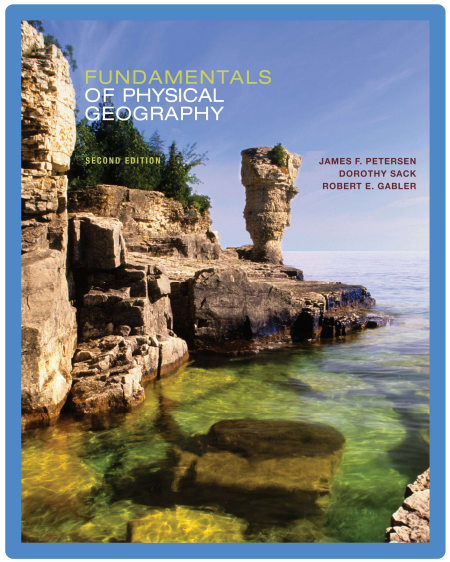
Fundamentals of Physical Geography 2e

Solar Energy and Atmospheric Heating

3



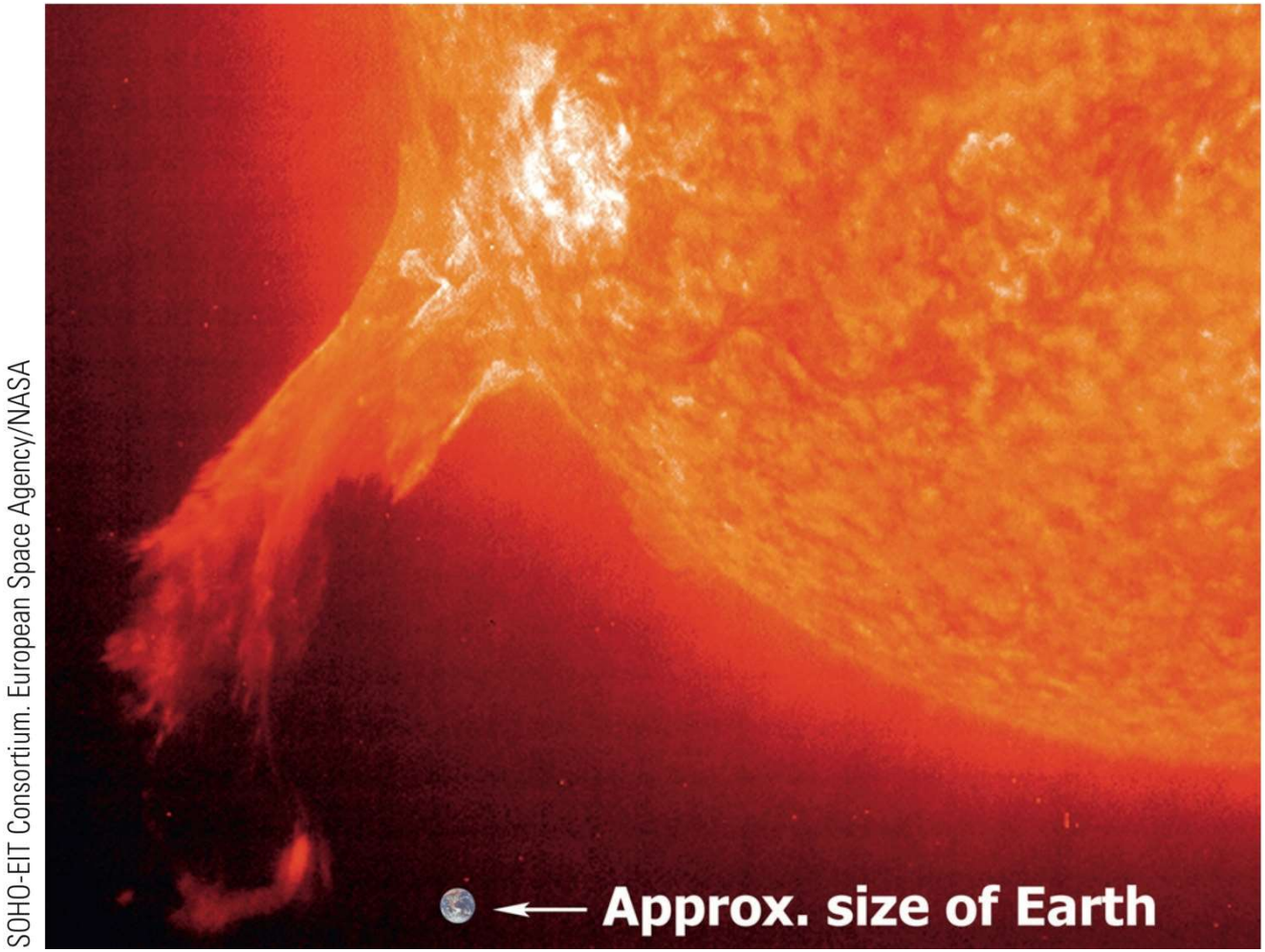
- Peterson
  - Sack
    - Gabler

Introduction

- Weather
  - Meteorology
- Climate
  - Climatology
- Five basic atmospheric elements
  - Solar energy (insolation), temperature, pressure, wind, and precipitation

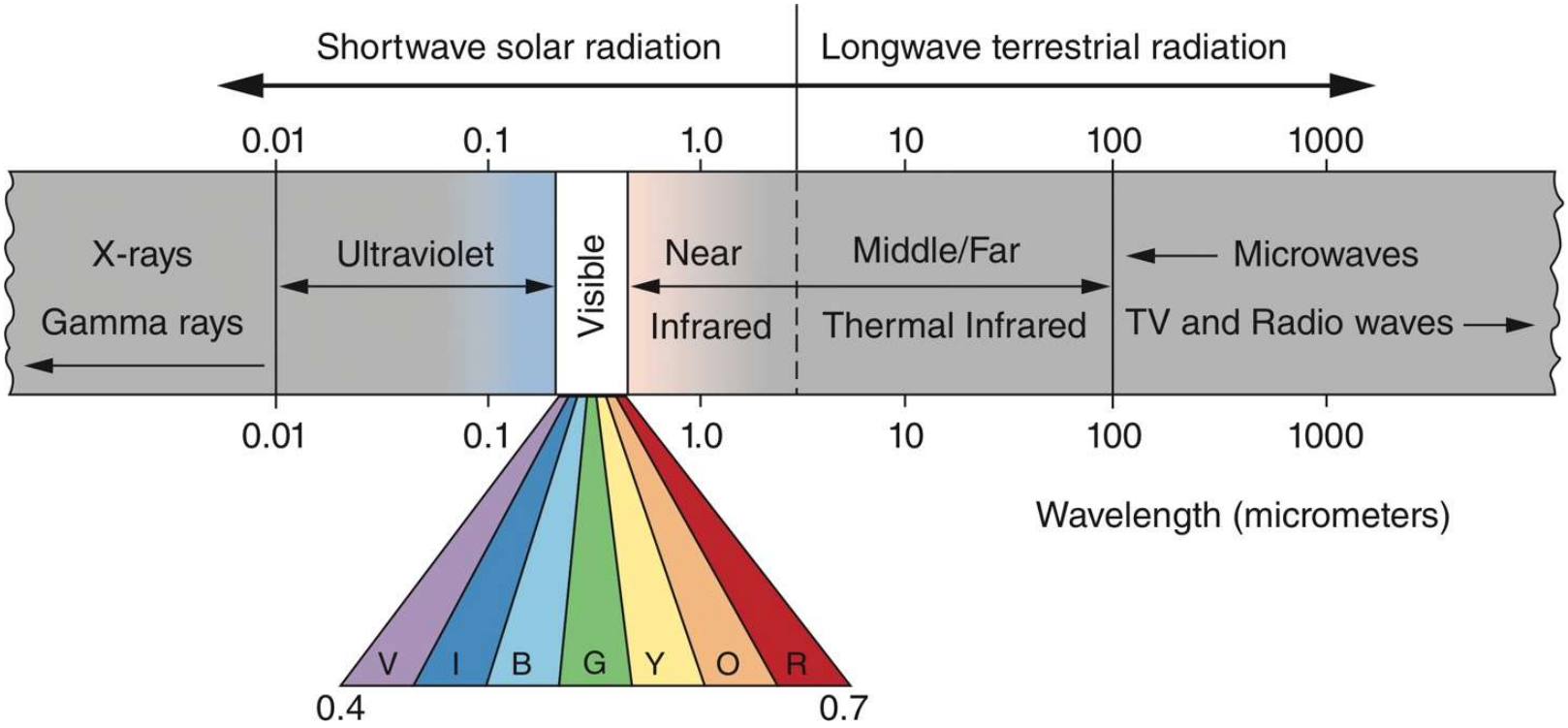
The Earth–Sun System

- The sun's energy comes from fusion
  - Electromagnetic energy
  - Shortwave radiation: gamma rays; x-rays, ultraviolet rays; visible light and near-infrared light
  - Longwave radiation: thermal infrared; microwaves; television and radio waves
  - Measures of energy: calorie, watts per square meter, joules per square meter, and solar constant



SOHO-EIT Consortium. European Space Agency/NASA

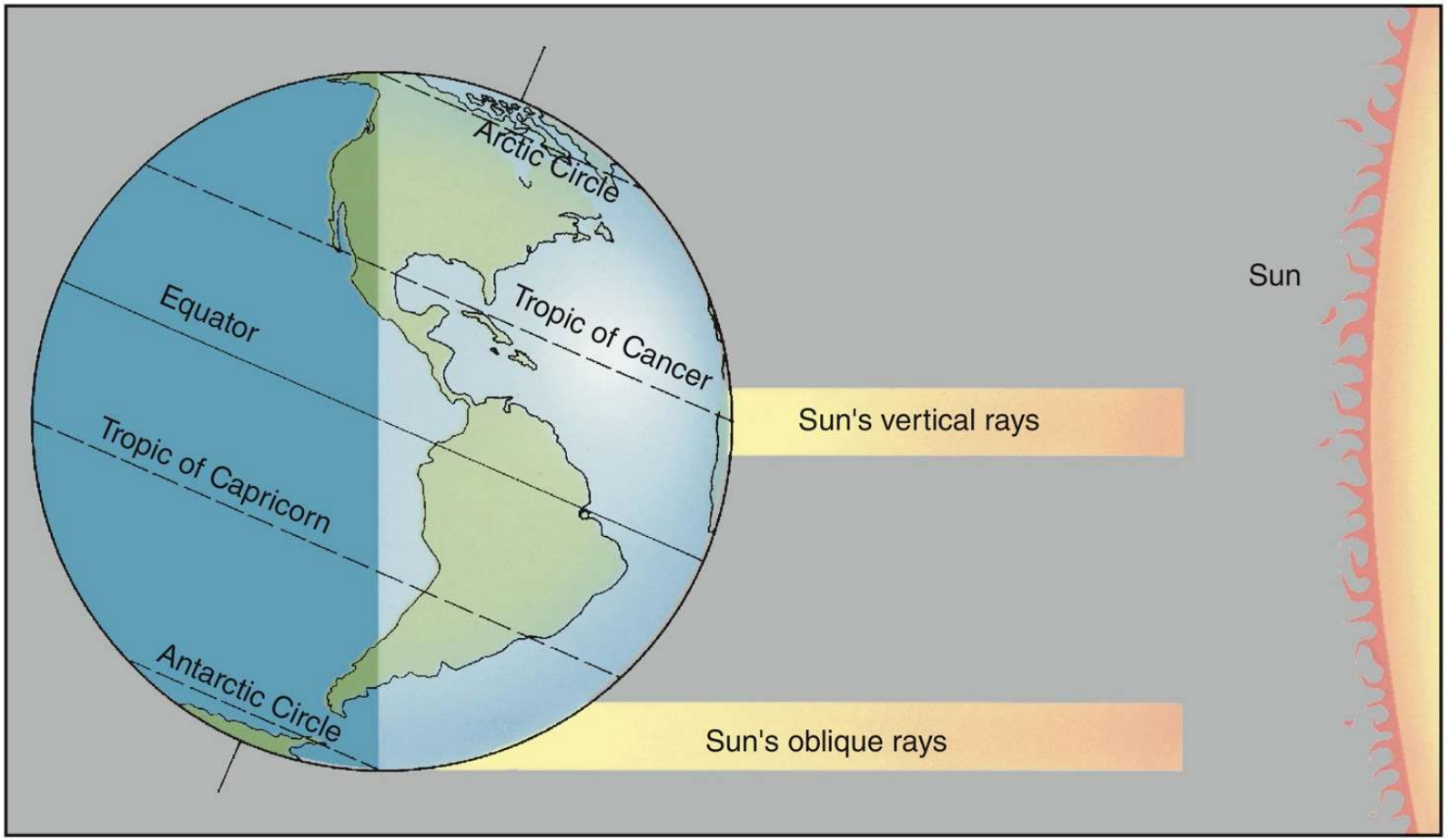
What elements drive a nuclear fusion reaction?



