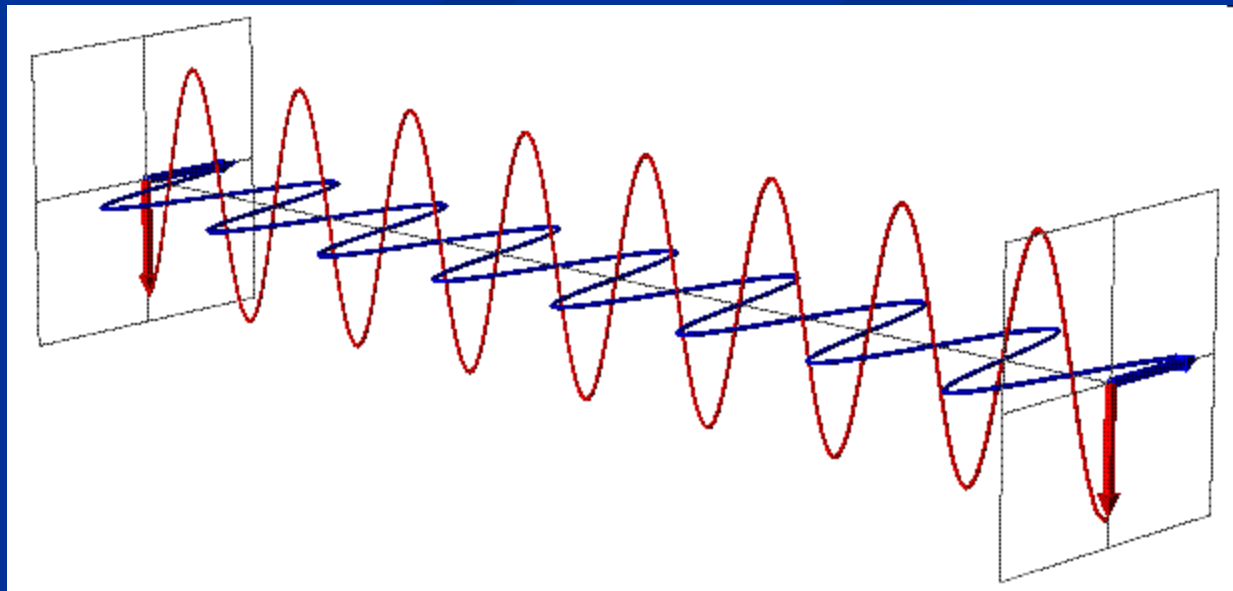
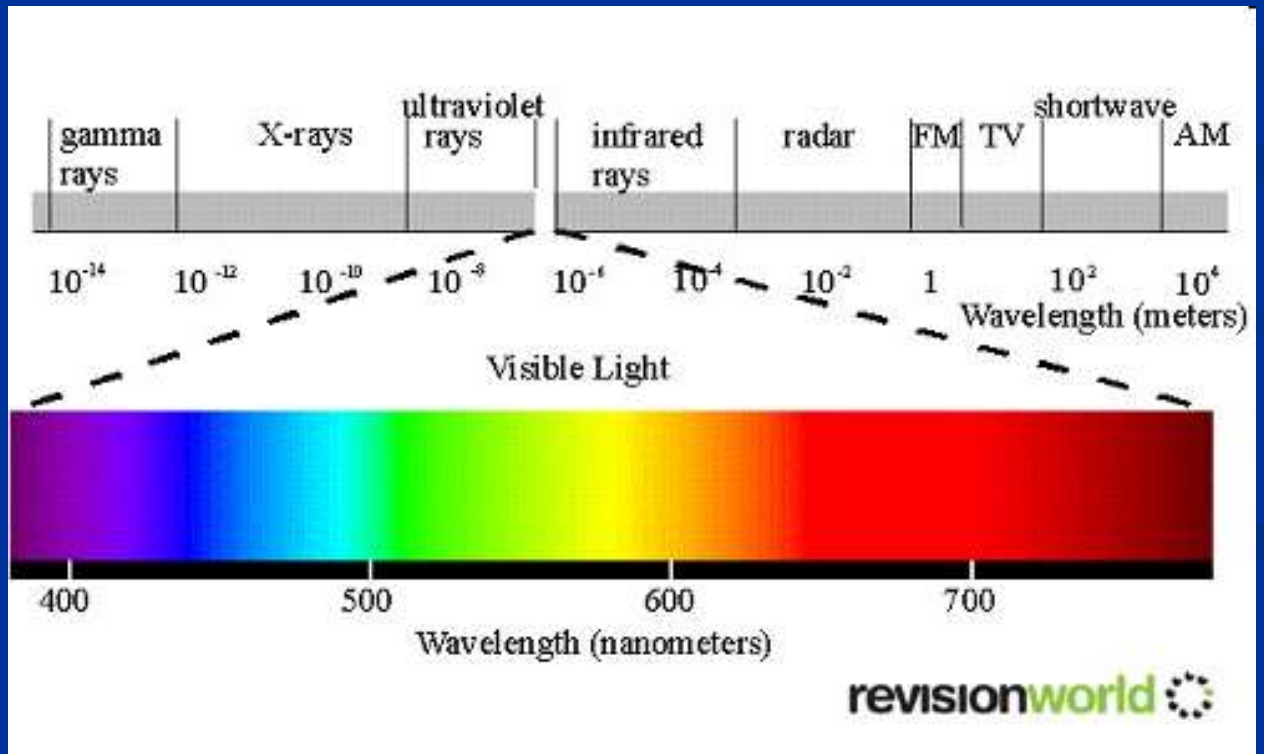
ELECTROMAGNETIC WAVES AND LIGHT



