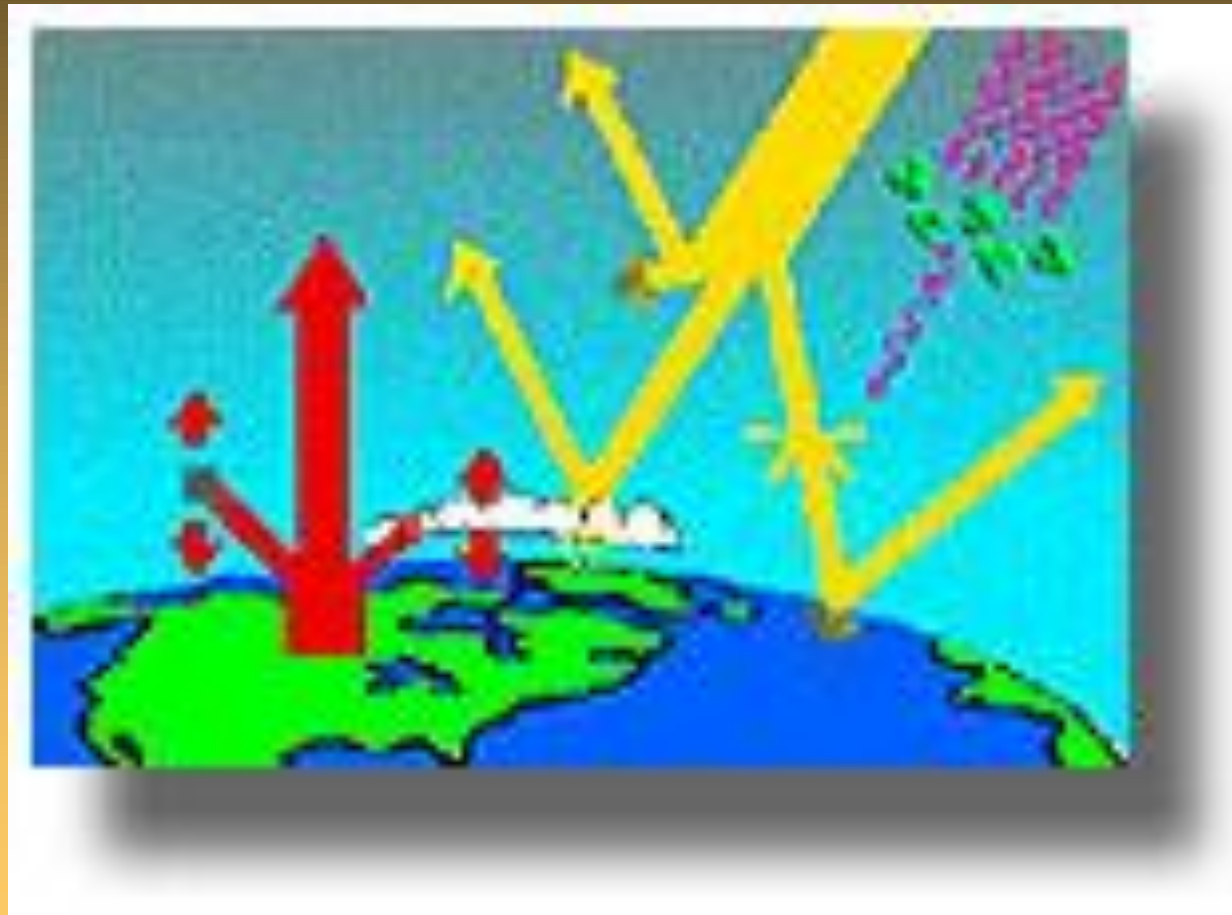


# Heat Energy of Atmosphere



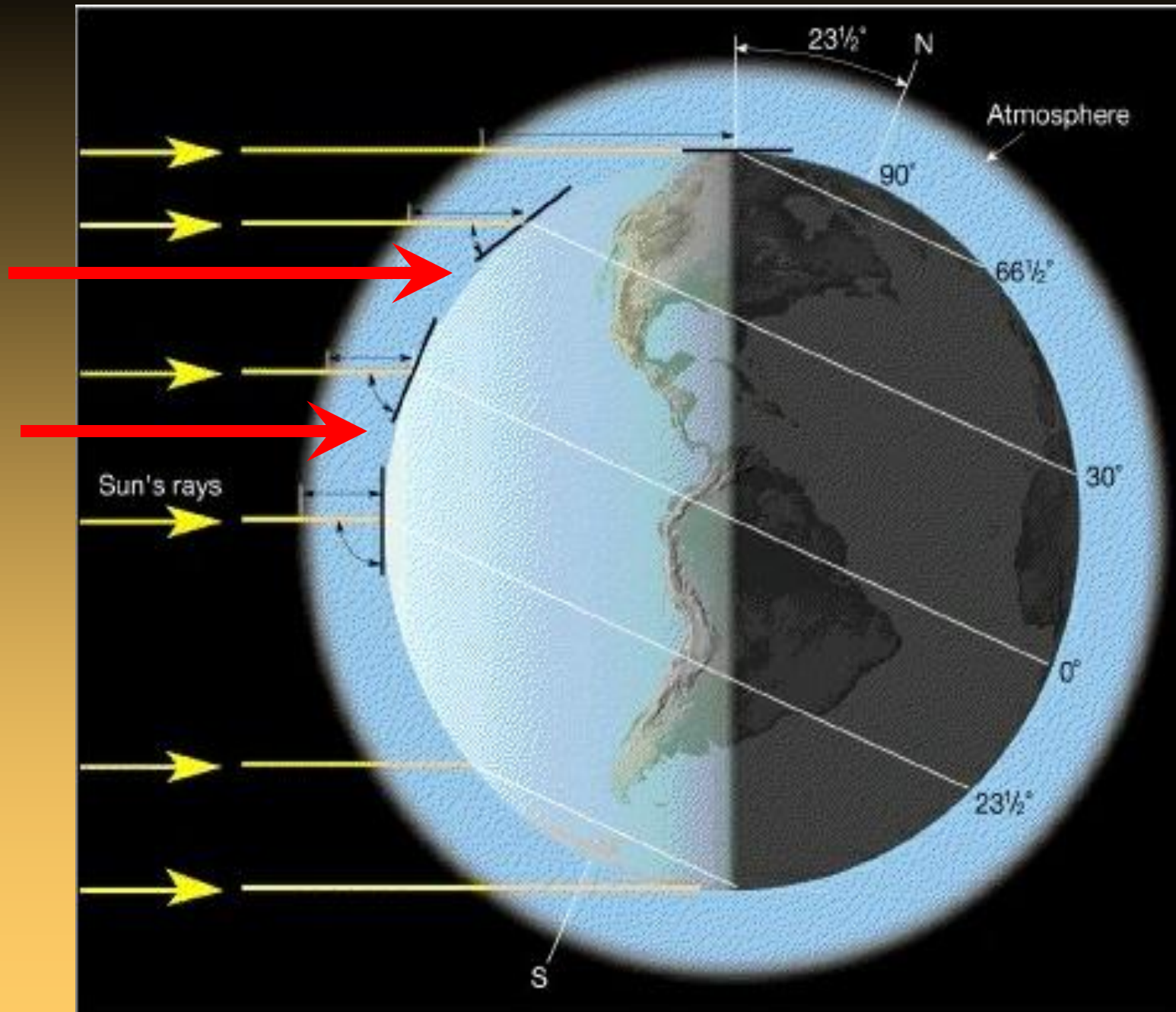
No.	Ritu	Season	Hindu lunar months	Gregorian month	Characteristics
1	Vasant वसन्तः	Spring	Chaitra and Vaisakha	~ March 20 to May 20	Temperature around 25-30 degrees; marriage season
2	Grishma ग्रीष्मः	Summer	Jyeshtha and Aashaadha	~ May 20 to July 20	Very hot, up to 40 degrees temperature (But now it is going up to 45-50 degrees in some part); farmers gear up for rice planting;
3	Varsha वर्षाः	Monsoon	Shraavana and Bhadrapada	~ July 20 to September 20	Very hot, very humid and heavy monsoon rains,
4	Sharad शरत्	Autumn	Ashwin and Kartika	~ September 20 to November 20	Mild temperatures;
5	Hemant हेमन्त	Winter	Margashirsha (Agrahayana) and Pausha	~ November 20 to January 20	Very pleasant temperatures (20-25 degrees); farmers reap the rice;
6	Shishir शिशिर	Winter & Fall	Magh and Phalguna	~ January 20 to March 20	Quite cold, but very pleasant during occasional sunshine; temperatures may go below 10 degrees. This season is typical to tropical and subtropical regions, because trees actually shed their leaves in this season in tropical areas. This is in contrast to temperate areas where fall starts as early as September.

