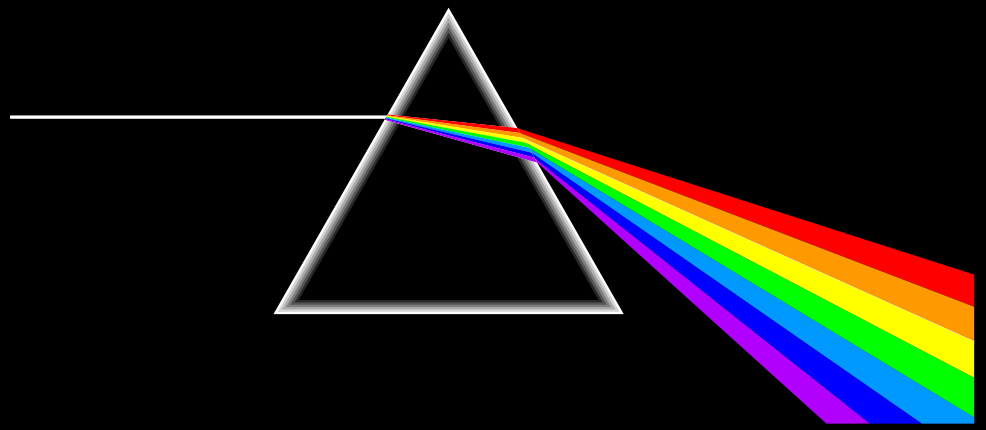
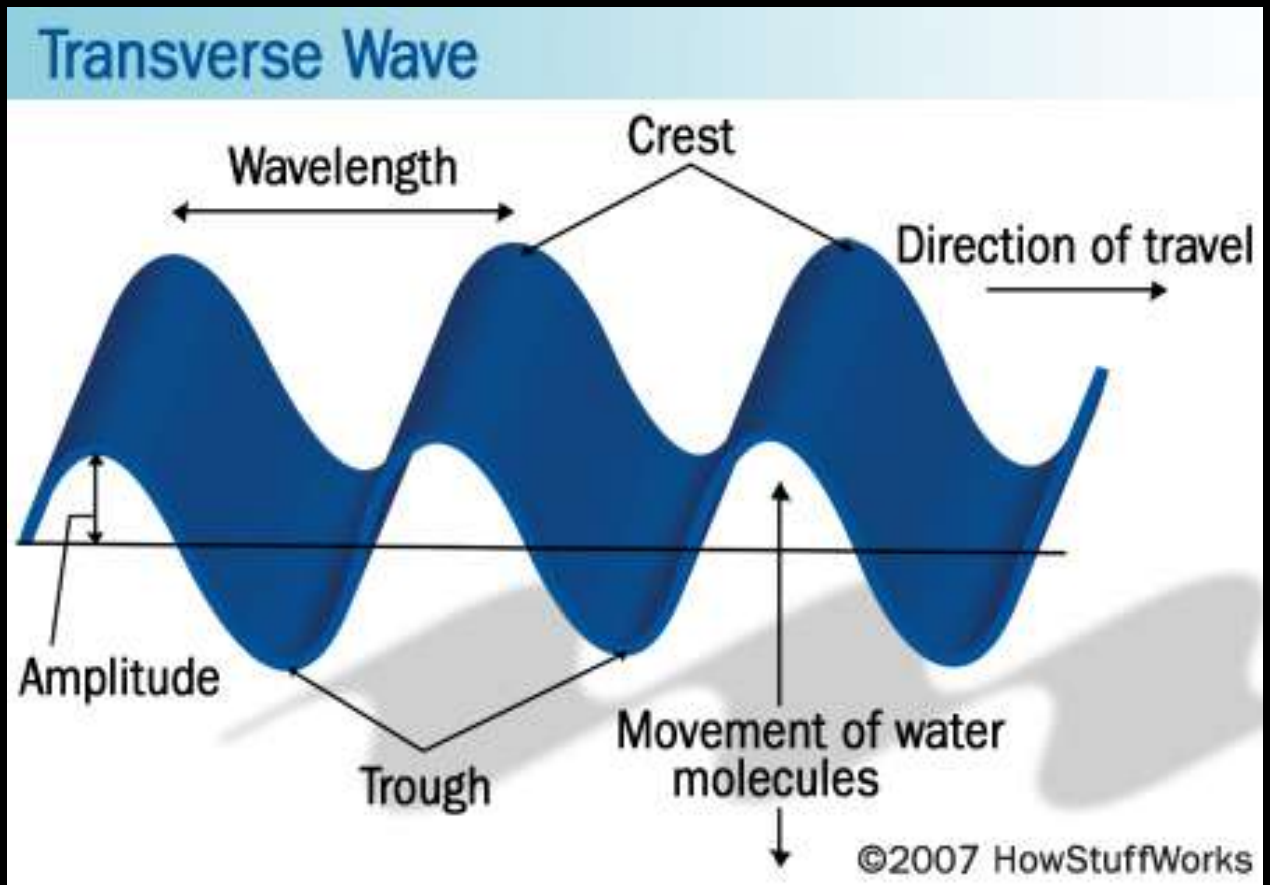
Electromagnetic Waves & the Electromagnetic Spectrum

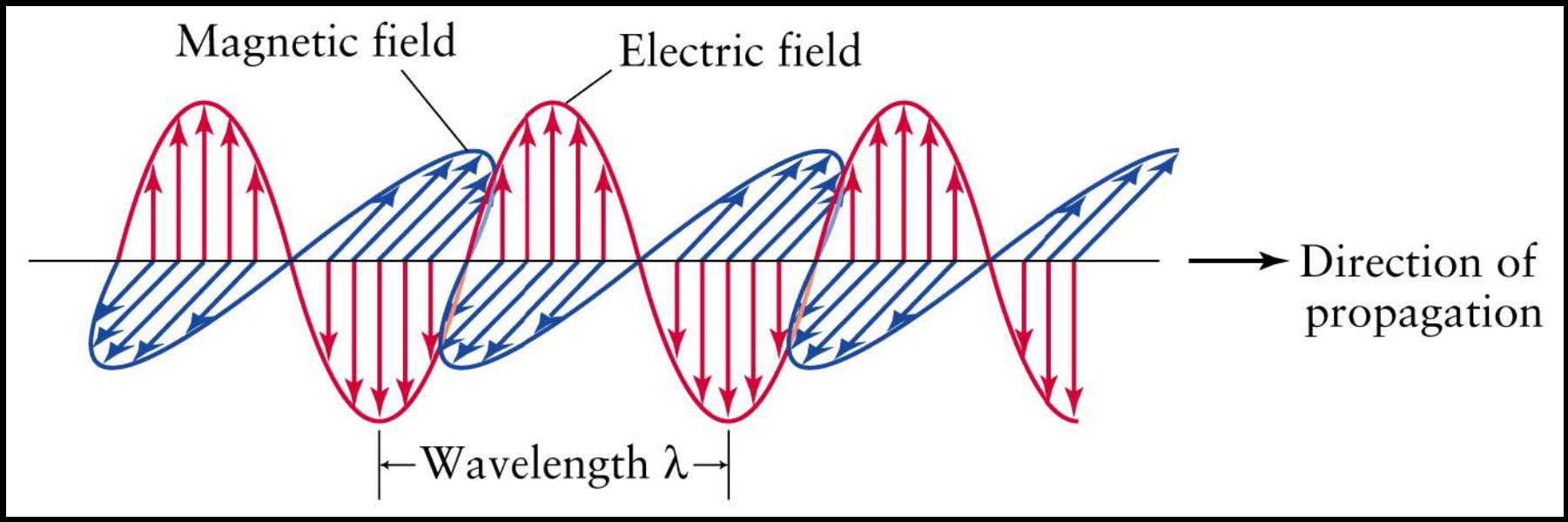


Electromagnetic Waves

- **Transverse waves without a medium!**
- (They can travel through **empty space**)

