increasing CO₂ levels in Earth's atmosphere**

41  **Figure 21.17B**

42  **Figure 21.18**

43  **Proxy data: tree rings, ice cores, corals, historical records**

44  **Methane sources:**

45  **Methane sources:**

46  **Climate-feedback mechanisms**

- When any component in the climate system is altered, scientists must consider many possible outcomes
 - These possible outcomes are called climate-feedback mechanisms

47  **Feedback Loop:**

48  **Figure 21.21 (right)**

49  **Human-generated aerosols**

50 

51 

52  **Figure 21.23C**

53  **Figure 21.24**

54  **Climate-feedback mechanisms**

- Climate-feedback mechanisms
 - ☒ Changes that reinforce the initial change are called positive-feedback mechanisms
 - ◆ Example – warmer surface temperatures cause an increase in evaporation, which further increases temperatures as water vapor absorbs more radiation

55  **Climate-feedback mechanisms**

- Climate-feedback mechanisms
 - ☒ Negative-feedback mechanisms produce results that are the opposite of the initial change and tend to offset it
 - ◆ Example – negative effect of increased cloud cover on the amount of solar energy available to heat the atmosphere

56  **How aerosols influence climate**

- Global climate is affected by human activities that contribute to the atmosphere's aerosol content
 - ☒ Produce a cooling effect by reflecting sunlight back to space
 - ☒ The effect on today's climate is determined by the amount emitted over the course of a few weeks
 - ☒ By contrast, carbon dioxide remains for much longer spans and influences climate for many decades
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 - ◆
 - ◆

- 57  ***Some possible consequences of global warming***
- Because the climate system is so complex, predicting specific regional changes related to increased levels of CO₂ is speculative
 - However, some possible consequences include
 - ☒ Altering the distribution of the world's water resources

- 58  ***Some possible consequences of global warming***
- However, some possible consequences include
 - ☒ Probable rise in sea level
 - ☒ Greater intensity of tropical cyclones
 - ☒ Changes in the extent of Arctic sea ice and permafrost

59  ***Tundra, Northern Siberia:***

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61  ***Figure 21.26***

62  ***Figure 21.25***

- 63  ***Some possible consequences of global warming***
- Due to complexity of the climate system, not all future shifts can be foreseen
 - ☒ Sudden unexpected changes in climate are possible
 - ☒ A constant state of change is very likely

64  ***Not the end of the story...***