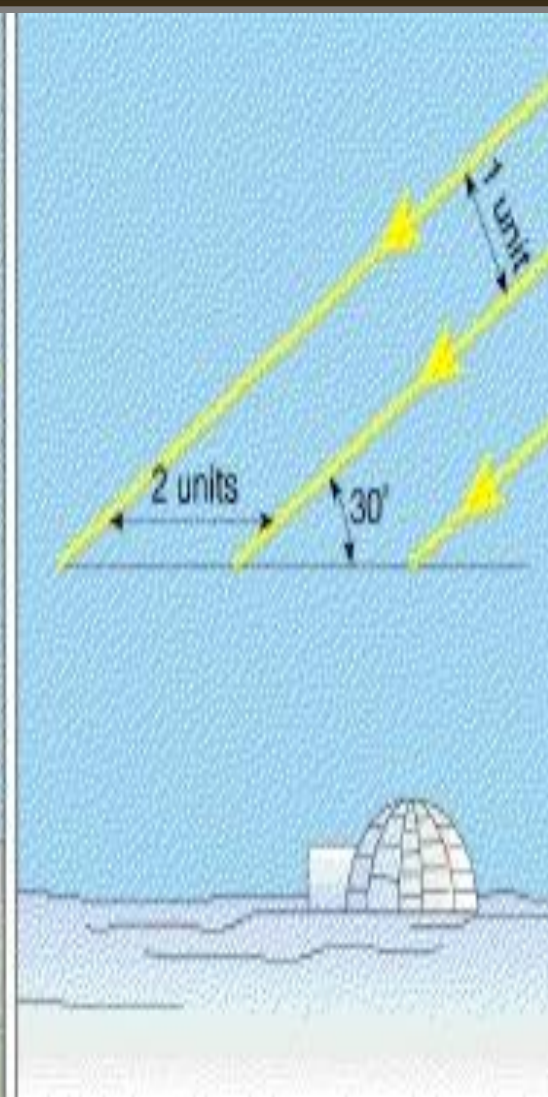
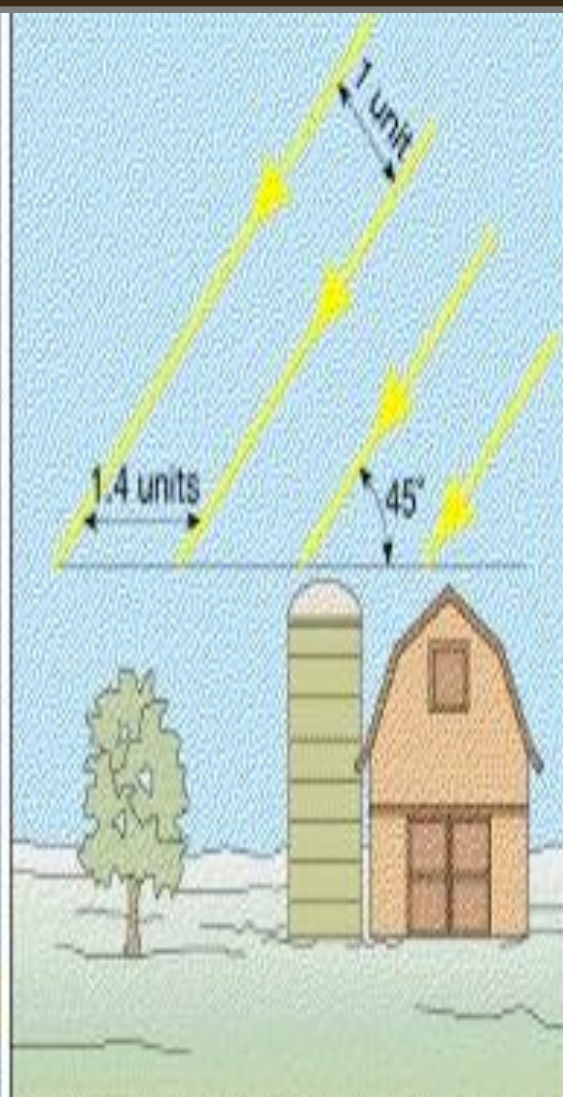
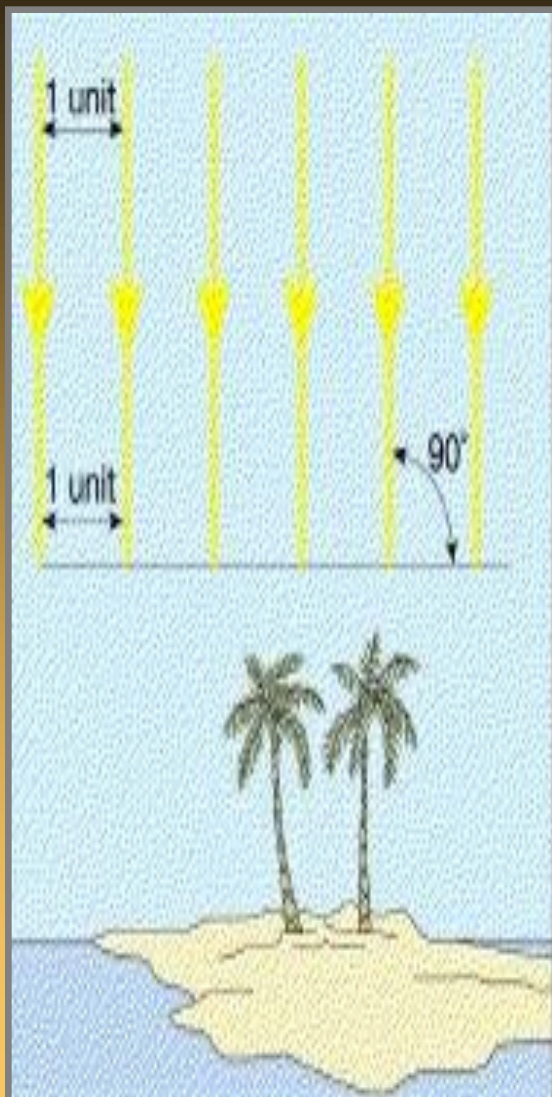
# Motion of the Earth

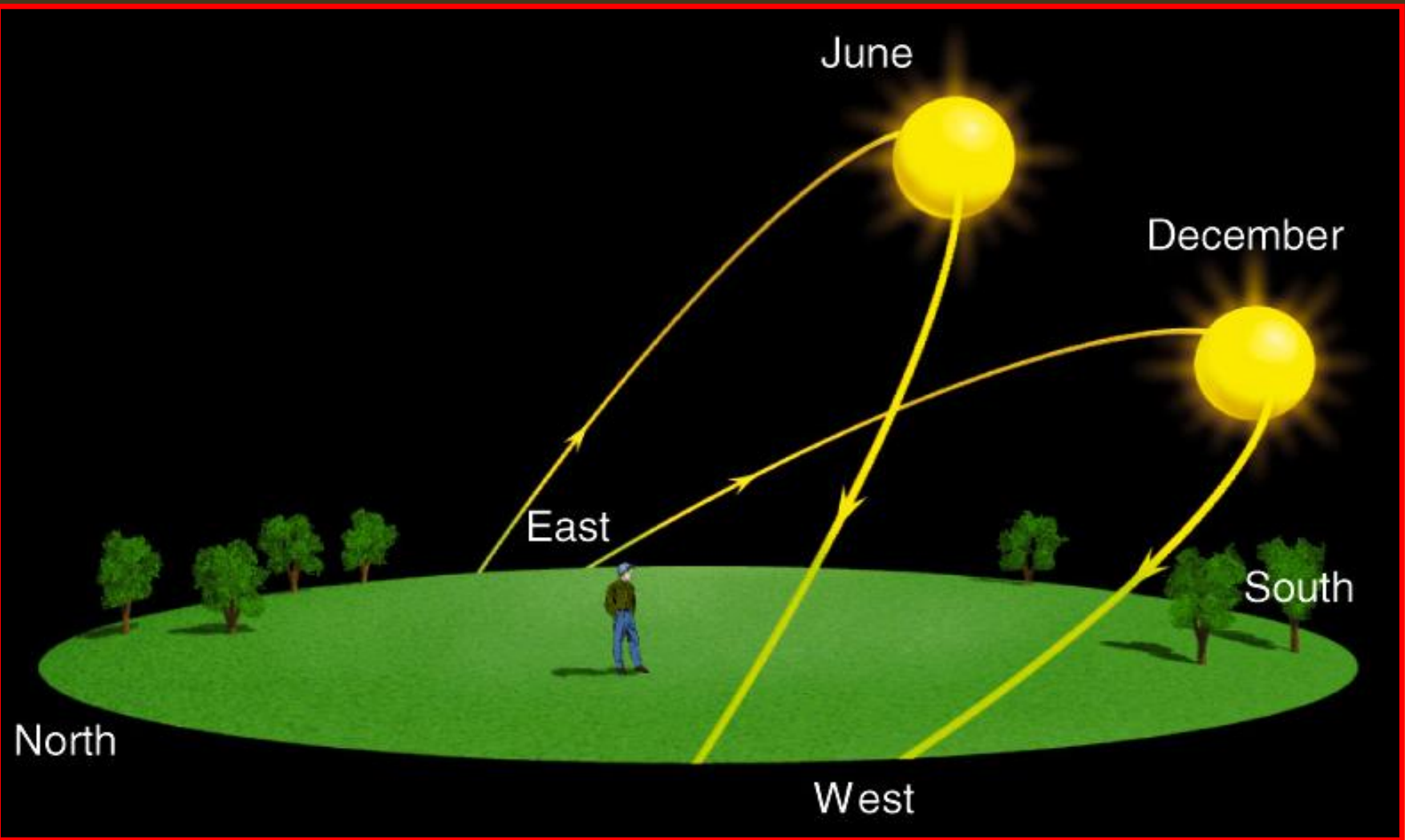
- Earth has two principal motions—*rotation and revolution*.
- Rotation is the spinning of **Earth about its axis**.
- Revolution refers to the movement of Earth in its **orbit around the Sun**.

