Objectives

- **Describe** different types of climate data.
- **Recognize** limits associated with the use of normals.
- **Explain** why climates vary.

Vocabulary

- climatology
- climate
- normal
- tropics
- temperate zone
- polar zone

What is Climate?

- Understanding and predicting climatic changes are the basic goals of climatology.

Climatology is the study of Earth's climate and the factors that affect past, present, and future climatic changes.

Climate: More Than Just Average Weather

Climate describes the long-term weather patterns of an area.

- Climate describes **annual variations of temperature, precipitation, wind, and other weather variables**.
- Studies of climate show **extreme fluctuations of these variables over time**.

Climate: More Than Just Average Weather

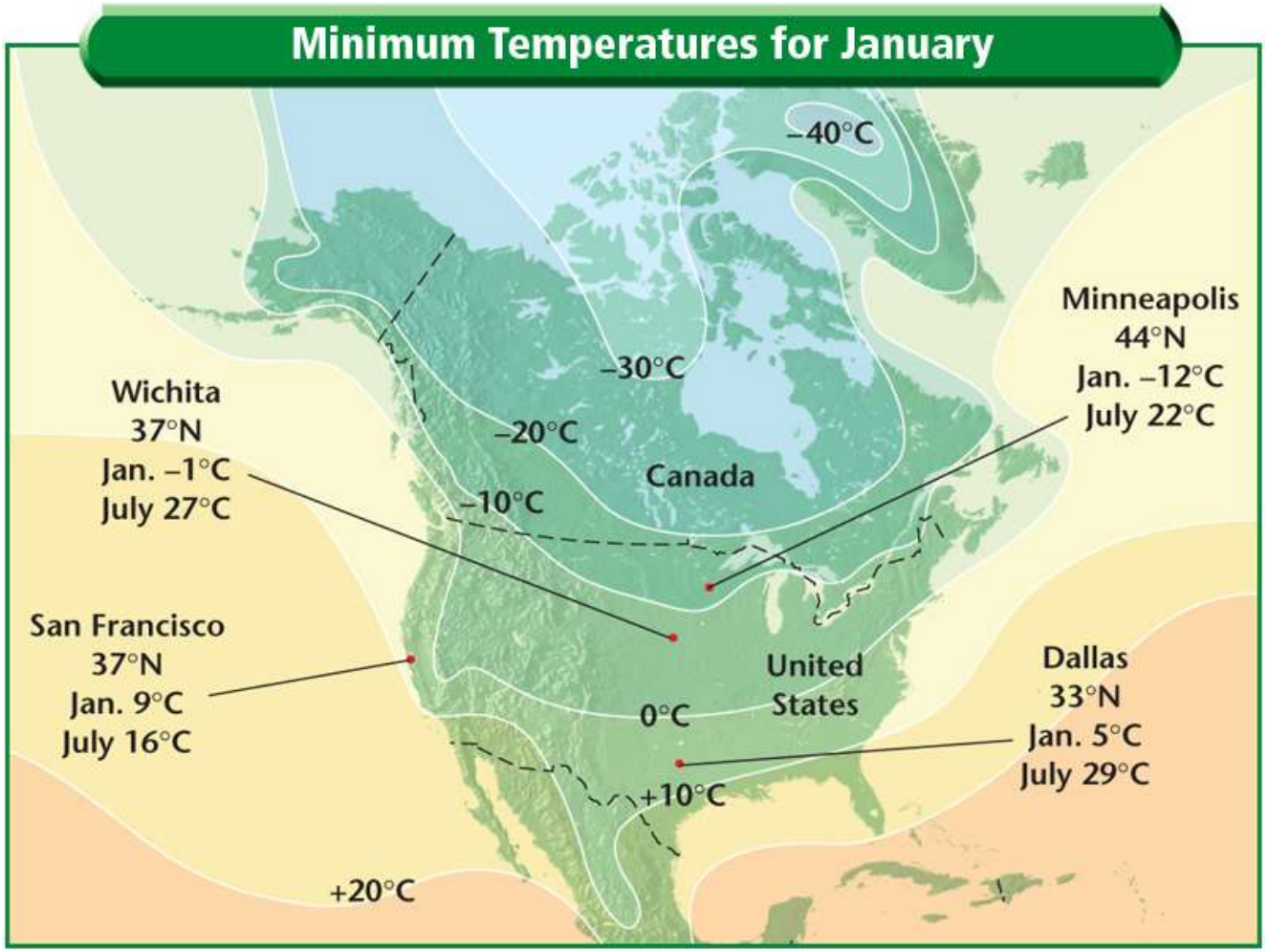
Normals

- The **data** used to describe an area's climate include daily high and low **temperatures**, amounts of **rainfall**, **wind speed and direction, humidity, and air pressure**.
- The **normals**, or standard values, for a location are the average values on a monthly or annual basis for a period of at least 30 years.
- Weather conditions on any given day might differ widely from normals.
- **Normals apply only to the specific place** where the meteorological data were collected, **not to regions**.

What Causes Climates?

- Climates around the country vary greatly due to **latitude, topography**, closeness of **lakes and oceans**, availability of **moisture, global wind patterns, ocean currents**, and air masses.

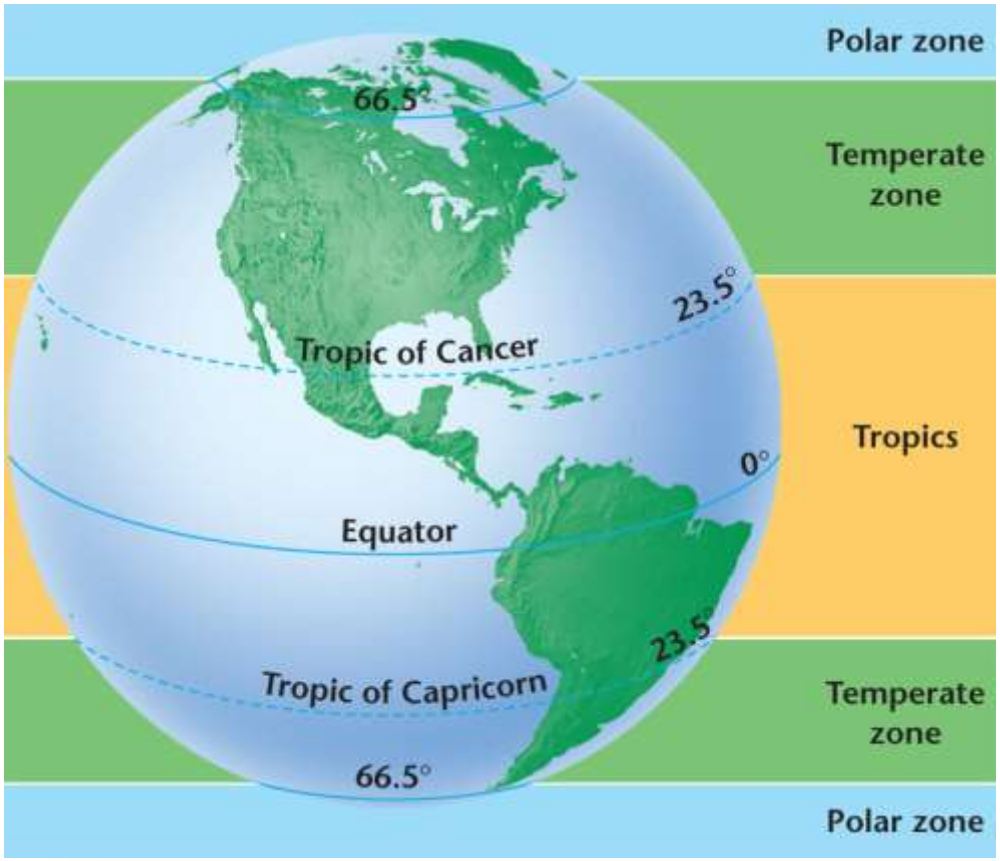
What Causes Climates?



What Causes Climates?

Latitude

– The amount of solar radiation received by any one place varies because Earth is tilted on its axis, and this affects how the Sun's rays strike Earth's surface.



What Causes Climates?

Latitude

- The **tropics** are the area between 23.5° south of the equator and 23.5° north of the equator.
- The **temperate zones** lie between 23.5° and 66.5° north and south of the equator.
- The **polar zones** are located from 66.5° north and south of the equator to the poles.

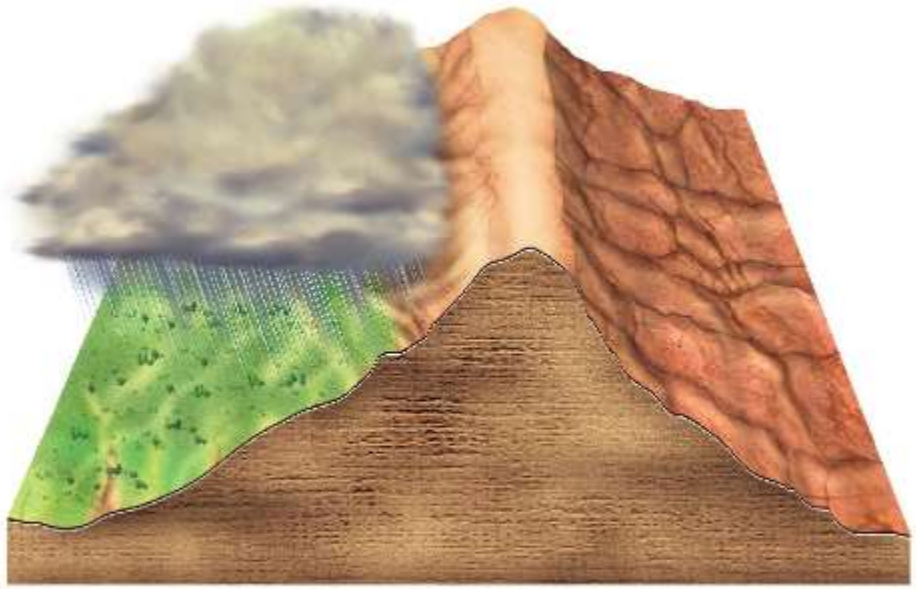
What Causes Climates?

Topographic Effects

- Large bodies of water affect the climates of **coastal areas** because **water heats up and cools down more slowly than land**.
- **Mountain climates are usually cooler** than those at sea level because **temperatures** in the lower atmosphere **generally decrease with altitude**.
- Climates often **differ on either side of a mountain**.

What Causes Climates?

Topographic Effects



reset

What Causes Climates?

Air Masses

- Two of the main causes of weather are the movement and interaction of air masses.
- Air masses affect climate as they have distinct regions of origin, caused primarily by differences in the amount of solar radiation.
- Average weather conditions in and near regions of air-mass formation are fairly similar to those exhibited by the air masses themselves.

Section Assessment

1. Match the following terms with their definitions.

B climatology

A climate

D normal

C tropics

A. the long-term weather patterns of an area

B. the study of Earth's climate and factors that affect past, present, and future climatic changes

C. the area on Earth between 23.5ºN and 23.5ºS

D. an average of meteorological records over a period of at least 30 years for a specific location

Section Assessment

2. Why are **deserts common on the leeward sides of mountains**?

As **air is forced upward on the windward side of the mountain through orographic lifting, moisture is squeezed out**.