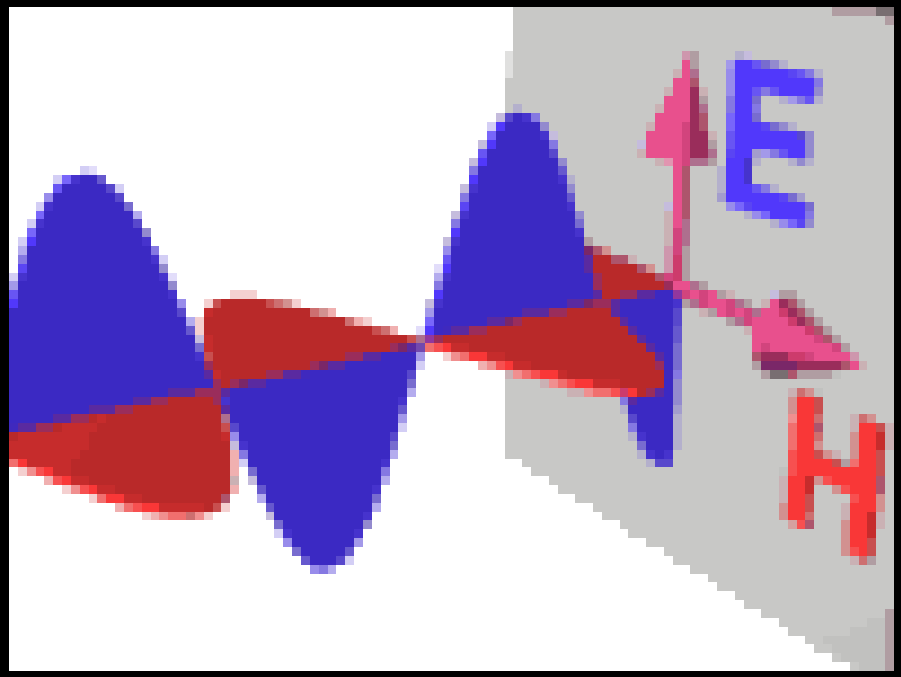


- They travel as **vibrations in electrical and magnetic fields.**
  - Have some magnetic and some electrical properties to them.



When an electric field changes, so does the magnetic field. The changing magnetic field causes the electric field to change. When one field vibrates—so does the other.

RESULT-An **electromagnetic wave.**

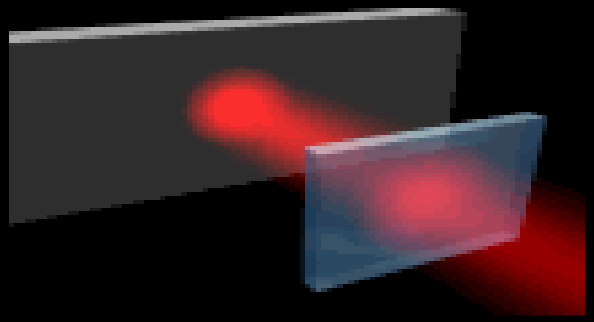


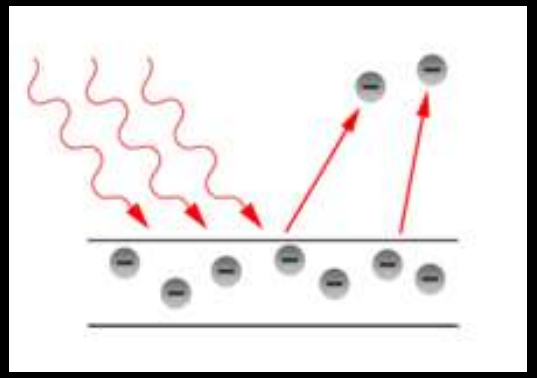
Electromagnetic waves travel VERY FAST – around 300,000 kilometres per second (the speed of light).

At this speed they can go around the world 8 times in one second.

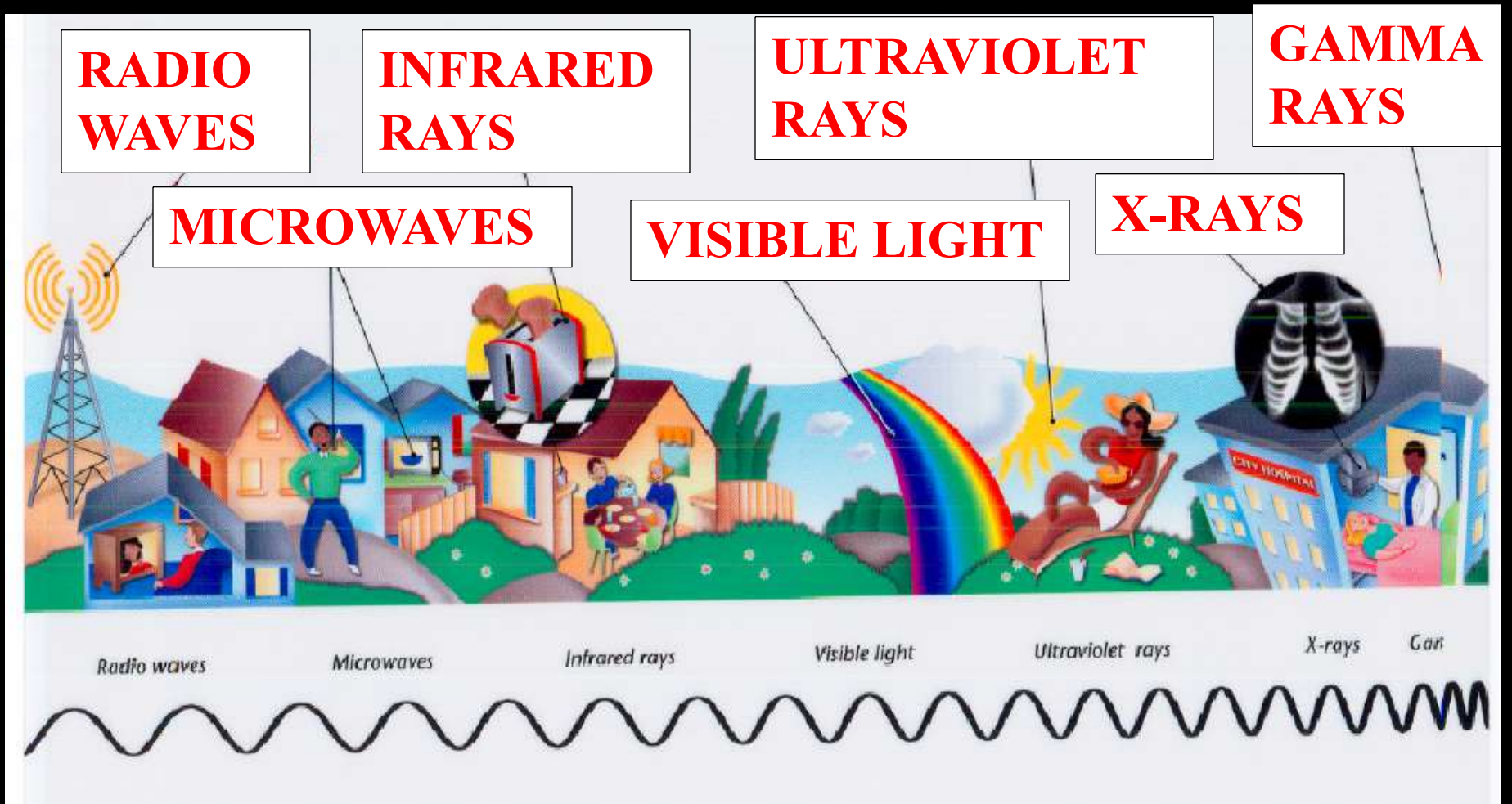
Waves or Particles?