# Variations in Solar Energy and Seasons

- The two most important reasons for the variation in solar energy reaching a particular location are:
  - ✓ The seasonal **changes in the angle** at which the Sun's rays strike the surface and
  - ✓ The **length of daylight**.
- The seasonal variation in the angle of the Sun affects :
  - where on Earth the solar rays are **most concentrated** and
  - the **thickness of atmosphere** the rays must penetrate.







# Four (4) Seasons

The four days each year given special significance based on the annual migration of the direct rays of the Sun and its importance to the yearly cycle of weather are:

## Equinoxes :

- either of the two annual crossings of the equator by the Sun, once in each direction,
- when the length of day and night are approximately equal everywhere on Earth.
- The equinoxes occur around March 21 and September 23.

## Solstices

- longest or shortest day**
- either of the times when the Sun is **farthest from the equator**, on or about June 21 or December 21.
- The summer solstice falls in June in the northern hemisphere but in December in the southern hemisphere, and vice versa for the winter solstice.



# Equinoxes and Solstices

- **March 21/22**, the spring, or vernal, equinox in the Northern Hemisphere, when the vertical rays of the Sun also strike the equator.
- **June 21/22**, the summer solstice for people living in the Northern Hemisphere, when the vertical rays of the Sun are striking 23.5° north latitude (Tropic of Cancer),
- **September 22/23**, the autumnal equinox in the Northern Hemisphere, when the vertical rays of the Sun strike the equator, and
- **December 21/22**, the winter solstice for people living in the Northern Hemisphere, when the vertical rays of the Sun are striking 23.5° south latitude (Tropic of Capricorn),

**Table 2–A** Occurrence of the seasons in the Northern Hemisphere

<b>Seasons</b>	<b>Astronomical Seasons</b>	<b>Climatological Seasons</b>
Spring	March 21 or 22 to June 21 or 22	March, April, May
Summer	June 21 or 22 to September 22 or 23	June, July, August
Autumn	September 22 or 23 to December 21 or 22	September, October, November
Winter	December 21 or 22 to March 21 or 22	December, January, February

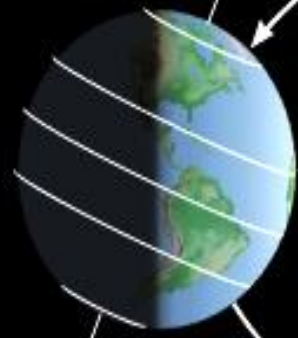
Arctic Circle  
Tropic of Cancer  
Equator  
Tropic of Capricorn

Spring, or  
vernal, equinox

Equinox  
March 21-22  
Sun vertical at equator

Winter  
solstice in  
NH

Summer  
solstice in NH



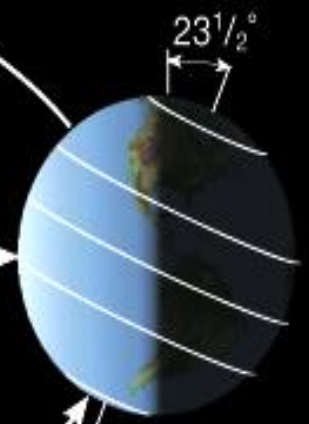
Solstice  
June 21-22  
Sun vertical at  
Latitude  $23\frac{1}{2}^{\circ}$  N

Orbit



Autumnal  
equinox in  
NH

Equinox  
September 22-23  
Sun vertical at equator



Solstice  
December 21-22  
Sun vertical at  
Latitude  $23\frac{1}{2}^{\circ}$  S

