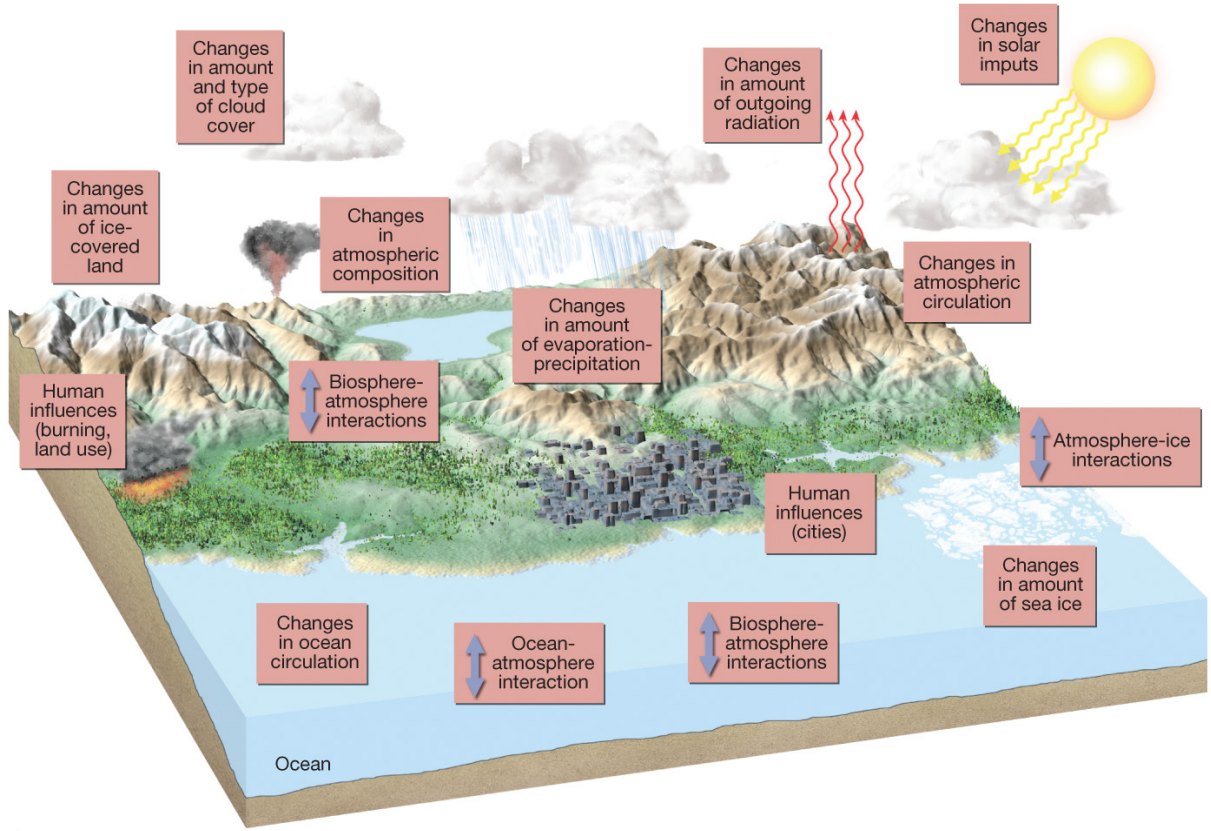
Climate Change

The Climate System

- **The climate system includes the:**
  - **Atmosphere**
  - **Hydrosphere**
  - **Geosphere**
  - **Biosphere**
  - **Cryosphere (Ice & Snow)**



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—The ratio of $^{18}O/^{16}O$ in shells of microorganisms reflect past temperatures.**

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**
    - **Drill cores in glacial ice**
    - **Pollen contained in sediment and coral reefs**
    - **Information found in historical documents**

Deep Sediment Drilling & Core Analysis

Tree Rings Are Useful Recorders of Past Climates

B.

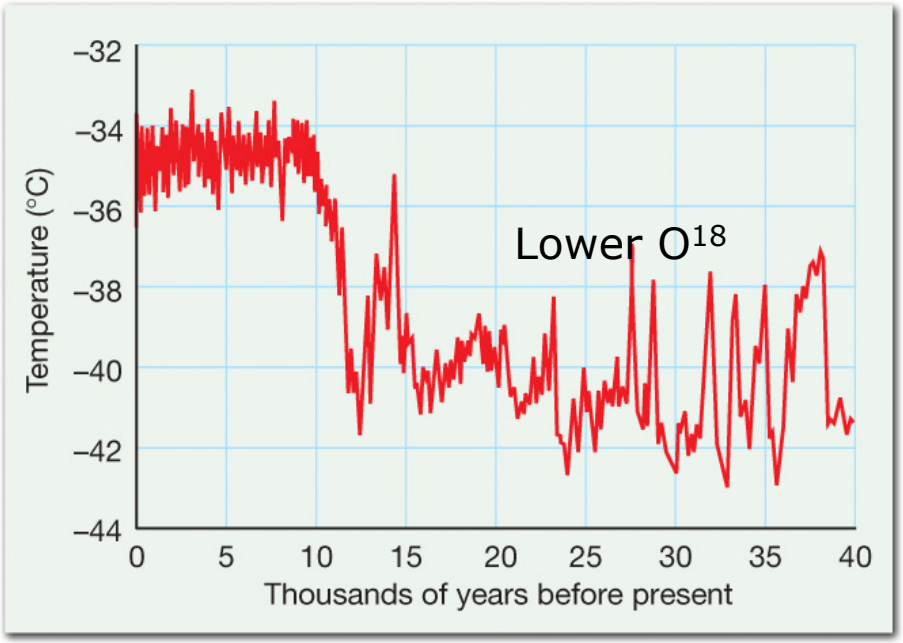
Oxygen ratios (O^{18} & O^{16}) in Foram shells

Warm Water = High O^{18} Cold Water = Low High O^{18}

Same Thing for Ice Cores!