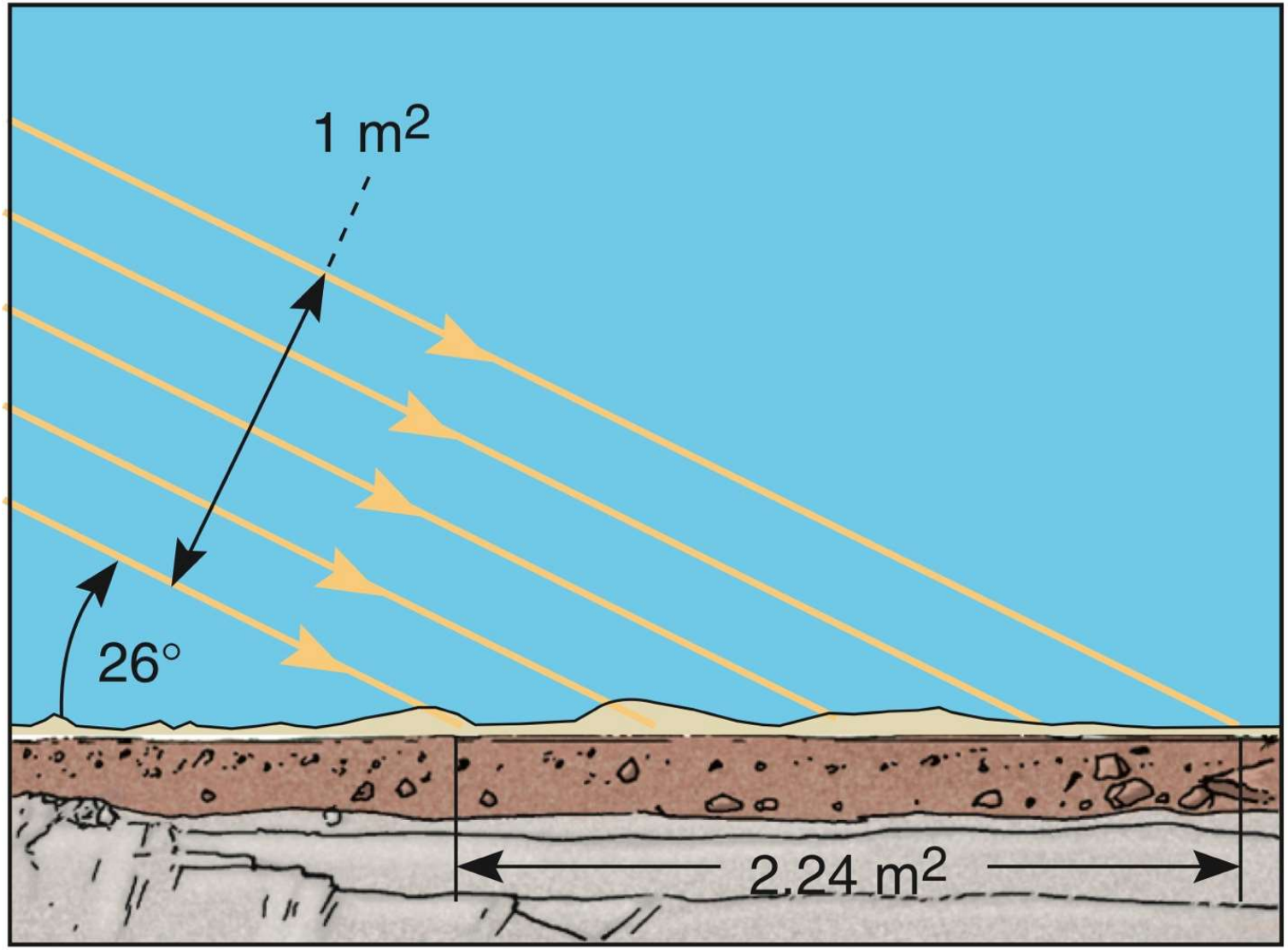
What colors represent the shortest and the longest wavelengths that humans can see?

The Earth–Sun System (cont'd.)

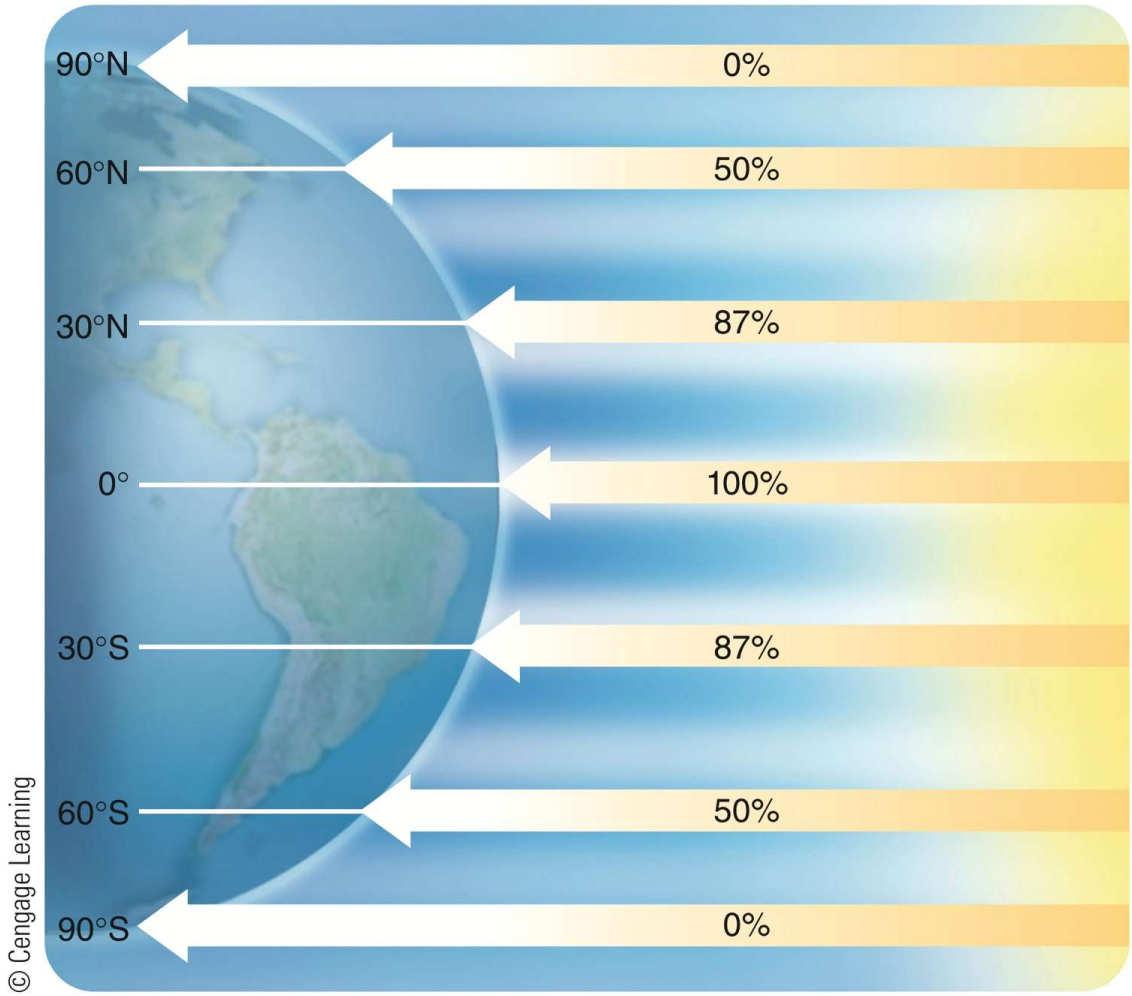
- Insolation, sun angle, and duration
  - Seasonal temperature variations
  - Factors affecting insolation: sun angle and duration



(a)



(c)

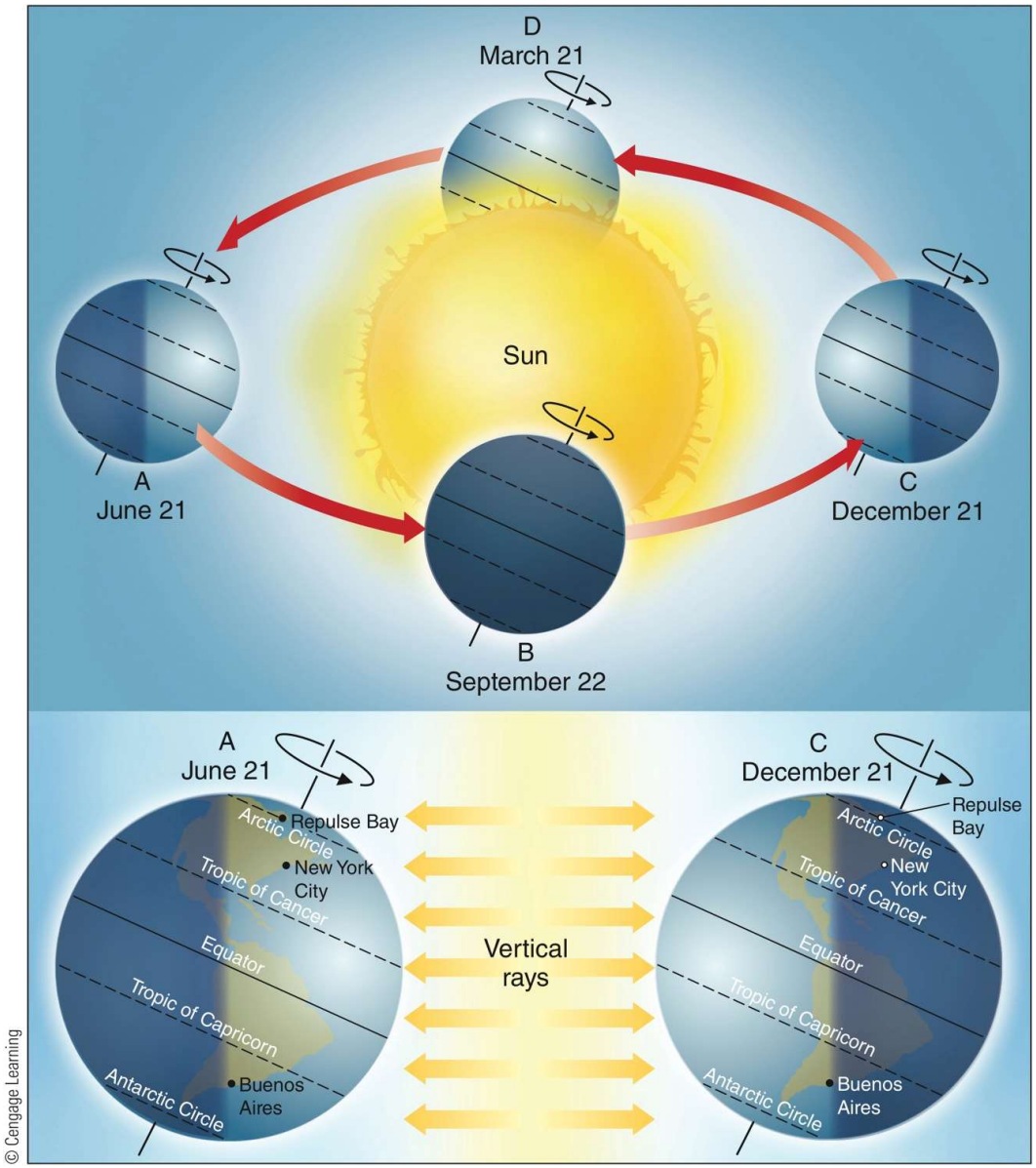


How much less solar energy is received at 60° latitude than that received at the equator?