Sun

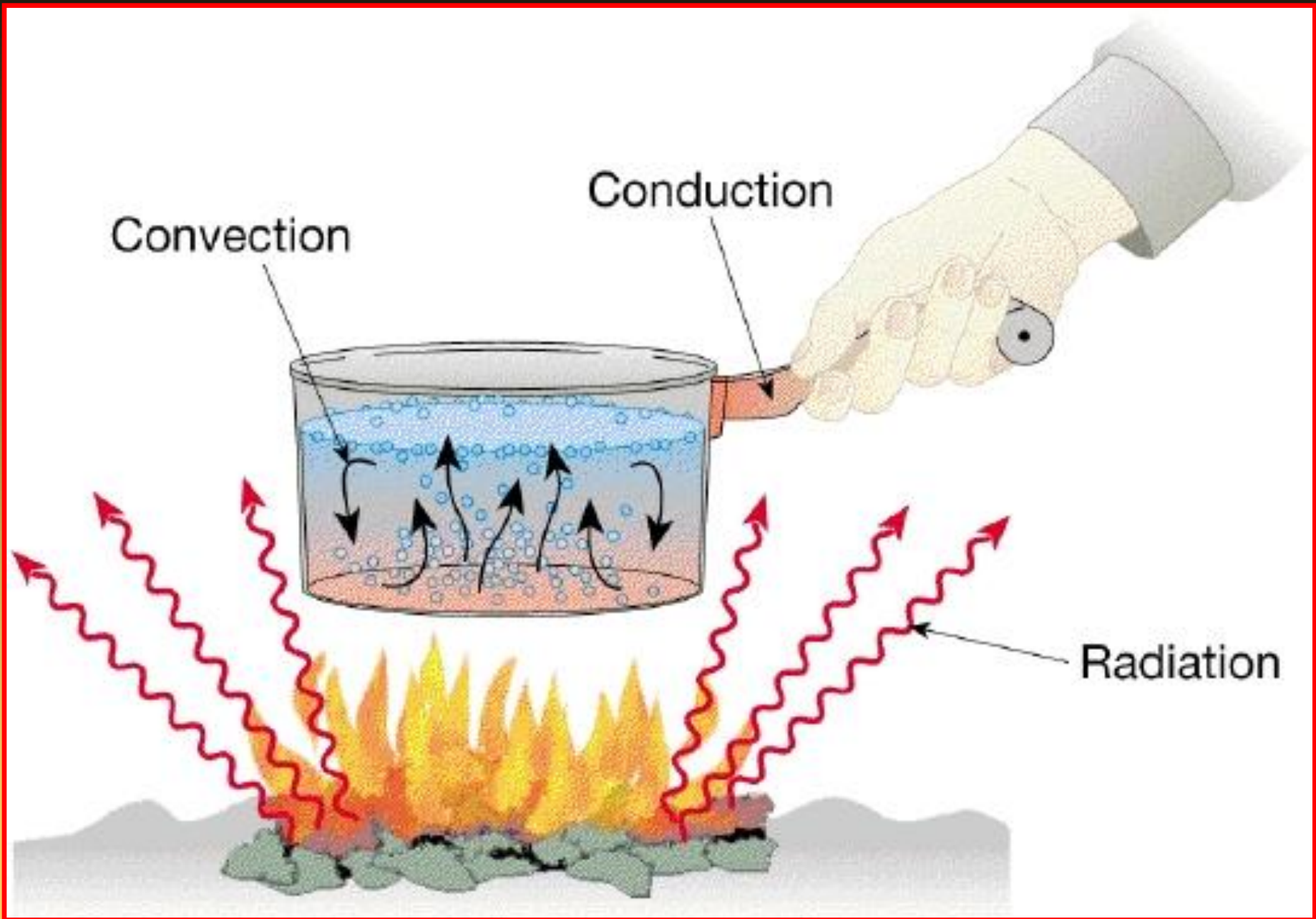
# Heat and Temperature

- Heat is a form of energy.
- Temperature refers to intensity—that is, **the degree of "hotness."**
- Temperature is a measure of the **average kinetic energy of the individual atoms or molecules** in a substance.
- Energy is the ability to do work. The two major categories of energy are:
  - (1) kinetic energy, which can be thought of as energy of motion, and
  - (2) potential energy, energy that has the capability to do work.

# Heat Transfer

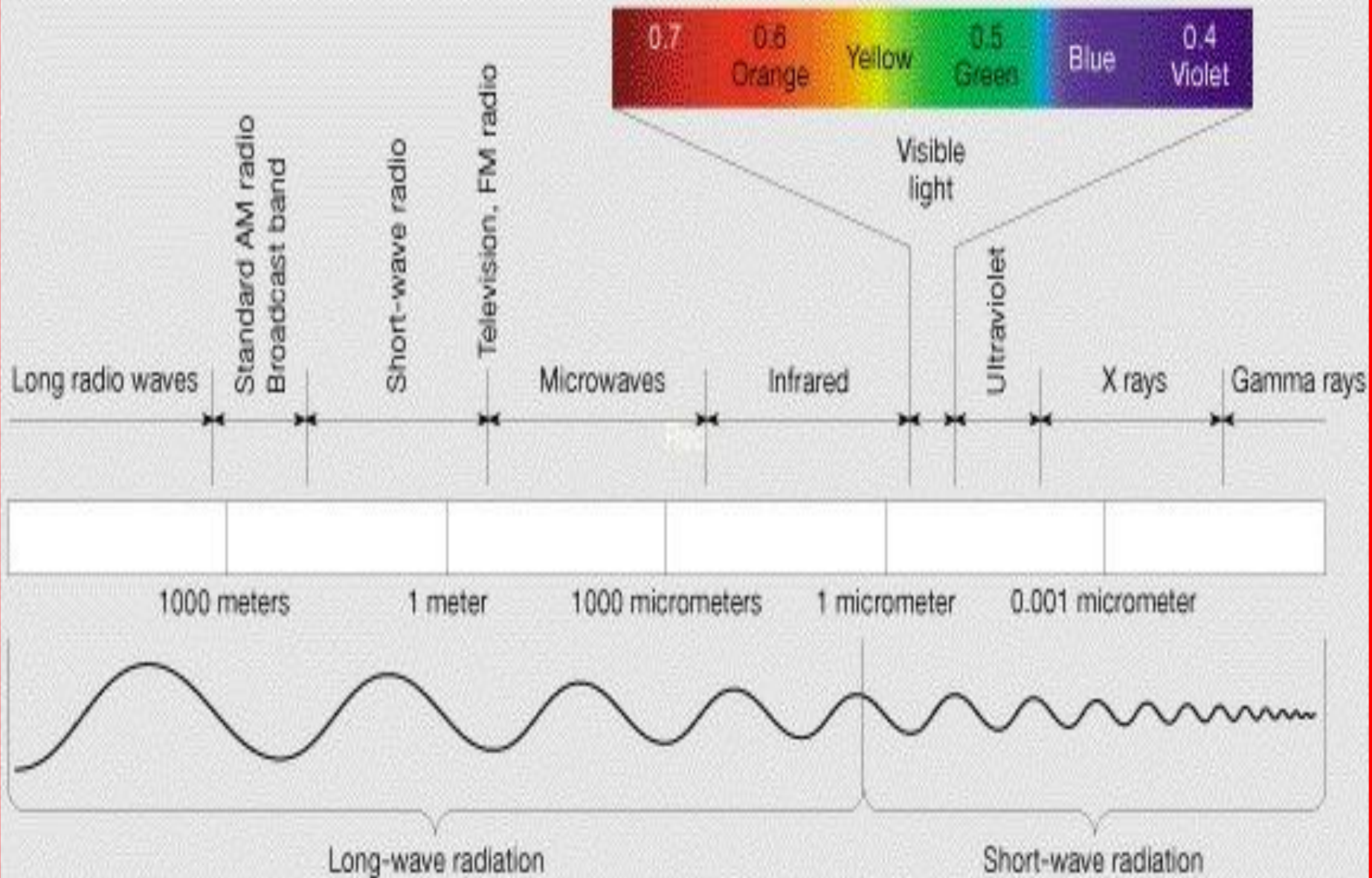
The three mechanisms of heat transfer are:

- (1) **conduction**, the transfer of heat through matter by **molecular activity**,
- (2) **convection**, the transfer of heat **by mass movement or circulation** within a substance, and
- (3) **radiation**, the heat-transfer mechanism by which solar energy reached our planet.



# Electromagnetic Radiation

- Radiation or *electromagnetic radiation*, whether x-rays, visible light, heat waves, or radio, travels as various size waves through the vacuum of space at 300,000 kilometers per hour.
- **Shorter wavelengths** of radiation are associated with **greater energy**.
- The wavelength of visible light ranges from 0.4 micrometer (violet) to 0.7 micrometer (red).





# The Sun's Radiation

- Although the Sun emits many forms of radiation, most of the energy is concentrated in the visible and near visible (**infrared** and **ultraviolet**) parts of the spectrum.
- The basic laws of radiation are:
  - (1) all objects **above  $-273^{\circ}$**  Celsius emit radiant energy,
  - (2) hotter objects radiate more total energy per unit area than colder objects,
  - (3) the **hotter the radiating** body, the **shorter the wavelength** of maximum radiation, and
  - (4) objects that are **good absorbers** of radiation are also **good emitters**.

# Where does the sun's radiation go?

- Approximately 50 percent of all radiant energy from the Sun reaches Earth's surface.
- About 30 percent is reflected back to space by the atmosphere.
- The remaining 20 percent of the energy is absorbed by clouds and the atmosphere's gases.
- The wavelength of the energy being transmitted, as well as the size and nature of the absorbing or reflecting substance, determines whether solar radiation will be scattered, reflected back to space, or absorbed.

# Albedo

- The fraction of **radiation reflected by a surface** is called its **albedo**.
- Radiation absorbed by Earth's surface is reradiated skyward.
- Because Earth has a much **lower surface temperature**, terrestrial radiation is primarily in the form of **longwave infrared radiation**.
- Because the atmospheric gases, primarily **water vapor** and **carbon dioxide**, are more efficient absorbers of terrestrial (longwave) radiation, the atmosphere is heated from the ground up.

**Table 2–3** Albedo (reflectivity) of various surfaces

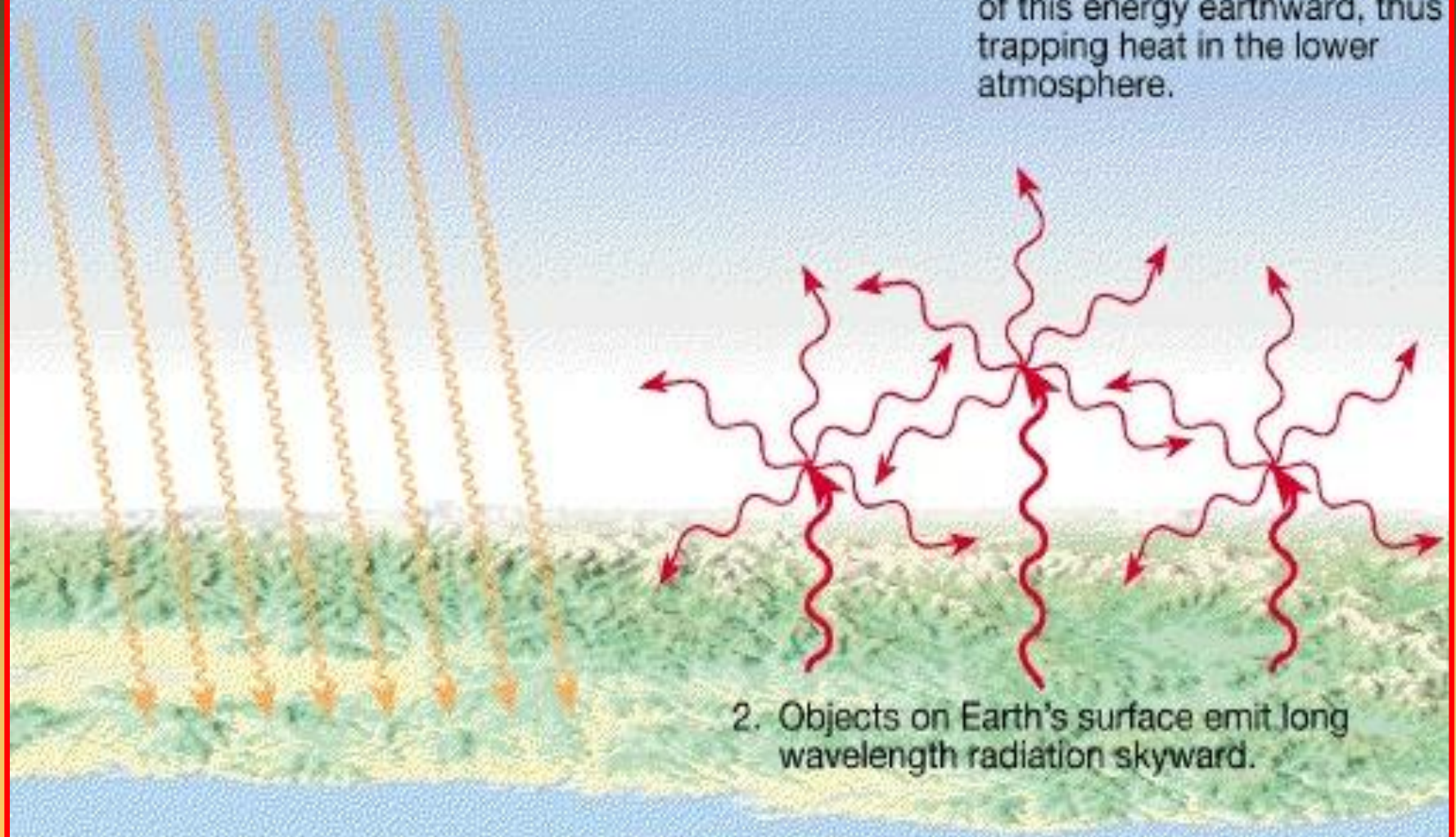
<b>Surface</b>	<b>Percent Reflected</b>
Fresh snow	80–85
Old snow	50–60
Sand (beach, desert)	20–30
Grass	20–25
Dry soil (plowed field)	15–25
Wet earth (plowed field)	10
Forest	5–10
Water (Sun near horizon)	50–80
Water (Sun near zenith)	3–5
Thick cloud	70–80
Thin cloud	25–30
Earth and atmosphere (overall total)	30