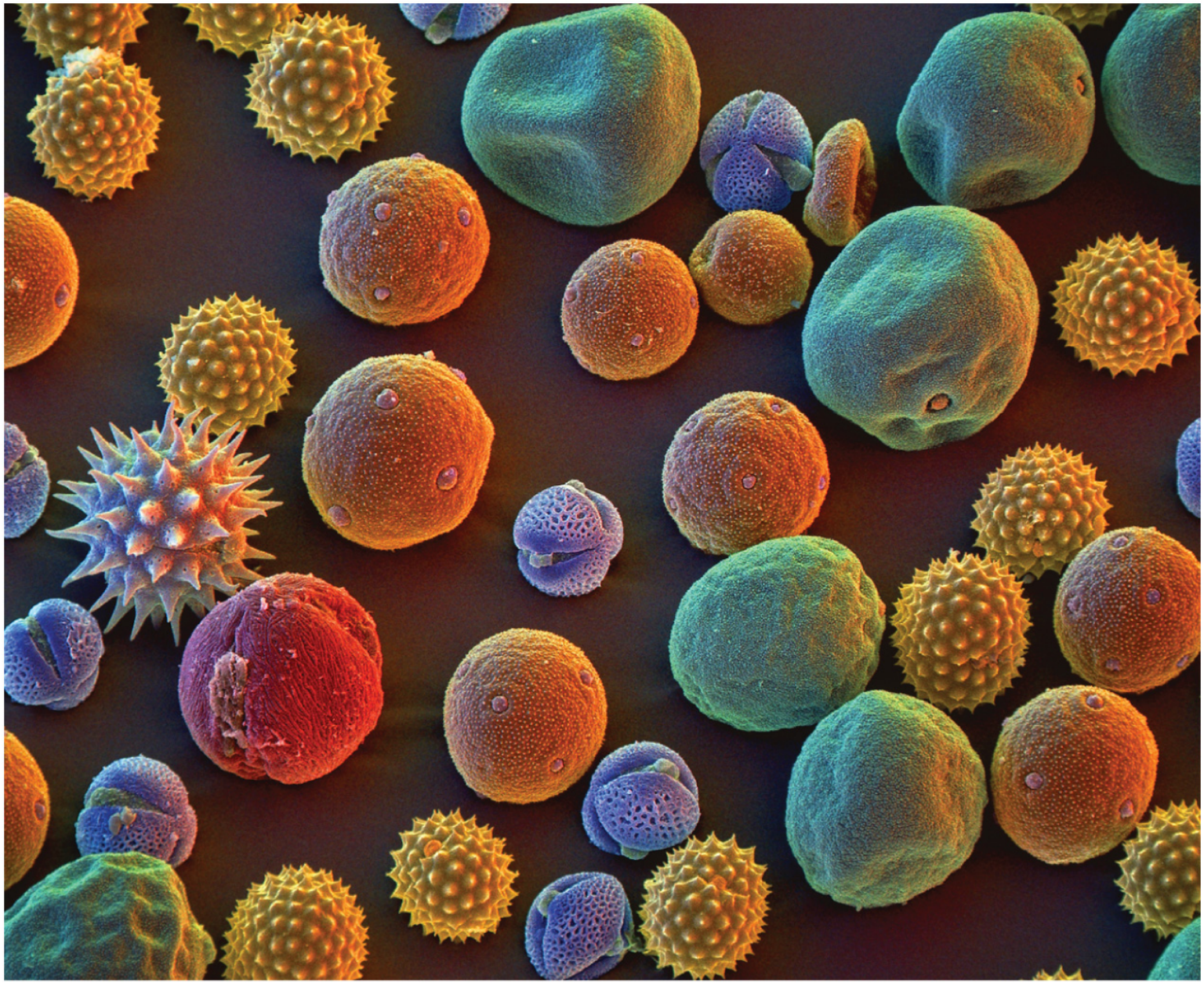
A.

Higher O^{18}

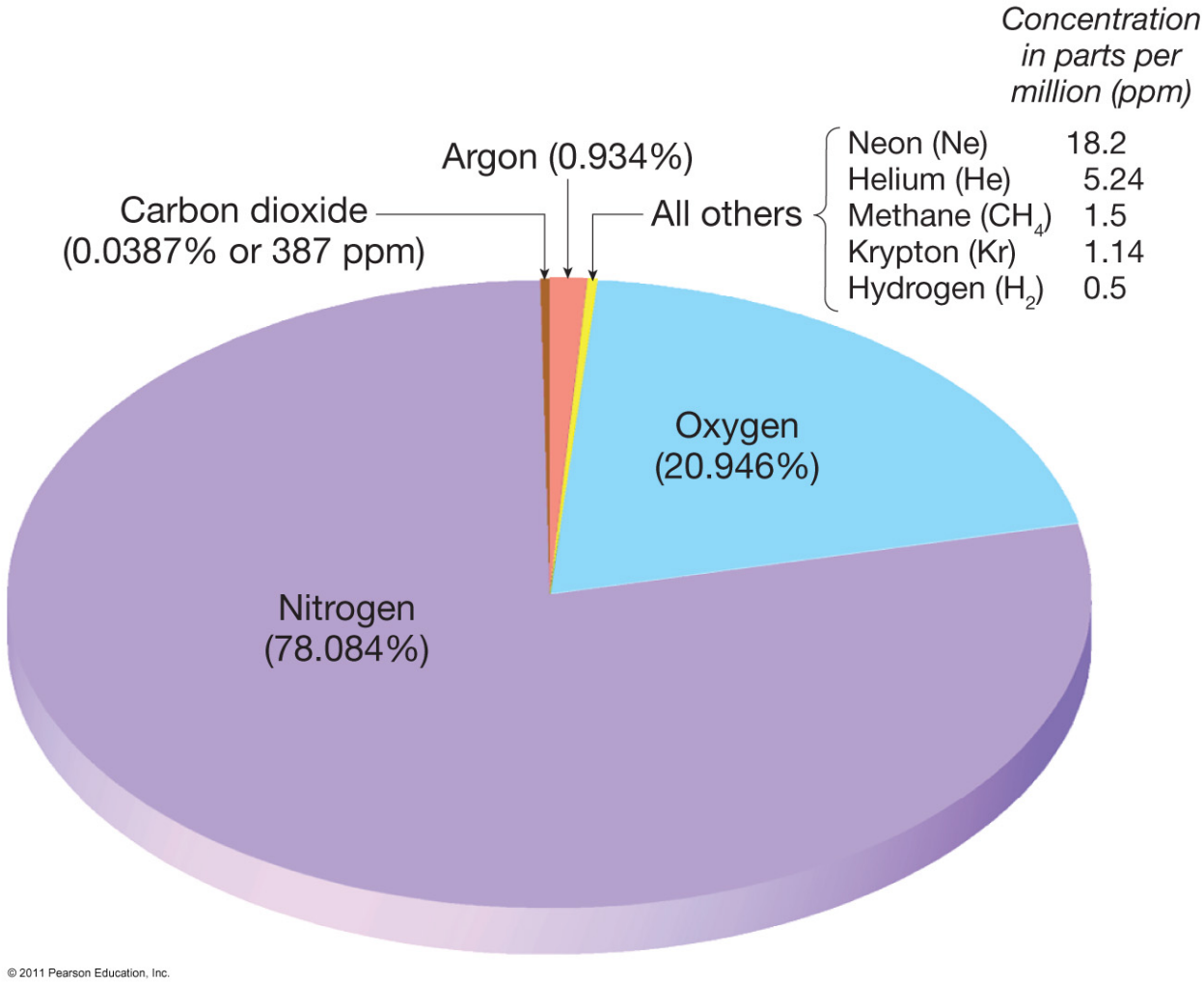


B.

