Energy Getting to the Biosphere

What are we doing in this unit?

We will look at 4 big ideas:

1. How energy moves from the Sun to the Earth and through the biosphere.

2. How energy moves around the Earth.

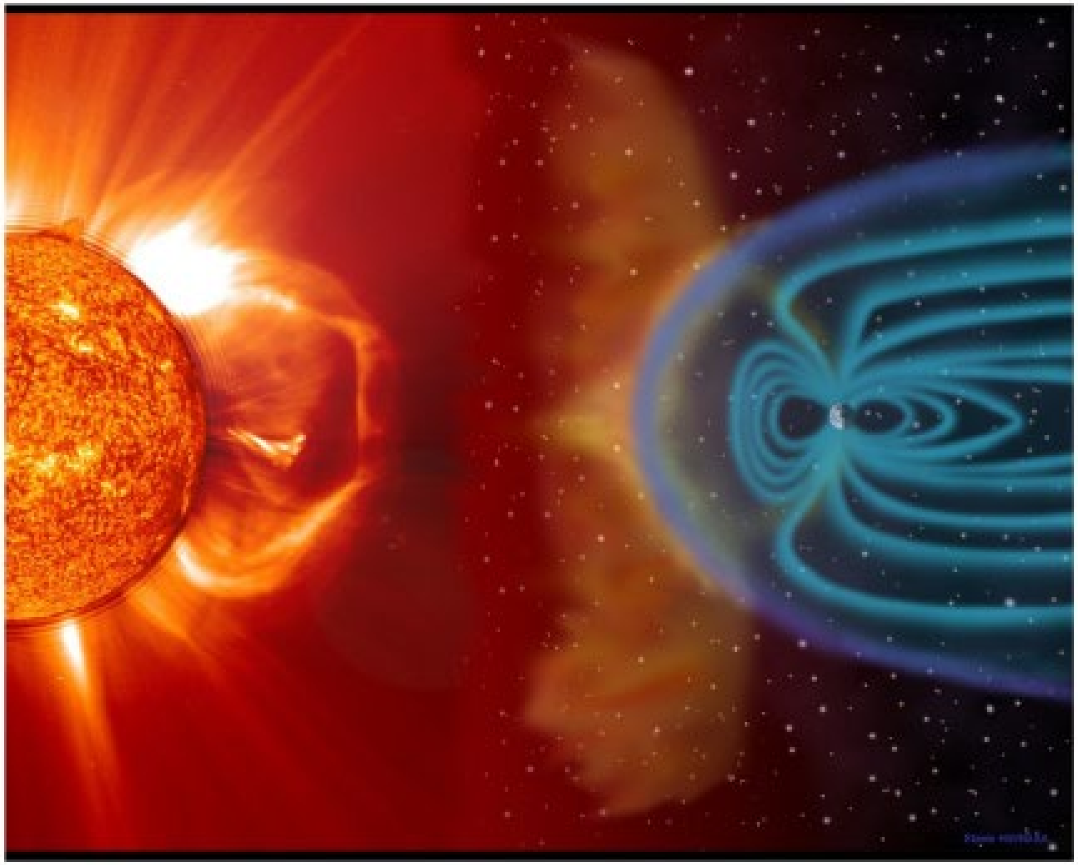
3. How different amounts of energy make for different biomes on Earth.

4. What happens when energy flow goes wrong.

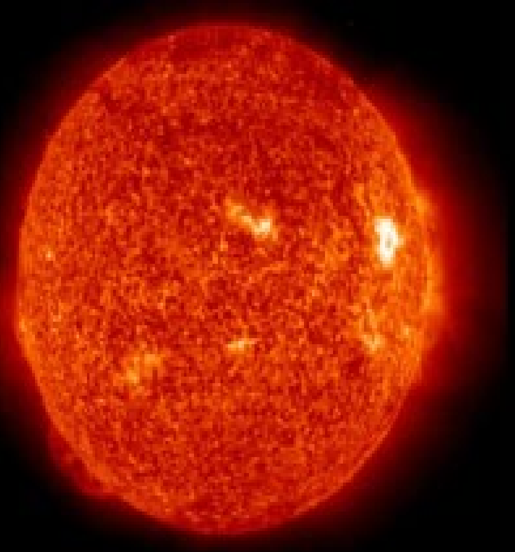
So, where does our energy come from? And how does it get here?

Alice and Bob

All of the energy we use on Earth has in one way or another come from the Sun.

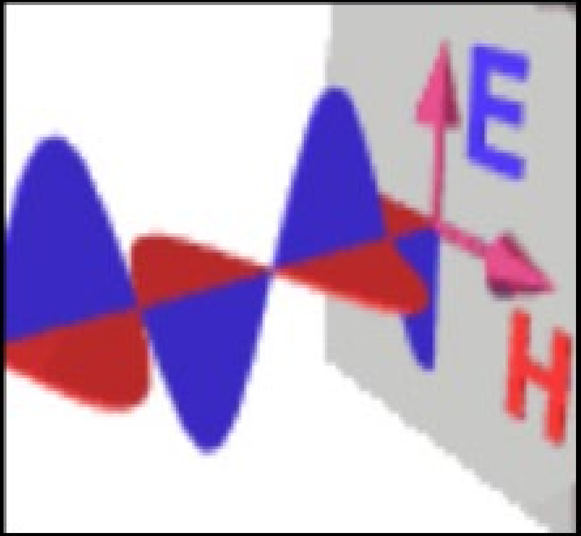


But seeing as the Earth and Sun are about 150 million km apart, how exactly does that energy get here?

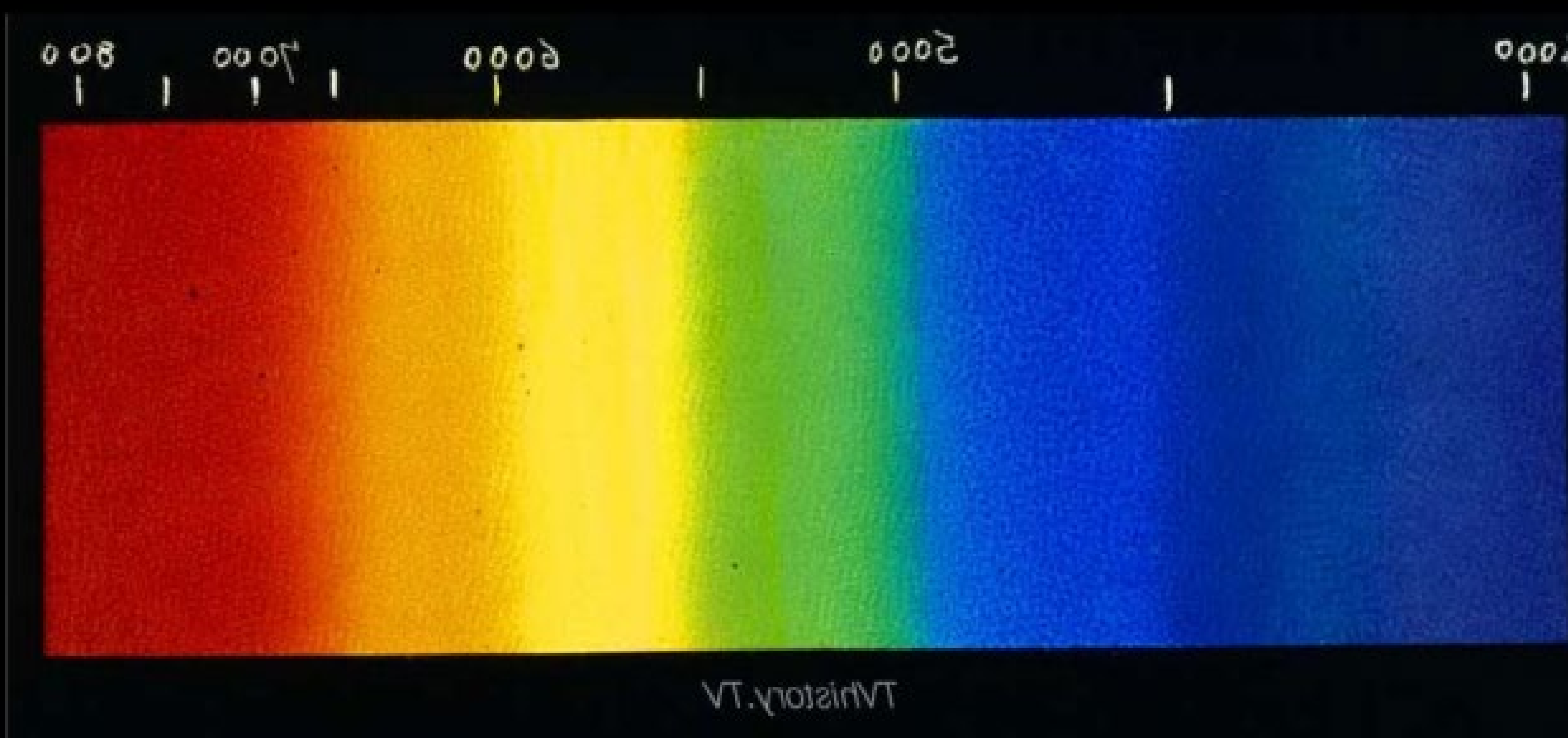


As you have probably guessed, the Sun transfers its energy to the Earth through light.