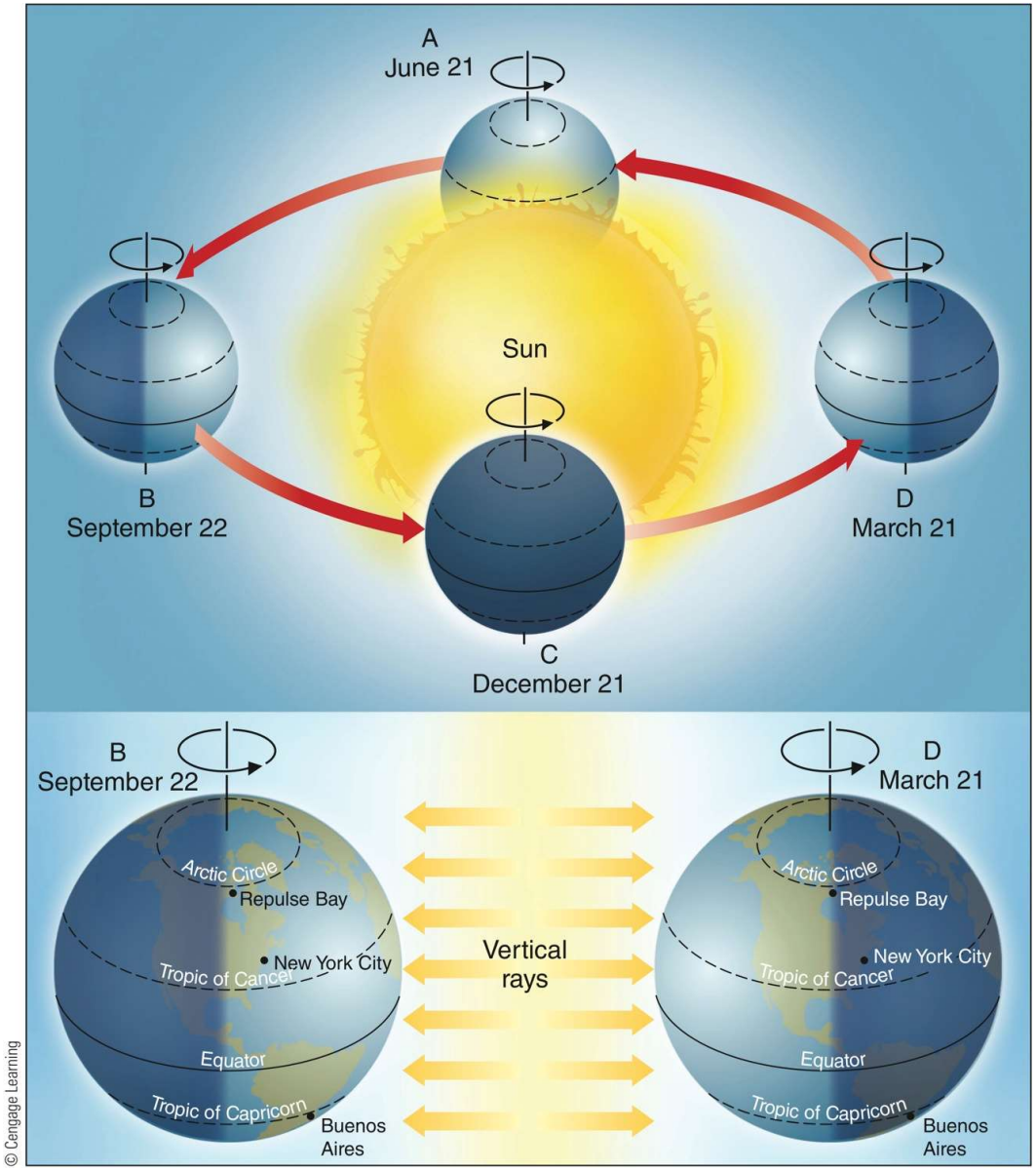
The Earth–Sun System (cont'd.)

- The seasons
  - Caused by:
    - The 23½° tilt of Earth's equator to the plane of the ecliptic
    - The parallelism of the axis that Earth maintains while orbiting the sun
  - Summer solstice and winter solstice
  - Equinox

How do the daylight hours of the two hemispheres compare during the solstice days?



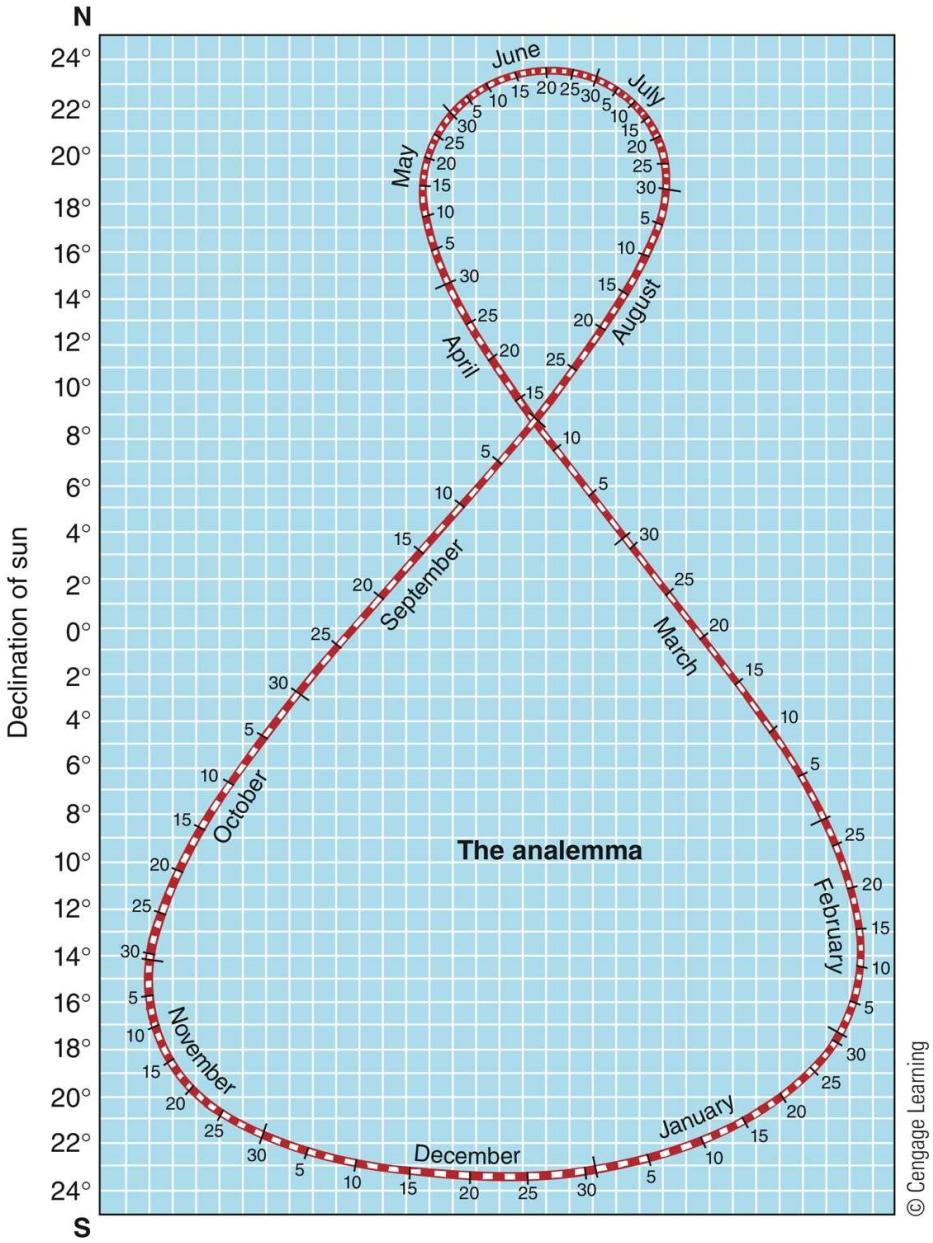
If Earth were not inclined on its axis, would there still be latitudinal temperature variations? Would there be seasons?



The Earth–Sun System (cont'd.)

- Latitude lines delimiting solar energy
  - June solstice: no darkness for all points north of the Arctic Circle
  - Antarctic Circle
  - Tropic of Cancer: most northern position possible for directly overhead solar rays
  - Tropic of Capricorn
  - Sun's declination

What is the declination of the sun on October 30th?

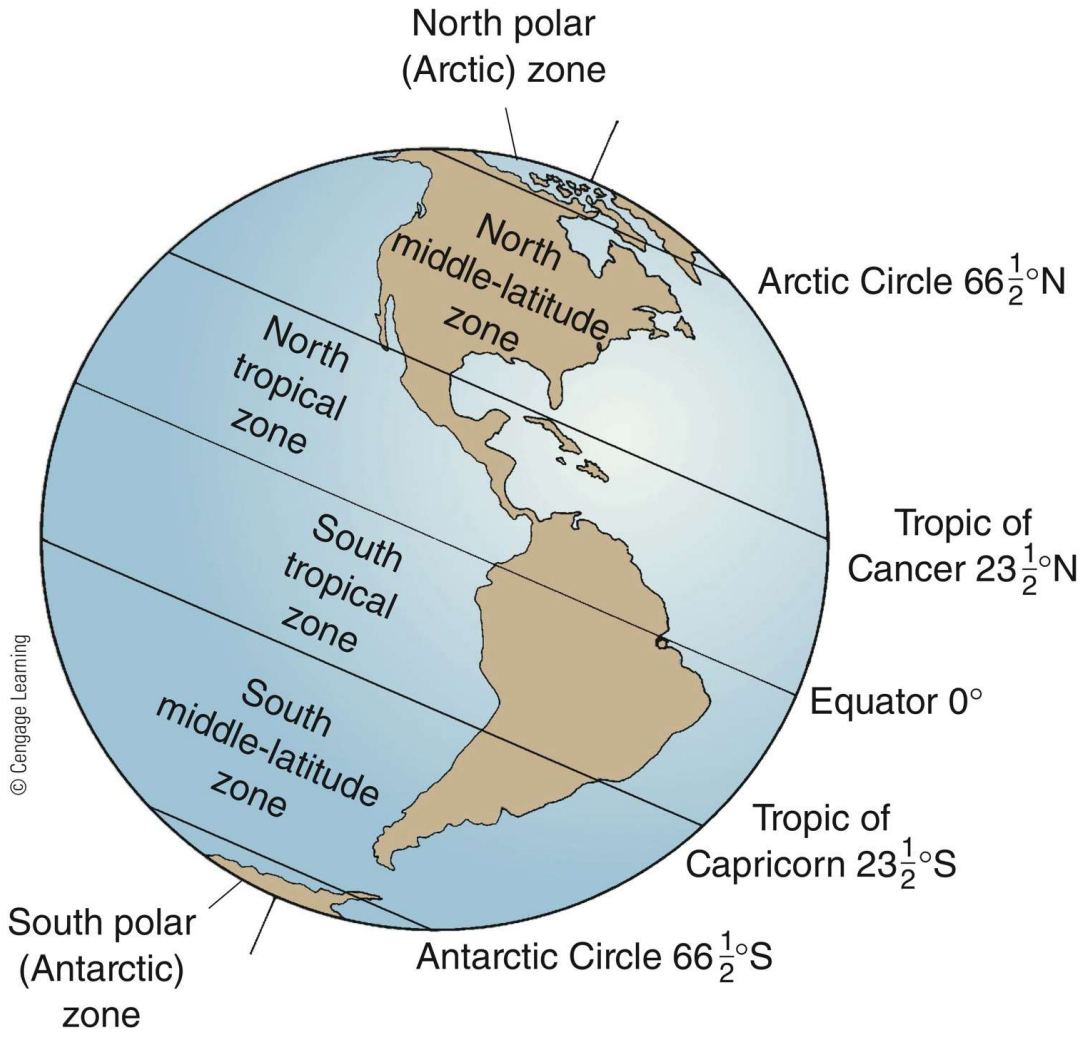


The Earth–Sun System (cont'd.)

- Passive solar energy, an ancient concept
  - Designing dwellings and other structures in accordance with the sun and solar energy
    - Early cultures: China, Egyptians, Greeks and Romans
    - Americas: ancient Maya, Incas, Aztecs, and North American tribes

The Earth–Sun System (cont'd.)

- Variations of insolation with latitude
  - North tropical zone
  - North middle-latitude zone
  - North polar zone or Arctic zone
  - South tropical zone
  - South middle-latitude zone
  - South polar zone or Antarctic zone



Which zones have the greatest and least annual variation in insolation? Why?

Characteristics of the Atmosphere

Table 3.2
Composition of the Atmosphere Near Earth's Surface

Permanent Gases			Variable Gases	
Gas	**Symbol**	**Percent (by volume) Dry Air**	**Gas (and particles)**	**Symbol**
Nitrogen	N_2	78.08	Water vapor	H_2O
Oxygen	O_2	20.95	Carbon dioxide	CO_2
Argon	Ar	0.93	Methane	CH_4
Neon	Ne	0.0018	Nitrous oxide	N_2O
Helium	He	0.0005	Ozone	O_3
Hydrogen	H_2	0.0006	Particles (dust, soot, etc.)	
Xenon	X_2	0.000009	Chlorofluorocarbons	>

Characteristics of the Atmosphere (cont'd.)