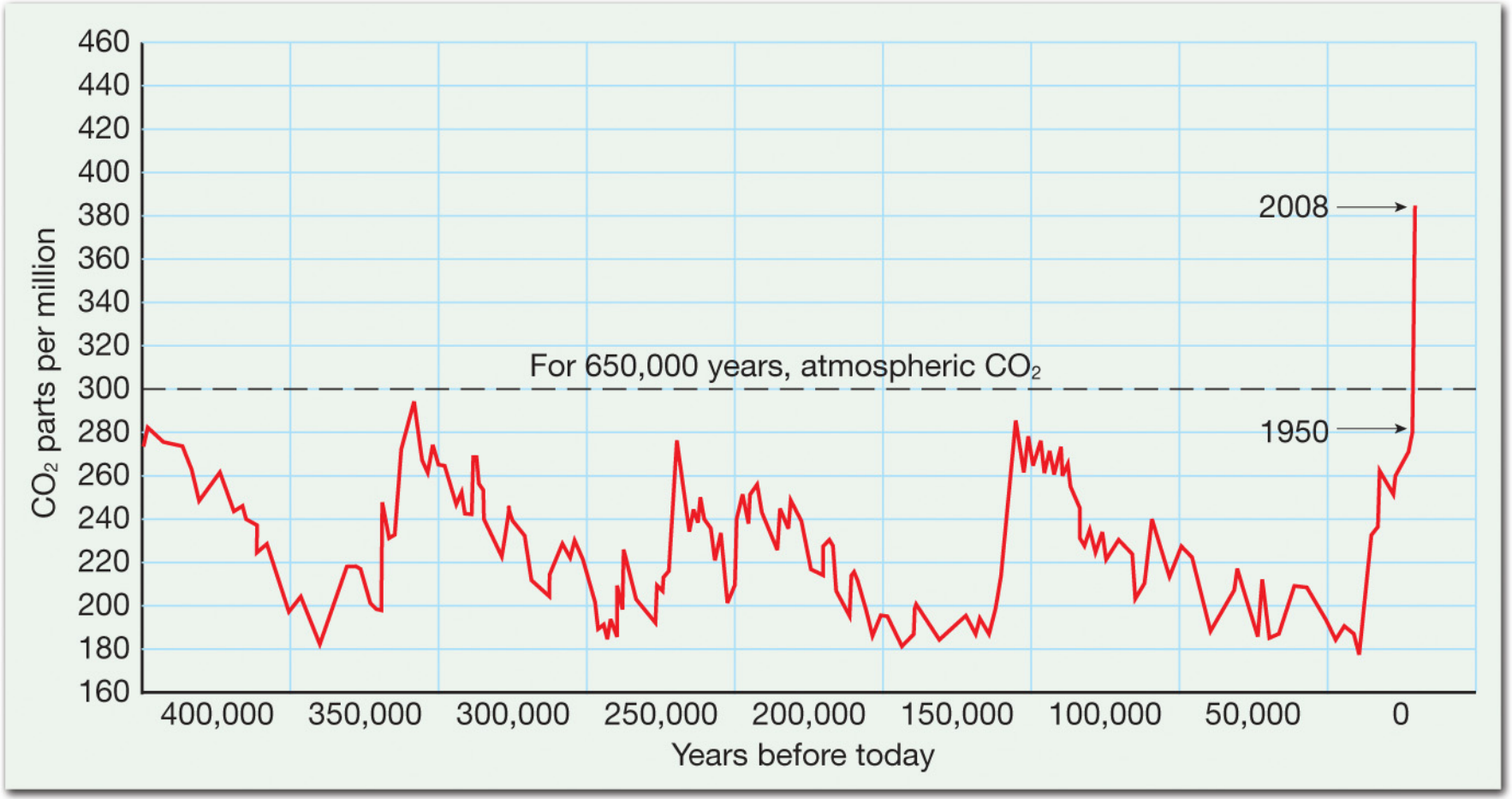
Abundance of Pollen Spores (Dinosaurs??)



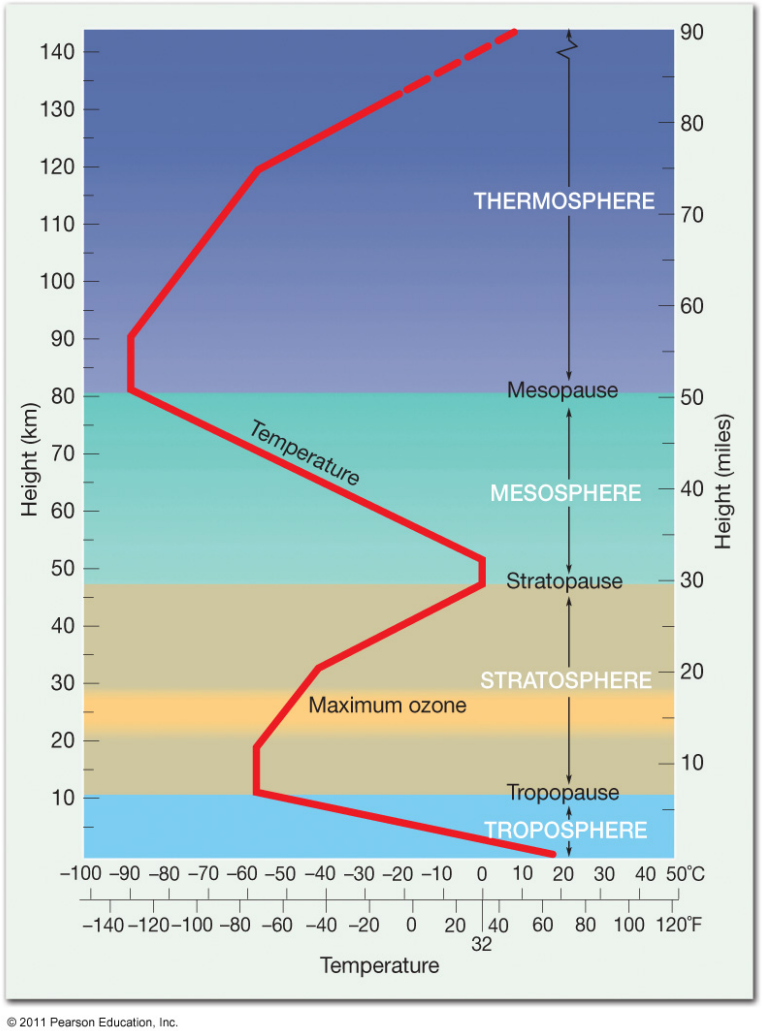
Composition of Earth's Atmosphere



CO_2 Concentrations Over the Past 400,000 Years (Famous "Hockey Stick" Graph)