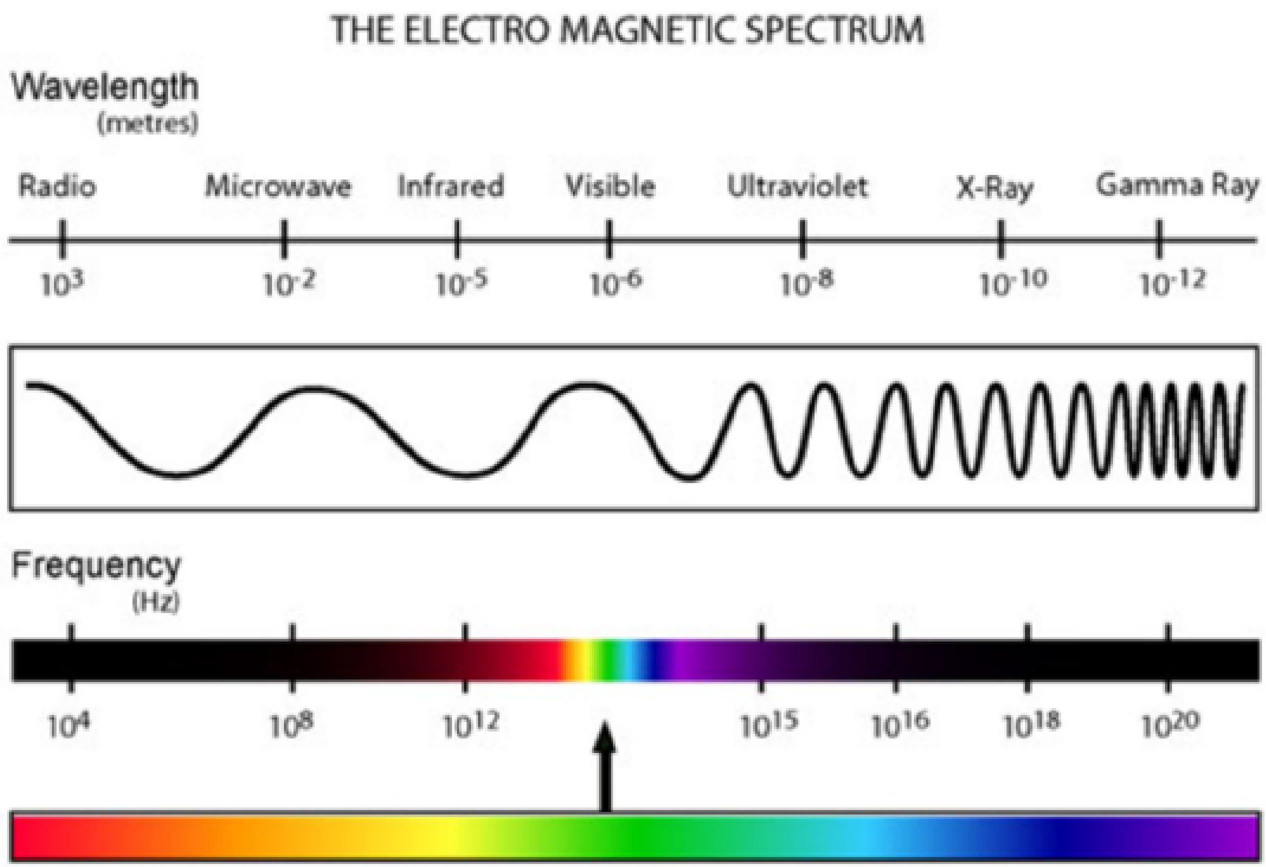
Us physicists call this light energy electromagnetic radiation, or EMR, as it is made up of alternating electric and magnetic waves (P30).



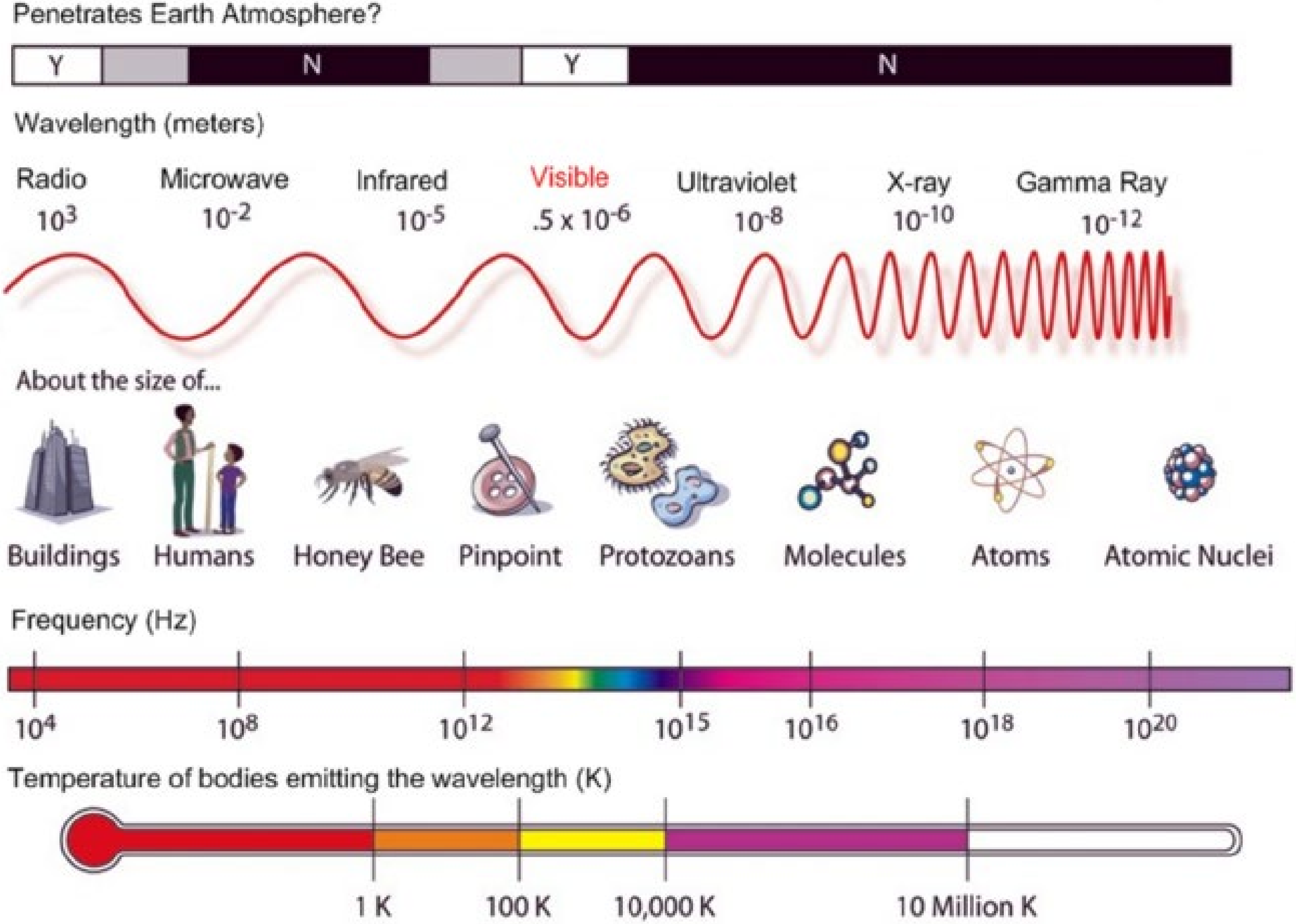
You may already know that if sunlight shines through a different material, like a glass or plastic prism, the beam of "white" light can split into different colours.



However, there are more categories of light than just the 7 colours. Light can actually be broken into a large spectrum of different waves:



The Electromagnetic Spectrum



Some of these types of waves are absorbed by the Earth. The really high energy waves (UV, X-Ray,gamma, cosmic) **USED** to get shielded by the ozone layer...

Now, much of this radiation gets through to the earth.

Hole in the Ozone Layer?

The amount of the sun's radiation absorbed by the earth is called the earth's <u>insolation</u>.

Where does the energy go from here? It moves throughout the *biosphere* of the Earth.