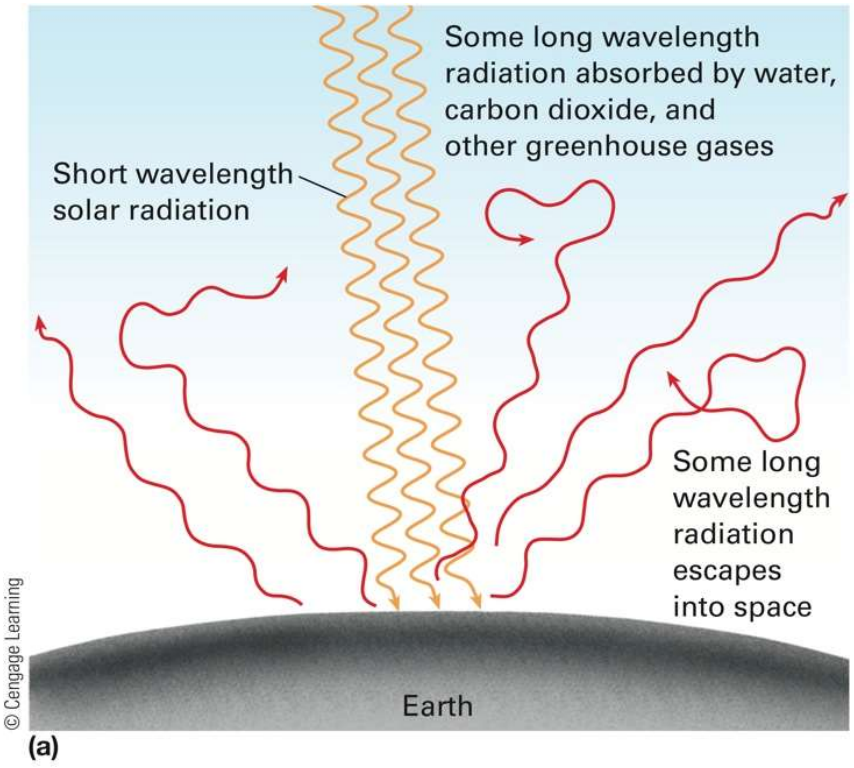
- Abundant gases
  - Nitrogen: largest proportion of air
  - Oxygen: vital to life
    - What is oxidation?
  - Argon: chemically inactive gas
- Water, particulates, and aerosols
  - Water vapor: absorbs heat in the lower atmosphere
  - Aerosols: particulates or liquids suspended in the atmosphere

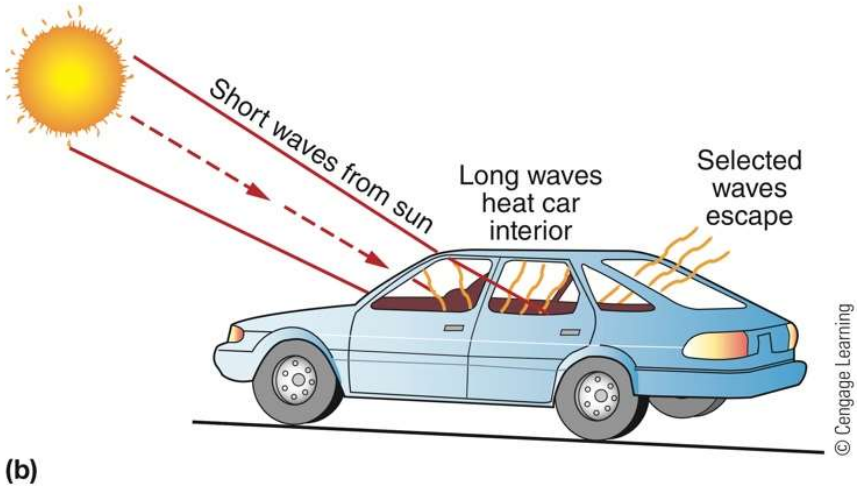
NASA International Space Station

What other ways are particles added to the atmosphere?

Characteristics of the Atmosphere (cont'd.)

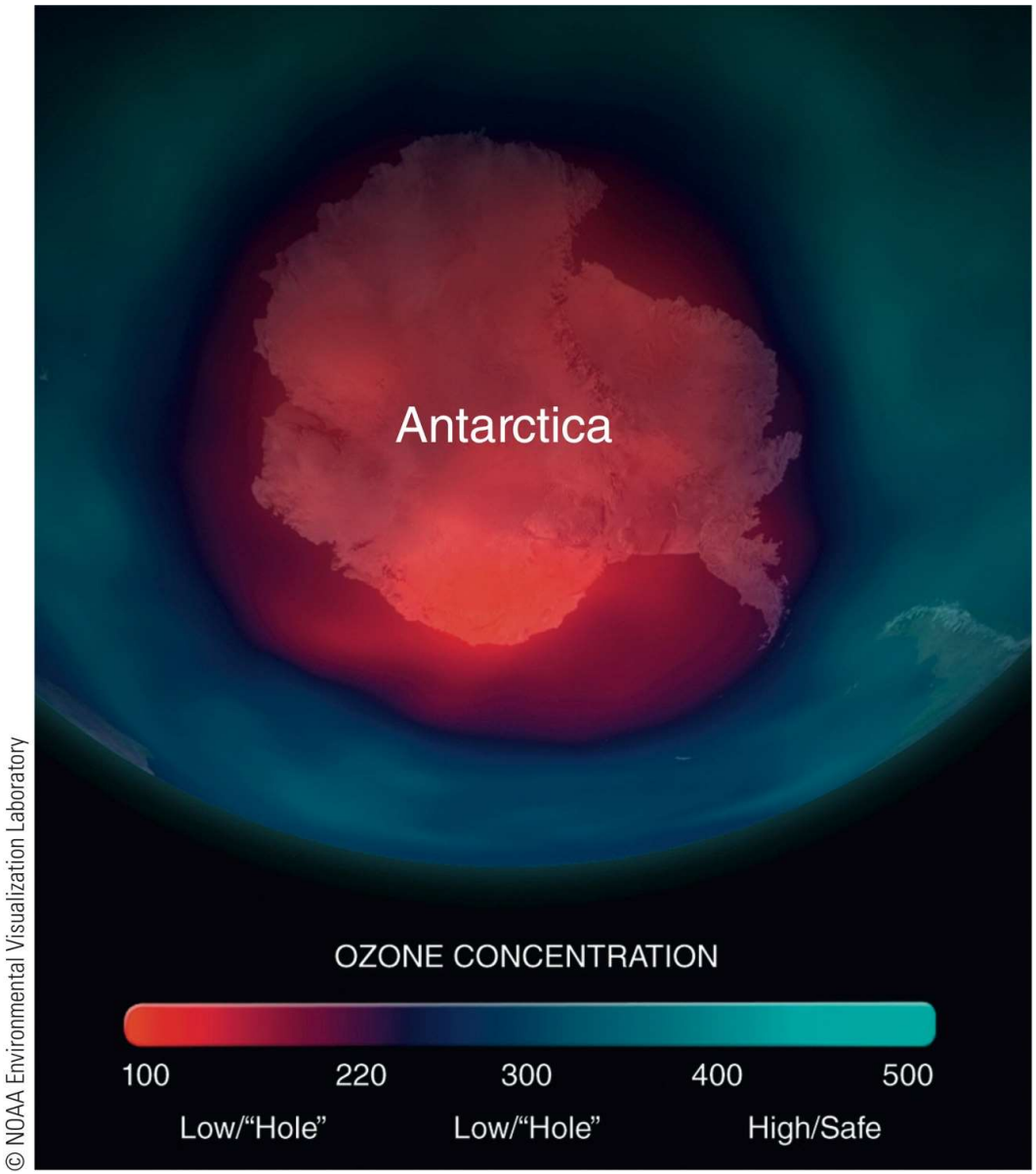
- Carbon dioxide
  - Carbon cycle
  - Photosynthesis
  - Atmospheric greenhouse effect
  - Deforestation
- Ozone
  - Toxic pollutant in lower atmosphere
  - Beneficial in upper atmosphere





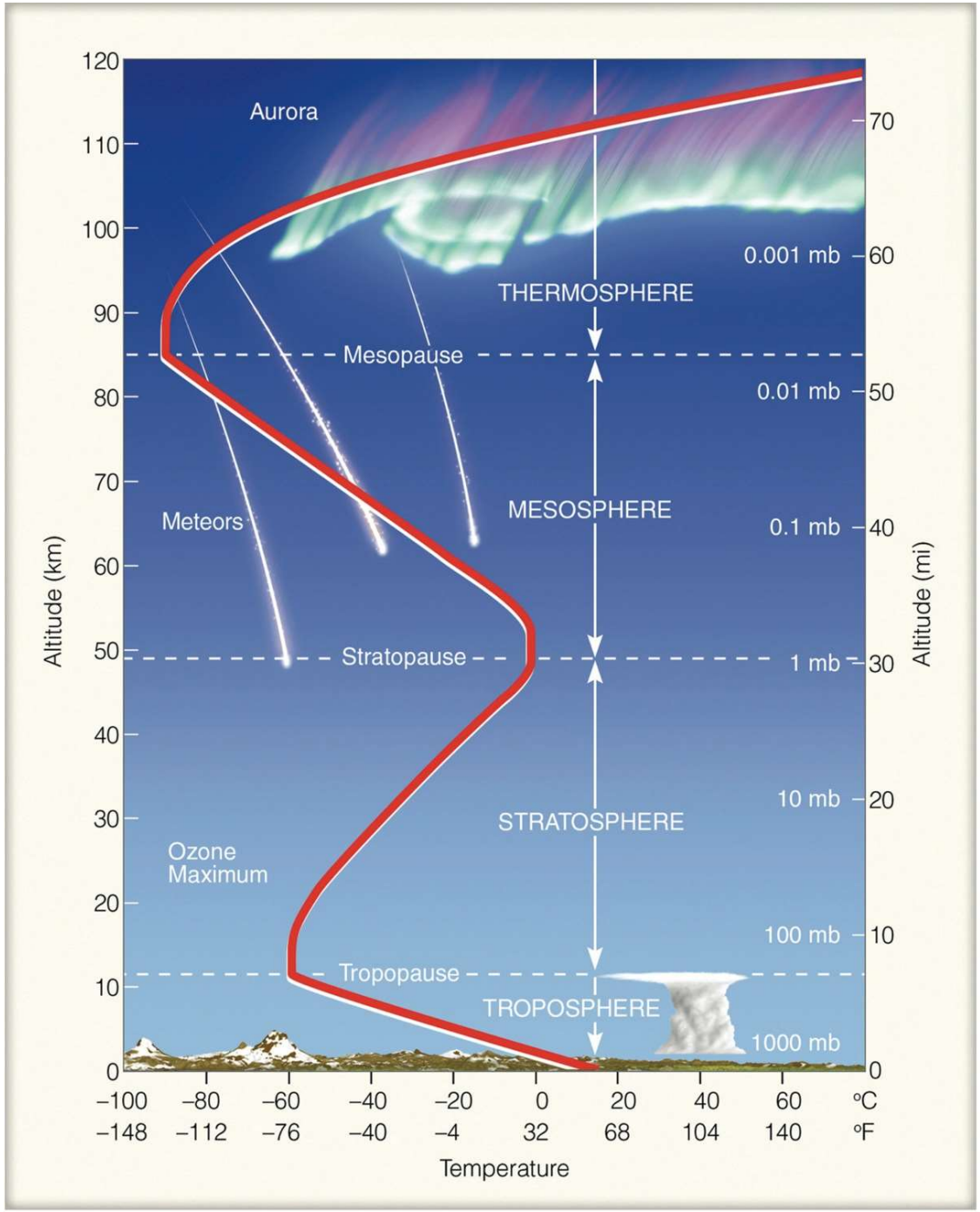
How might you prevent your car interior from becoming so hot on a summer day?

What are the potential effects of ozone depletion on the world's human population?