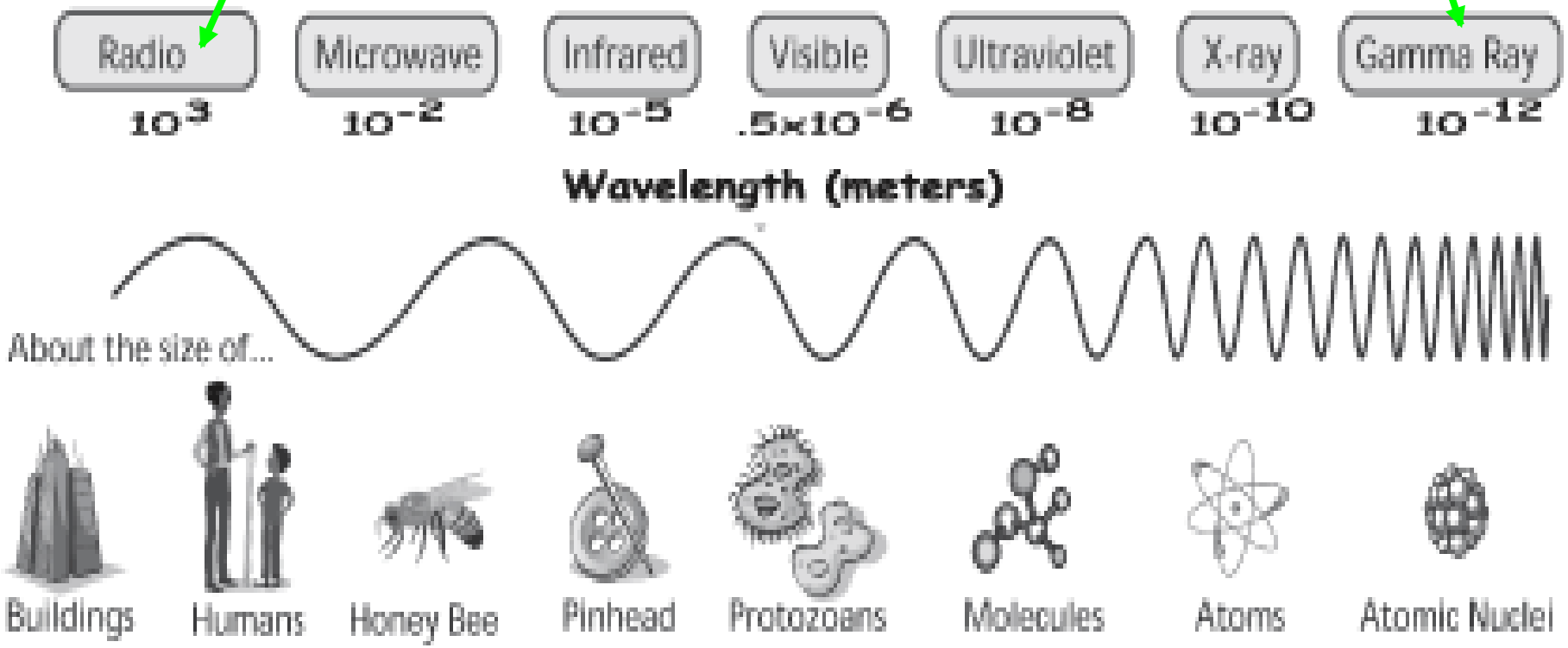
- Electromagnetic radiation has properties of waves but also can be thought of as a **stream of particles.**
  - Example: Light
    - Light as a wave: Light behaves as a transverse wave which we can filter using polarized lenses.
    - Light as particles (photons): When directed at a substance light can knock electrons off of a substance (Photoelectric effect)



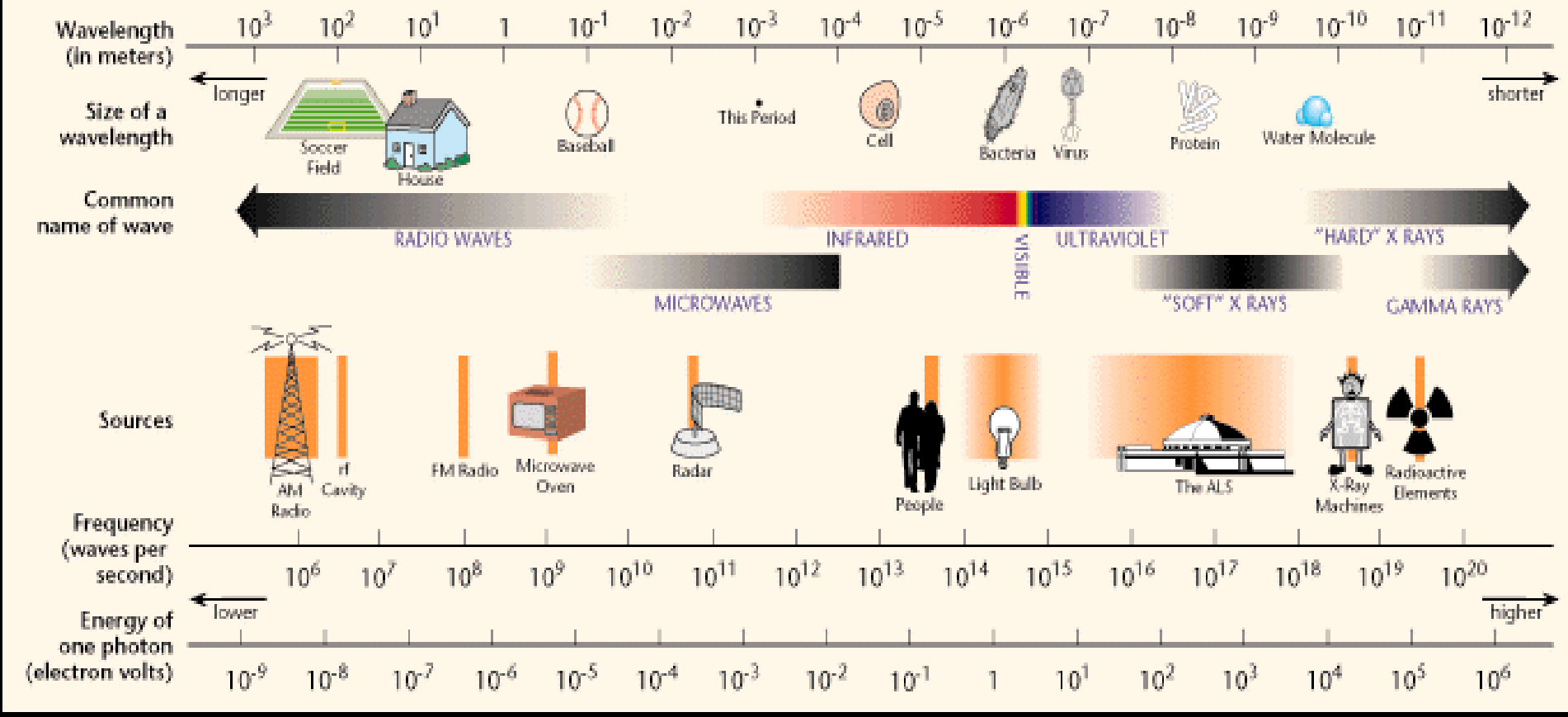


Electromagnetic Spectrum—name for the range of electromagnetic waves when placed in order of increasing frequency