# The Greenhouse Effect

- The general drop in temperature with increased altitude in the troposphere (about **6.5°C/kilometer**, a figure called the **normal lapse rate**) supports the fact that the atmosphere is heated from below.
- The transmission of shortwave solar radiation by the atmosphere coupled with the selective absorption of terrestrial radiation by atmospheric gases that results in the warming of the atmosphere is referred to as the **greenhouse effect**.

1. Much of the incoming, short wavelength, solar radiation penetrates the atmosphere and heats Earth's surface.

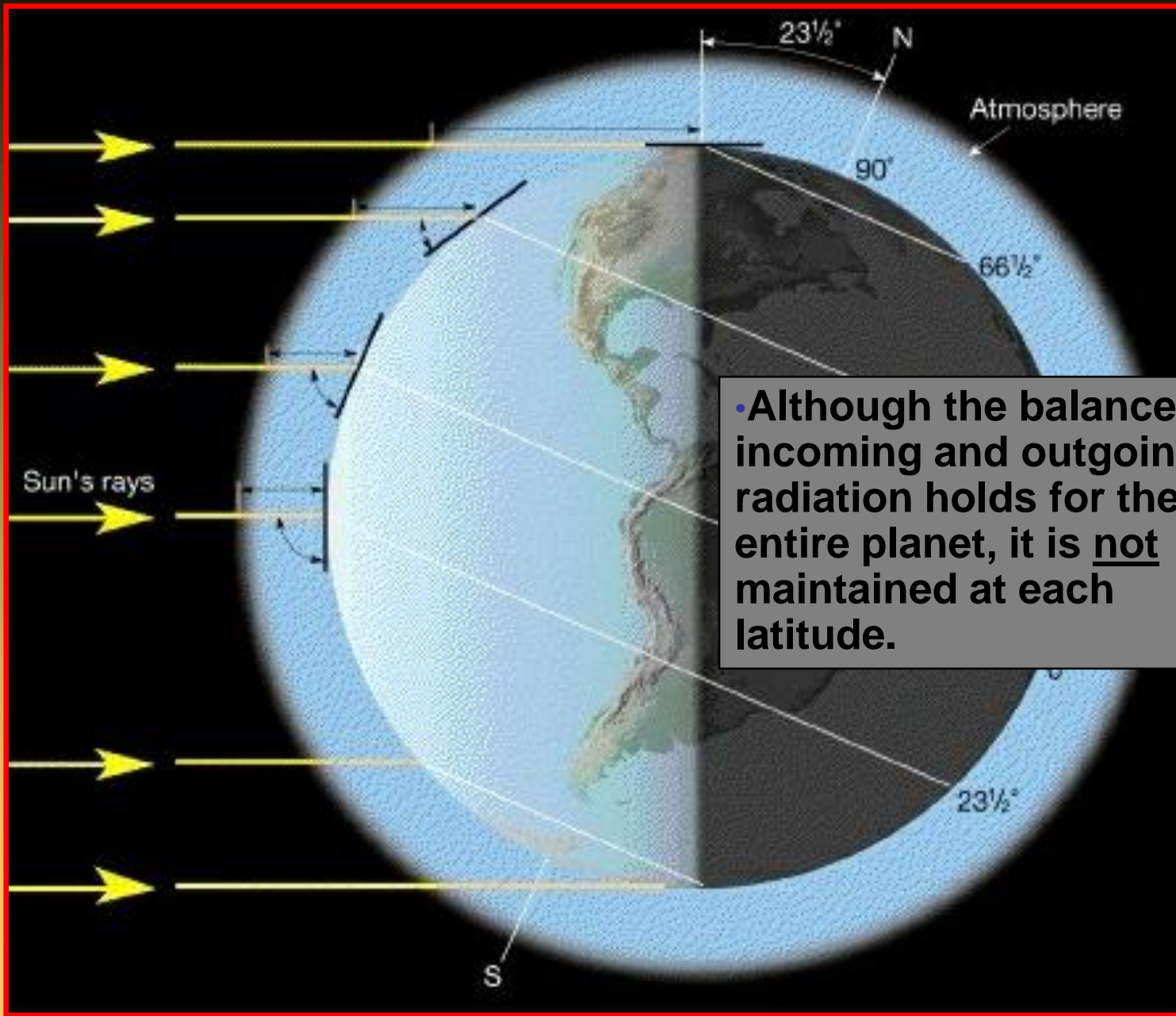
3. Greenhouse gases absorb outgoing, long wavelength, radiation and reradiate some of this energy earthward, thus trapping heat in the lower atmosphere.