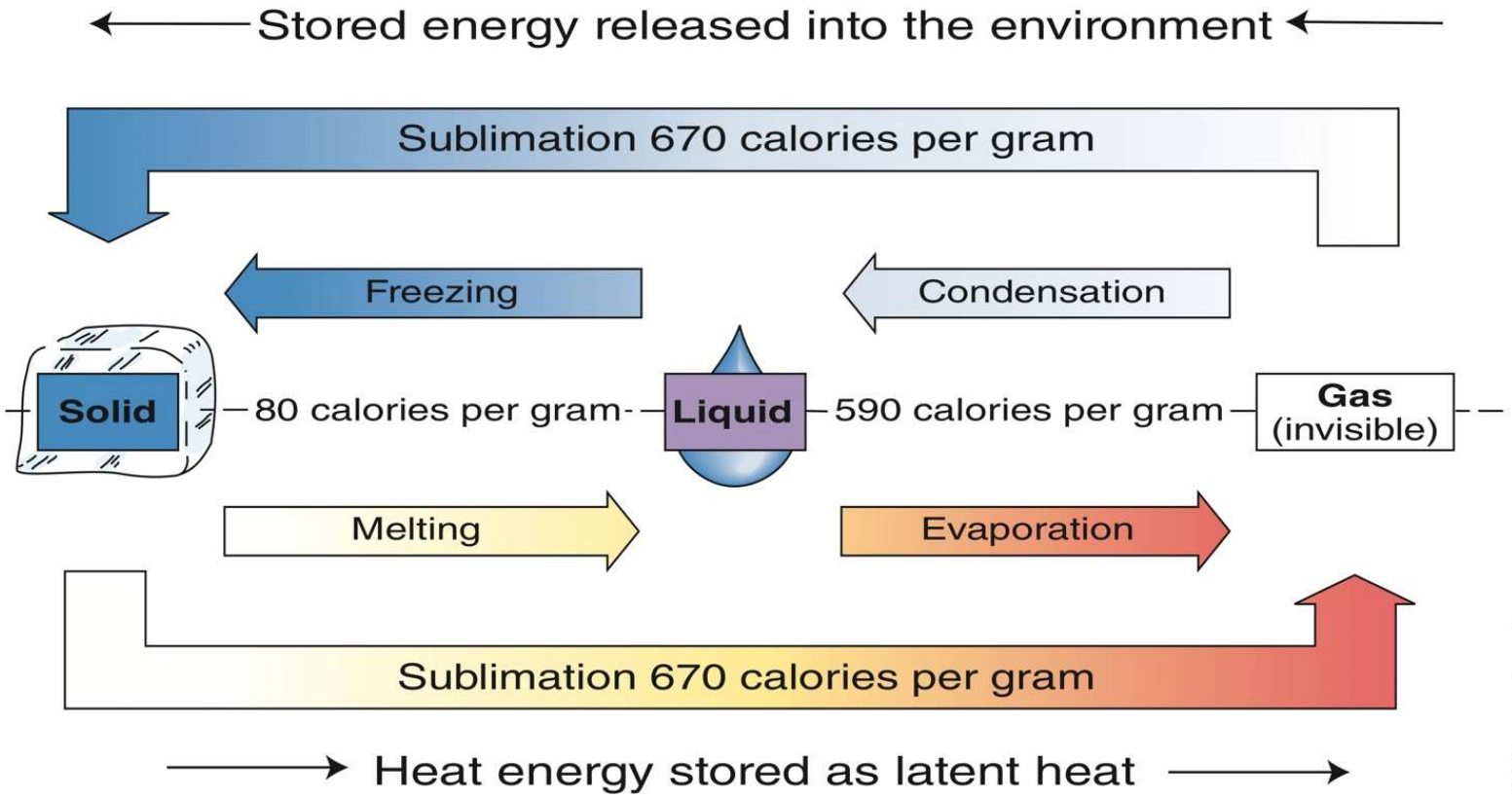
Characteristics of the Atmosphere (cont'd.)

- Vertical layers of the atmosphere
  - Defined by three systems, based on:
    - Protective layers
    - Chemical composition
    - Differences in temperature and rates of temperature change: troposphere, stratosphere, mesosphere, and thermosphere



Energy Interactions

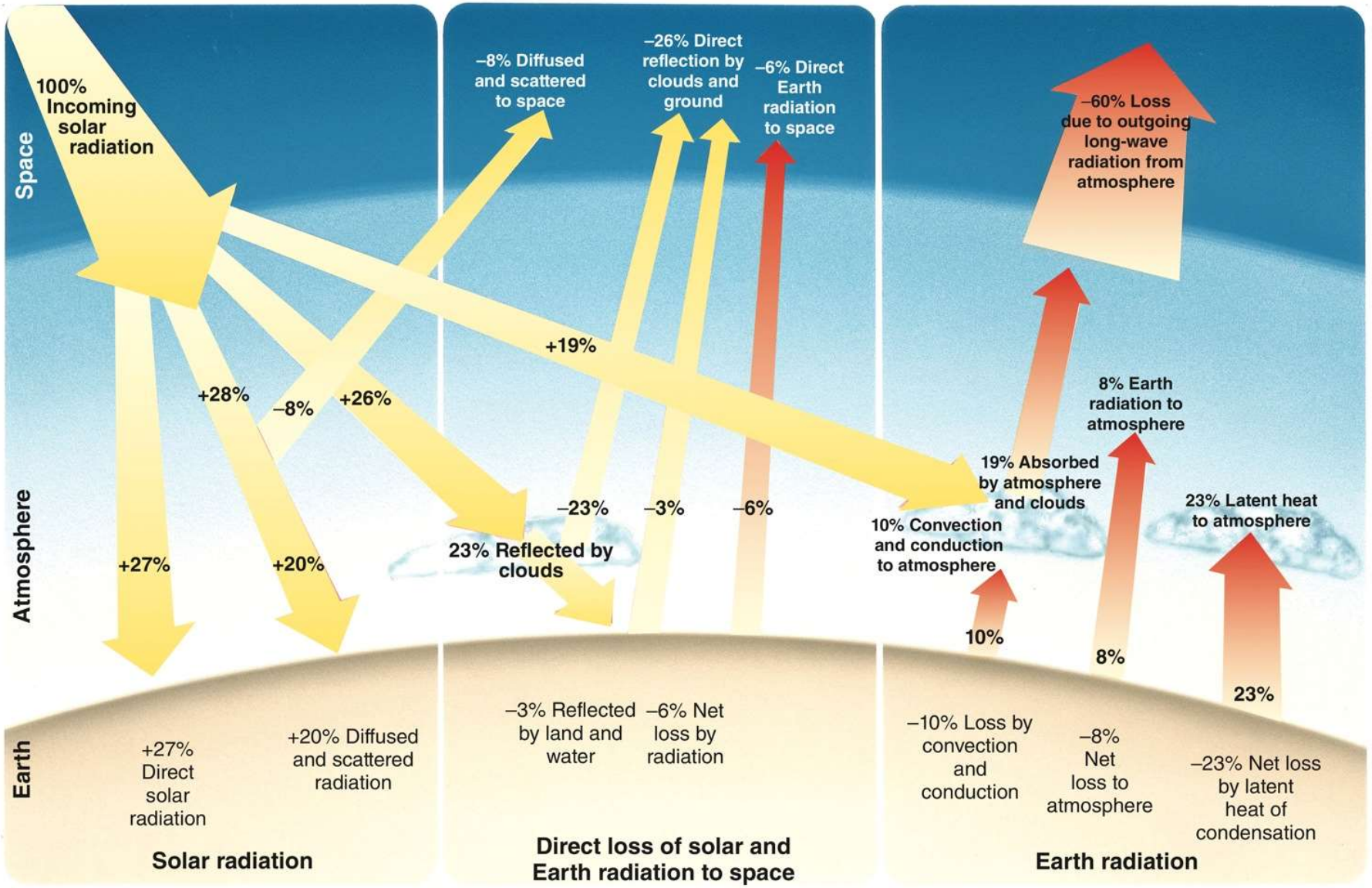
- Energy transfer processes
  - Radiation: sun to Earth
  - Conduction: substances in contact
  - Convection: vertical transfer of heat
  - Advection: horizontal heat transfer
- Water, energy, and heat
  - Latent heat exchange
  - Evaporative cooling



Why is some of the energy in these exchanges referred to as "latent heat?"

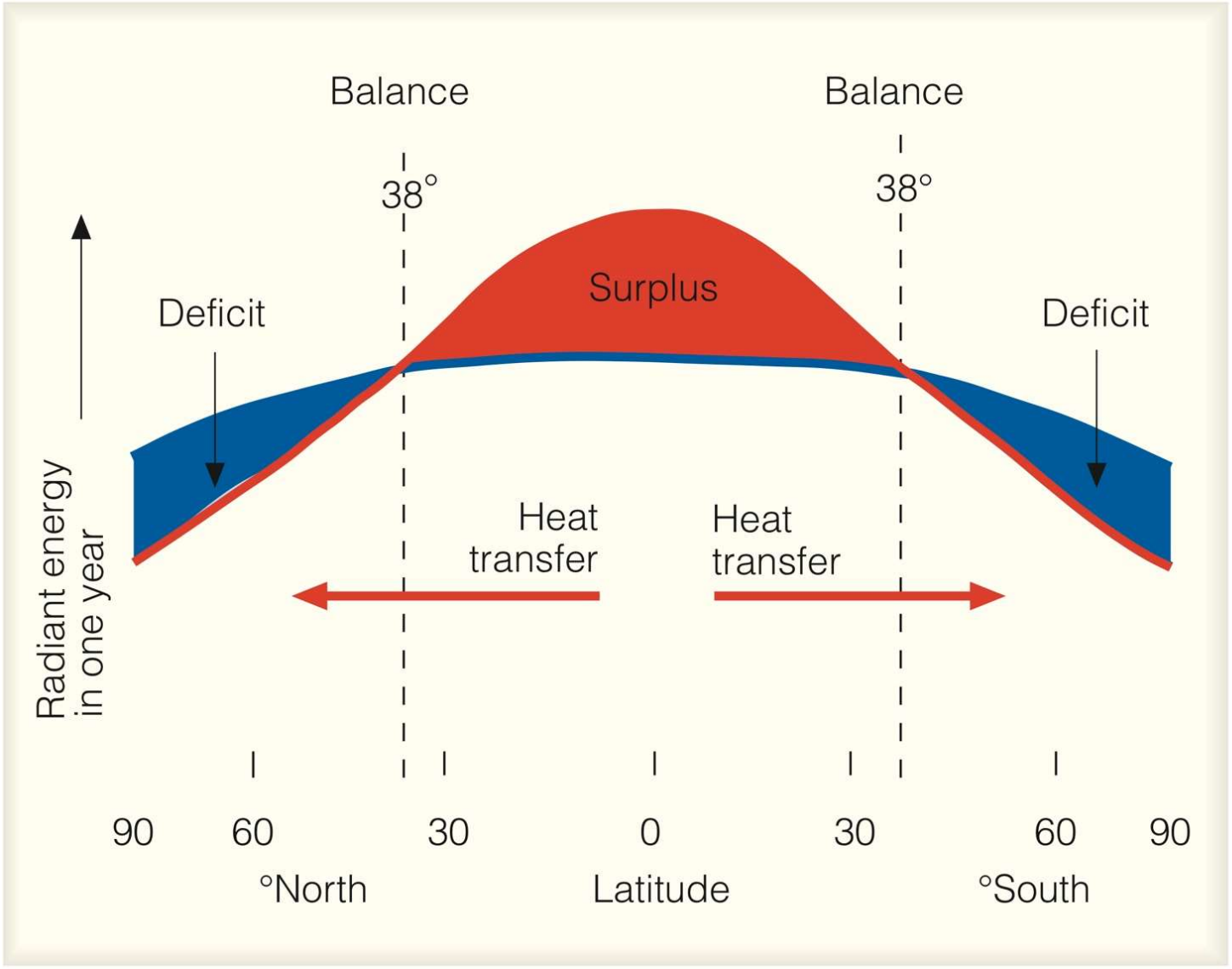
Earth's Energy Budget

- Earth's energy budget
  - Determination/inventory of incoming energy, its storage, and outgoing energy processes
- Heating the atmosphere
  - Terrestrial radiation: ultimate source of atmospheric heat
  - Earth's surface energy budget
    - No long-term gain or loss



Earth's Energy Budget (cont'd.)