Thermal Structure of the Atmosphere



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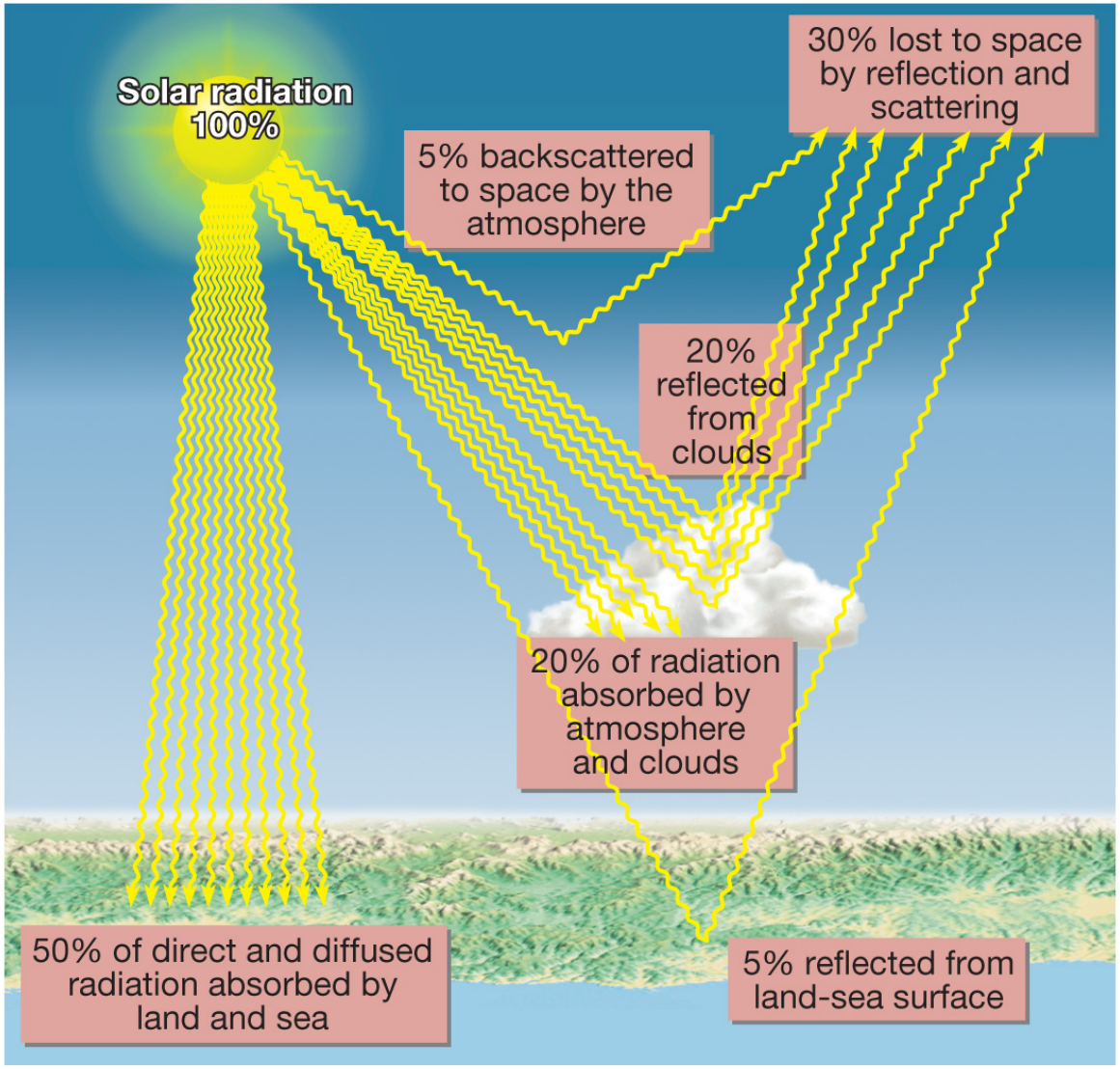
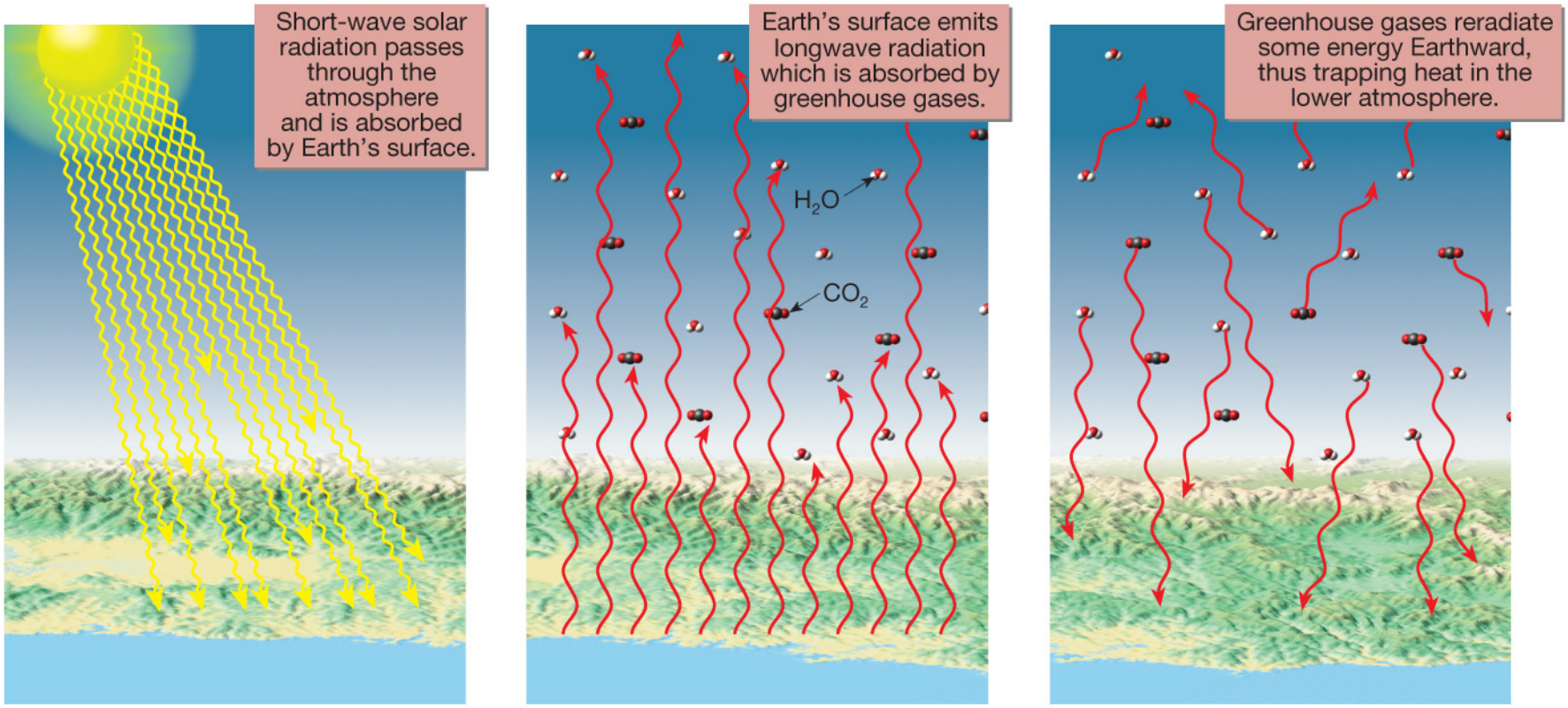
Incoming Solar Radiation