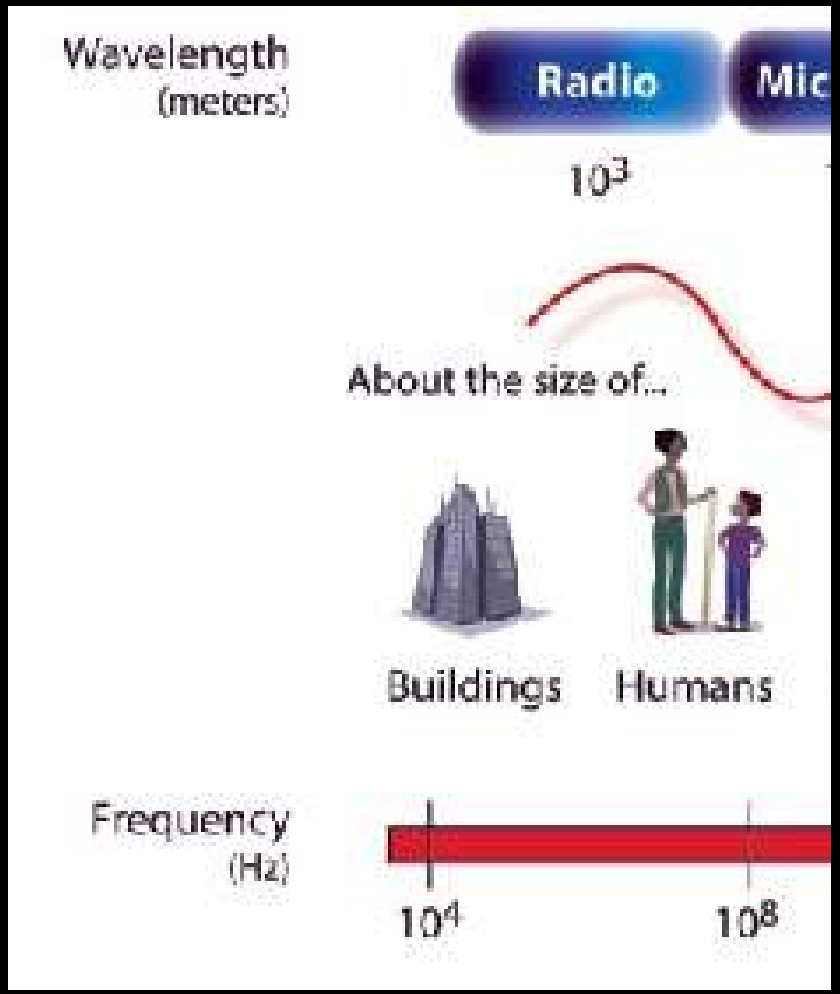

Radio
Microwave
Infrared
Visible
Ultraviolet
X-ray
Gamma Ray
10^{3}
10^{-2}
10^{-5}
$.5\times10^{-6}$
10^{-8}
10^{-10}
10^{-12}
Wavelength (meters)
About the size of...
Buildings
Humans
Honey Bee
Pinhead
Protozoans
Molecules
Atoms
Atomic Nuclei

THE ELECTROMAGNETIC SPECTRUM

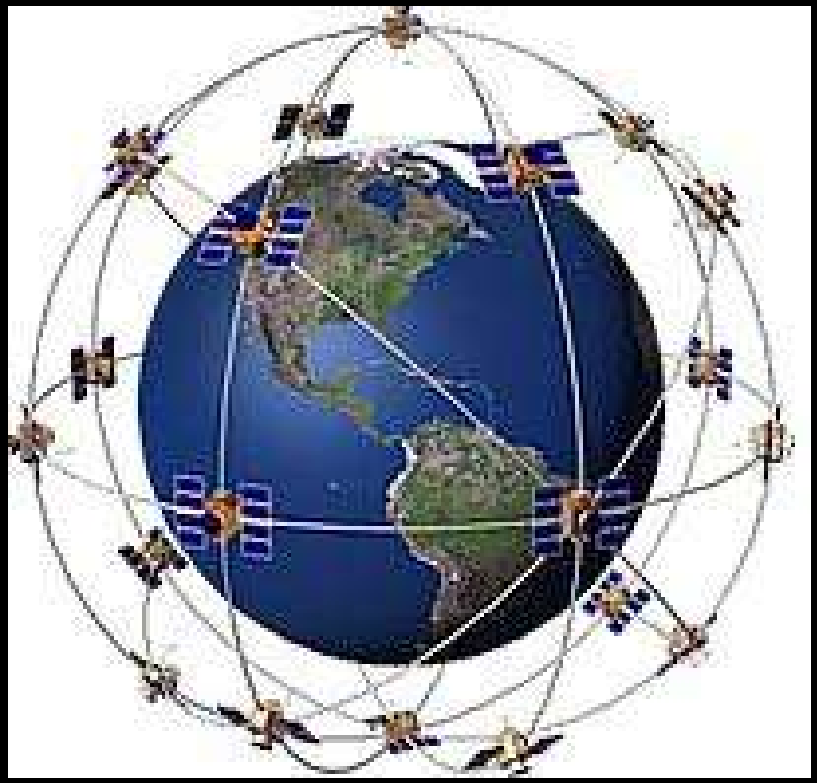


RADIO WAVES

Have the **longest** wavelengths and **lowest** frequencies of all the electromagnetic waves.