On the **leeward side of the mountain the air is dry, and it warms** as it descends.

Section Assessment

3. Identify whether the following statements are true or false.

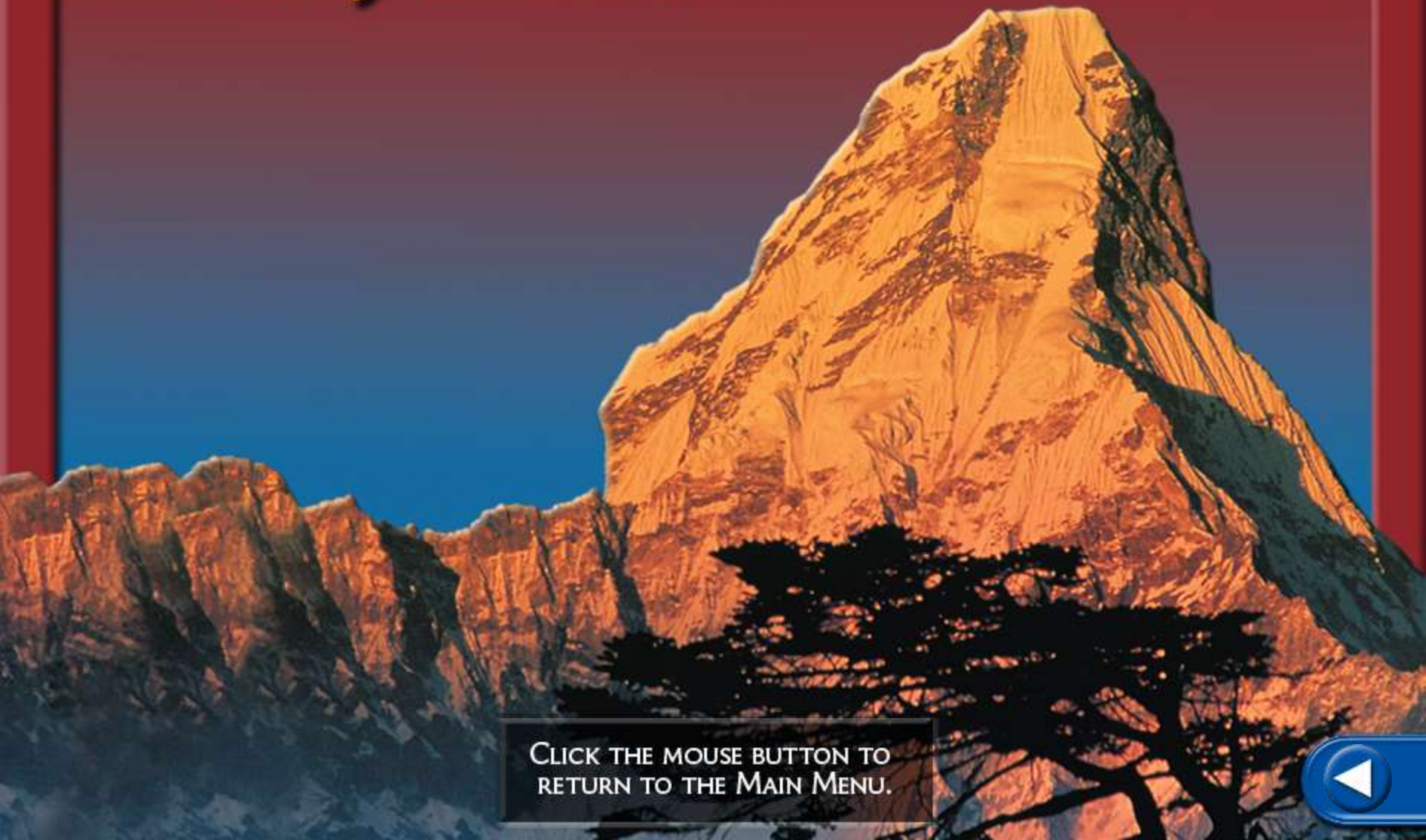
false Normals refer to regional climates.

true Coastal areas are usually cooler in the summer than areas that are inland.

true Continental regions generally experience a wider range of annual temperature than coastal regions.

false The entire area between 23.5ºN and 80ºN is a temperate zone.

End of the Section



Click the mouse button to return to the Main Menu.

Objectives

- **Describe** the criteria used to classify climates.
- **Compare** and contrast different climates.

Vocabulary

- – Koeppen classification system
- – microclimate
- – heat island

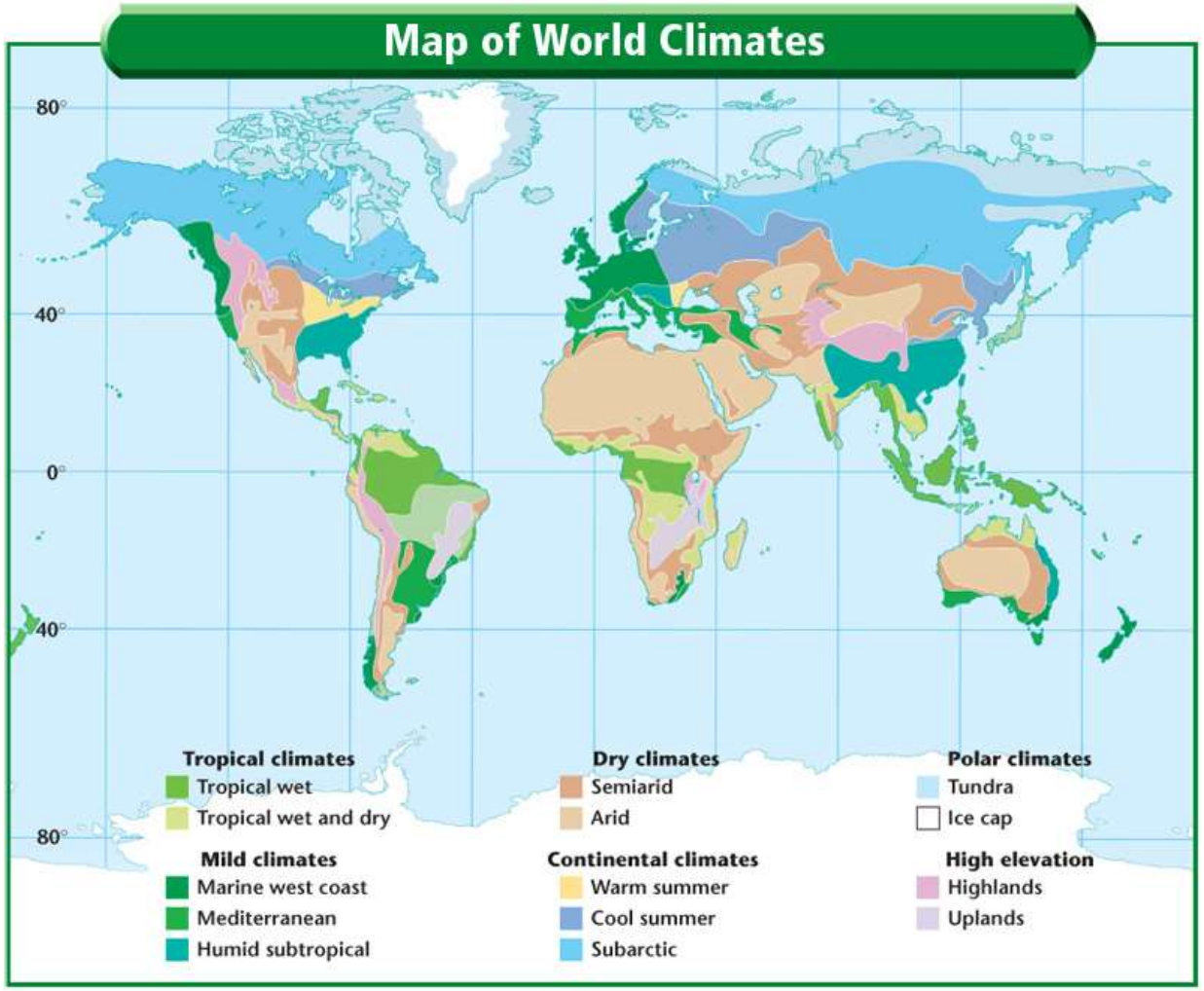
Climate Classification

- The **Koeppen classification system** is a climate classification system that takes into account temperature, precipitation, and the distinct vegetation found in different climates.

Koeppen Classification System

- Koeppen decided that a good way to distinguish among different climatic zones was by **natural vegetation**.
- He revised his system to include the **numerical values of temperature and precipitation** for a more scientific approach.
- Koeppen's classification system has **six main divisions: tropical, mild, dry, continental, polar, and high elevation** climates.

Koeppen Classification System



Koeppen Classification System

Tropical Climates

- **Constant high temperatures** characterize tropical climates.
- Some tropical areas, where tropical rain forests are located, receive **up to 600 cm of rain each year**.
- The transition zones that border the rainy tropics north and south of the equator, known as **tropical wet and dry** zones, have **distinct dry winter seasons** as a result of the occasional influx of dry continental air masses.
- Tropical wet and dry zones include savannas, which are tropical grasslands.

Koeppen Classification System

Dry Climates

- Dry climates, which cover about 30 percent of Earth's land area, make up the **largest climatic zone**.
- In these climates, continental tropical (cT) air dominates, precipitation is low, and vegetation is scarce.
- Overall, evaporation rates exceed precipitation rates, causing a moisture deficit.
- Within this classification, there are **two subtypes: arid** regions or deserts, **and semi-arid regions** or steppes.
- **Steppes are more humid** than deserts; they generally separate arid regions from bordering wet climates.

Koeppen Classification System

Mild Climates

- Mild climates can be classified into **three subtypes**: humid subtropical climates, marine west coast climates, and mediterranean climates.
  - **Humid subtropical** climates are influenced by the subtropical high-pressure systems that are normally found over oceans in the summer.
  - The **marine west coast** climates are dominated by the constant inland flow of air off the ocean.
  - **Mediterranean** climates are influenced by the Mediterranean Sea, which is generally warm.

Koeppen Classification System

Continental Climates

- Continental climates are also classified into **three subtypes**: warm summer climates, cool summer climates, and subarctic climates.
- Continental climates are battlegrounds for **clashing tropical and polar air masses**.
- Both **summer and winter temperatures** can be **extreme**.
- **Summers are generally wetter than winters**, especially in latitudes that are relatively close to the tropics.