Some Atmospheric Basics

- **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 H_2O and CO_2, are more efficient absorbers of longwave radiation.**
    - **This selective absorption, called the greenhouse effect, results in warming of the atmosphere.**

The Greenhouse Effect



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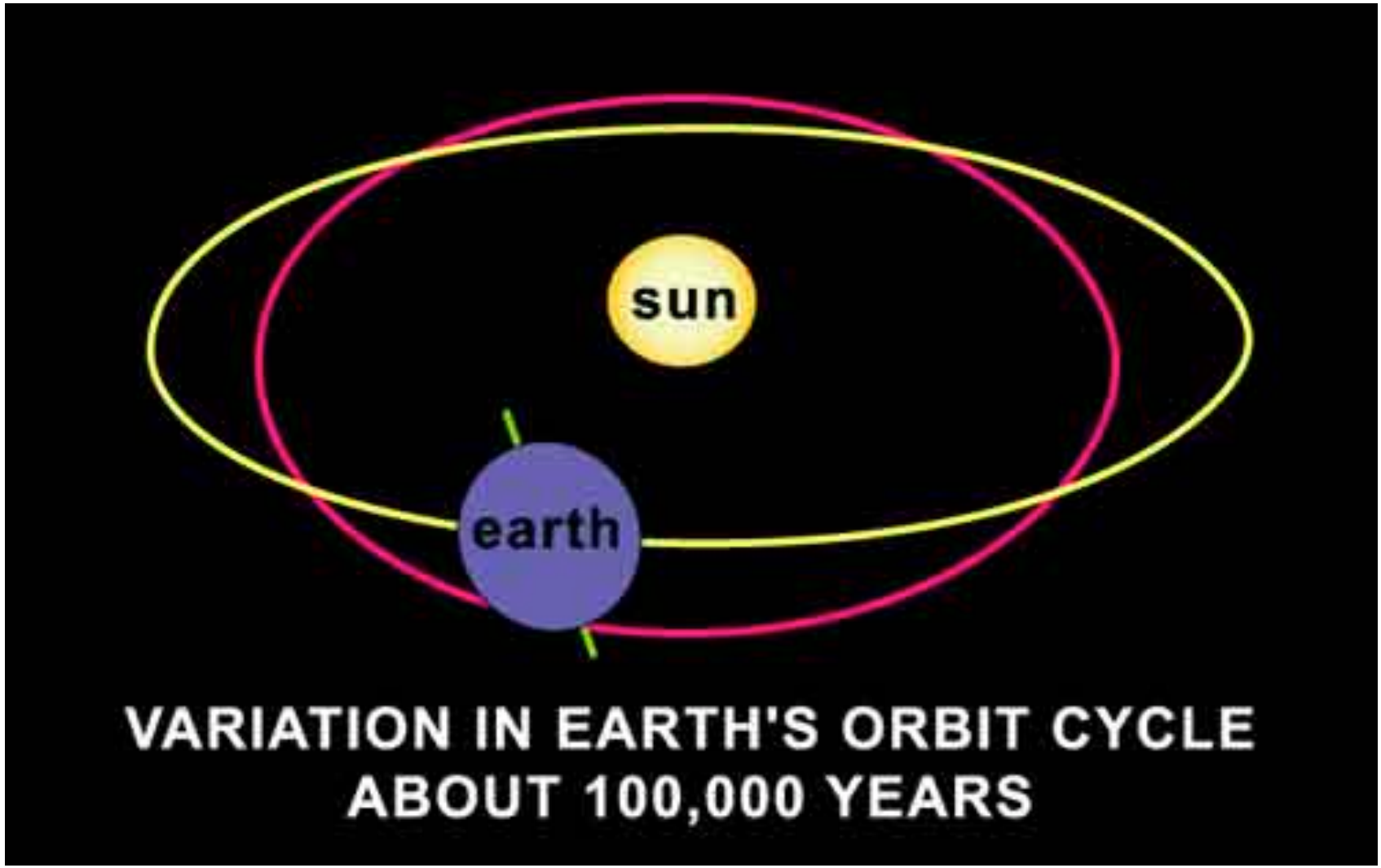
Natural Causes of Climate Change

- **Several explanations have been formulated to explain climate change, including:**
  - **Exposed Land Surface Changes**
  - **Variations in Earth's orbit—eccentricity, obliquity, and precession**
  - **Volcanic activity**
  - **Changes in the Sun's output associated with sunspots**