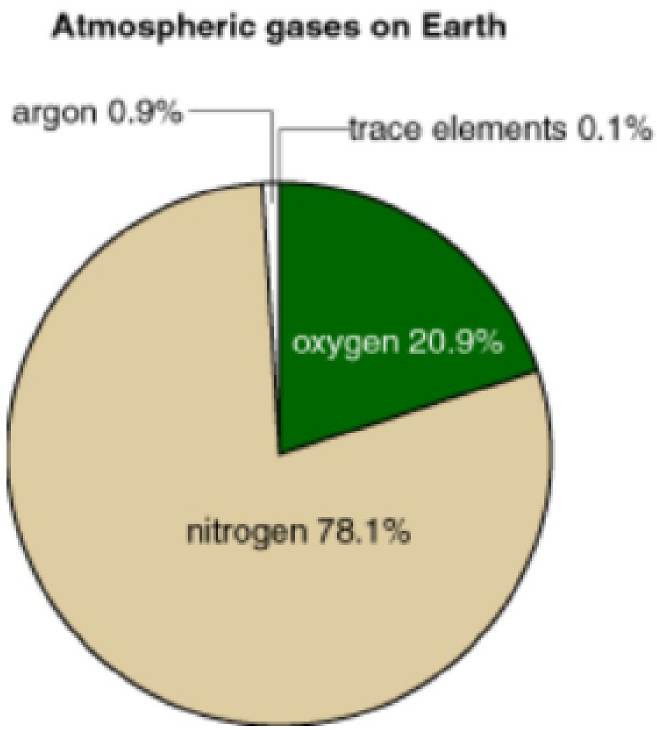
what is the biosphere?

- the narrow zone around the earth where life exists.

The biosphere is made up of three parts:

1. The Atmosphere

- roughly 500 km altitude above Earth's surface
- made up of gases and bits of atmospheric dust



The atmosphere is mostly nitrogen, with a little oxygen and argon thrown in for good measure.

Notice gases like carbon dioxide only make up 0.1% of the atmosphere, but still cause many problems!

Wow, that's a lotta nitrogen!

What is it good for?

- **Nitrogen is mostly unreactive (we breath it with no effect to our bodies)**
- **Plants require nitrogen to grow (nitrogen cycle, S20/Bio20)**
- **Suckers put it in their tires**

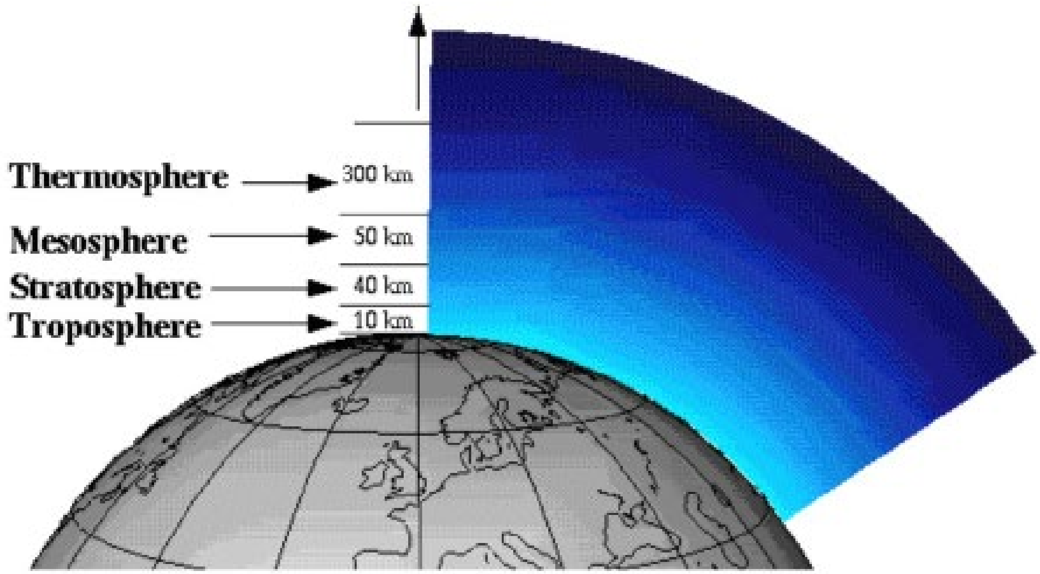
The atmosphere is broken into four layers:

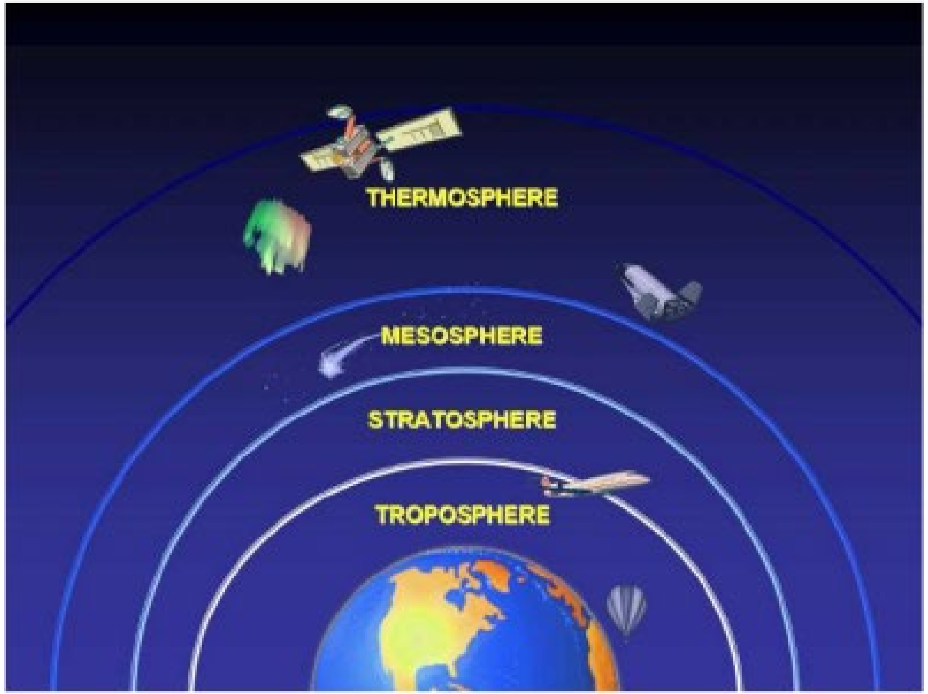
4. Thermosphere
(~300 km)

3. Mesosphere
(~80 km altitude)

2. Stratosphere
(~50 km altitude)

1. Troposphere
(~10 km altitude)





As one moves upwards, atmospheric pressure and temperature decrease.

Note that the gases that make up the ozone layer are mostly found in the stratosphere.

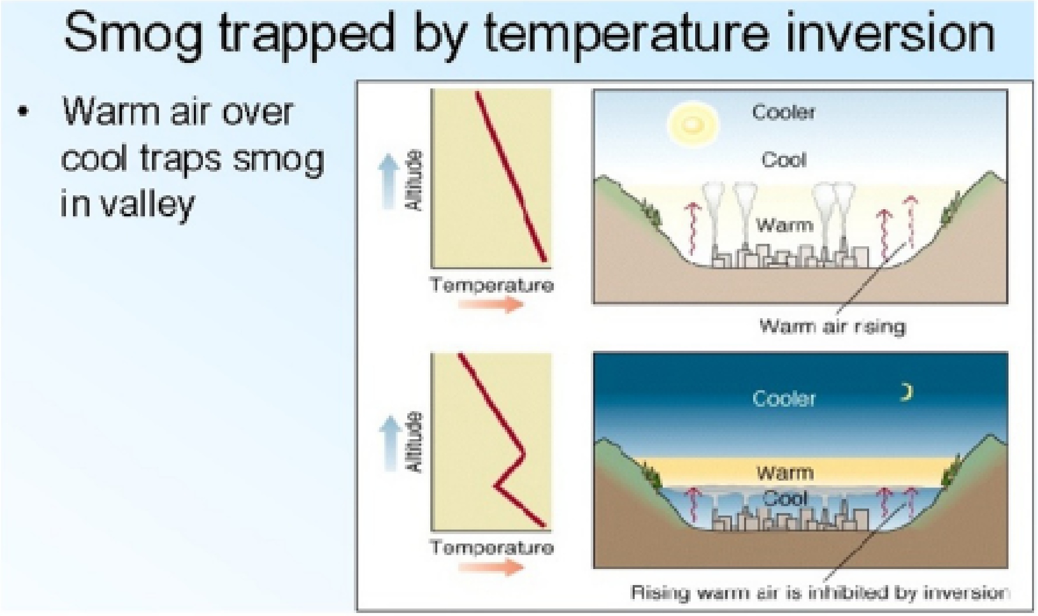
Altitudes and Temperatures

- Generally, as the altitude increases, the temperature of the air decreases.

- In areas near mountains, cool air can be trapped close to the ground by a layer of warmer air.

- This process is known as a temperature inversion.

- Pollutants can become trapped close to the ground due to the warm layer (like a lid) above affecting the health of some people.