Koeppen Classification System

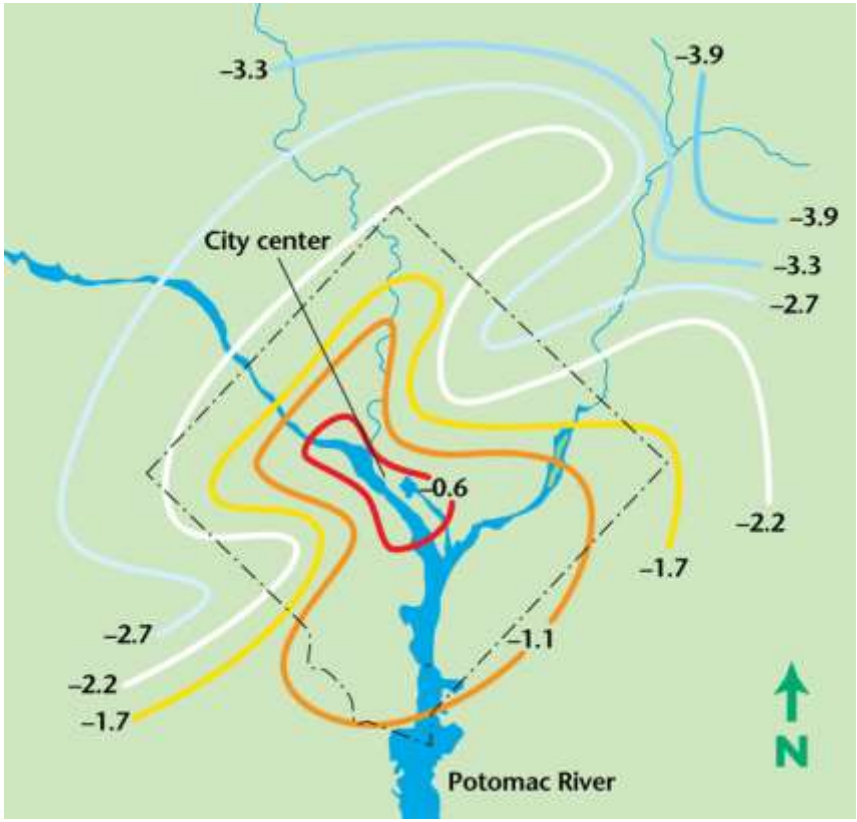
Polar Climates

- The polar climates are the **coldest** regions on Earth.
- The mean temperature of the warmest month is less than 10°C.
- **Precipitation is generally low** because cold air holds less moisture than warm air and there is not enough heat radiated by Earth's surface to produce strong convection currents.
- A variation of the polar climate is **found at high elevations**.

Microclimates

- A **microclimate** is a localized climate that differs from the main regional climate.

In the example to the right, which shows winter temperatures in Washington, D.C., the buildings and **paved surfaces of the city create a microclimate**. The temperature in the center of the city is –0.6ºC, nearly 3ºC **warmer** than temperatures in some parts of the surrounding area.



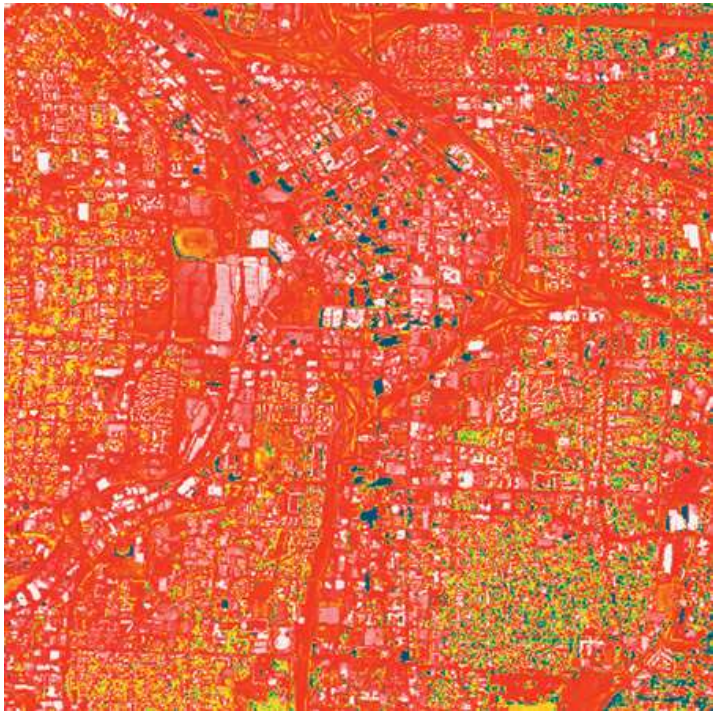
Microclimates

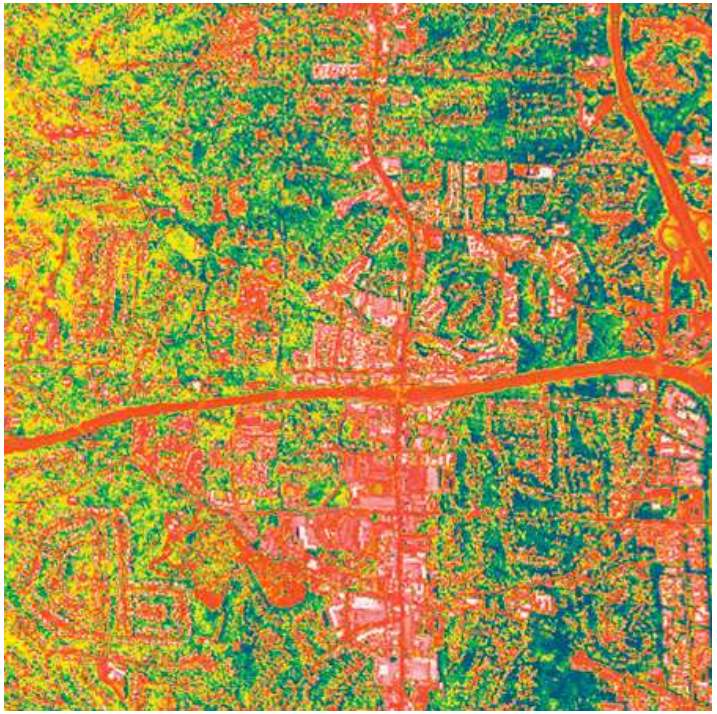
Heat Islands

- **Heat islands**, wherein the climate is warmer than in surrounding rural areas, are caused by the presence of many concrete buildings and large expanses of asphalt.
- The **heat-island effect** causes greater changes in temperature with altitude, which **sparks strong convection currents and increases precipitation in cities**.
- Heat islands are examples of climatic change on a small scale.

Microclimates

Heat Islands





These images show differences in daytime temperatures between an urban area (left) and a suburban area (right). The coolest temperatures are represented by blue; the warmest temperatures are represented by red.

Section Assessment

1. Match the following terms with their definitions.

C tropical climates

A dry climates

D continental climates

B polar climates

A. climates in which evaporation rates exceed precipitation rates

B. climates characterized by constant cold temperatures

C. climates characterized by constant high temperatures

D. climates in which tropical and polar air masses clash

Section Assessment

2. Which is the largest climatic zone? How much of Earth's surface does it cover?

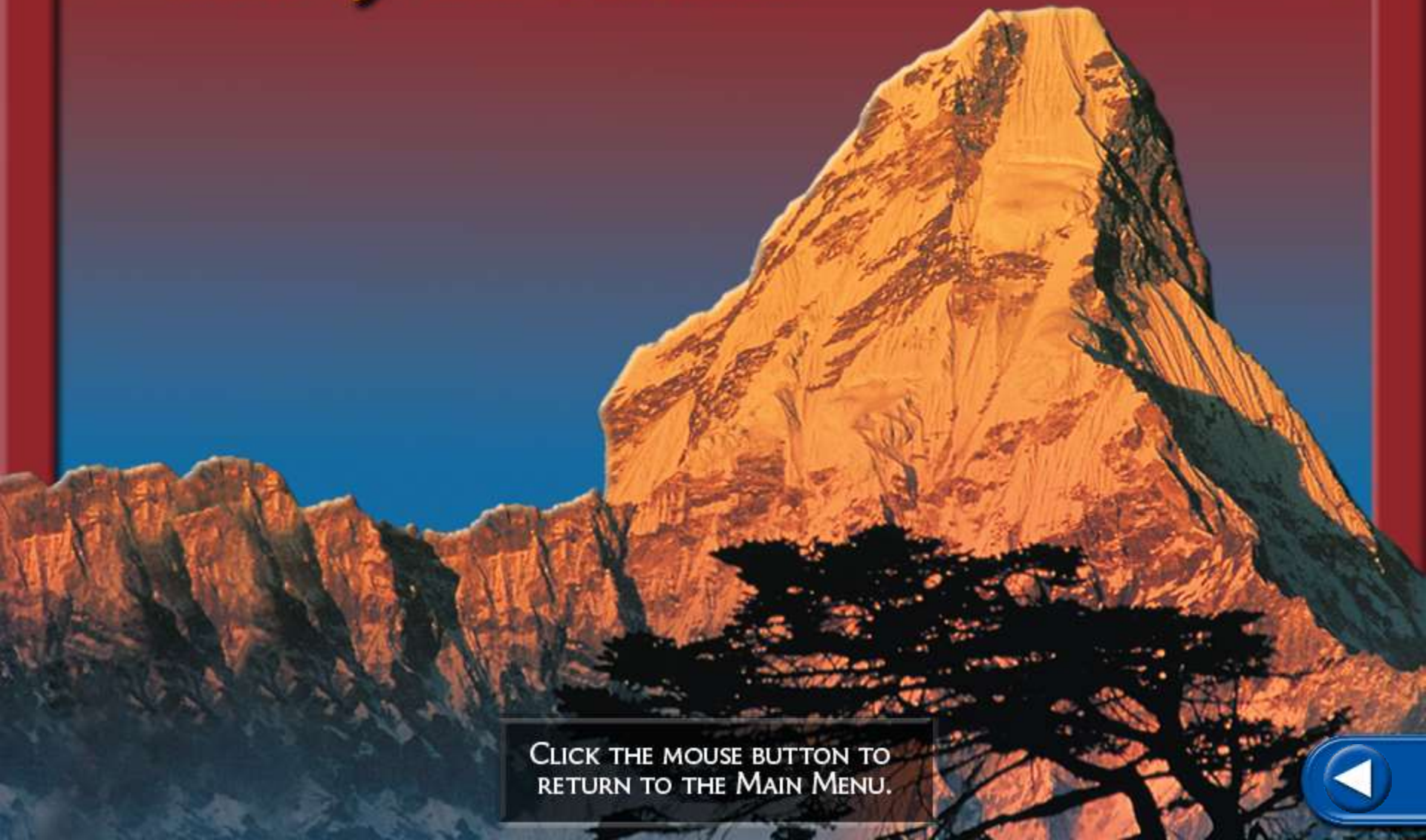
Dry climates, which cover about 30 percent of Earth's land area, make up the largest climatic zone.

Section Assessment

3. **Why do heat islands form**?

The heat-island effect occurs because large areas of **asphalt and concrete radiate far more heat** into the air **than do grasslands, wooded areas, and bodies of water**.

End of the Section



Click the mouse button to return to the Main Menu.

Objectives

- **Distinguish** among different types of climatic changes.
- **Recognize** why climatic changes occur.

Vocabulary

- ice age
- season
- El Ninõ
- Maunder minimum

Climatic Changes

- During the average human lifetime, climates do not appear to change significantly.
- Climatic change is constantly ongoing and usually takes place over extremely long time periods.

Ice Ages

- **Ice ages** were periods where the average global temperatures decreased by an estimated 5°C and there was extensive glacial coverage.
- Ice ages alternate with warm periods called interglacial intervals.
- The **most recent ice age** ended only **about 10 000 years ago**.