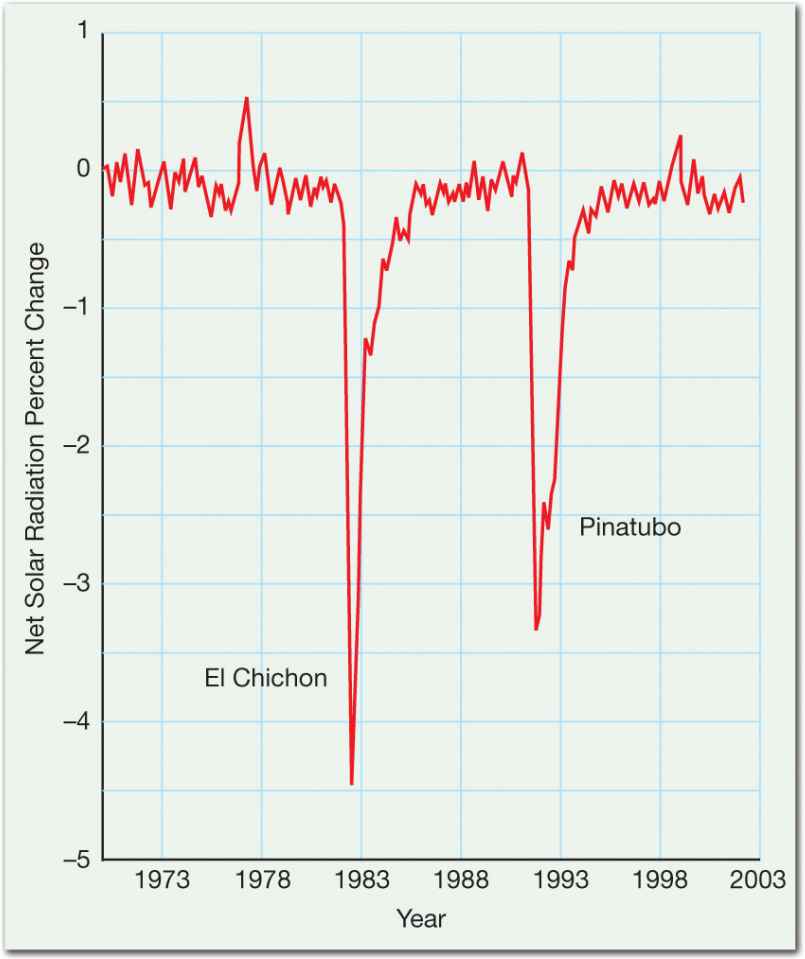
Changing Land Surface Elevation

Orbit & Tilt Changes



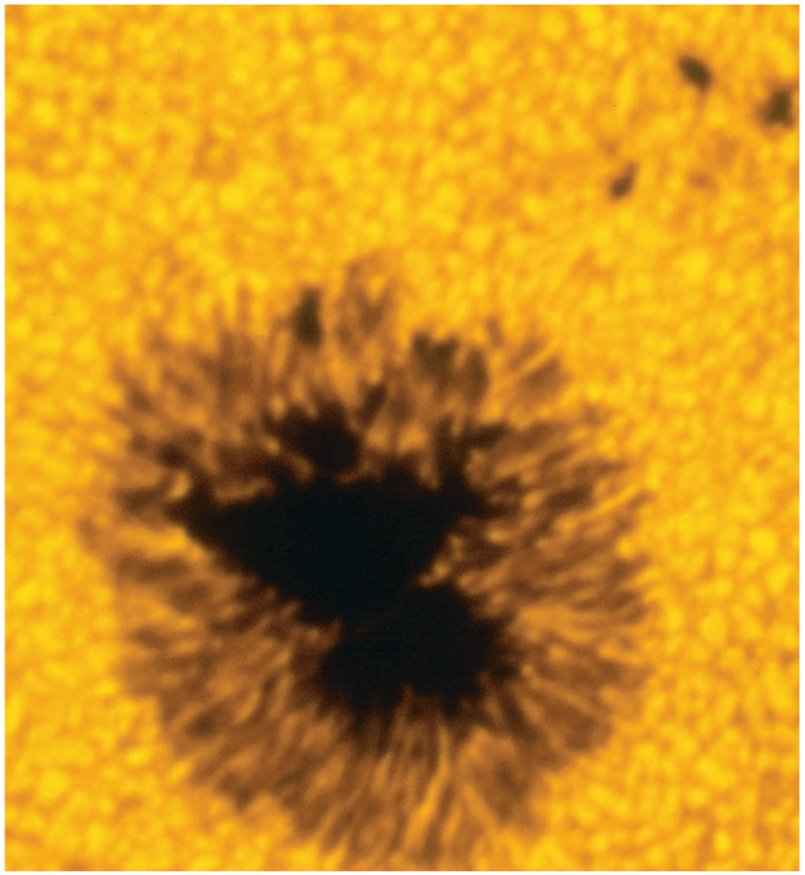
Effect of Volcanic Activity on Solar Radiation

A.



B.

A.