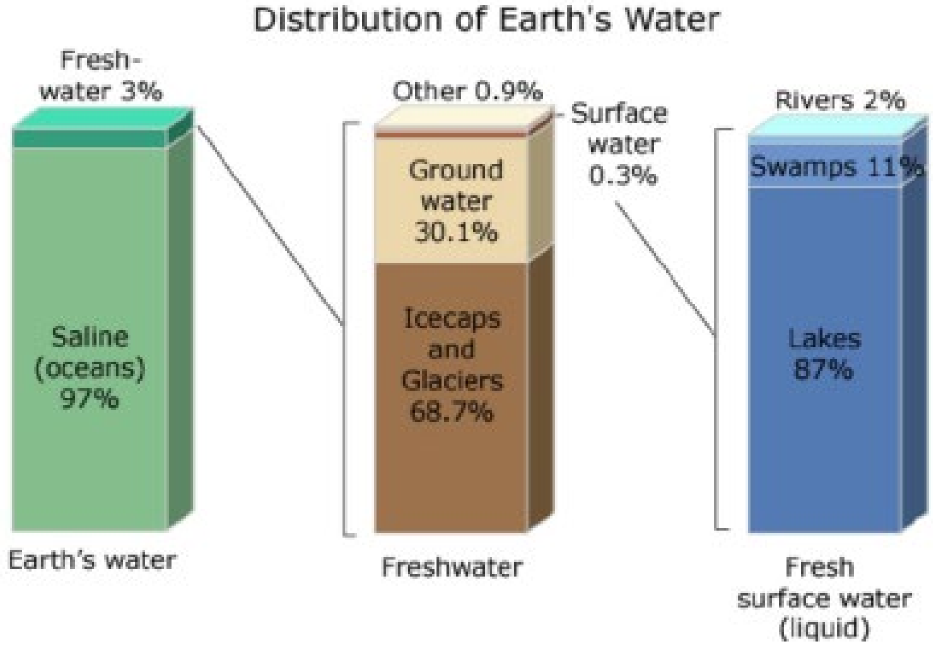
2. The Lithosphere

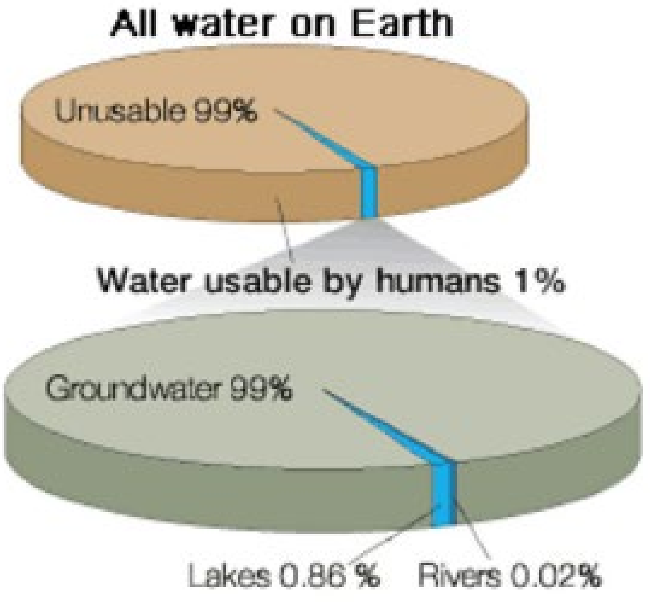
- The livable part of the earth's crust, including that under the ocean.

- This is where we live (except when I'm on my houseboat or house-blimp.

3. The Hydrosphere

- The livable part of the earth's water.
- About 97% is salt water ocean, only 3% is fresh water.





So, we've seen that energy come from the Sun, travels through space in the form of EMR, then is transfered to the 3 parts of the Earth's biosphere.

But there's a little more to the story than that.

The energy transfer is actually a pretty sticky process...

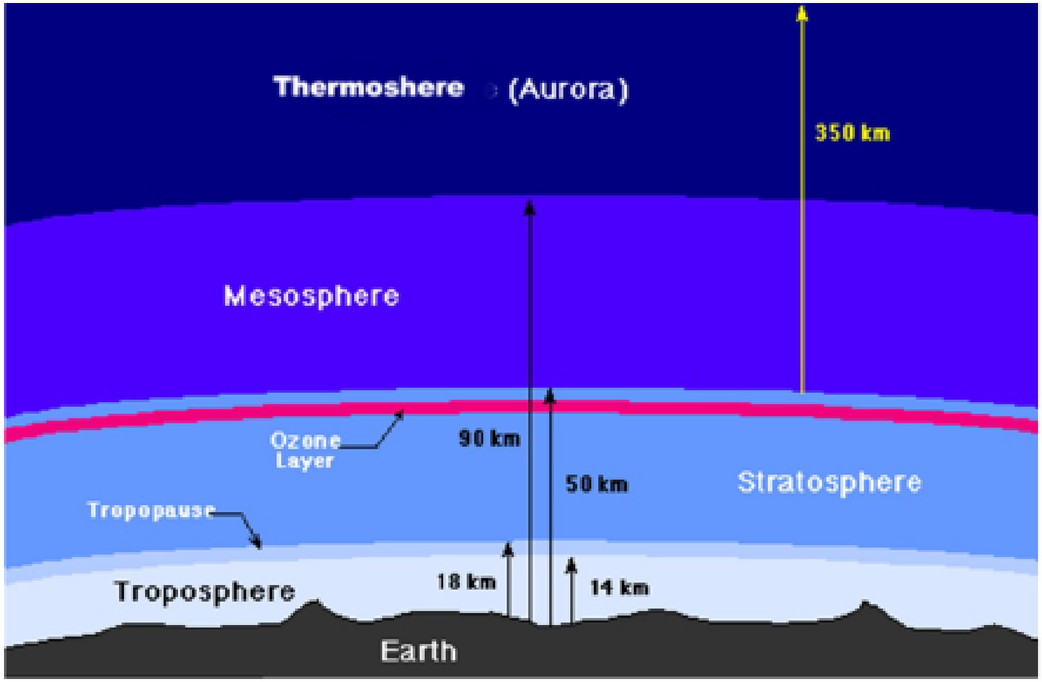
Absorption and Reflection by the Biosphere

Not all of the Sun's energy is simply taken by the Earth. Some energy is absorbed and some is reflected. This happens in all 3 layers of the biosphere.

- **Absorbed energy (insolation): re-emitted as heat, drives water cycle, used for photosynthesis.**

- **Reflected energy: goes back to space, or is reabsorbed.**

Absorbtion in the Atmosphere



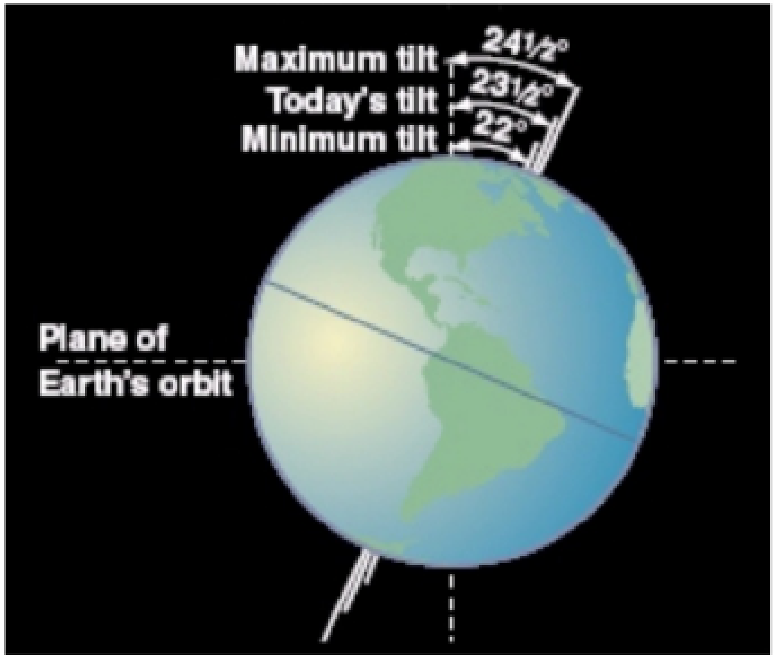
- Each layer contains different gases, all reflect and absorb different energies.