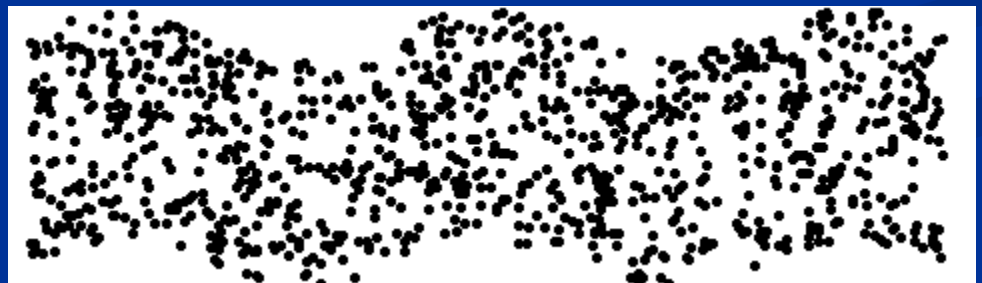
ELECTROMAGNETIC WAVES

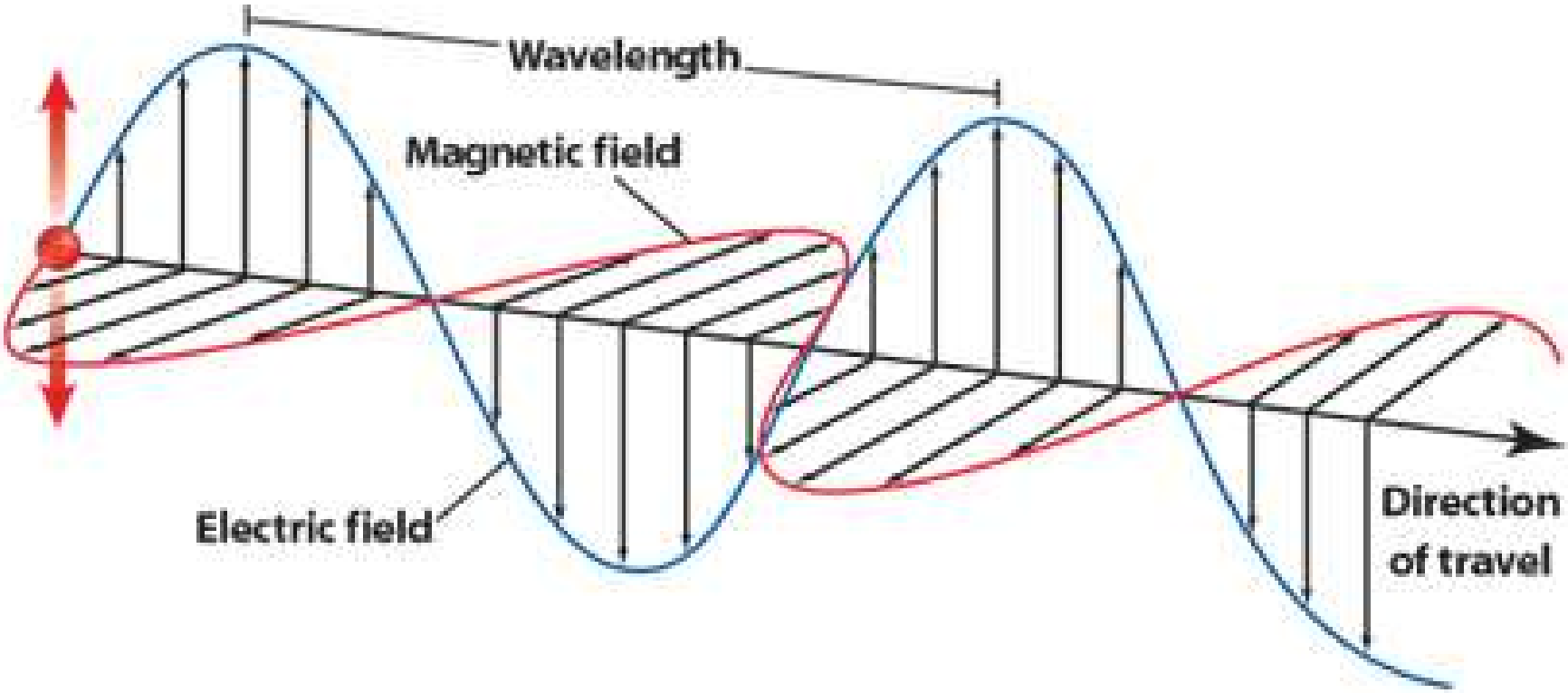
Electromagnetic Waves travel through empty space or through matter and are produced by charged particles that are in motion.



ELECTROMAGNETIC WAVES

- **Transverse, non-mechanical** waves.
- Electromagnetic waves are produced by charged particles, such as electrons, that **move back and forth** or vibrate.