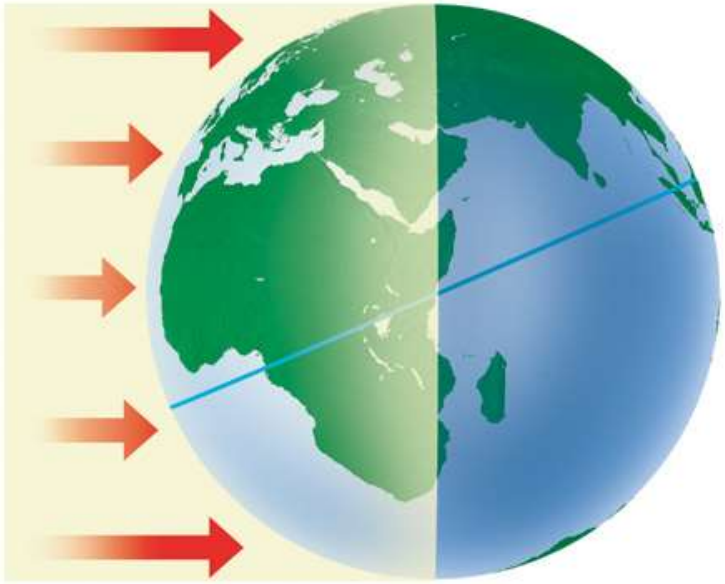
Ice Ages


Aral Sea
China
Caspian Sea
Black Sea
Siberia
Japan
Alps
Arctic Ocean
Europe
Iceland
North Pacific Ocean
Alaska
Sea ice
North Atlantic Ocean
United States

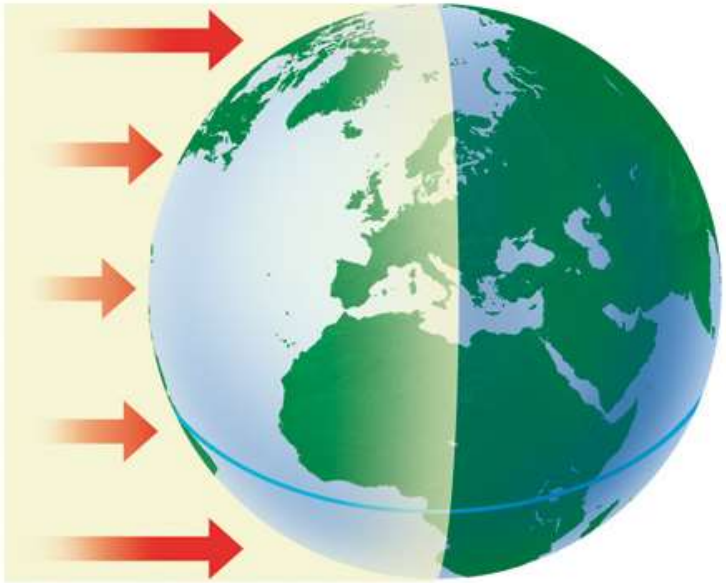
Short-Term Climatic Changes

- **Seasons** are short-term periods of climatic change caused by regular variations in daylight, temperature, and weather patterns.
- These variations are the result of changes in the amount of solar radiation an area receives.
- During summer in the northern hemisphere, the north pole is tilted toward the Sun, and this hemisphere experiences long hours of daylight and warm temperatures.
- Throughout the year, the seasons are reversed in the north and south hemispheres.

Short-Term Climatic Changes



When the **north pole is pointed toward the sun, the northern hemisphere experiences summer and the southern hemisphere experiences winter**.



During **spring and fall, neither pole points toward the sun**.

Short-Term Climatic Changes

El Ninõ

- **El Ninõ** is a warm ocean current that occasionally develops off the western coast of South America that causes many short-term climatic changes.
  - During an **El Ninõ, warm water from the western Pacific** surges eastward **toward the South American coast.**
  - Increased **precipitation over the northwestern coast of South America** pumps large amounts of heat and moisture into the upper atmosphere.
  - This hot, moist air in the upper atmosphere causes sharp temperature differences in the upper air that allows the **jet stream to shift farther south.**

Short-Term Climatic Changes

El Ninõ

- El Ninõ brings **stormy weather to areas that are normally dry and drought conditions to areas that are normally wet**.
- The strong upper winds produced by an El Ninõ help keep tropical disturbances from increasing to hurricane-strength storms in the Atlantic Ocean.
- Eventually, the South Pacific high-pressure system becomes reestablished and El Ninõ weakens.

Change Can Be Natural

- **Climatic changes** occurred long before humans came on the scene.
- **Studies of tree rings, ice-core samples, fossils**, and radiocarbon samples **provide evidence** of past climatic changes.
- These changes in Earth's climate were caused by natural events such as variations in solar activity, changes in Earth's tilt and orbit, and volcanic eruptions.

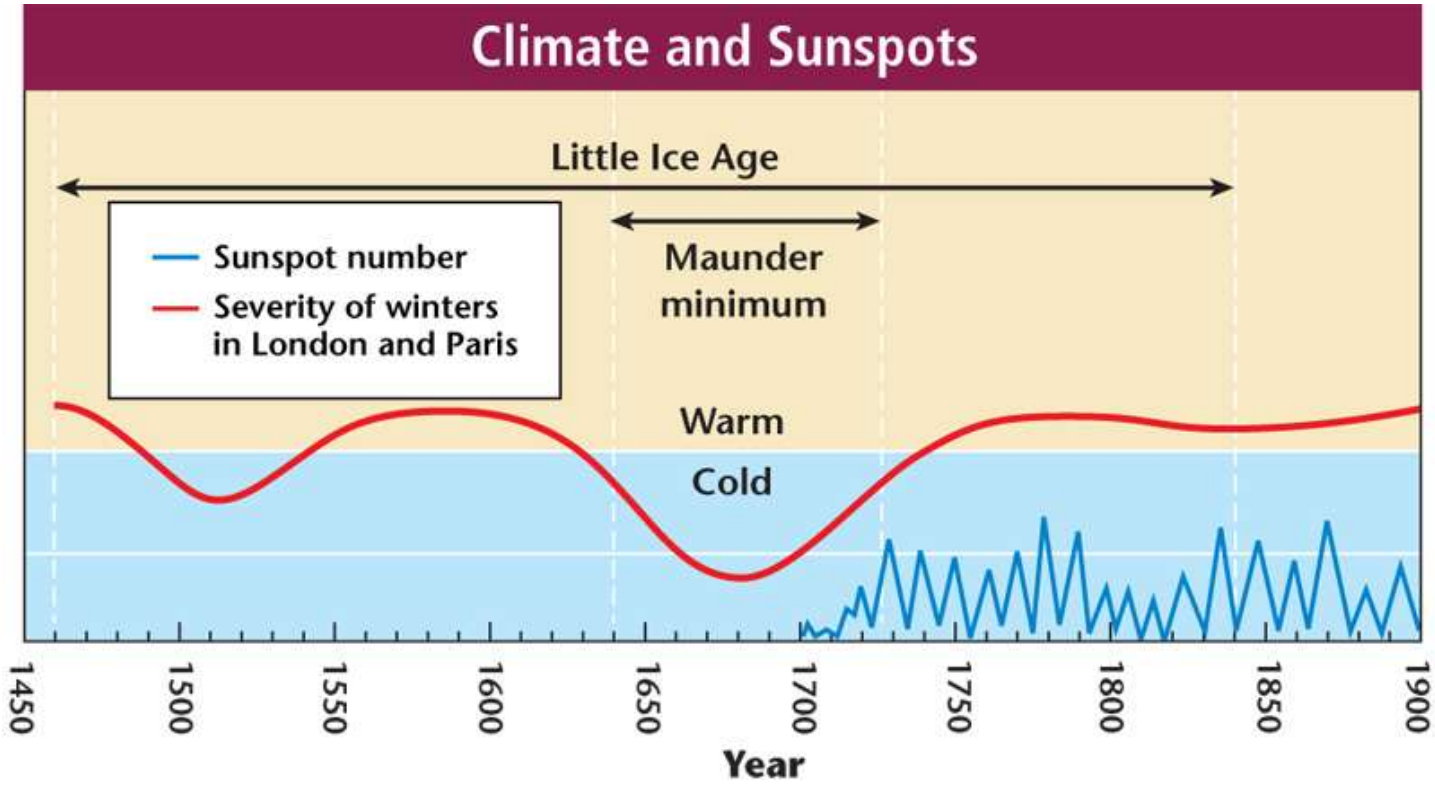
Change Can Be Natural

Solar Activity

- The existence of sunspot cycles lasting approximately 11 years had been recognized since the days of Galileo.
- The **Maunder minimum** was a period of very low sunspot activity from 1645 to 1716, discovered by English astronomer E. W. Maunder in 1893, that closely corresponds to an unusually cold climatic episode called the “Little Ice Age.”
- Studies indicate that increased solar activity coincides with warmer-than-normal climates, while **periods of low solar activity, such as the Maunder minimum, coincide with cold climatic conditions**.