- $O_{2(g)}$ and $N_{2(g)}$: absorb high-energy radiation (X-rays, gamma rays).
- Ozone: absorbs UV radiation
- $CO_{2(g)}$ and $H_2O_{(g)}$: absorb IR radiation

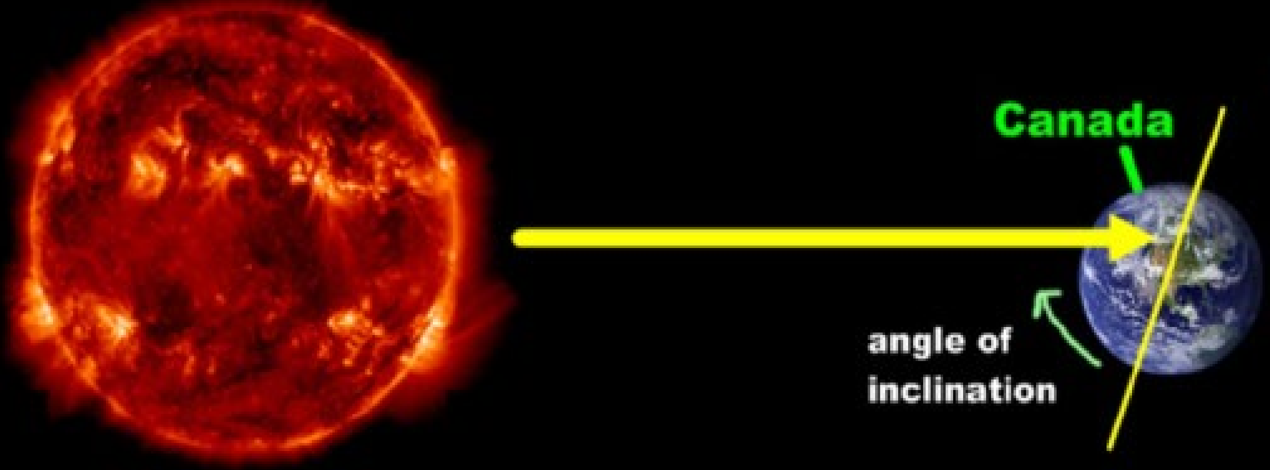
Insolation and the Angle of Inclination

Insolation is also affected by the angle the Earth makes with the suns rays. This angle is called the angle of inclination.

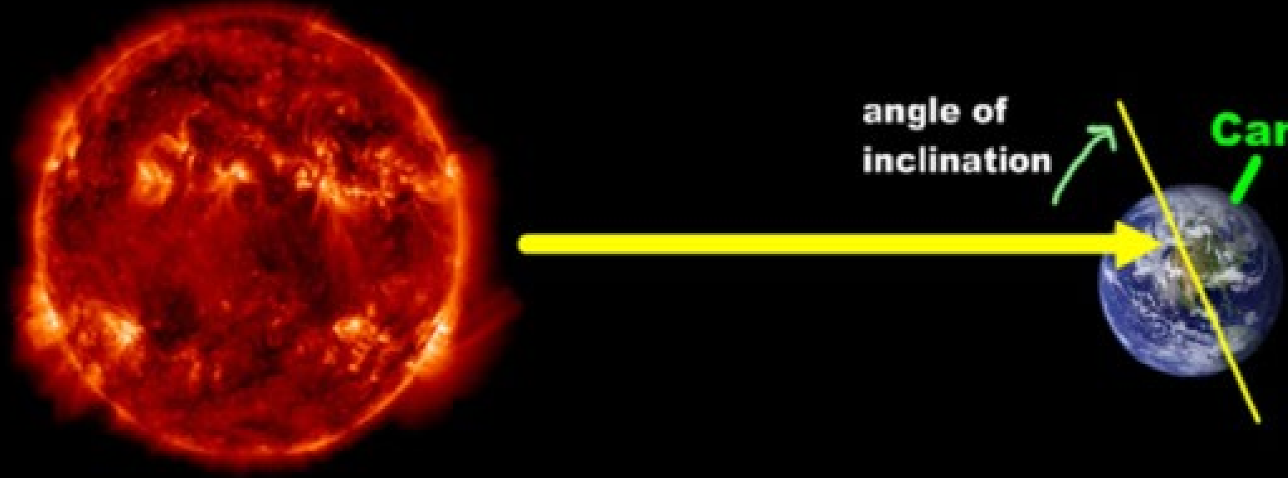
The current angle of inclination is 22.5 degrees.



So, what effect does this tilt have?



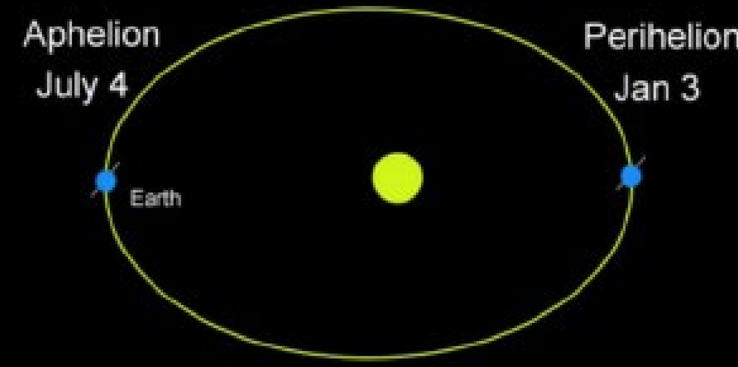
When our part of the earth is tilted towards the sun, we experience summer.



When our part of the earth is tilted away from the sun, we experience winter.

The other seasons occur between these two extremes.

It's a common misconception that the seasons depend on how far the Earth is from the Sun, but this distance <u>does not</u> have an affect on seasons for two reasons:

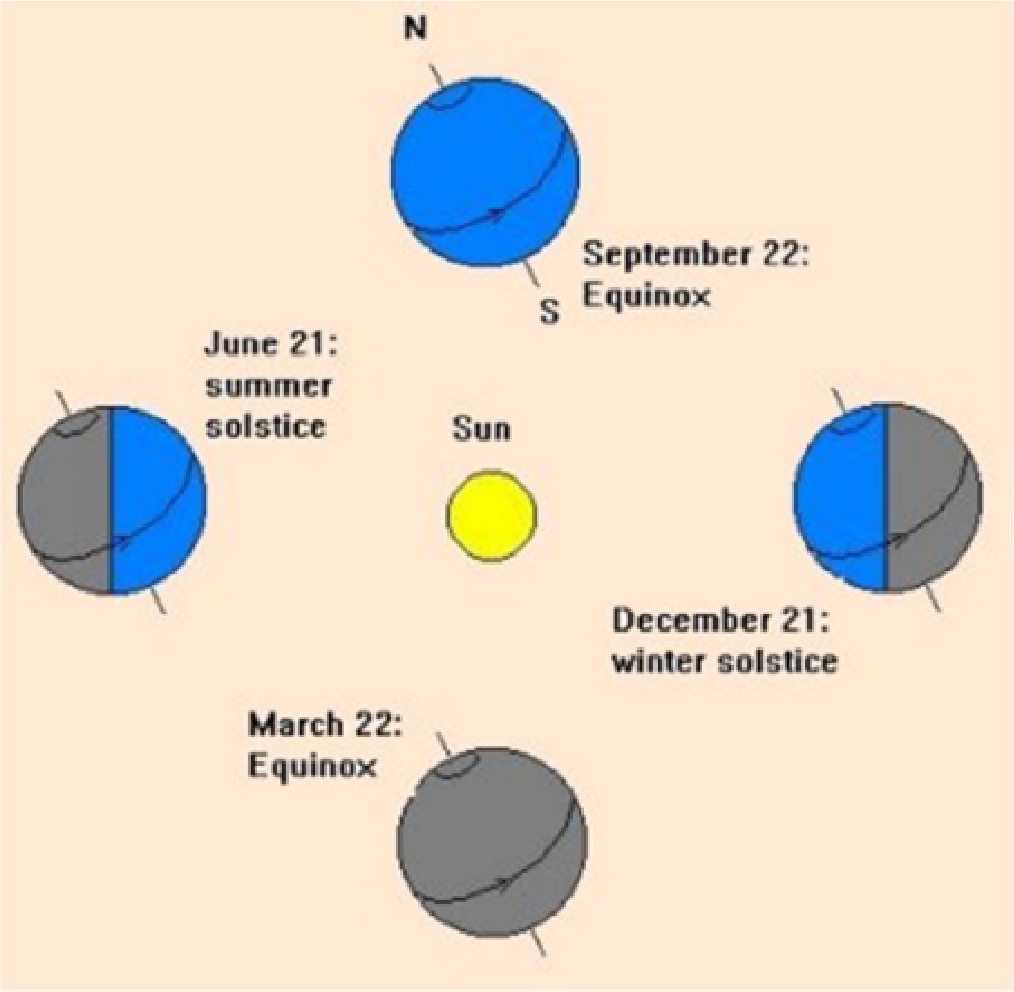


1. While the Earth-Sun distance does change throught the year, it isn't by very much (relatively speaking).

2. If Earth-Sun distance <u>did</u> change seasons, then everywhere on Earth would have winter when we were farthest from the Sun and summer when we were the closest; this just doesn't happen.

The northern hemisphere is at it's maximum angle towards the sun on approx. June 21st every year. This day is called the summer solstice, the longest day of the year (most hours of sunlight).

The northern hemisphere is at it's minimum angle towards the sun on approx. Dec 21st every year. This day is called the winter solstice, the shortest day of the year (fewest hours of sunlight).



There are also two days throughout the year where the number of hours of sunlight are equal to the number of hours of darkness. These are called equinoxes and occur on the 22nd of September and March.