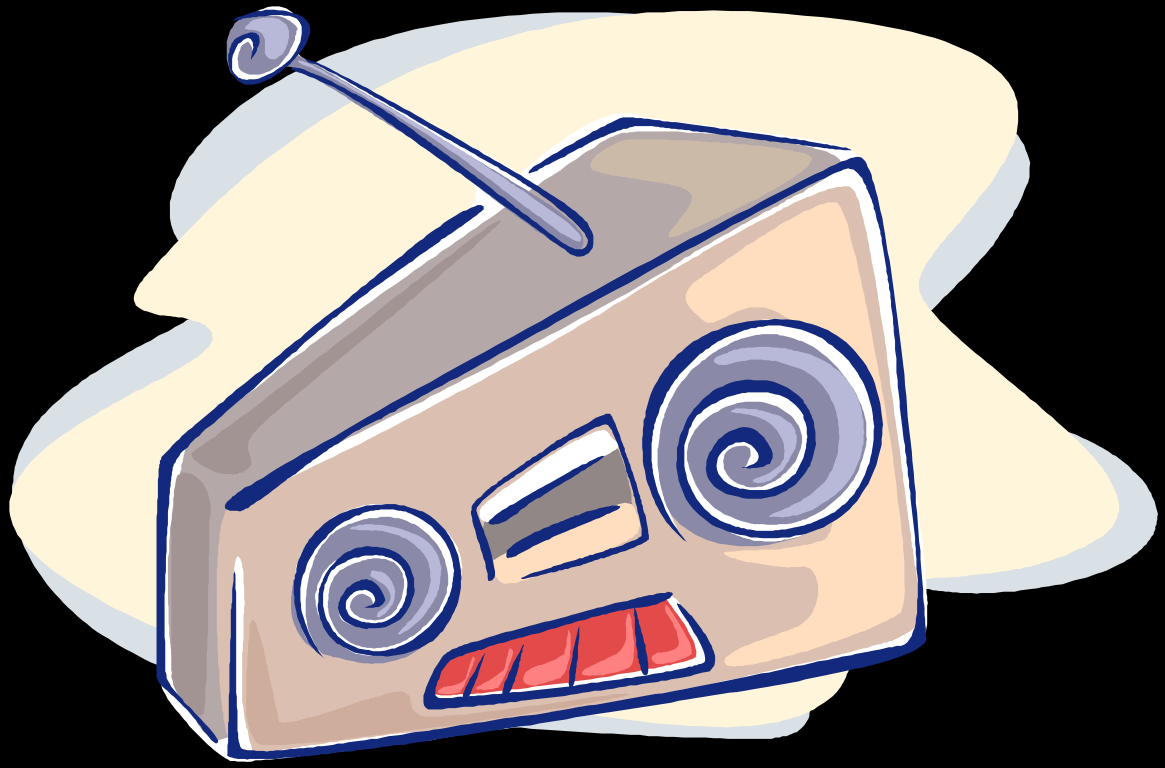


Global Positioning Systems (GPS) measure the time it takes a radio wave to travel from several satellites to the receiver, determining the distance to each satellite.



A radio picks up radio waves through an antenna and converts it to **sound waves.**

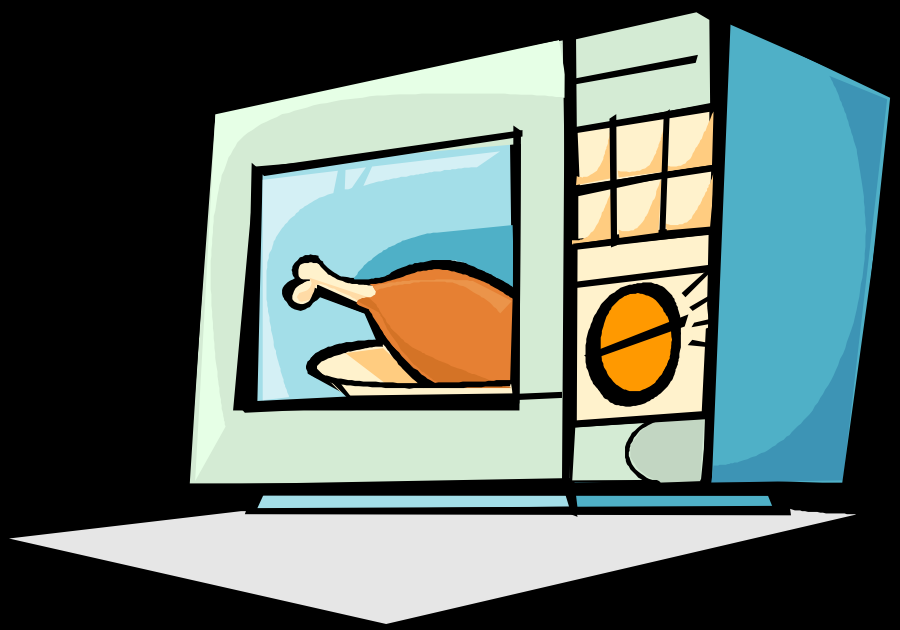
- Each radio station in an area broadcasts at a different frequency.
  - # on radio dial tells frequency.



Uses Short wave radio waves with a magnet to create an image.

MICROWAVES

Have the shortest wavelengths and the highest frequency of the **radio waves.**



Used in microwave ovens.

- Waves transfer energy to the water in the food causing them to vibrate which in turn transfers energy in the form of heat to the food.

RADAR (Radio Detection and Ranging)

- Used to find the speed of an object by sending out radio waves and measuring the time it takes them to return.

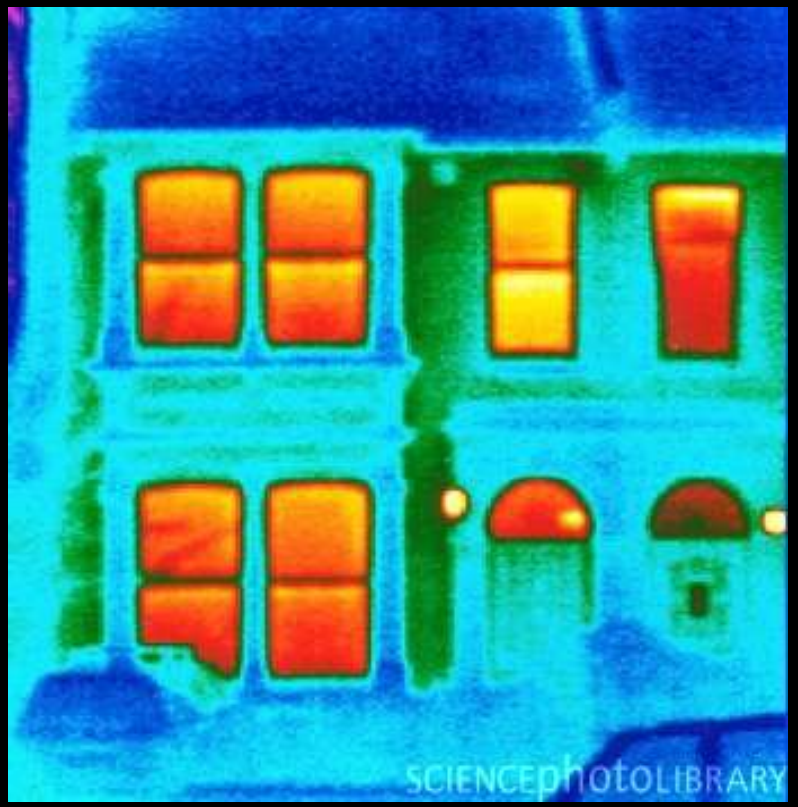
INFRARED RAYS

Infrared= below red

Shorter wavelength and higher frequency than microwaves.