Change Can Be Natural

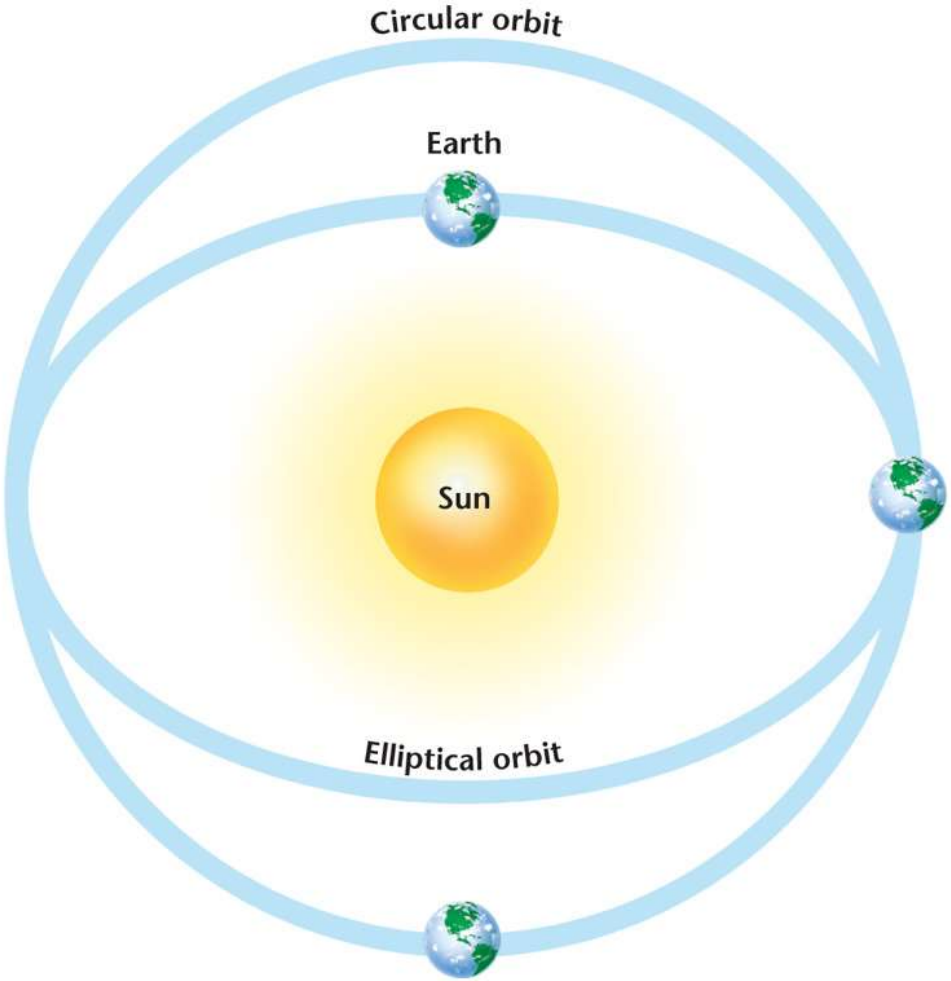
Solar Activity



Change Can Be Natural

Earth's Orbit

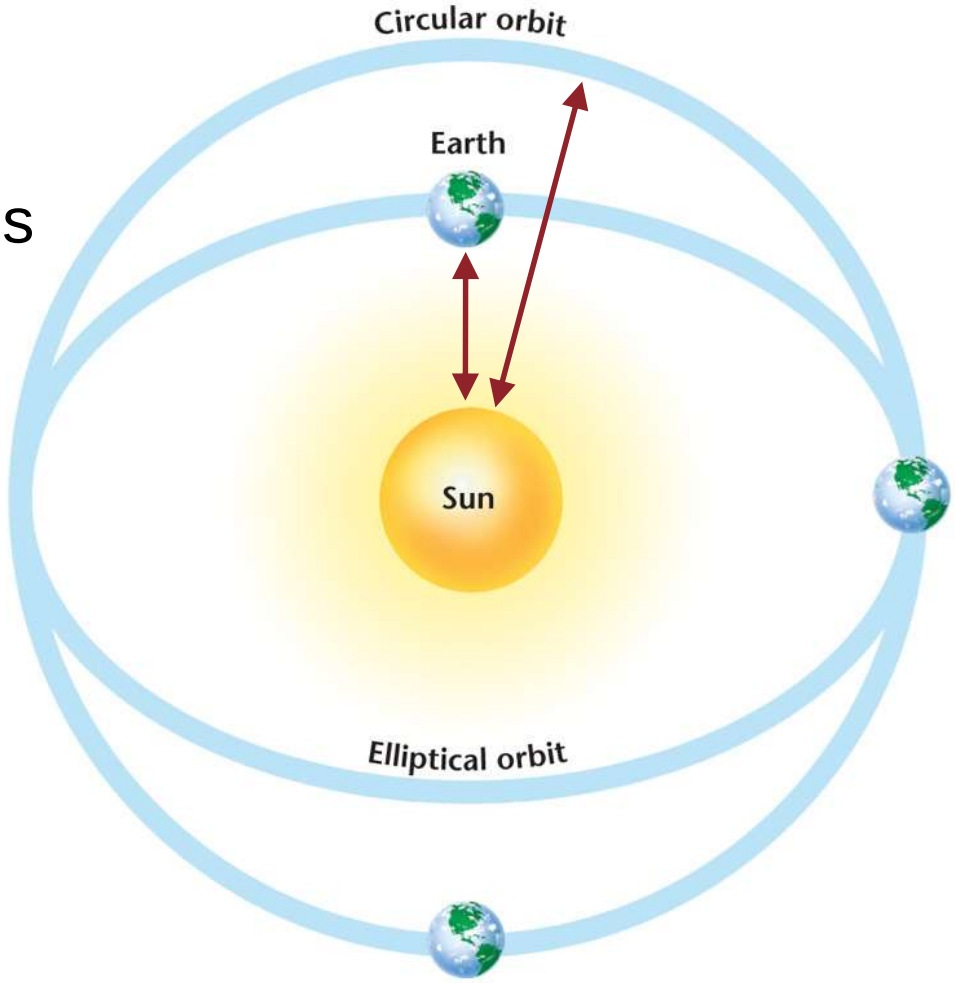
- Climatic changes may also be triggered by changes in Earth's axis and orbit.
- The shape of **Earth's elliptical orbit appears to change, becoming** more elliptical, **then more circular, over the course of a 100 000-year cycle**.



Change Can Be Natural

Earth's Orbit

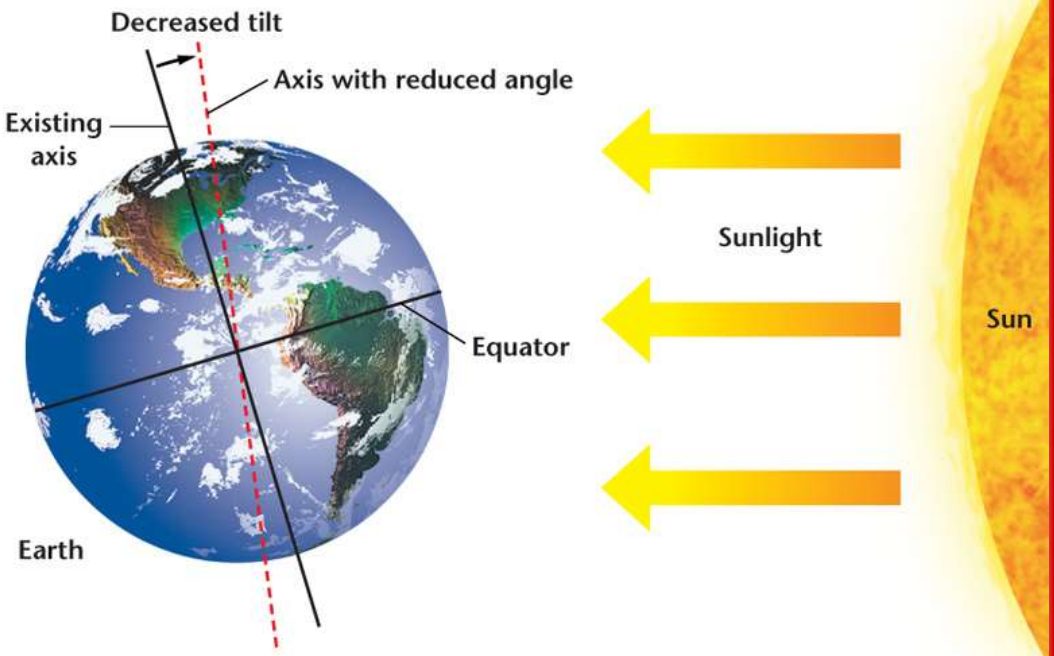
- When the orbit elongates, Earth passes closer to the Sun, and temperatures become warmer than normal.
- When the orbit is more circular, Earth is farther from the Sun and temperatures dip below average.



Change Can Be Natural

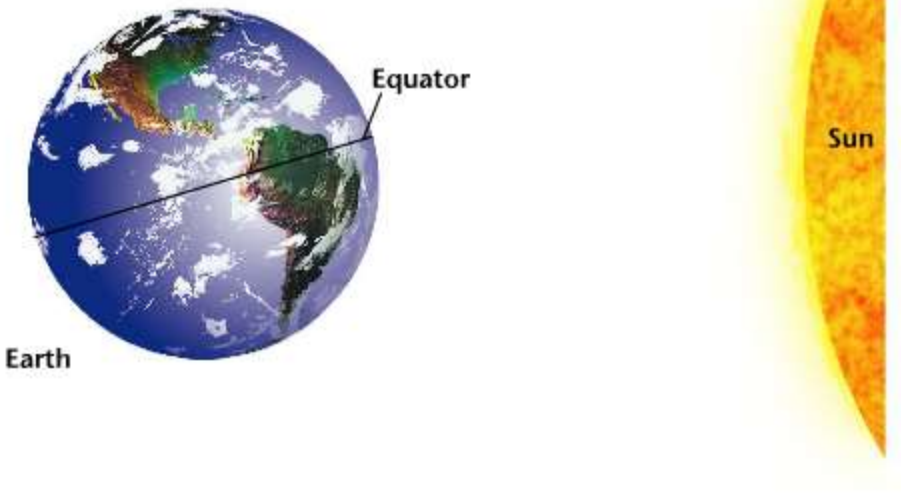
Earth's Orbit

- The angle of **Earth's tilt varies from** a minimum of **22.1° to** a maximum **of 24.5° every 41 000 years**.
- Scientists theorize that these changes in angle cause **seasons** to become **more severe and may cause ice ages**.



Change Can Be Natural

Earth's Orbit



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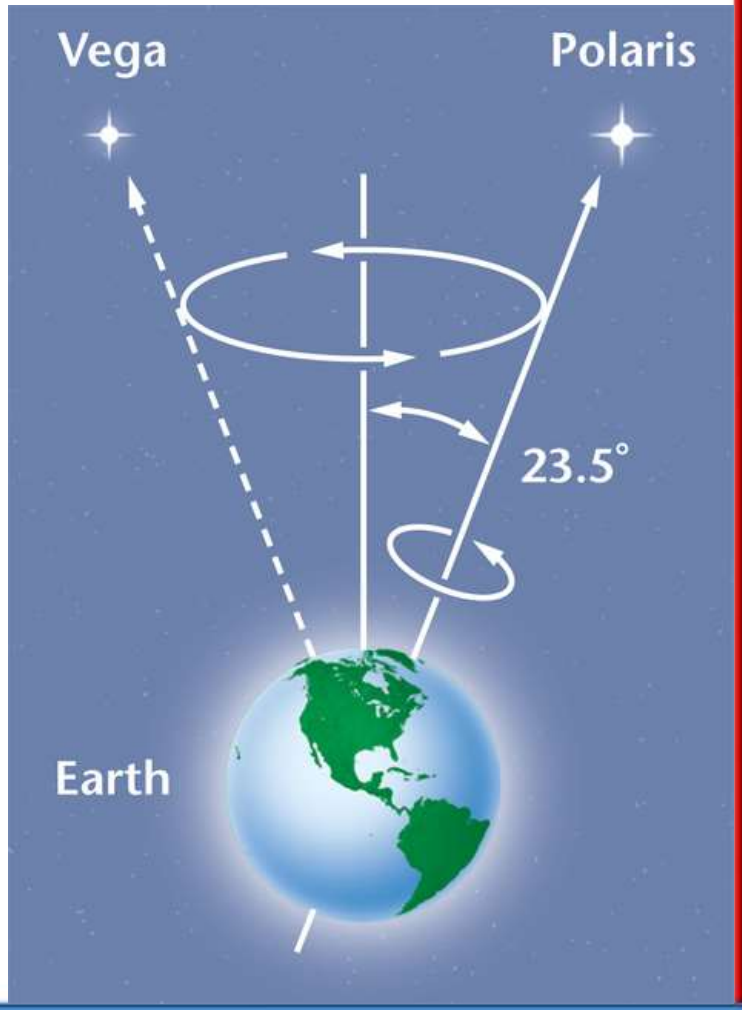
Change Can Be Natural