Places which are furthest away from the sun in winter and closest in summer (i.e. at the poles of the earth) receive longer longest days and shorter shortest days.

Places that are near the equator receive days of mostly equal length throughout the year.

These locations are separated by lines of latitude (horizontal lines running parallel to the equator).

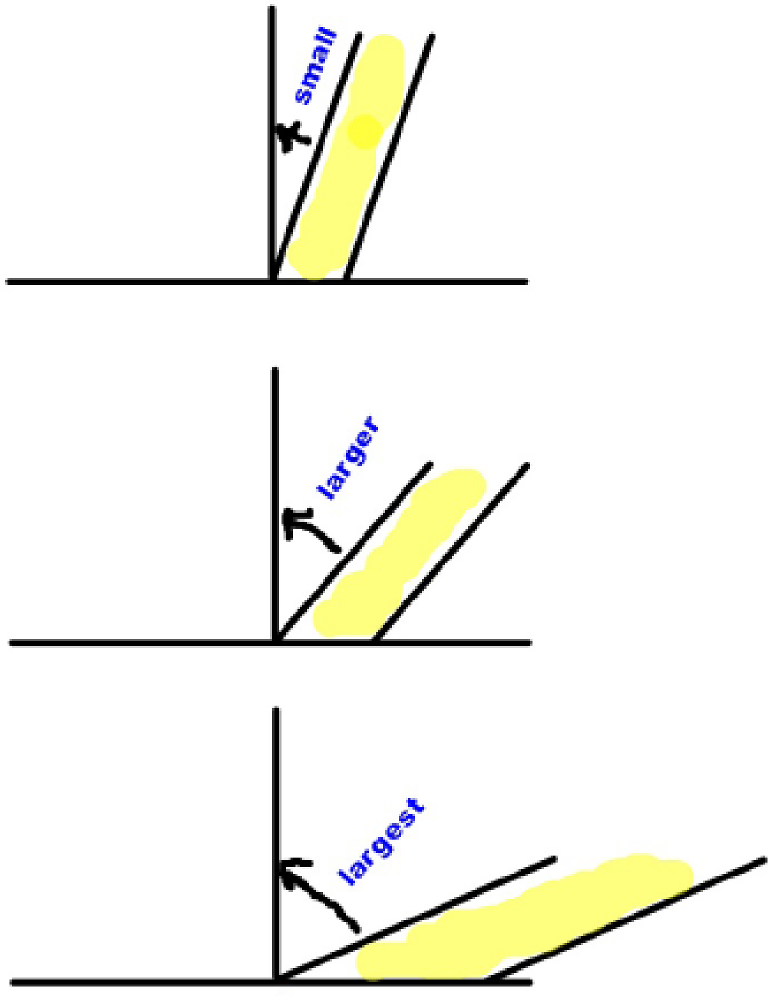
Insolation and the Angle of Incidence

The difference in insolation also occurs because of the angle of incidence sunlight makes with the earth.

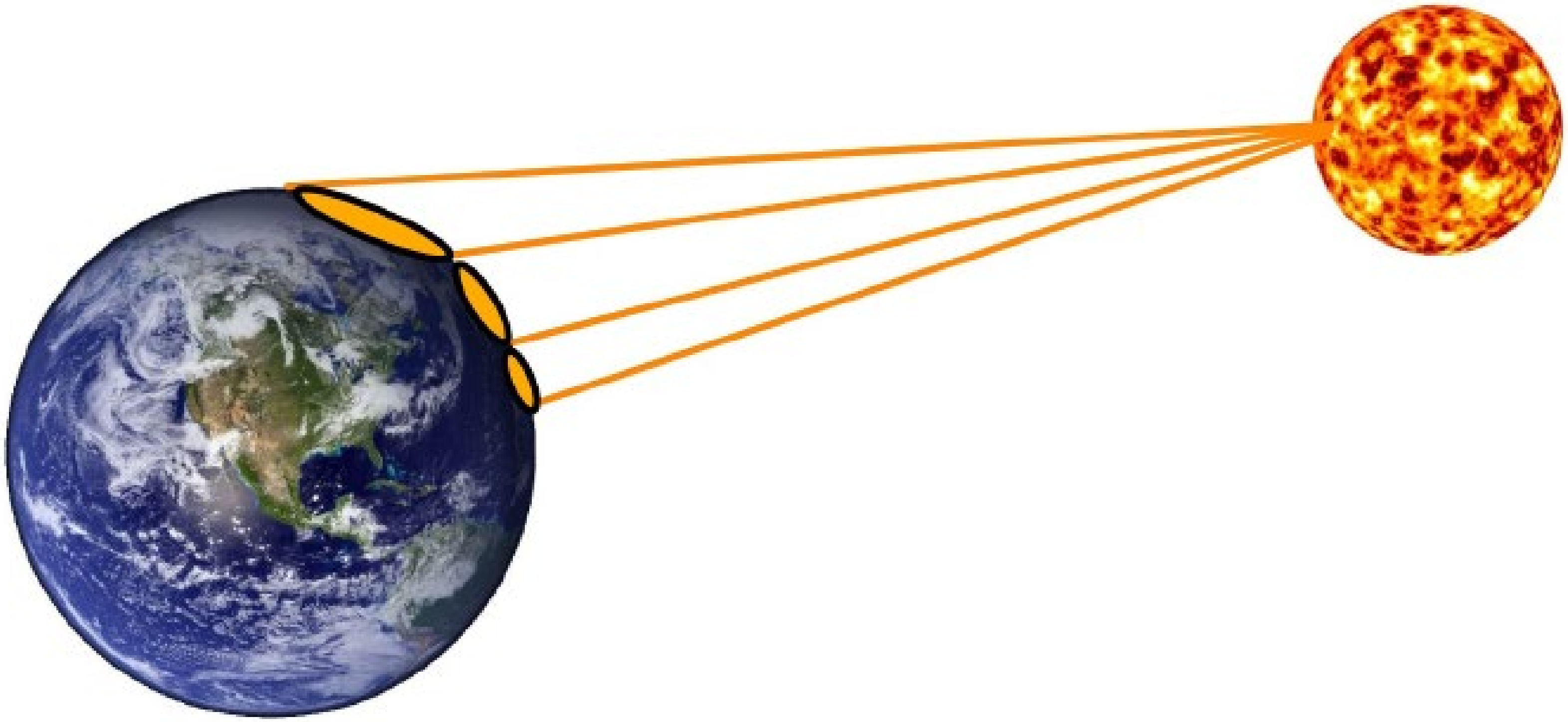
To find the angle of incidence, draw a 90 degree right angle coming off the surface of the earth and measure the angle the light hits the earth from that right angle.

This is the angle the sunlight is hitting the earth at.

As the angle of incidence increases, the same amount of sunlight is spread out over longer distances.

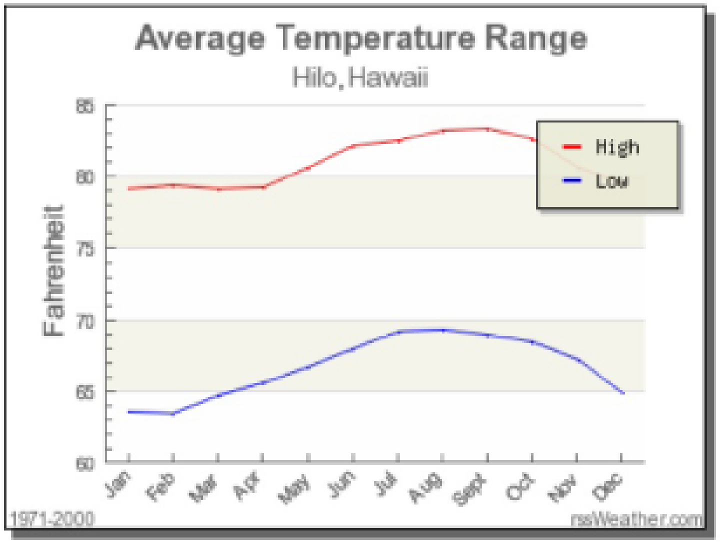


This means the light has less energy per square meter of earth: it is diluted.

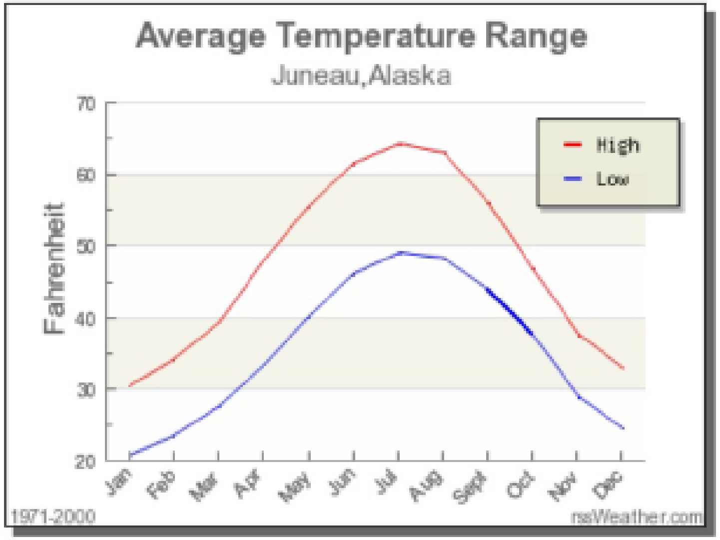


As the angle of incidence increases as we go further away from the equator, the sun's rays have less intensity, resulting in overall cooler climate.