2. Objects on Earth's surface emit long wavelength radiation skyward.

# Earth's Heat Budget

- Because of the annual balance that exists between incoming and outgoing radiation, called Earth's **heat budget**,
- Earth's average temperature remains relatively constant, despite seasonal cold spells and heat waves.
- Although the balance of incoming and outgoing radiation holds for the entire planet, it is not maintained at each latitude.

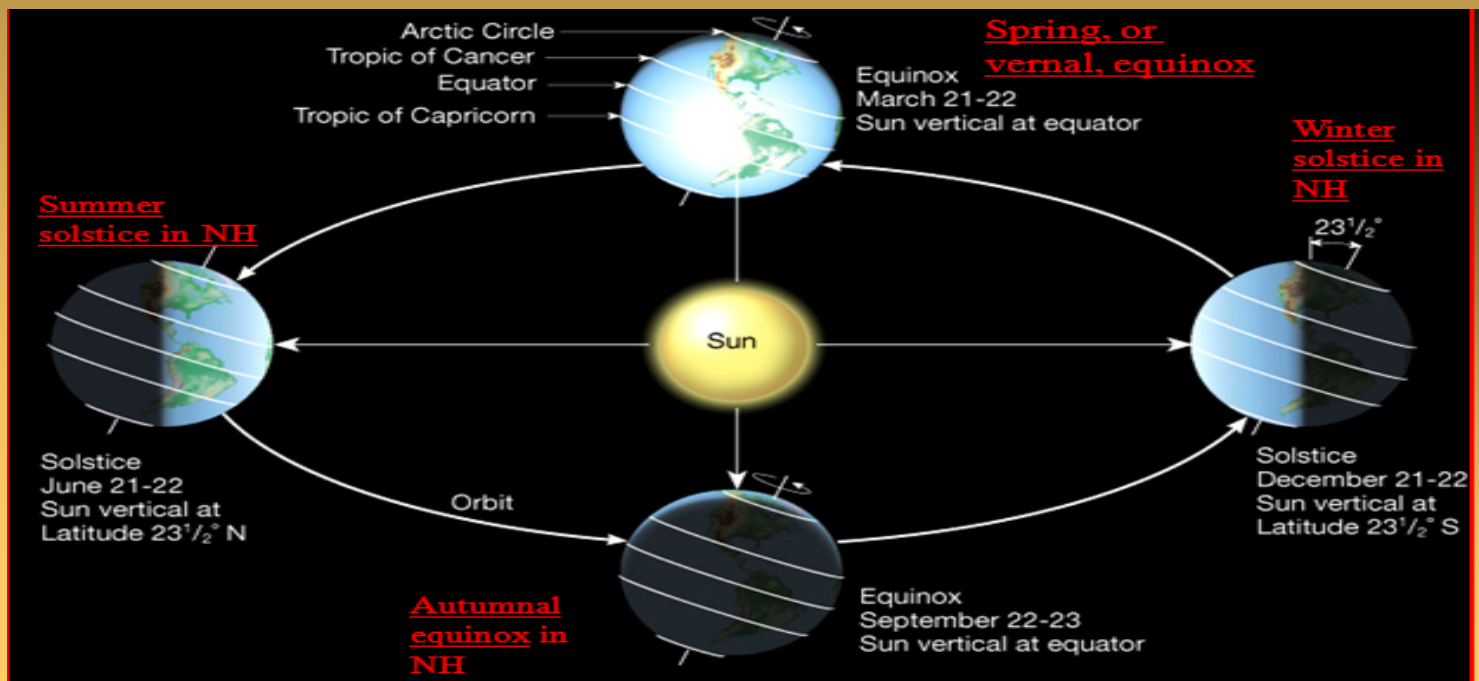


• Although the balance of incoming and outgoing radiation holds for the entire planet, it is not maintained at each latitude.



Table 2-2 Length of daylight

Latitude (Degrees)	Summer Solstice	Winter Solstice	Equinoxes
0	12 hr	12 hr	12 hr
10	12 hr 35 min	11 hr 25 min	12 hr
20	13 hr 12 min	10 hr 48 min	12 hr
30	13 hr 56 min	10 hr 04 min	12 hr
40	14 hr 52 min	9 hr 08 min	12 hr
50	16 hr 18 min	7 hr 42 min	12 hr
60	18 hr 27 min	5 hr 33 min	12 hr
70	2 mo	0 hr 00 min	12 hr
80	4 mo	0 hr 00 min	12 hr
90	6 mo	0 hr 00 min	12 hr



- Averaged over the entire year, a zone around Earth between  $36^{\circ}\text{N}$  and  $36^{\circ}\text{S}$  receives more solar radiation than is lost to space.
- The opposite is true for higher latitudes, where more heat is lost through longwave terrestrial radiation than is received.
- It is this energy imbalance between the low and high latitudes that:
  - drives the global winds and ocean currents,
  - which in turn, transfers surplus heat from the tropics poleward.

# Radiation Balance Fluctuations

- Furthermore, the radiation balance of a given place fluctuates with changes in:
  - cloud cover,
  - atmospheric composition, and most importantly,
  - Sun angle and length of daylight.
- Thus, areas of radiation surplus and deficit migrate seasonally as the Sun angle and length of day change.

## Key Terminology

Rotation

Revolution

Equinox

Solstice

Conduction

Convection

Radiation

Electromagnetic radiation

Albedo

Longwave radiation

Shortwave radiation

Greenhouse Effect