You can feel the longest ones as warmth on your skin

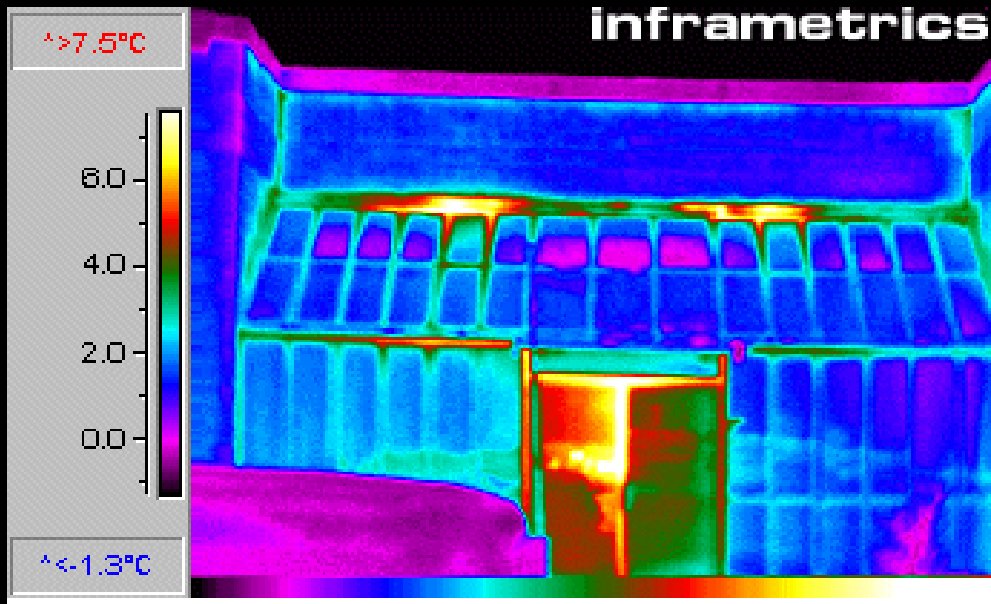
Warm objects give off more heat energy than cool objects.

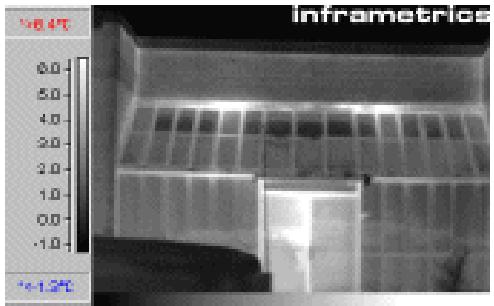


Thermogram

Therefore people give off infrared rays.

Heat lamps give off infrared waves.





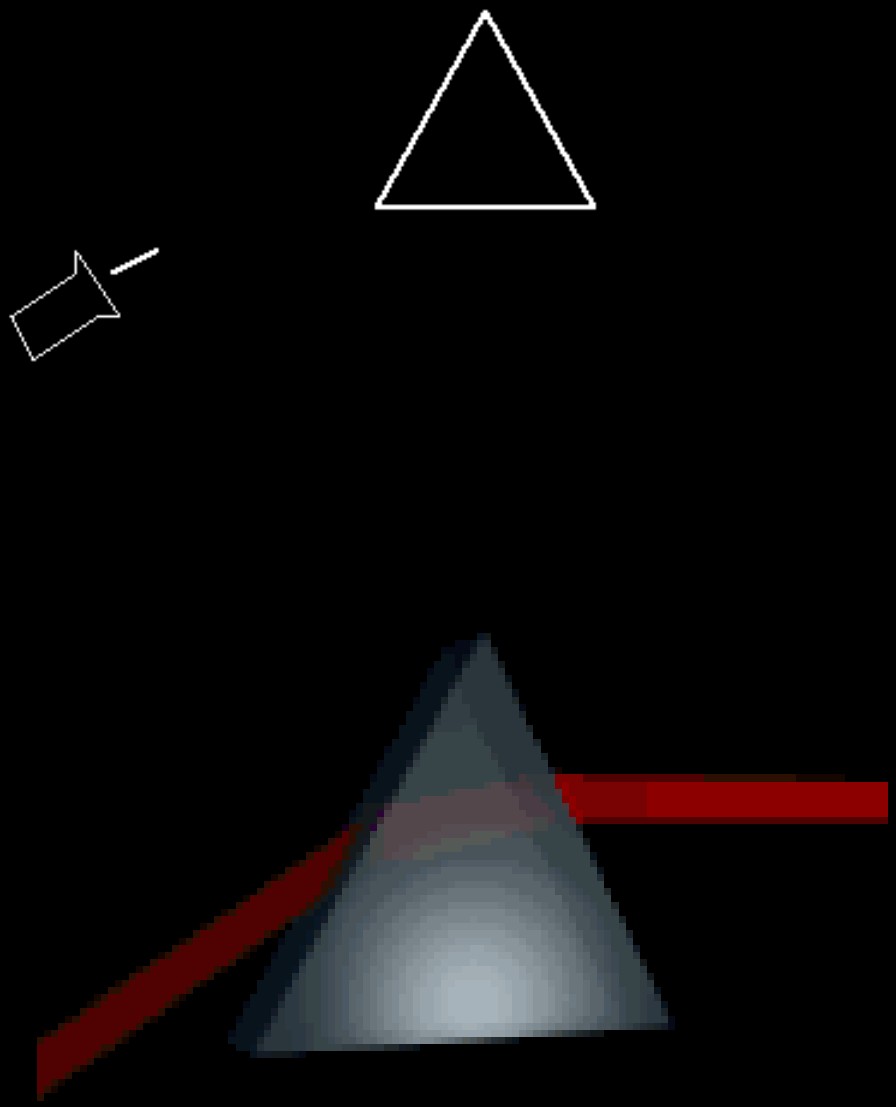
VISIBLE LIGHT

Shorter wavelength and higher frequency than infrared rays.

Electromagnetic waves we **can see.**

Longest wavelength= red light

Shortest wavelength= violet (purple) light

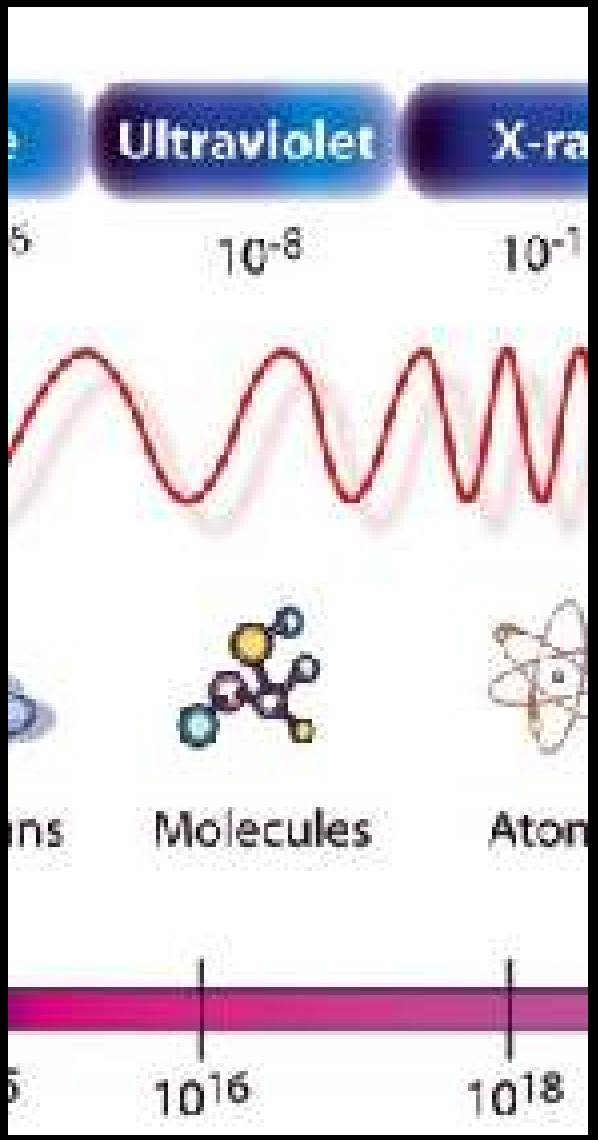


ROYGBIV.