Earth's Wobble

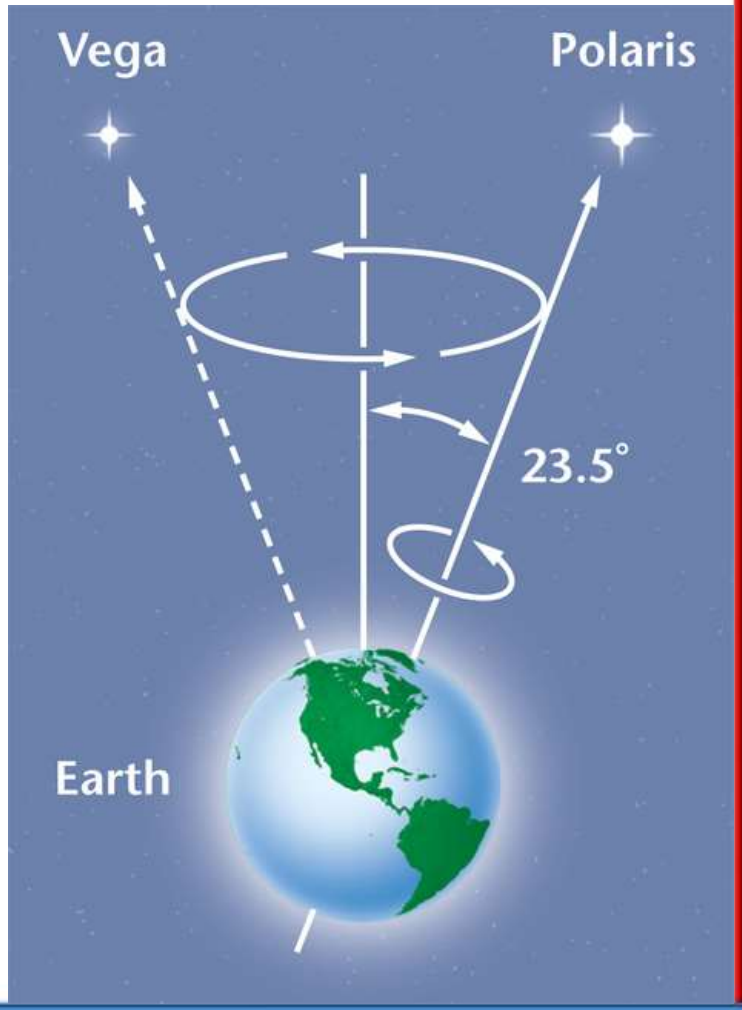
- Over a period of about **26 000 years, Earth wobbles as it spins** on its axis.
- Currently, the axis points toward the North Star, Polaris.
- Because of Earth's wobbling, however, the axis will tilt toward another star, Vega, by about the year 14 000.



Change Can Be Natural

Earth's Wobble

- Winter currently occurs in the northern hemisphere when Earth is closest to the Sun.
- When the axis tilts toward Vega winter will occur in the northern hemisphere when Earth is farthest from the Sun.
- This will cause warmer summers and colder winters than those that we now experience.



Change Can Be Natural

Volcanic Activity

- Climatic changes can also be triggered by the immense quantities of **dust released** into the atmosphere during major volcanic eruptions.
- Volcanic dust can remain **suspended in the atmosphere for several years, blocking incoming solar radiation** and thus **lowering global temperatures**.
- Some scientists theorize that periods of high volcanic activity cause cool climatic periods.

Section Assessment

1. Match the following terms with their definitions.

__D__ ice age

__B__ season

__C__ El Ninõ

__A__ Maunder minimum

A. a period of very low sunspot activity that closely corresponds to an unusually cold climatic episode called the "Little Ice Age"

B. short-term periods of climatic change caused by regular variations in daylight, temperature, and weather patterns

C. a warm ocean current that occasionally develops off the western coast of South America

D. periods where the average global temperatures decreased and there was extensive glacial coverage

Section Assessment

2. What is the relationship between solar activity and Earth's climate?

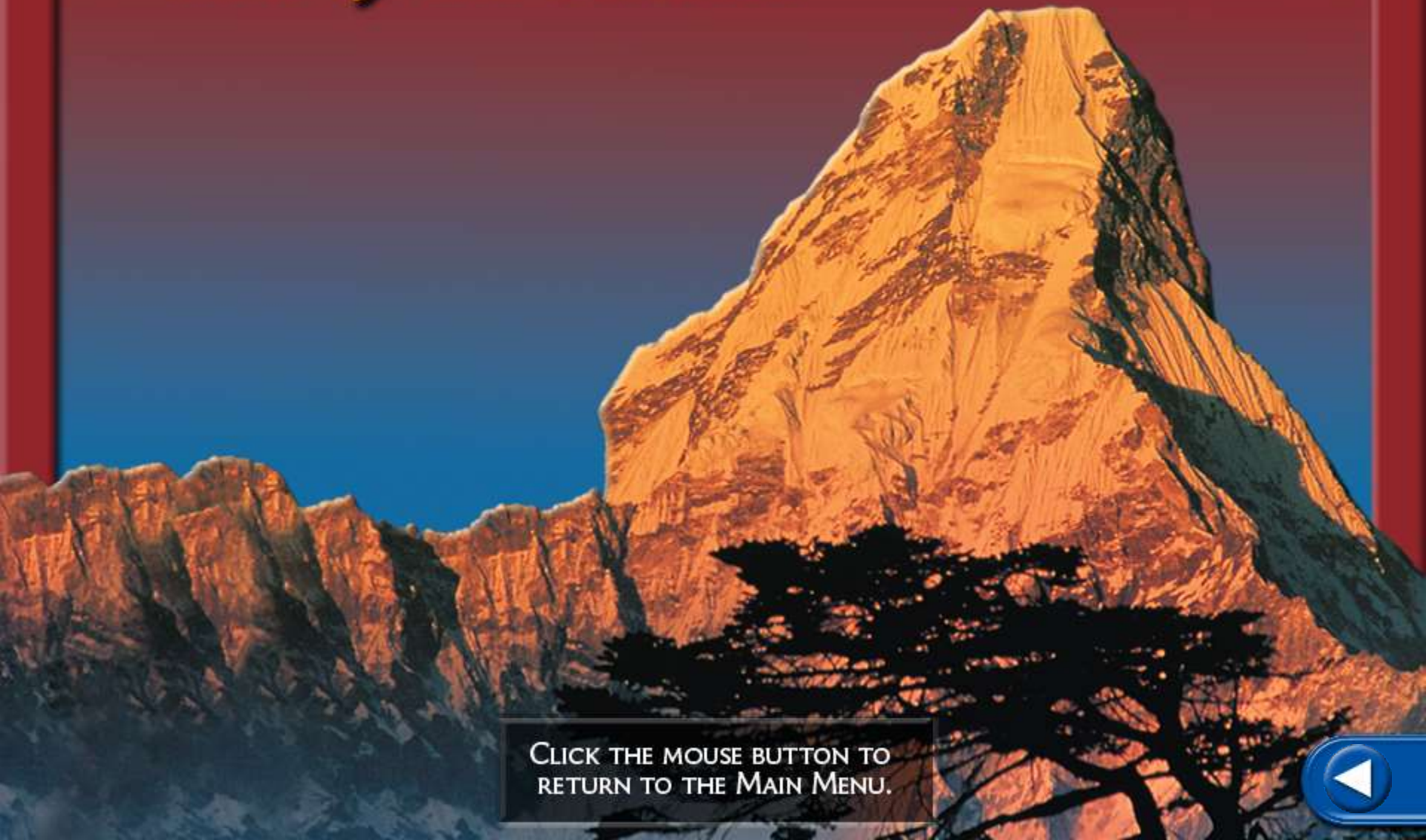
Studies indicate that increased solar activity coincides with warmer-than-normal climates, while periods of low solar activity, such as the Maunder minimum, coincide with cold climatic conditions.

Section Assessment

3. How will the seasons in the northern hemisphere differ around the year 14 000?

Due to Earth's wobble, the seasons will be reversed with summer instead of winter occurring in the northern hemisphere when Earth is closest to the sun. This will cause the seasons in the northern hemisphere to be more pronounced.

End of the Section



Click the mouse button to return to the Main Menu.

Objectives

- **Compare** and **contrast** the greenhouse effect and global warming.
- **Identify** how humans impact climate.

Vocabulary

– greenhouse effect

– global warming

The Human Factor

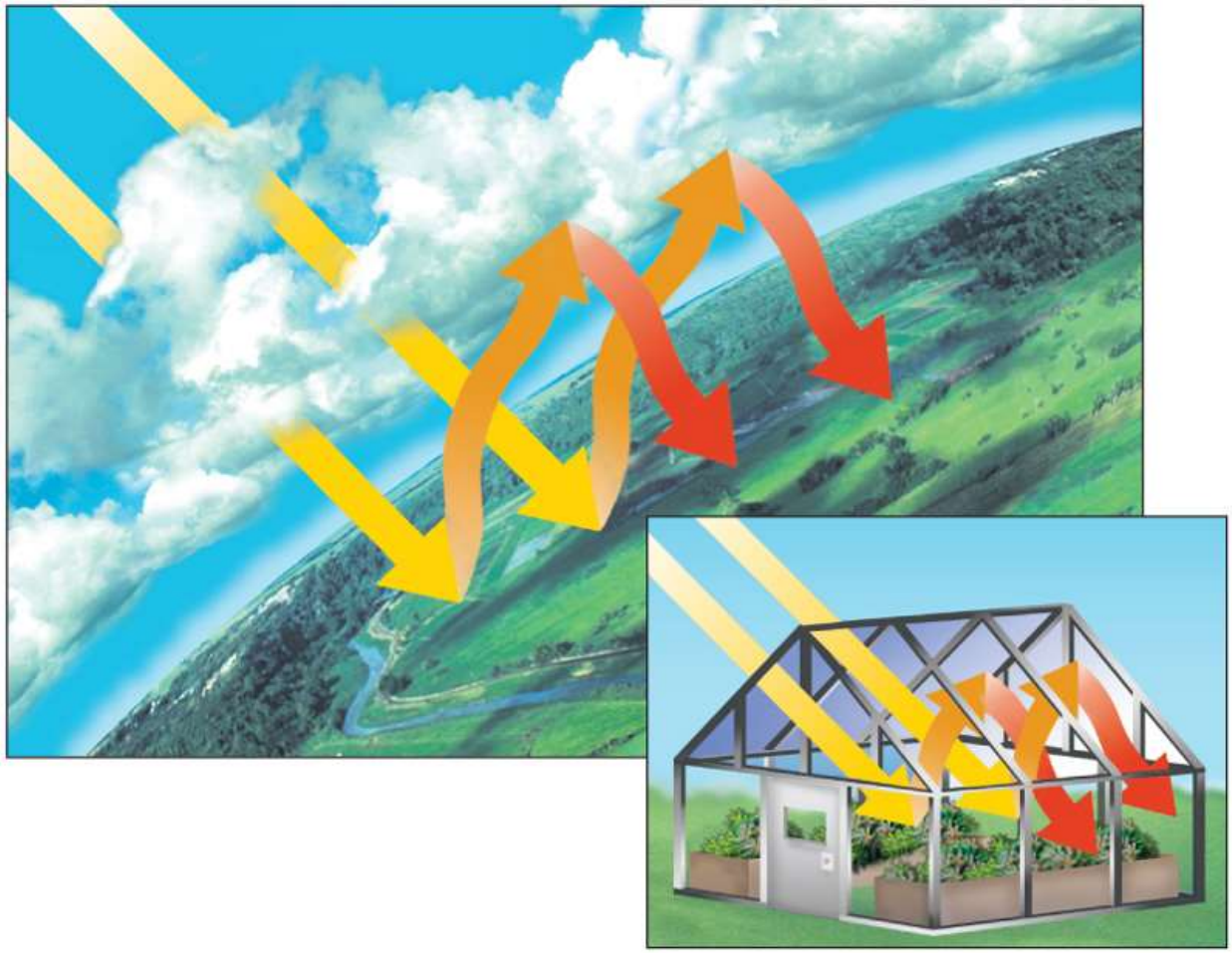
- Solar radiation that is not reflected by clouds passes freely through the atmosphere.
- It is then absorbed by Earth's surface and released as long-wavelength radiation.
- This radiation is absorbed by **atmospheric gases such as water vapor, methane, and carbon dioxide – "greenhouse gases"**.
- The atmospheric gases then reradiate the stored energy, so that Earth receives energy from two sources: the Sun and the atmosphere.