- Earth's energy balance
  - Energy system
    - Input
    - Output
    - Dynamic equilibrium
- Variations in the energy budget
  - Most likely not balanced for any particular location
  - Attributed to latitude and seasonal fluctuations



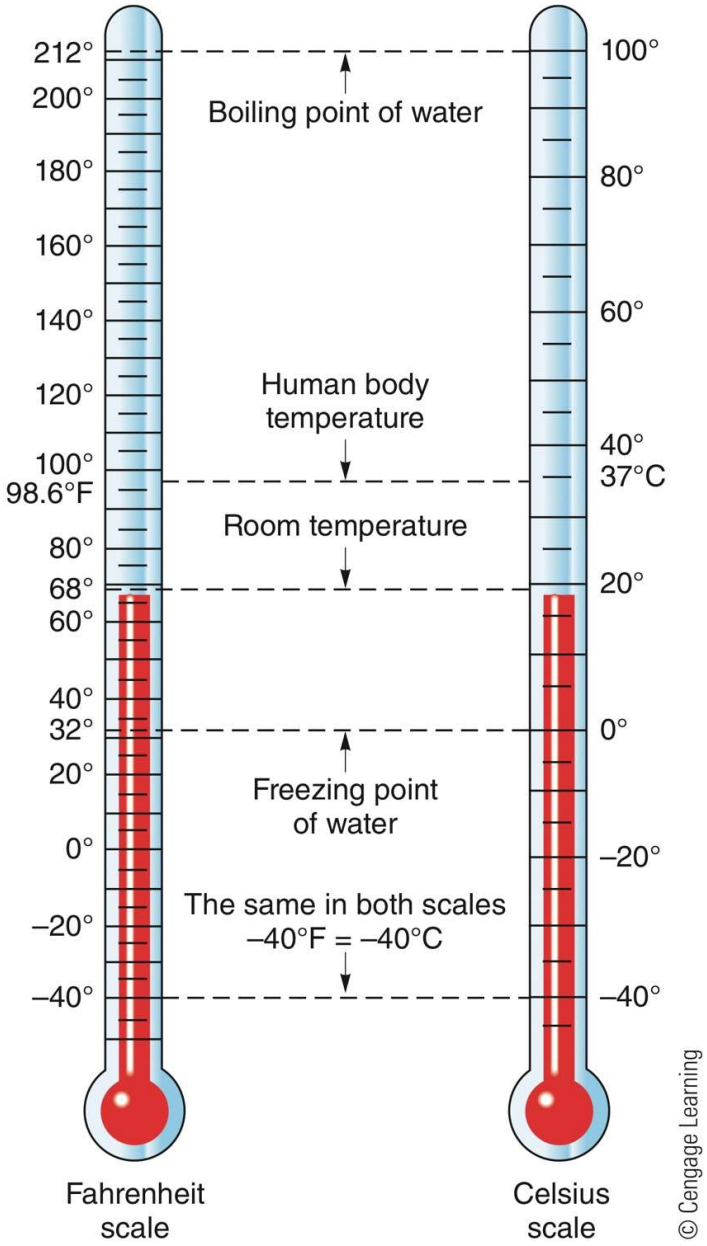
How is the surplus energy in the low latitudes transferred to higher latitudes?

Air Temperature

- Temperature and heat
  - Heat: form of energy
  - Temperature: energy of individual molecules
  - Temperature scales: Fahrenheit and Celsius

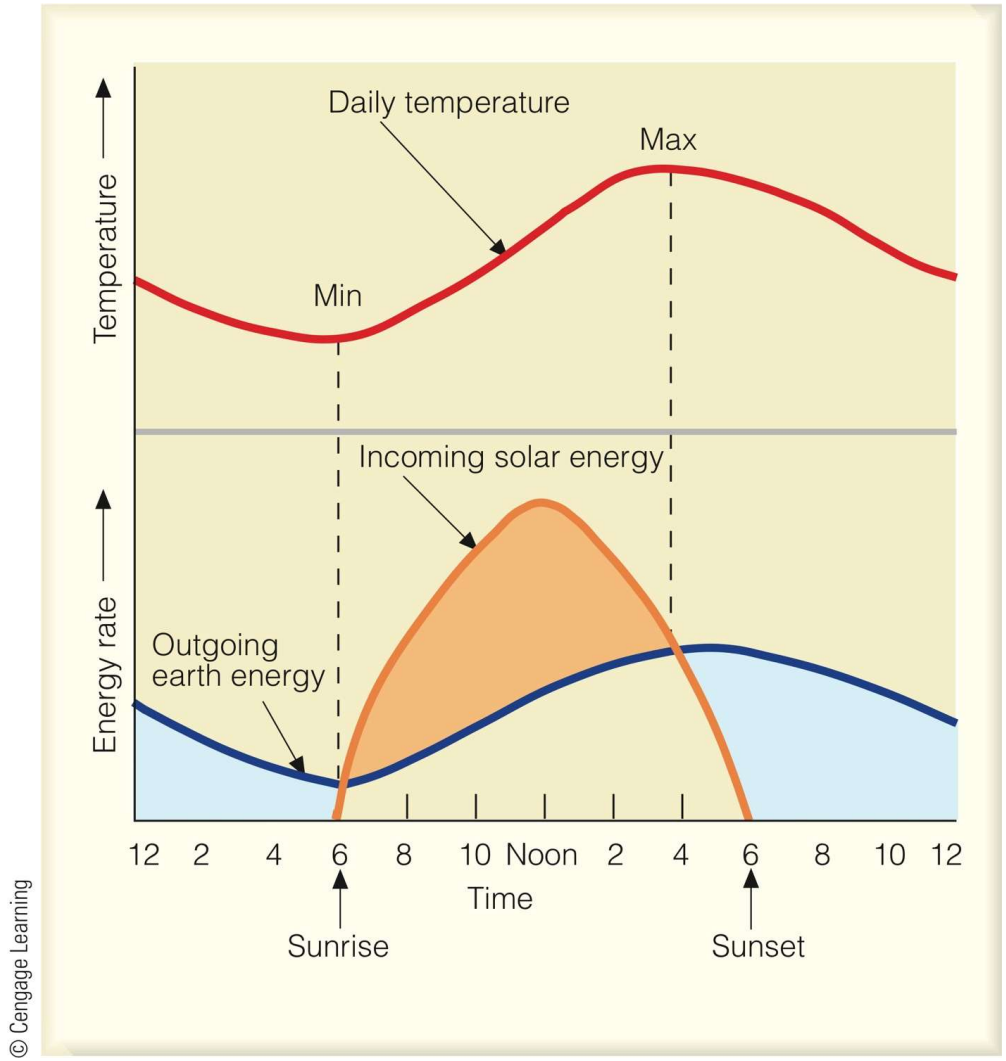
$$°C = (°F - 32) \div 1.8$$
$$°F = (°C \times 1.8) + 32$$

When it is 70°F, what is the temperature in Celsius degrees?

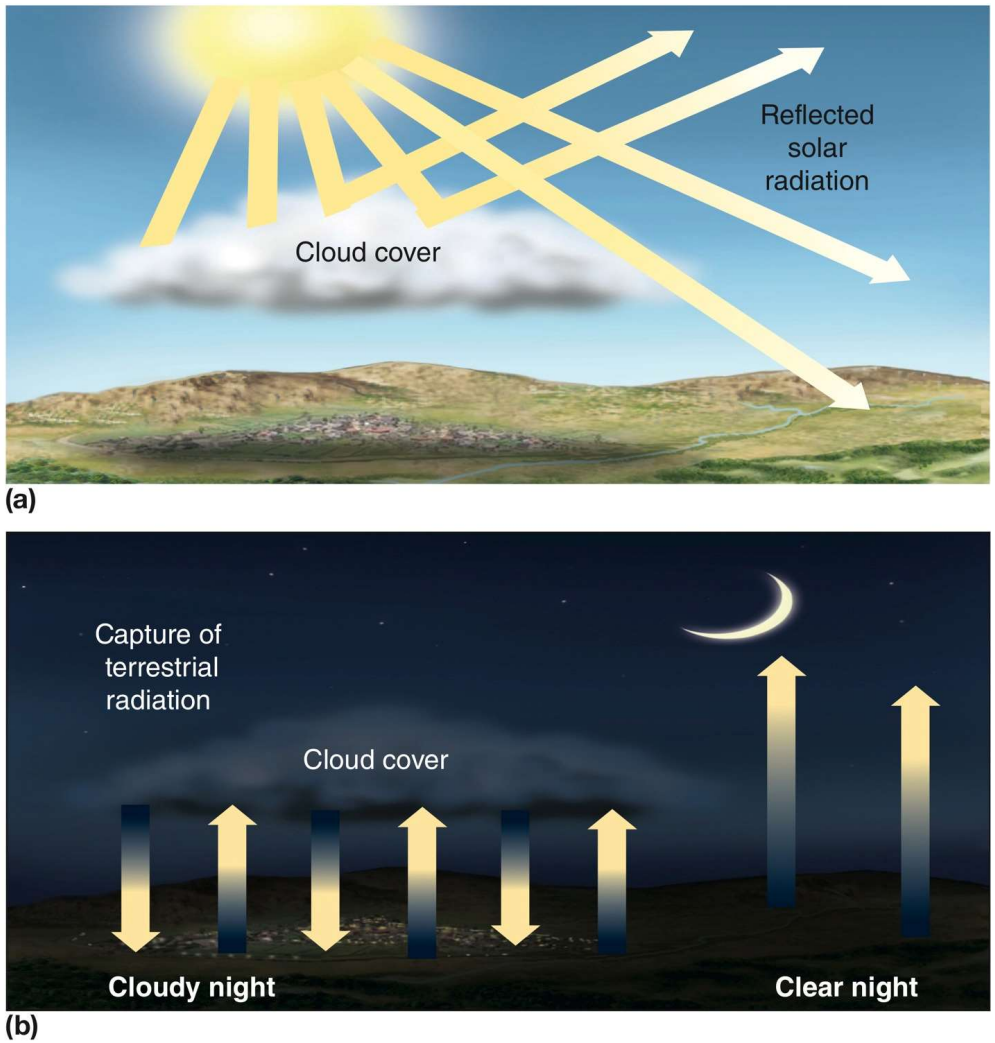


Air Temperature (cont'd.)

- Short-term variations in temperature
  - The daily effects of insolation: Earth's daily rotation
    - Daily temperature lag
    - Daily march of temperature
  - Cloud cover: extent and density
  - Differential heating of land and water
    - Maritime locations
    - Continentality of a location



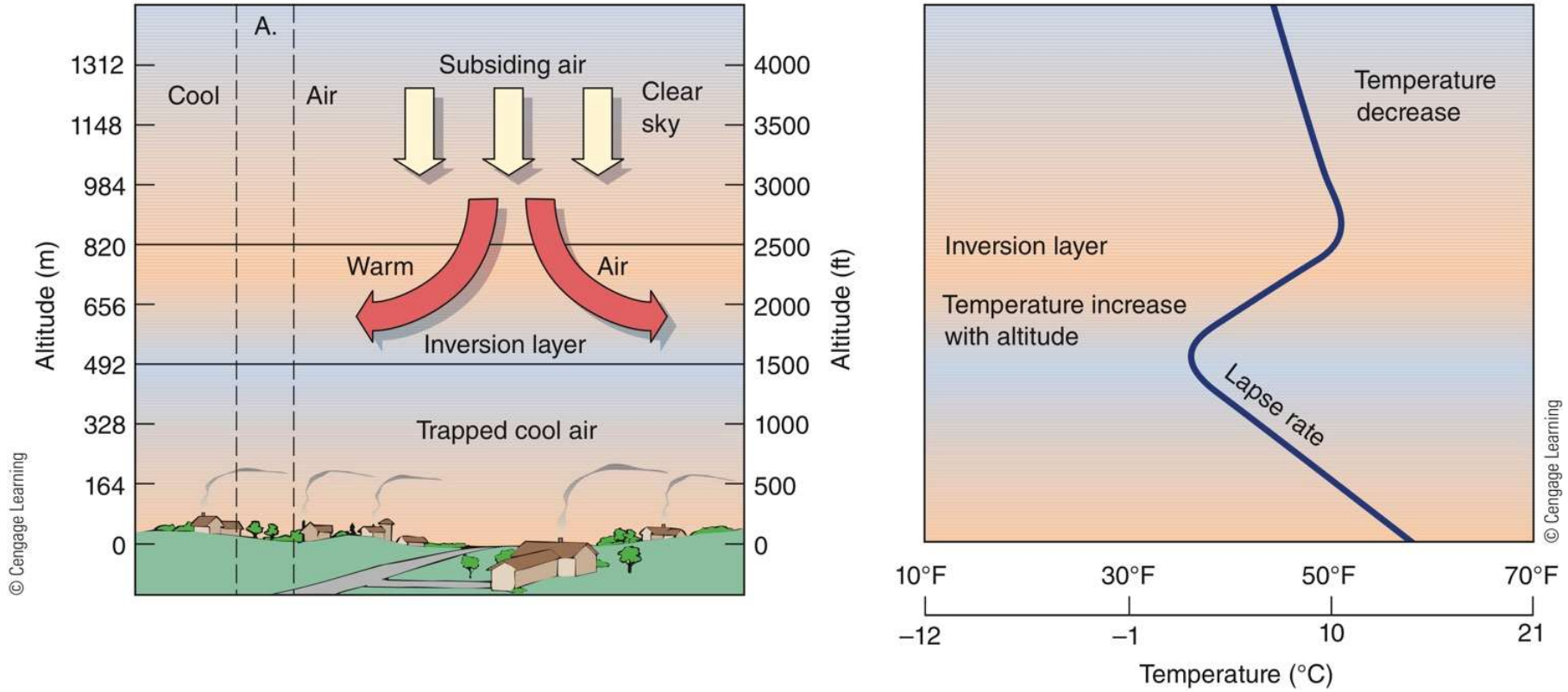
Why does temperature rise even after the input of solar energy declines?