Both angle of inclination and angle of incidence affect climate. **Now we can see why places on the earth closer to the equator have less extreme climates; they have smaller angles of incidence and are not as affected by the earth's tilt or angle of inclination.**



Near the equator...



Far from the equator...

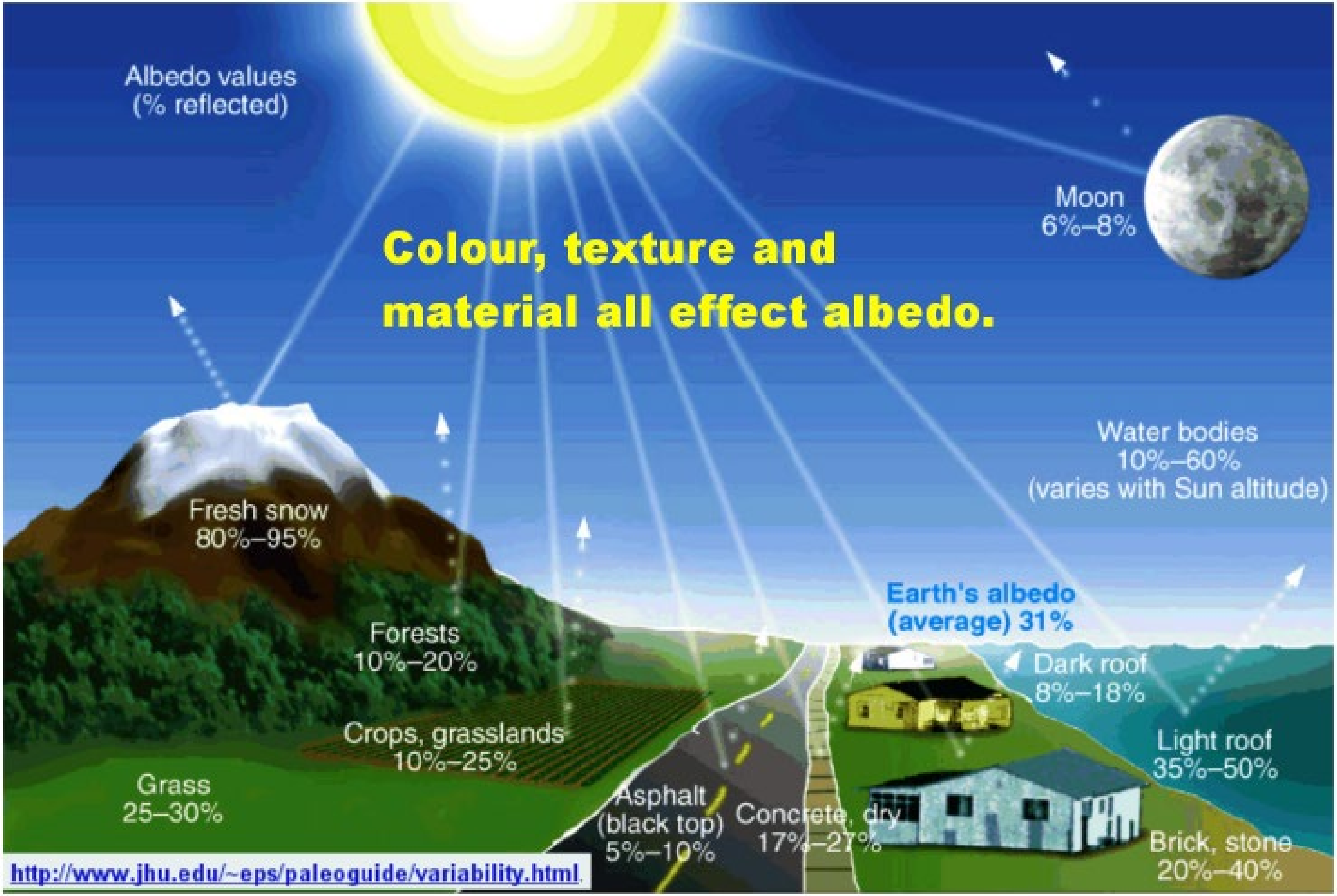
City A is located on the equator, and city B is at the North Pole. In a table, compare the relative number of hours of daylight and the amount of insolation that would be received in these cities on Dec. 21st and Mar. 21st of any year.

Albedo

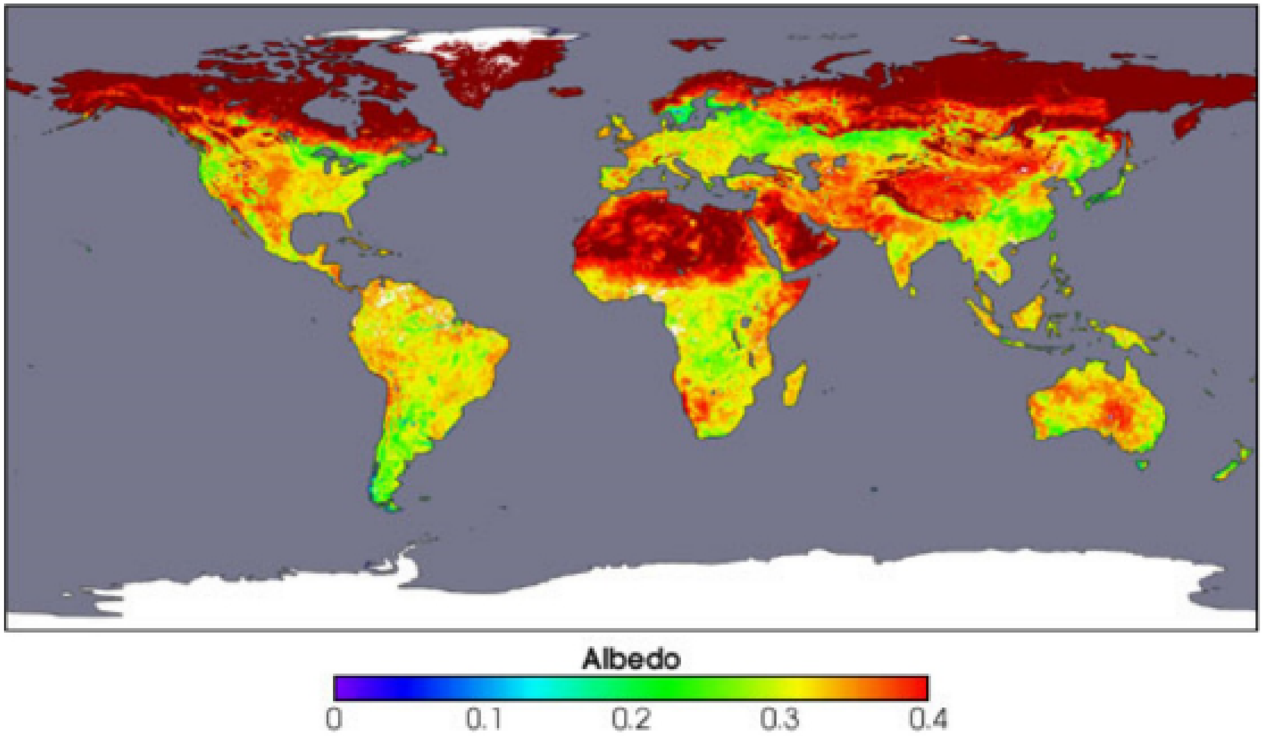
The characteristics of the lithosphere (i.e. the ground) also play a role in determining climate.

The lithosphere absorbs and reflects EMR from the sun. The percent amount of reflection the lithosphere does is called albedo. The average albedo for the earth is 30%.