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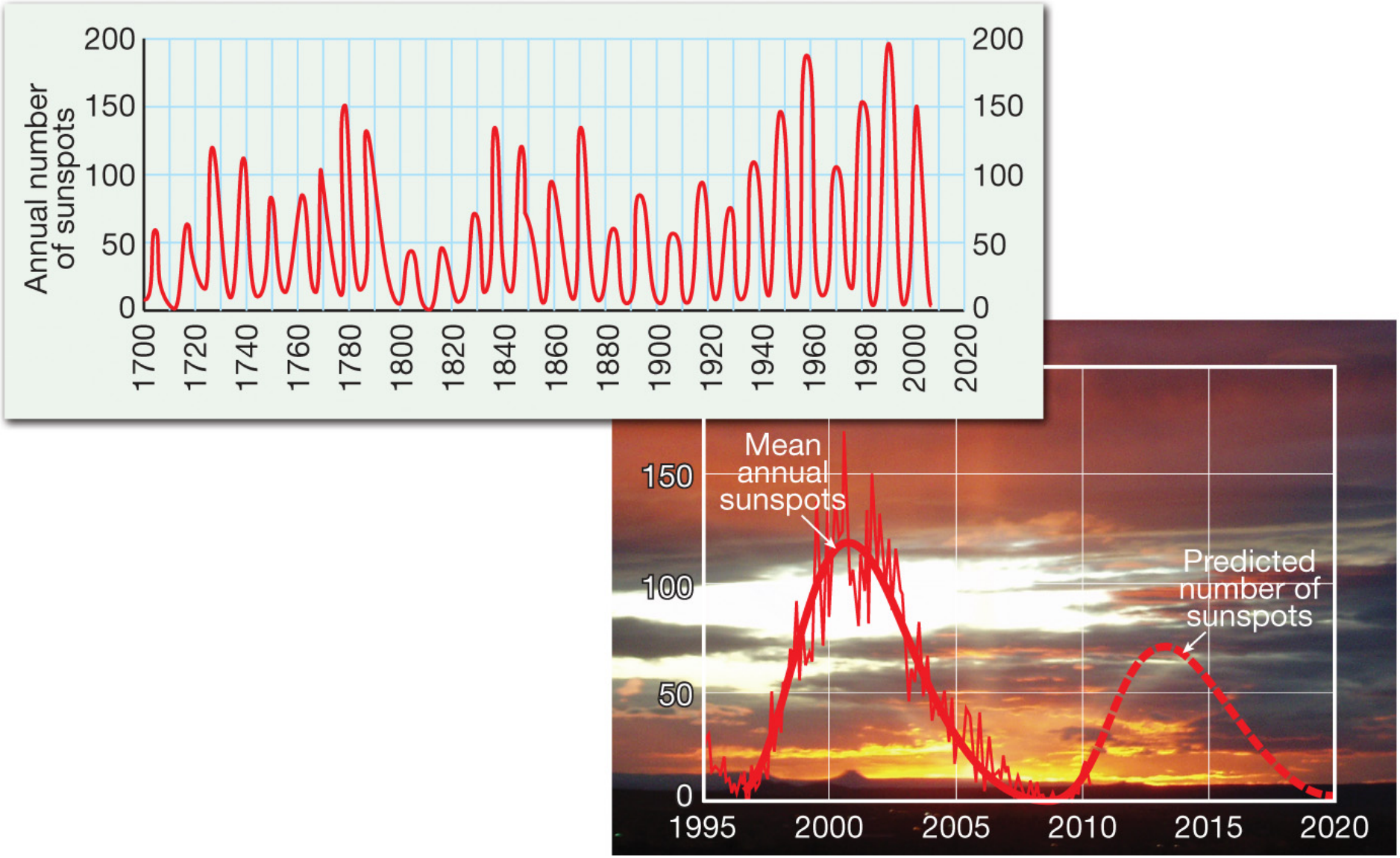
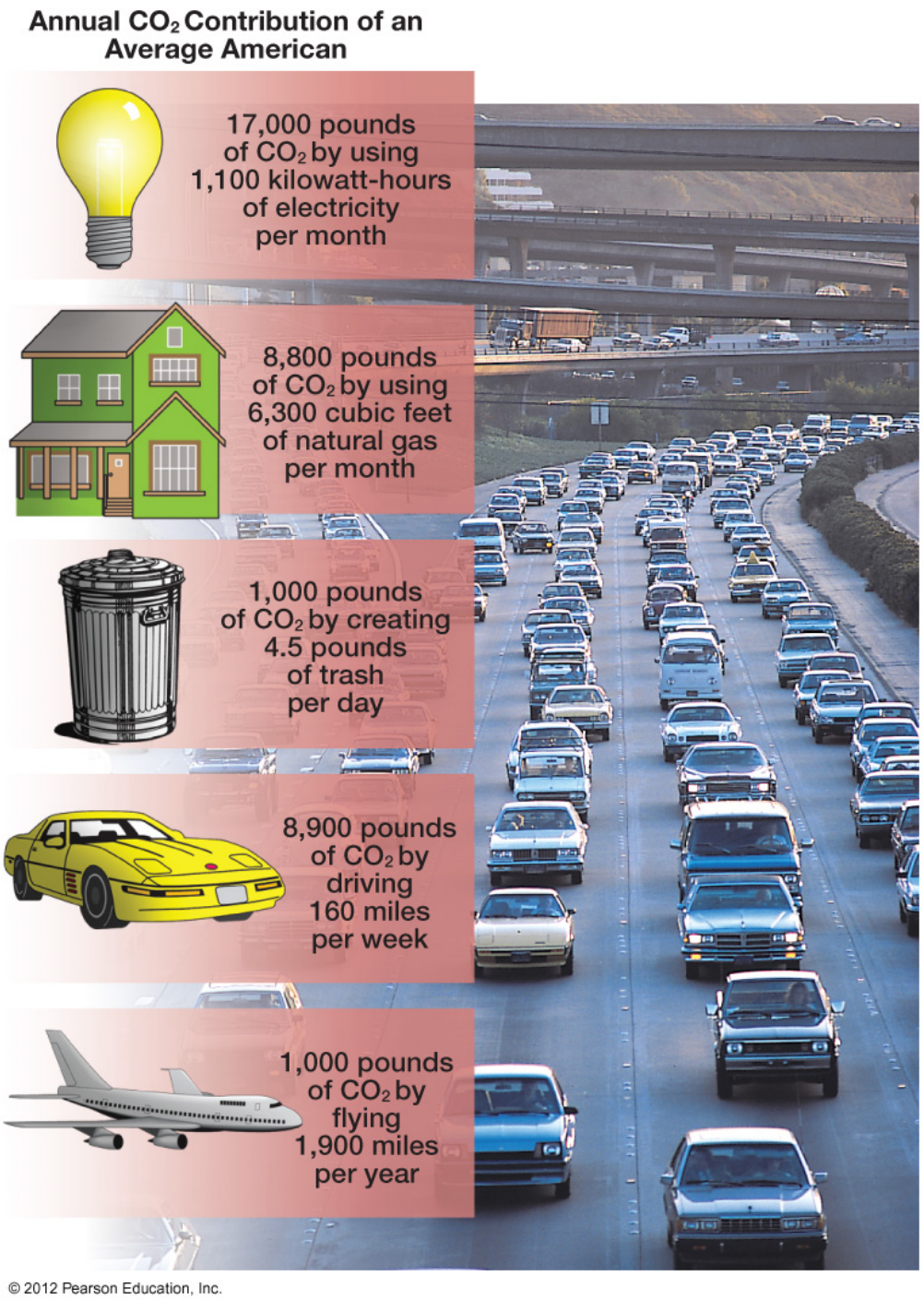
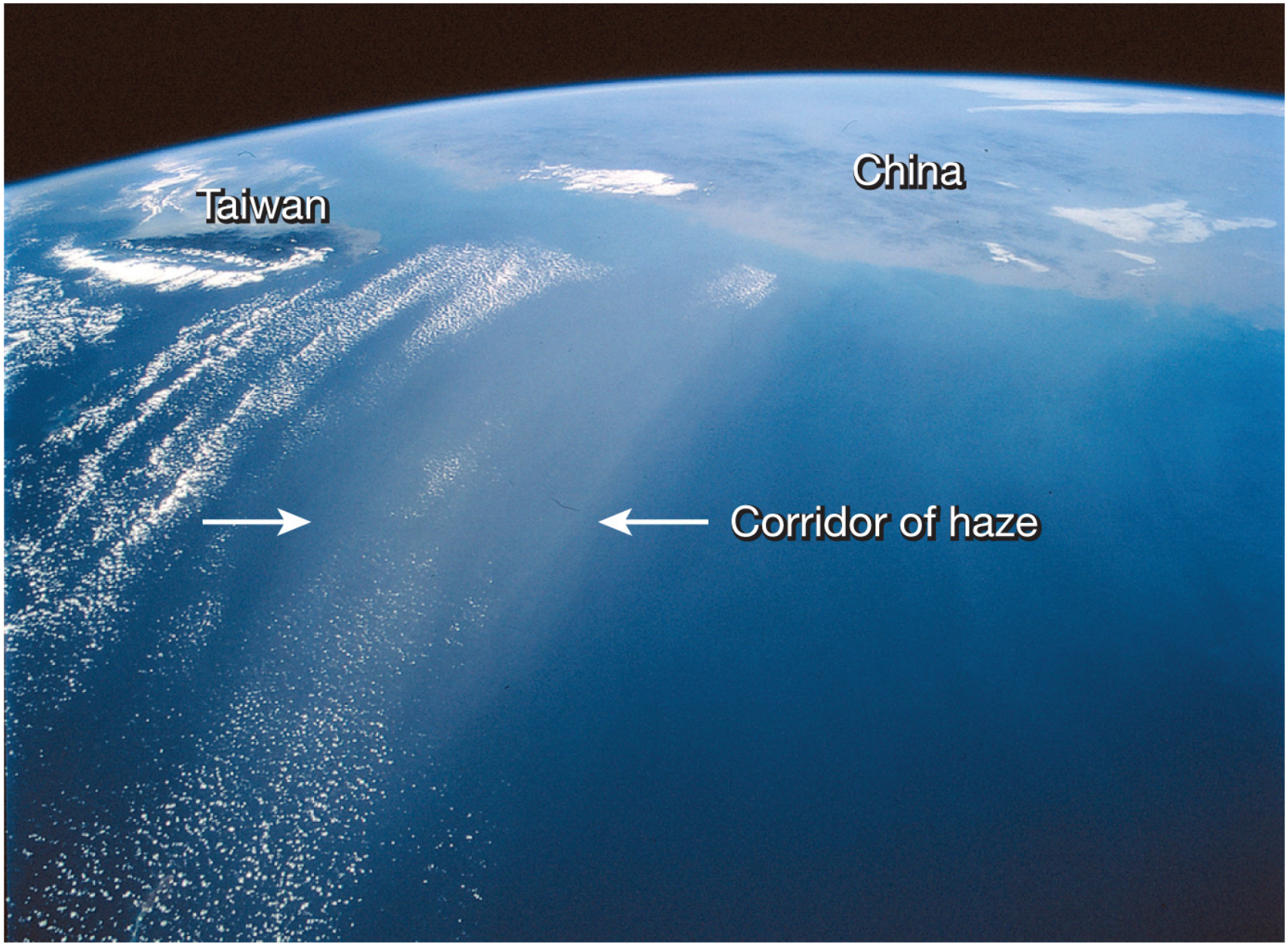


More Sun Spots = Warmer Climates

Human Influences



Air Pollution Haze from China



A.