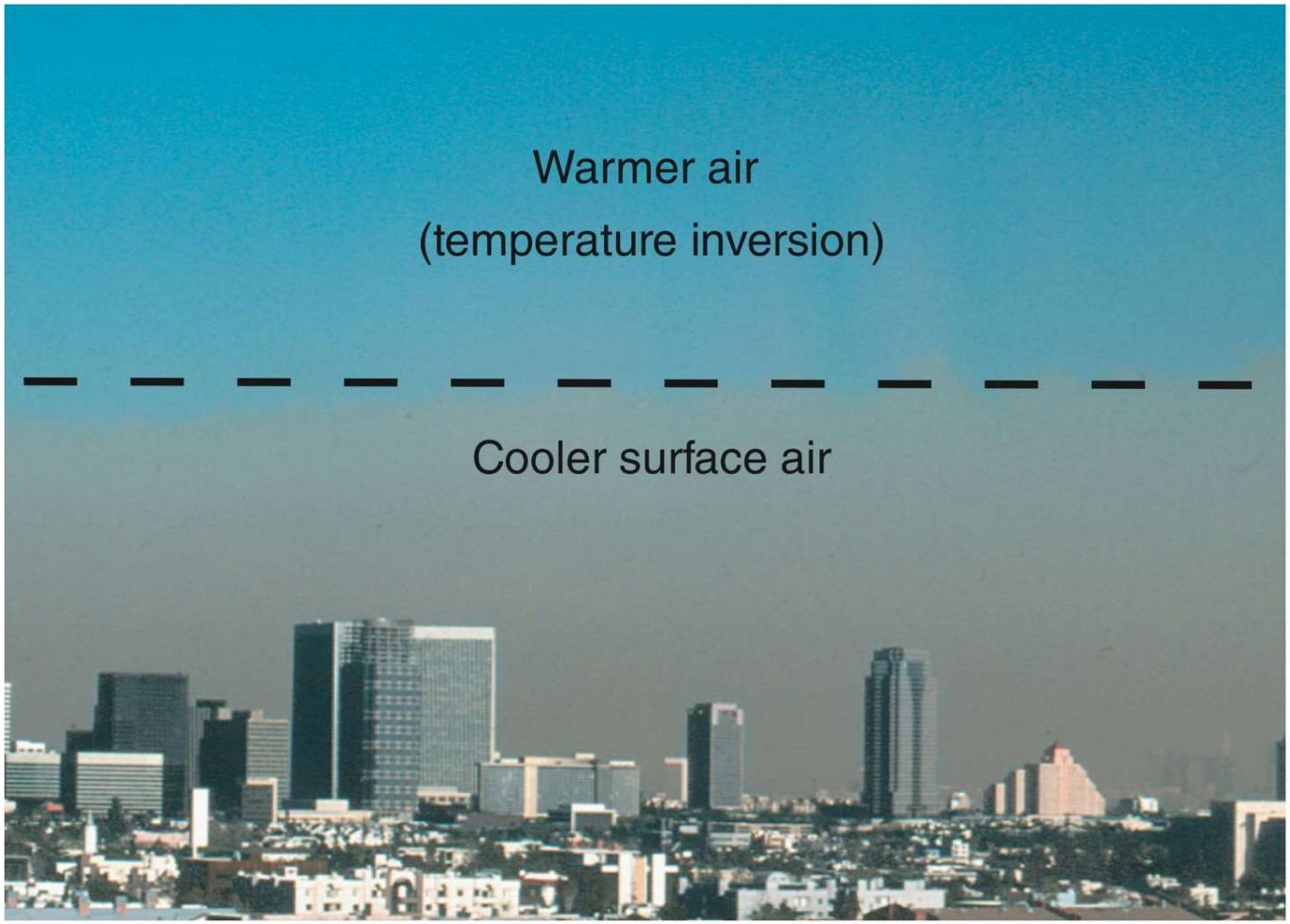
Why do desert regions have large diurnal temperature variations?

Air Temperature (cont'd.)

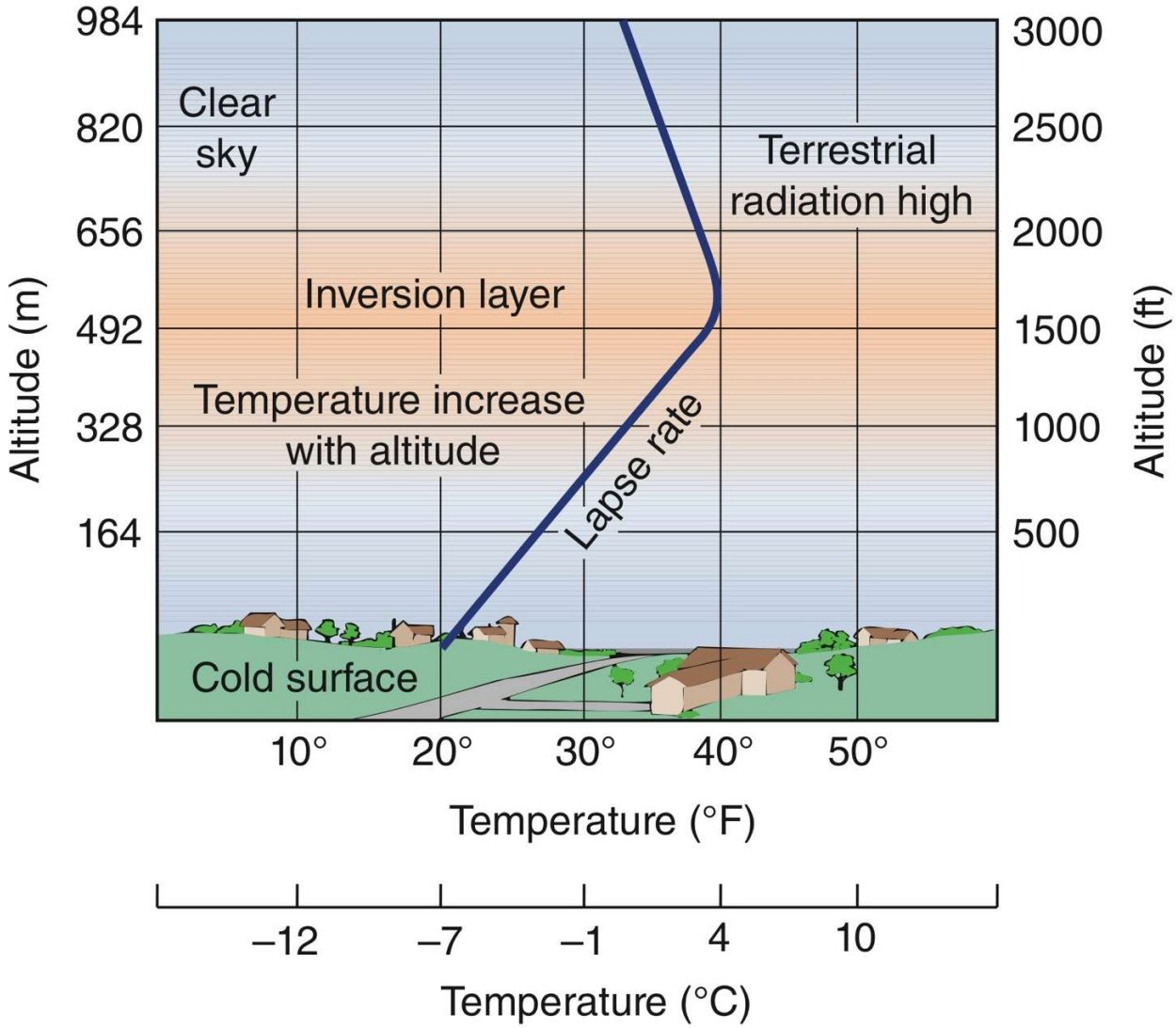
- Short-term variations in temperature
  - Reflection
    - Albedo related to absorption of energy
  - Horizontal air movement
- Vertical temperature distributions
  - Environmental lapse rates
    - Average decrease in air temperature with altitude
  - Temperature inversions
    - Inversion layer



Why is the pattern (to the right) called a temperature inversion?



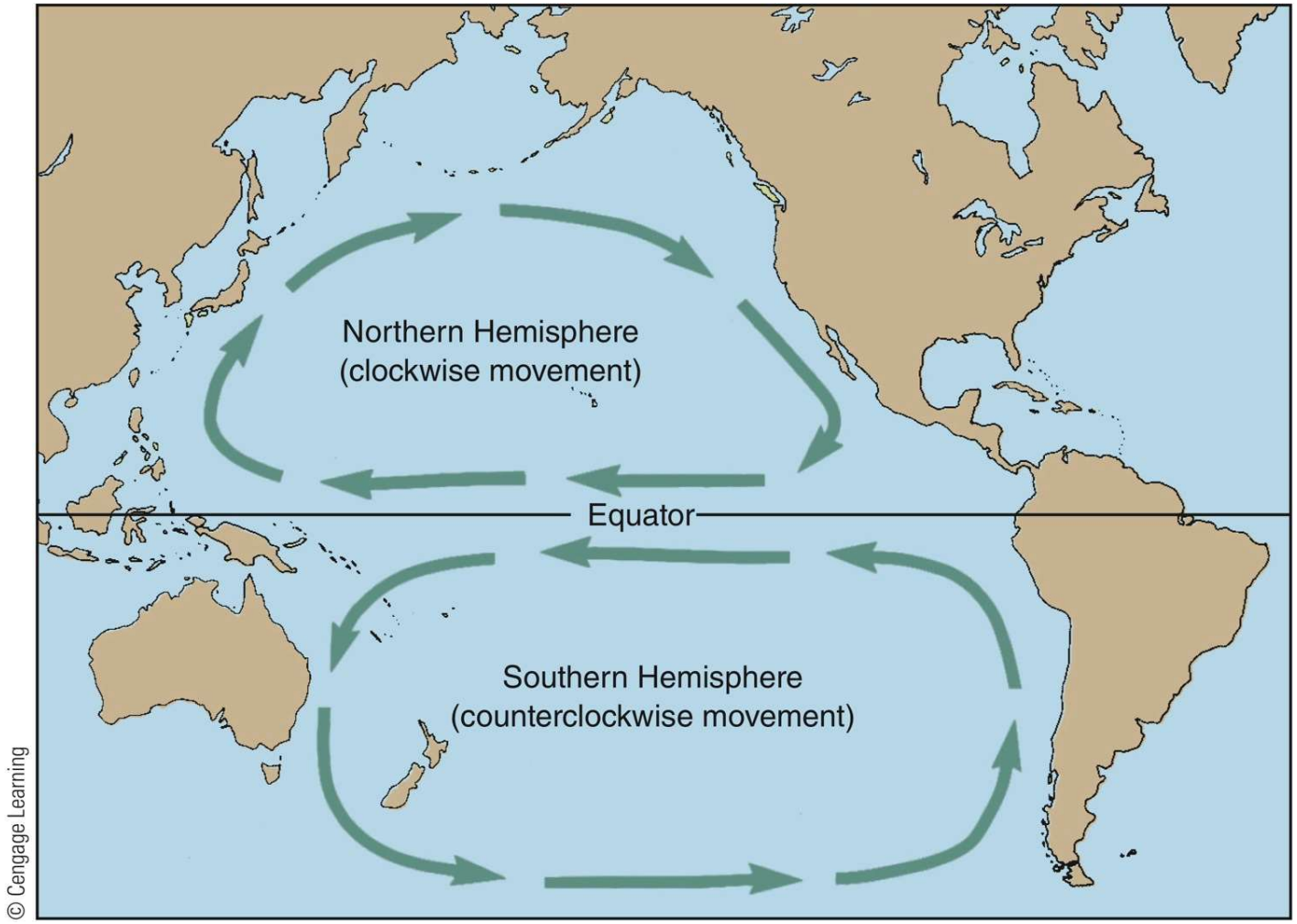
Why is the air clear above the inversion layer?