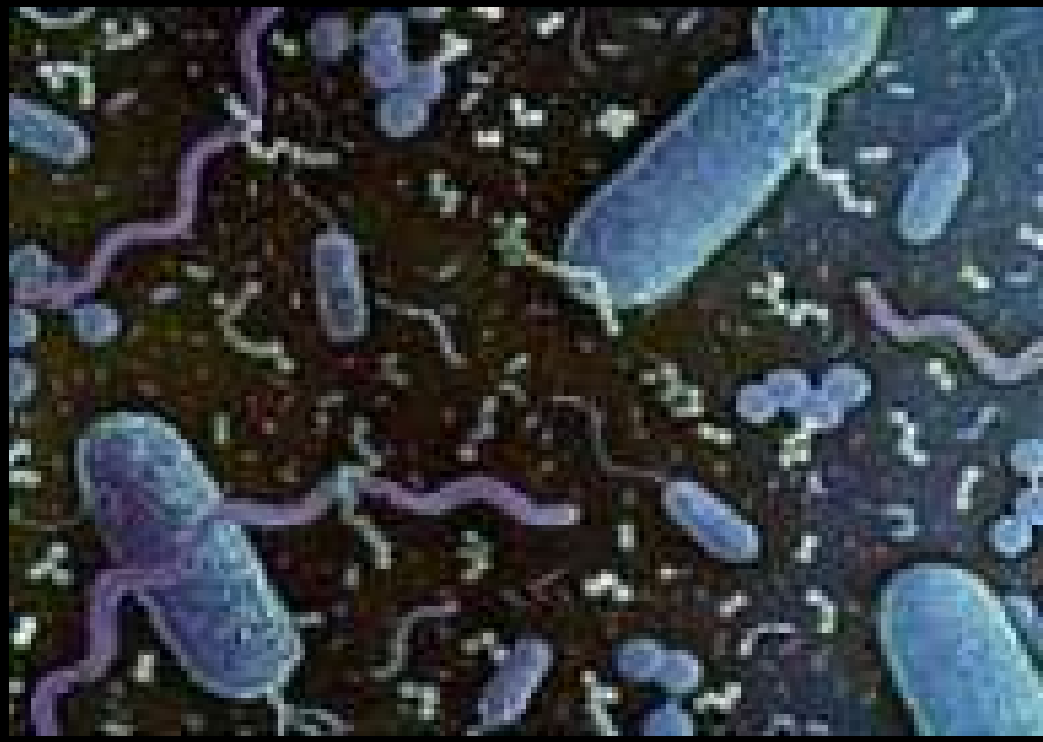
ULTRAVIOLET RAYS

Shorter wavelength and higher frequency than visible light

Carry **more energy** than visible light



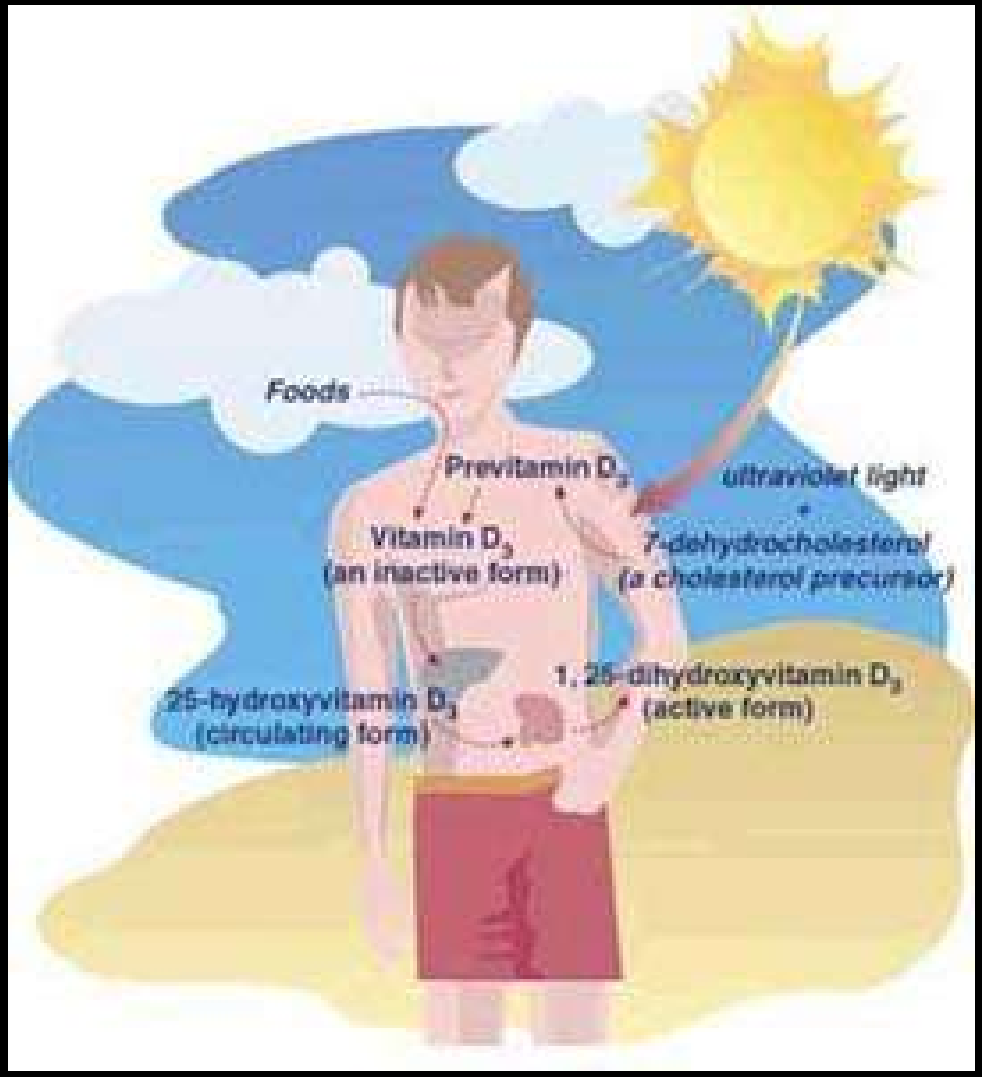
Used to **kill bacteria.** (Sterilization of equipment)



Too much can cause skin cancer.