B.

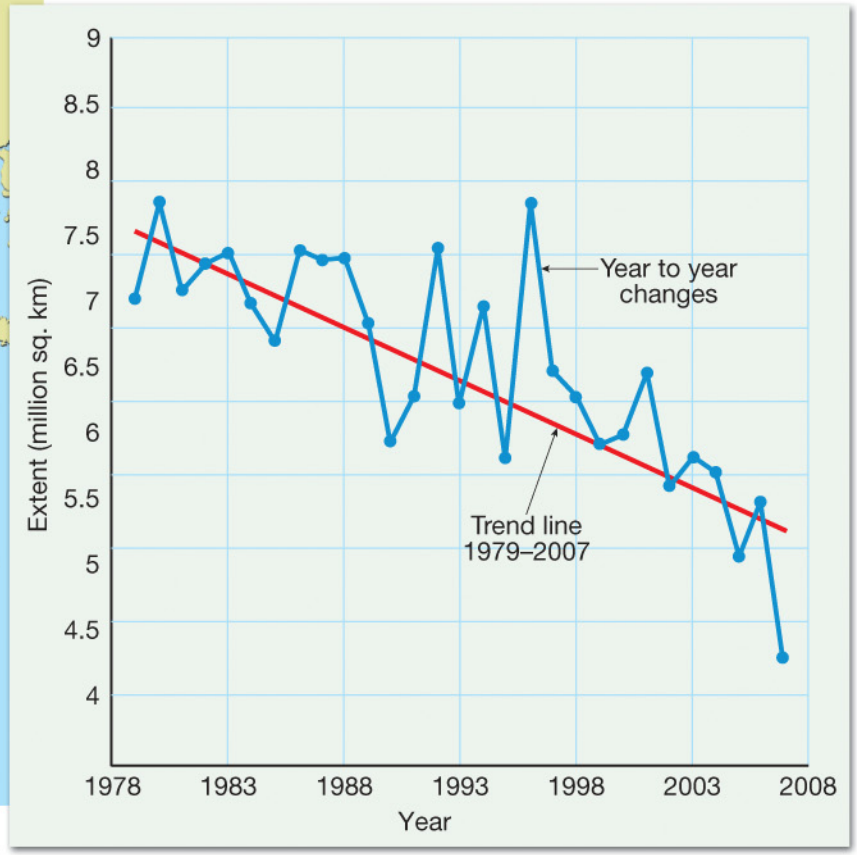
Methane

Less than 15%

Natural Sources
More than 50%

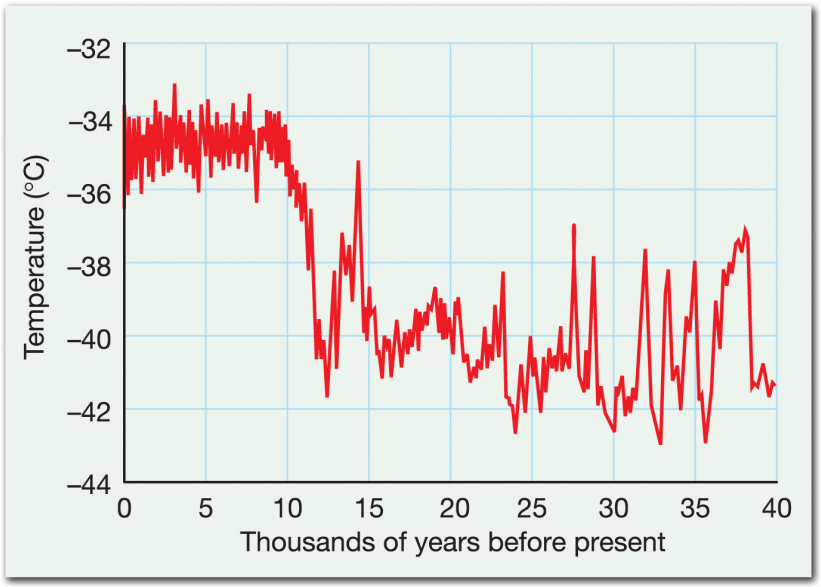
Net Effect: Changes in Arctic Sea Ice

A.



B.

Warming for 100 years or 10,000 years?



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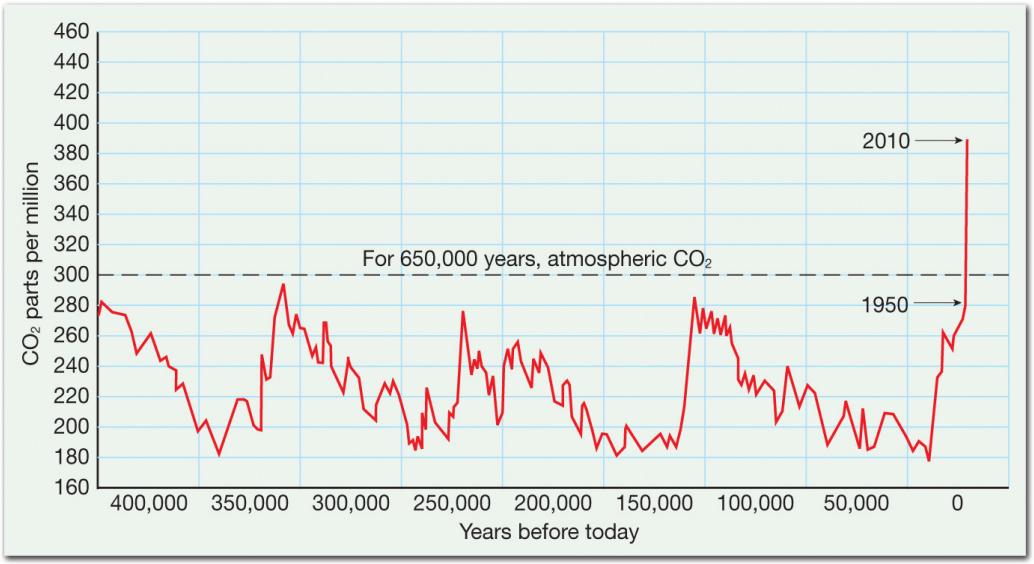

Ice Cores-Temps

CO_2 Studies

Some Possible Consequences of Climate Change

- **Although complex to predict, some possible consequences include:**
  - **Probable rise in sea level**
  - **Greater intensity of tropical cyclones**
  - **Changes in the extent of Arctic sea ice and permafrost**
  - **Sudden unexpected changes in climate are possible.**
  - **A constant state of change is very likely.**