The Greenhouse Effect

- The **greenhouse effect** is the natural heating of Earth's surface caused by the retention of heat by certain atmospheric gases called greenhouse gases.
  - Without the greenhouse effect our planet would be cold.
  - A marked increase in the greenhouse effect might cause our planet to be hot.

The Greenhouse Effect

Solar radiation reaches Earth's surface and is reradiated as long-wavelength radiation. This radiation cannot escape through the atmosphere and is absorbed and re-released by atmospheric gases. This process is called the greenhouse effect because it is similar to the way that heat is trapped and released in a greenhouse.



The Greenhouse Effect

- Scientists theorize that any increase in the amount of greenhouse gases, particular carbon dioxide (CO_2), would result in the increased absorption of radiation.

Global warming is a rise in global temperatures that could result from the increased absorption of radiation due to higher levels of greenhouse gases.

Global Warming

- Several of **the warmest years on record have occurred within the last decade**.
- Based on available evidence, most **scientists** agree that global warming is occurring, but they **disagree about what is causing this warming**.
  - Some scientists hypothesize that natural changes adequately explain the increased temperatures.
  - Mounting **evidence indicates** that the warming trend is a **result of increases in atmospheric carbon dioxide**.

Impact of Human Activities

- Almost any process that involves the **burning of fossil fuels results in the release of carbon dioxide** and other gases into the atmosphere.
- During photosynthesis, vegetation removes carbon dioxide from the atmosphere.
- When **trees are cut down through deforestation, rates of photosynthesis** are reduced and more carbon dioxide remains in the atmosphere.

Environmental Efforts

- We must closely **examine activities that cause pollution and deforestation and work to reduce their environmental impact**.
- **Individuals** can combat global warming by **conserving energy**, which in turn reduces the consumption of fossil fuels.

Section Assessment

1. What would Earth be like without the greenhouse effect?

Without the greenhouse effect, life as we know it would not exist on Earth. Our planet would be extremely cold like Mars, where the surface temperature dips to –90ºC.

Section Assessment

2. What would Earth be like with a “runaway” greenhouse effect?

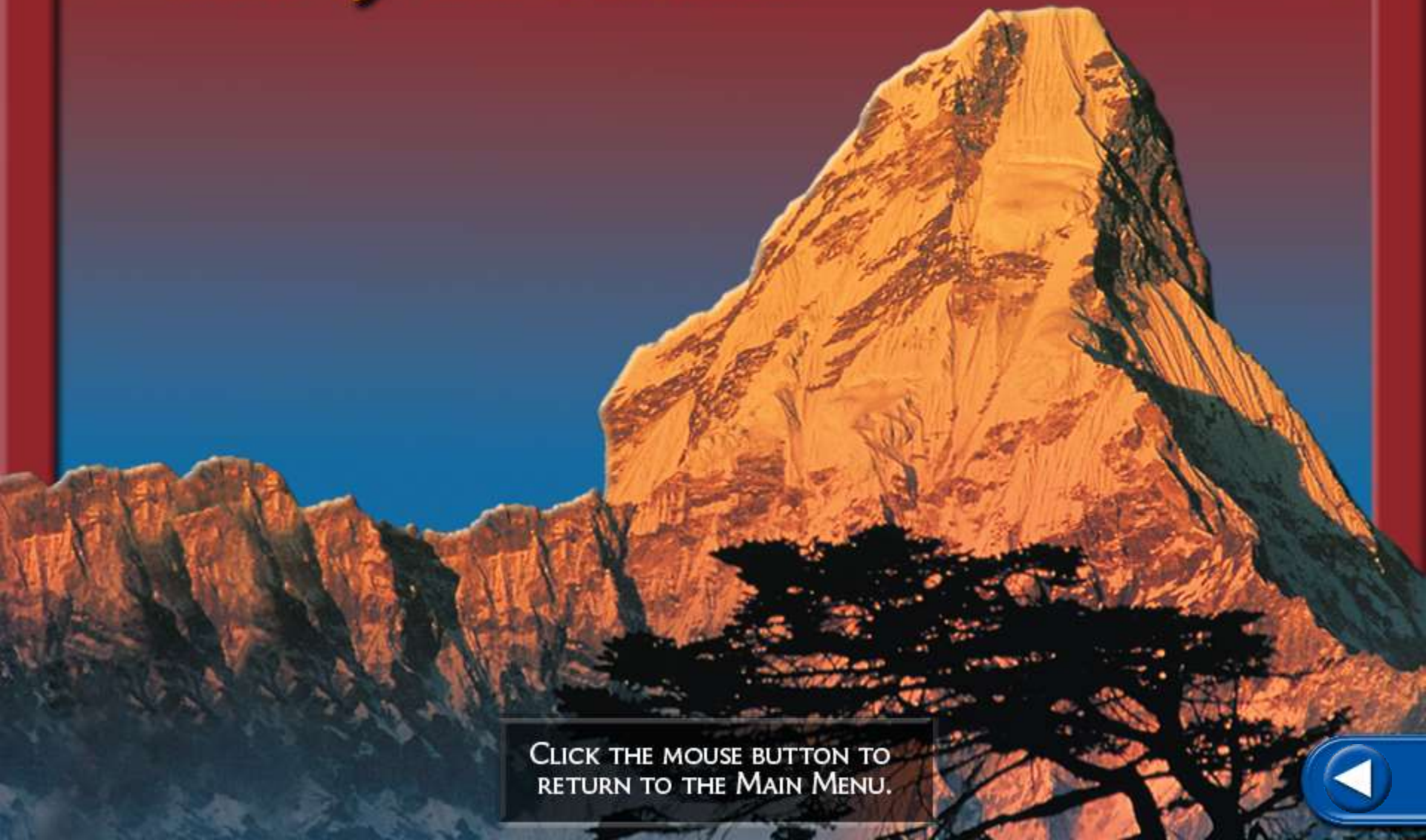
A runaway greenhouse effect might cause Earth to be extremely hot. Venus has an intense greenhouse effect and as a result has surface temperatures of 470ºC.

Section Assessment

3. **How does deforestation possibly play a role in global warming?**

Trees remove carbon dioxide (CO_2) from the atmosphere through photosynthesis. **Through the mass removal of trees, less photosynthesis can occur which leaves more CO_2 in the atmosphere.**

End of the Section



Click the mouse button to return to the Main Menu.

Study Guide

Section 14.1 Main Ideas

- Climate describes the long-term weather patterns of a region. Climatological data include annual variations of temperature, precipitation, wind, and other weather variables, as well as extreme fluctuations in these variables.
- The factors that influence climate include latitude, topography, closeness of lakes and oceans, availability of moisture, global wind patterns, ocean currents, and air masses.

Section 14.2 Main Ideas

- The Koeppen classification system divides climates into five basic types according to temperature, rainfall, and vegetation.
- A microclimate is a localized climate that differs from the surrounding regional climate. In cities, the numerous concrete buildings and large expanses of asphalt can create heat islands, wherein the climate is warmer than in surrounding rural areas.

Section 14.3 Main Ideas

- Earth's climate is in a constant state of change. These changes usually take place over extremely long time periods. Fossils, ice cores, and other geologic records show that Earth was sometimes much colder or warmer than it is today.
- Periods of extensive glacial coverage, called ice ages, are examples of long-term climatic changes. Examples of short-term climatic changes include the seasons and the effects of El Ninõ.
- Some changes in Earth's climate may be caused by a combination of numerous natural cycles involving solar activity, changes in the tilt of Earth's axis and its orbit, and volcanic eruptions.

Section 14.4 Main Ideas

- The greenhouse effect is the retention of heat by atmospheric gases that helps to keep Earth warm enough to sustain life. An increase in greenhouse gases may lead to global warming.
- Some scientists theorize that human activities such as the burning of fossil fuels and deforestation contribute to global warming.

Multiple Choice

1. What criteria does the Koeppen classification system use to differentiate climates?

a. precipitation

b. temperature

c. distinct vegetation

d. all of the above

The *Koeppen classification system* combines precipitation, temperature, and the types of distinct vegetation to classify Earth's climates into six main divisions: tropical, mild, dry, continental, polar, and high elevation.

Multiple Choice

2. Which latitude zones lie between 23.5º and 66.5º north and south of the equator?

a. tropics

b. temperate zones

c. polar zones

d. Tropic of Cancer

The *tropics* lie between 23.5ºN and 23.5ºS. The *polar zones* are located from 66.5º north and south of the equator to the poles. The *Tropic of Cancer* is the northernmost extent of the tropics, 23.5ºN.

Multiple Choice

3. Which climate type is likely to have the greatest temperature extreme between summer and winter?

a. continental climates

b. polar climates

c. tropical climates

d. mild climates

Continental climates are influenced by both polar and tropical air masses. *Polar climates* are cold throughout the year. *Tropical climates* are warm throughout the year. *Mild climates* are dominated by maritime influences that moderate seasonal variation.

Multiple Choice

4. Which of the following is a likely outcome of an El Ninõ?

a. drought in Southern California

b. more northerly jet stream

c. increased rain in northwestern South America

d. increased Atlantic hurricanes

During *El Ninõ* the jet stream is further south, increasing rainfall in Southern California. Due to the strong upper winds generated by El Ninõ-driven convection, conditions are not favorable for tropical disturbances in the Atlantic to develop into hurricanes.

Multiple Choice

5. Which human activity is responsible for adding the most CO_2 to the atmosphere?

a. deforestation

b. burning fossil fuels

c. heat island effect

d. volcanic eruptions

Deforestation complicates the greenhouse effect because fewer trees are available to remove CO_2 from the atmosphere. The *heat island effect* is an example of a microclimate. *Volcanic eruptions* do add CO_2 to the atmosphere, but they are completely natural.

Short Answer

6. What is the climatic effect of a circular Earth orbit around the sun versus a more elliptical path?

When the orbit elongates, or becomes elliptical, Earth passes closer to the Sun, resulting in warmer than normal conditions. When the orbit is more circular, Earth is farther from the Sun and temperatures dip below average.

Short Answer

7. What are normals?

Normals, or standard values, are the average daily weather observations for a given location for a period of at least 30 years. Normals are simply the average values over a long period of time.

True or False

8. Identify whether the following statements are true or false.

false Deserts are commonly found on the windward side of mountains.

false Steppes are considered a continental climate zone.

true Generally, volcanic eruptions cause short-term climatic changes.

false High solar activity coincides with cooler climatic conditions on Earth.

true Earth's climate is always slowly changing.