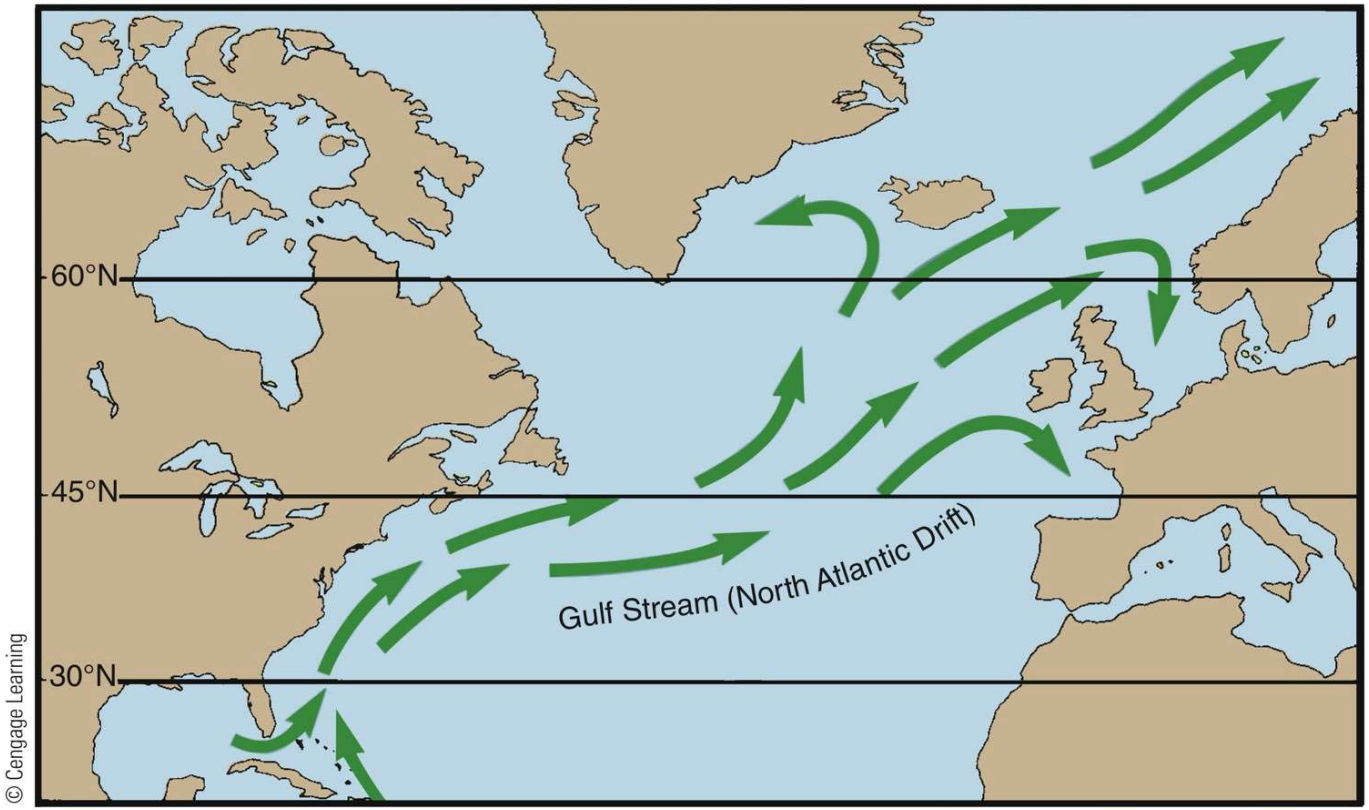
What is the significance of an inversion?

Air Temperature (cont'd.)

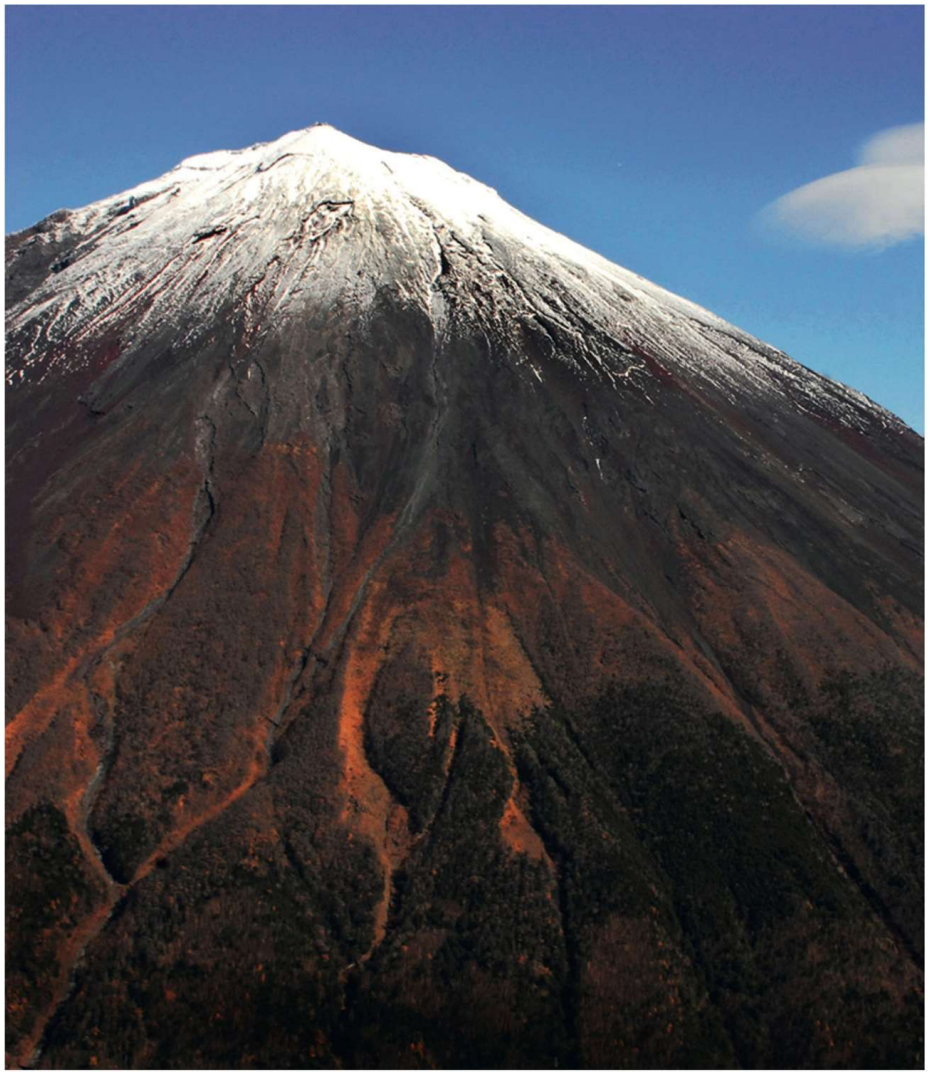
- Vertical temperature distributions
  - Surface inversions: fog and frost
- Controls of surface temperature
  - Latitude
  - Land and water distribution
    - Different substances heat and cool at different rates
  - Ocean currents



What direction would a hurricane forming off western Africa take as it approached North America?



Use this figure and the information gained in Figure 3.25 to discuss the route sailing ships would follow from the United States to Europe and back.



U.S. Navy/Bryan Reckard

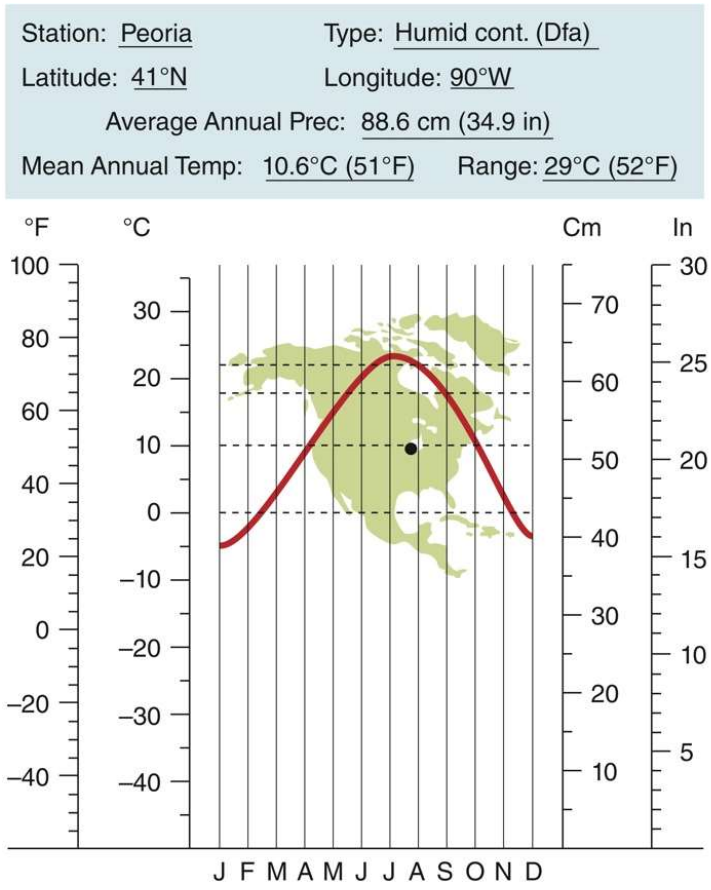
At what rate per 1,000 meters do temperatures decrease with height in the troposphere?

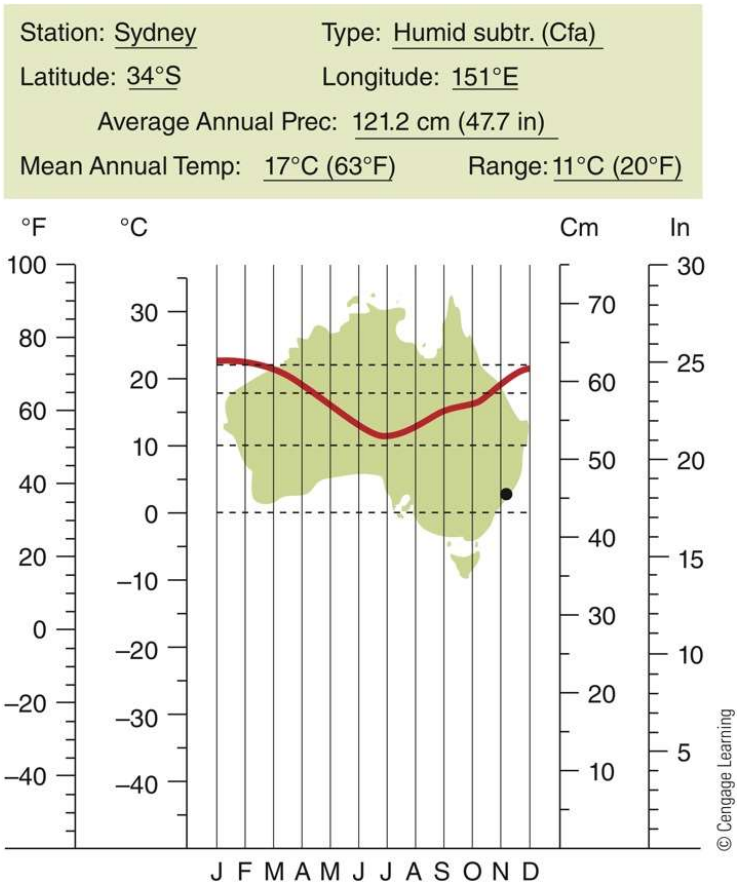
Air Temperature (cont'd.)

- Controls of surface temperature
  - Altitude
  - Landform barriers
  - Human activities
- Surface temperature distribution
  - Isothermal maps show temperature gradients
  - Refer to "Understanding Map Content 3.1"

Air Temperature (cont'd.)

- Annual temperature changes
  - Annual temperature lag
  - Annual march of temperature





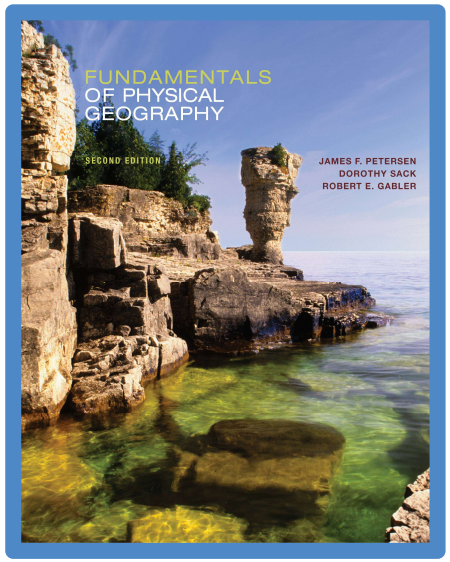
Why do these two locations have opposite temperature curves?

Fundamentals of Physical Geography 2e

Solar Energy and Atmospheric Heating

3

<end of chapter>



- Peterson
  - Sack
    - Gabler