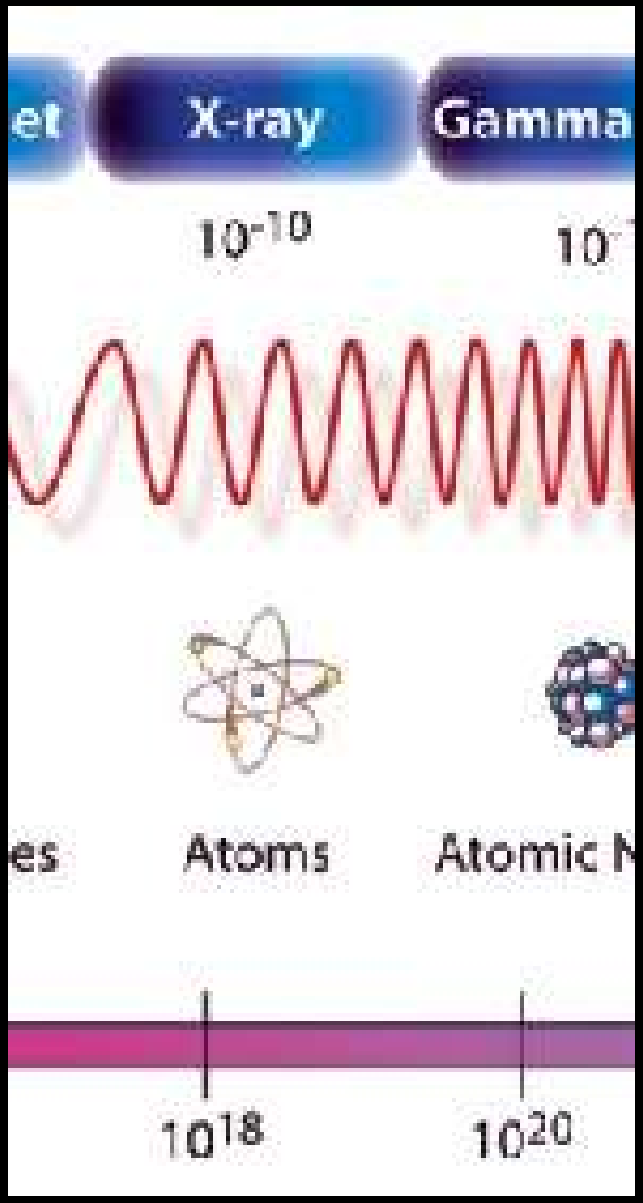
Use sun block to protect against (UV rays)

Causes your skin to produce **vitamin D** (good for teeth and bones)



X- RAYS

- Shorter wavelength and higher frequency than UV-rays
- Carry a great amount of energy
- Can penetrate most matter.



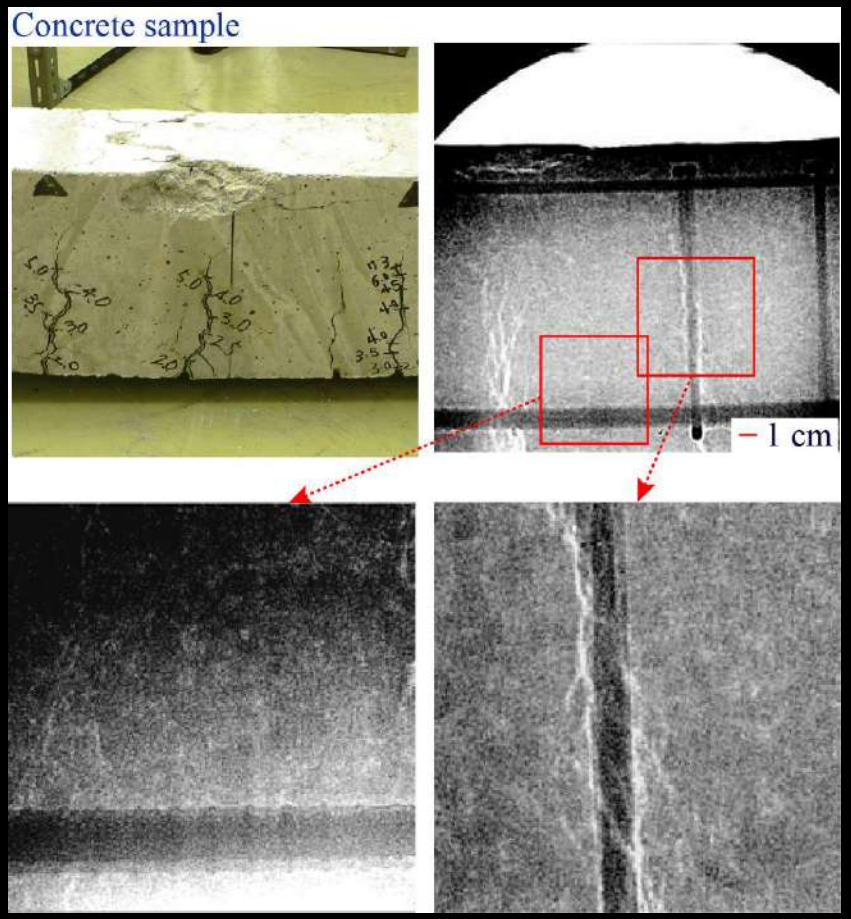
Bones and teeth absorb

can cause cancer

(lead vest at dentist protects organs from unnecessary exposure)

Used by **engineers** to check for tiny cracks in structures.

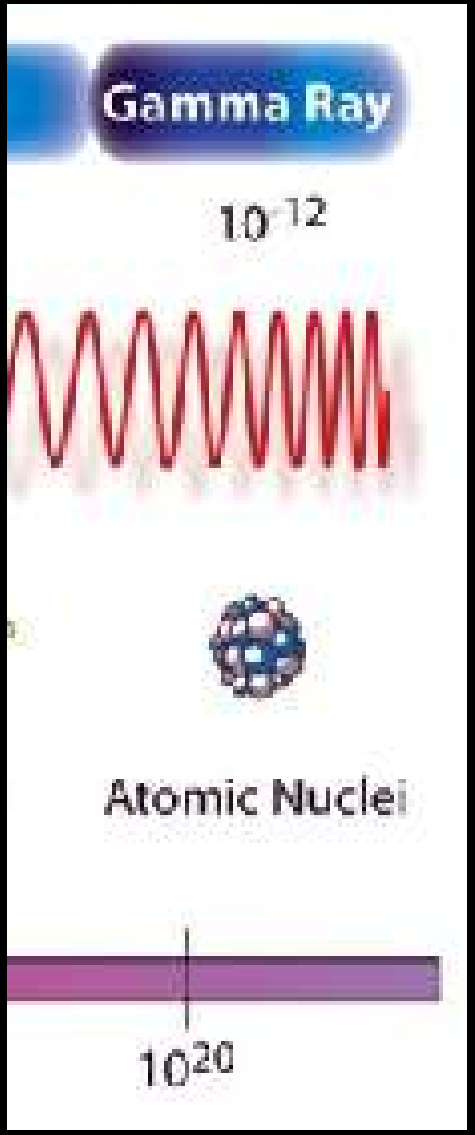
- The rays pass through the cracks and the cracks appear dark on film.



GAMMA RAYS

Shorter wavelength and higher frequency than X-rays

Carry the **greatest amount of energy** and penetrate the most.



Used in **radiation treatment** to kill cancer cells.

Can be very harmful if not used correctly.

The Incredible Hulk was the victim of gamma radiation.

Exploding nuclear weapons emit gamma rays.

Brief SUMMARY

A. **All electromagnetic waves** travel at the same speed. (300,000,000 meters/second) in a vacuum.

B. They all have different **wavelengths** and different **frequencies.**

- Long wavelength-→lowest frequency
- Short wavelength→ highest frequency
- The higher the frequency the **higher the energy.**

THE ELECTROMAGNETIC SPECTRUM