Albedo varies depending on a number of factors:


Albedo values
(% reflected)
Colour, texture and
material all effect albedo.
Moon
6%–8%
Water bodies
10%–60%
(varies with Sun altitude)
Fresh snow
80%–95%
Earth's albedo
(average) 31%
Forests
10%–20%
Dark roof
8%–18%
Crops, grasslands
10%–25%
Light roof
35%–50%
Grass
25–30%
Asphalt
(black top)
5%–10%
Concrete, dry
17%–27%
Brick, stone
20%–40%
http://www.jhu.edu/~eps/paleoguide/variability.html

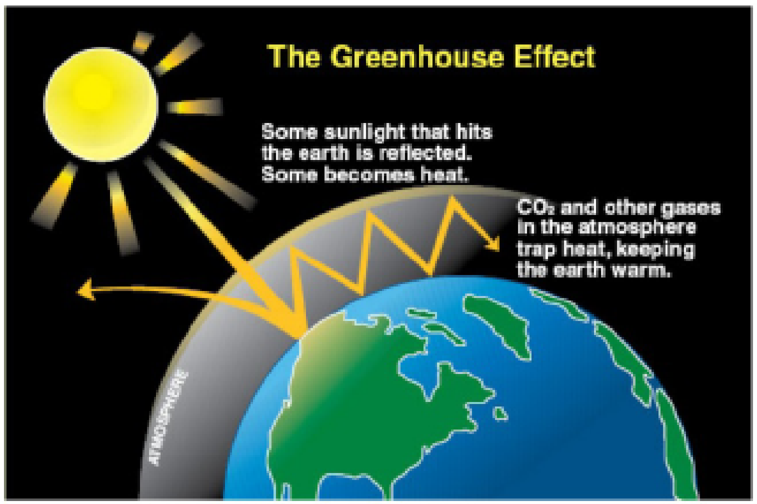
Areas of the earth with more snow and ice have higher albedo values, meaning they reflect more light and stay cold.



Question! Why is there such high albedo in Africa and the Middle East?

As much of the EMR is reflected from Earth, it is necesary that some be redirected back to keep the Earth warm.

This re-reflecting is the job of the Greenhouse Effect.



The Earth has a natural greenhouse effect: gases like CO_2, CH_4 and N_2O all trap reflected sunlight and allow for greater absorption.

Without this effect, the earth would be on average about 30°C lower in temp.

The greenhouse effect, albedo and the amount of absorption and reflection all contribute to the earth's net radiation budget.

Net Radiation Budget: The difference between the amount of incoming radiation and outgoing radiation from the surface.

Incoming radiation = all energy that reaches surface.

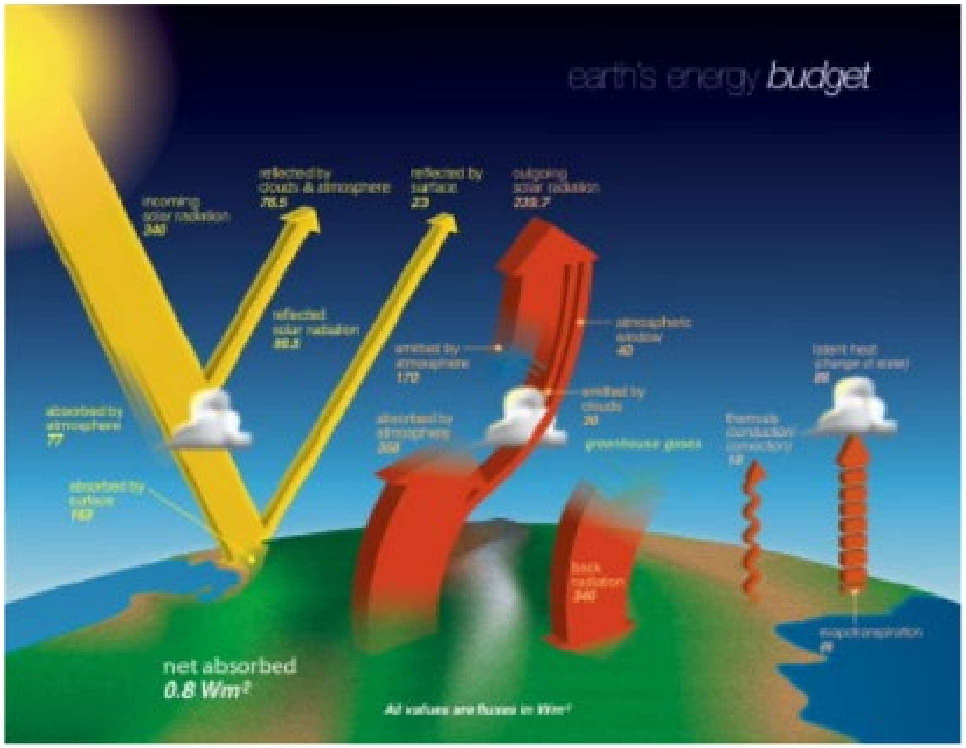
Outgoing radiation = radiation emitted that is not reabsorbed by atmosphere.

This could also be written as:

Net Radiation = Incoming Radiation - Outgoing Radiation

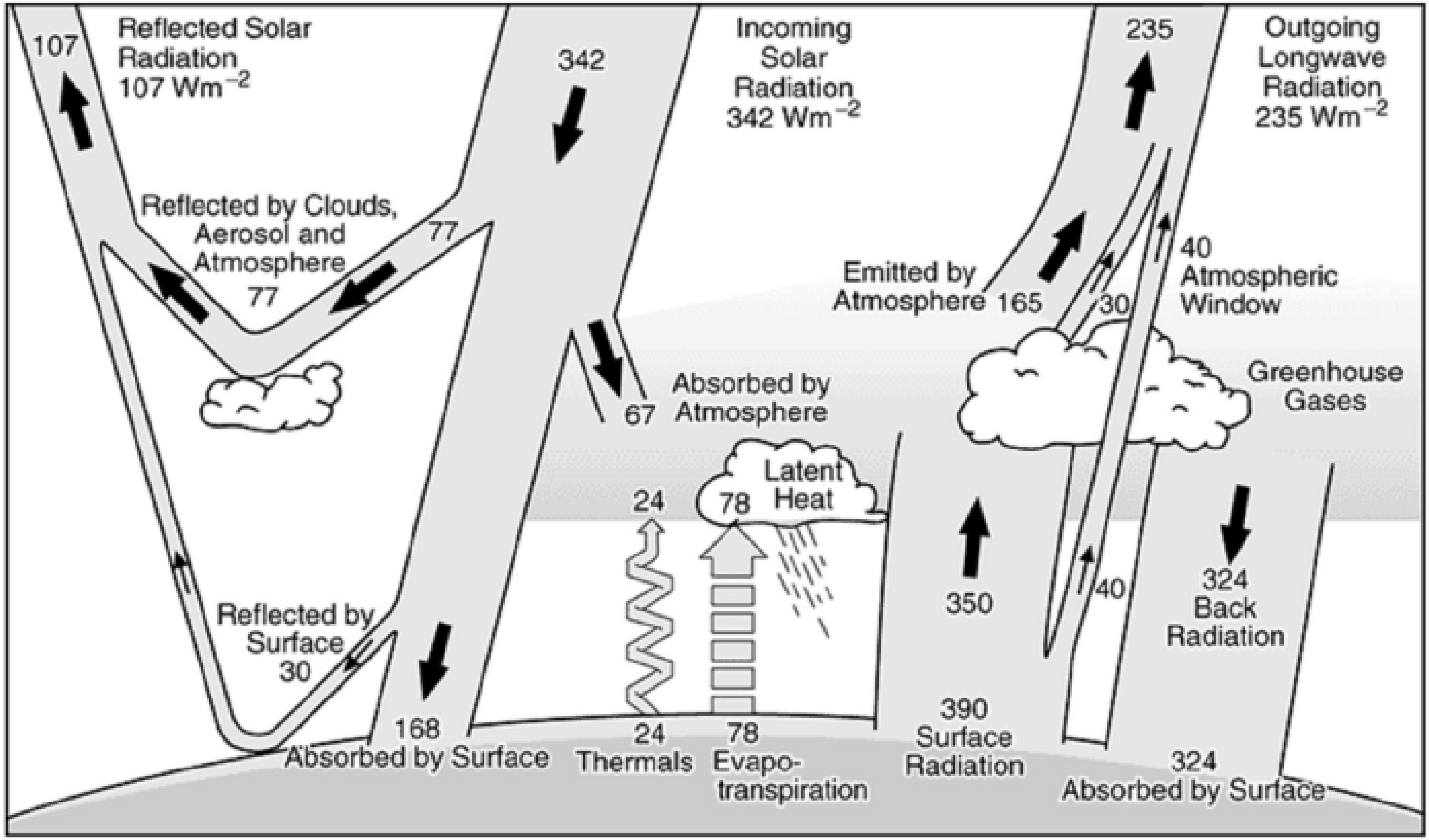
If the balance changes, the earth will:

- **heat up (incoming > outgoing) or**
- **cool down (outgoing > incoming).**



Many experts believe our net radiation budget is increasing, meaning we are absorbing more energy than we are reflecting. This is resulting in a global warming trend.

Where does the energy go?
(Energy measured in watts/m^2)



Climate in the Biosphere

- **Climate is the trend** in temperature, atmospheric pressure, humidity, and precipitation of a region **over a long period of time** (usually a minimum of 30 years). The term **weather** applies to those conditions as the are at **one place and time**.

Alberta's climate is snow for most of the time (and sometimes, the weather is snow most of the time).

Climate results from the interactions among the components of the biosphere.