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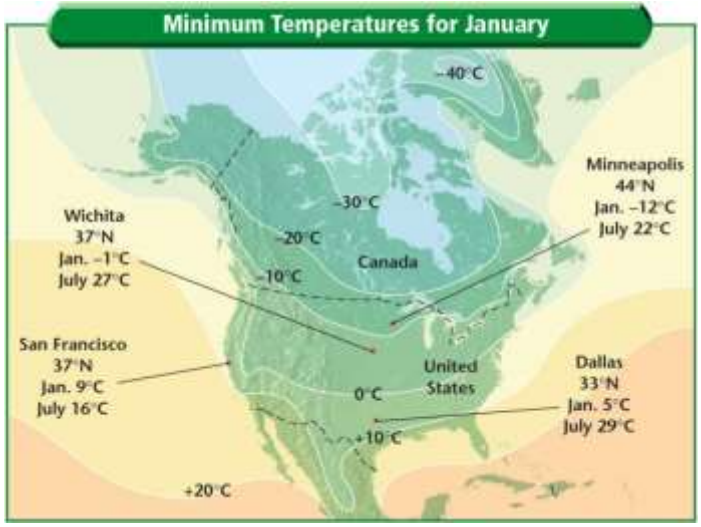

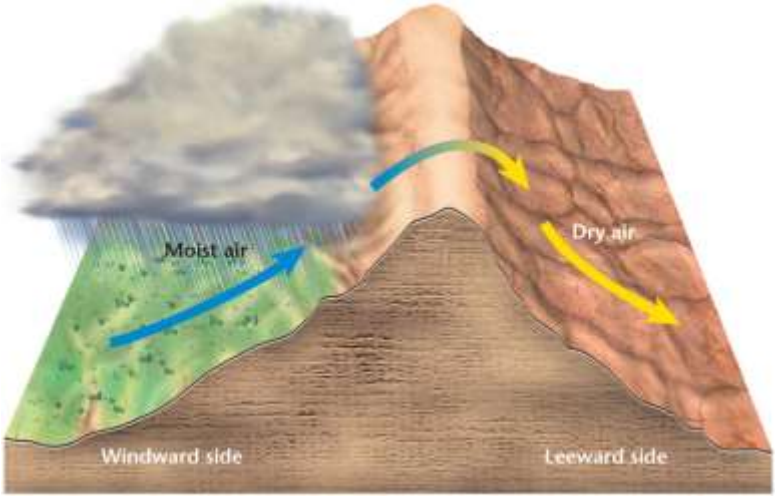

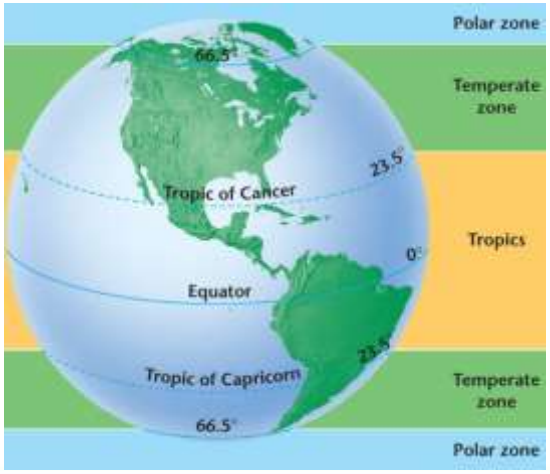

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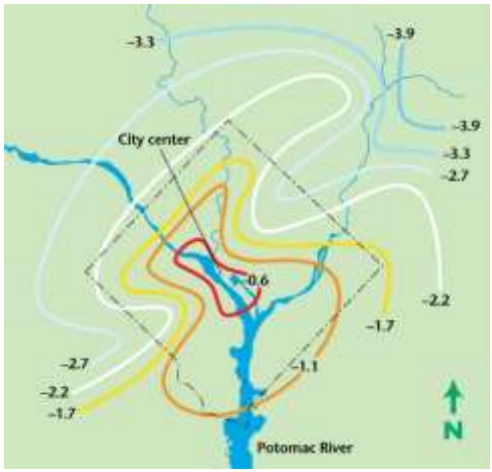

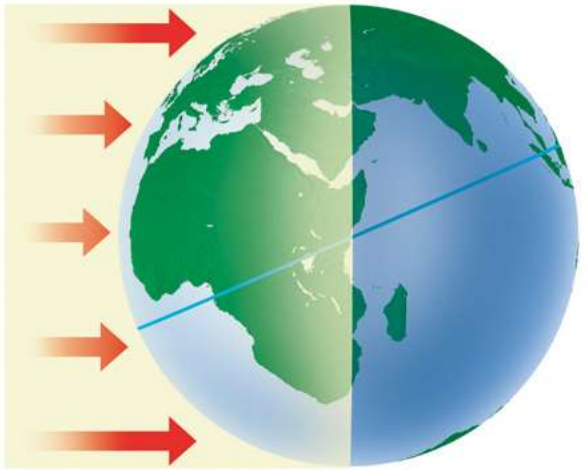

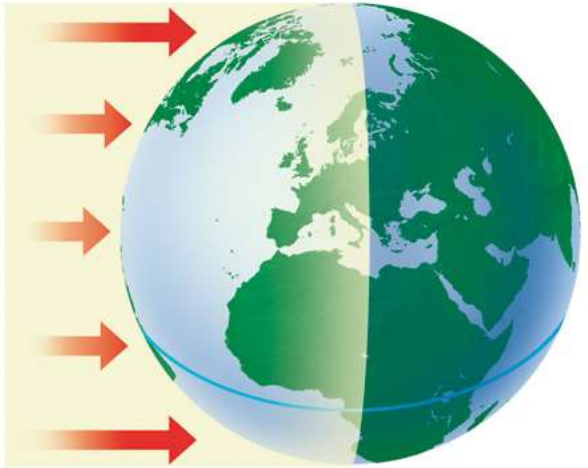

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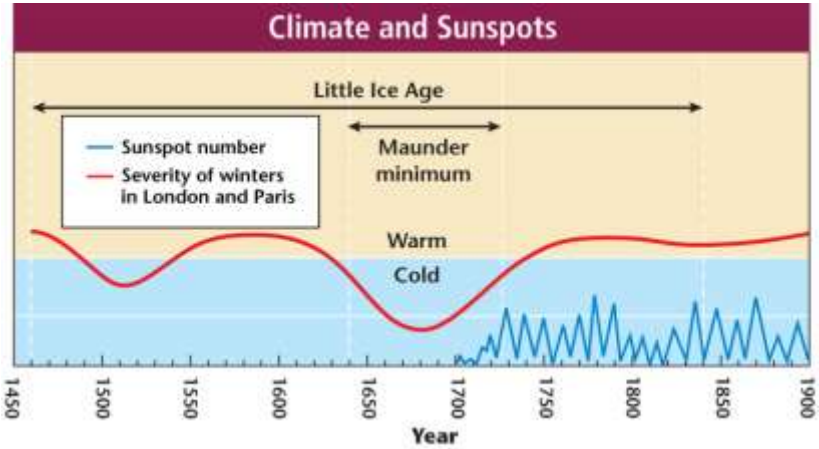

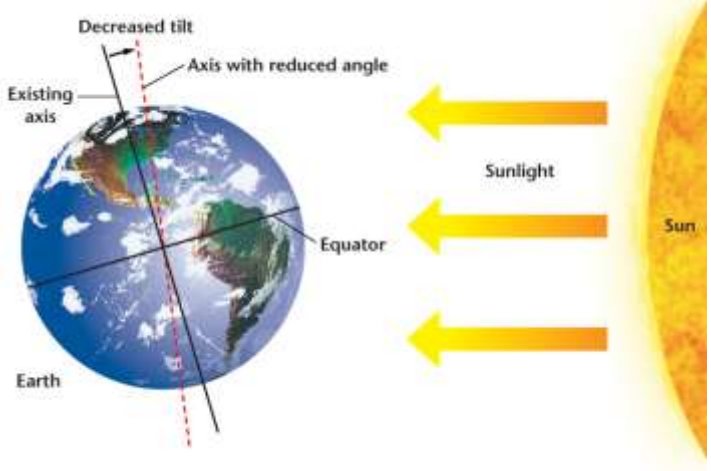

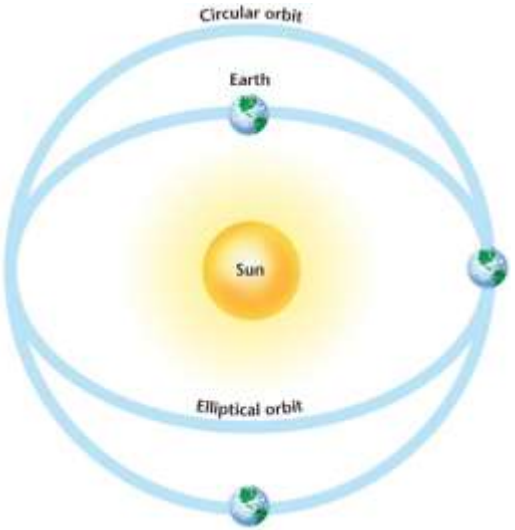

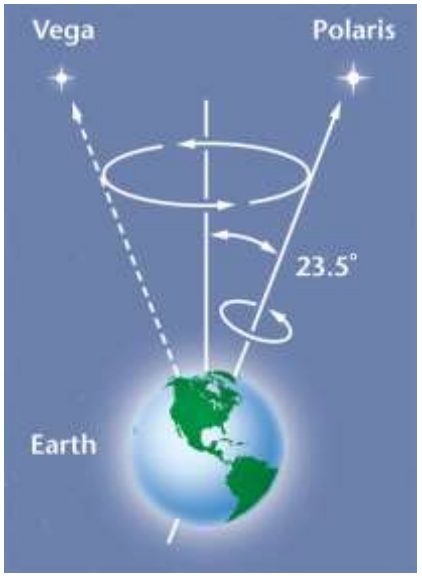

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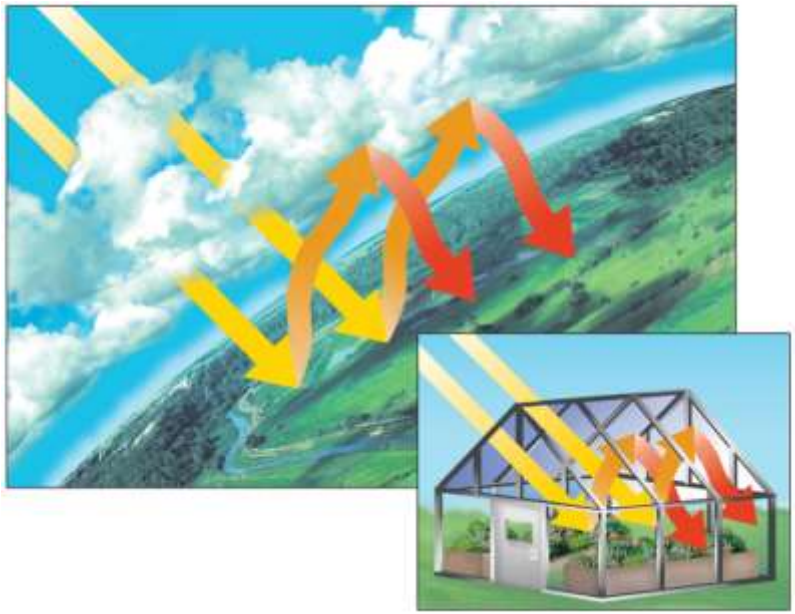

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