- As a charged particle vibrates by moving up and down or back and forth, it produces changing **electric** and **magnetic** fields that move away from the vibrating charge in many directions.



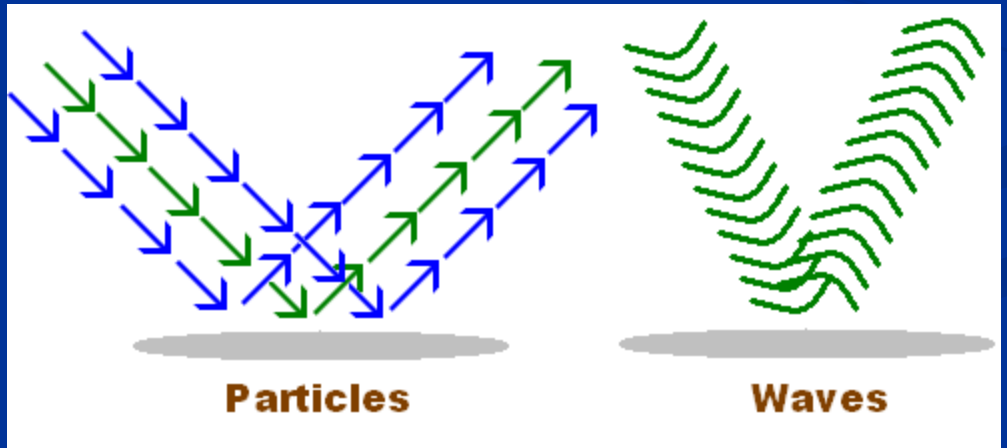


- These changing fields **travel** in many directions.
- They form an **electromagnetic** wave.

PARTICLE OR WAVE?

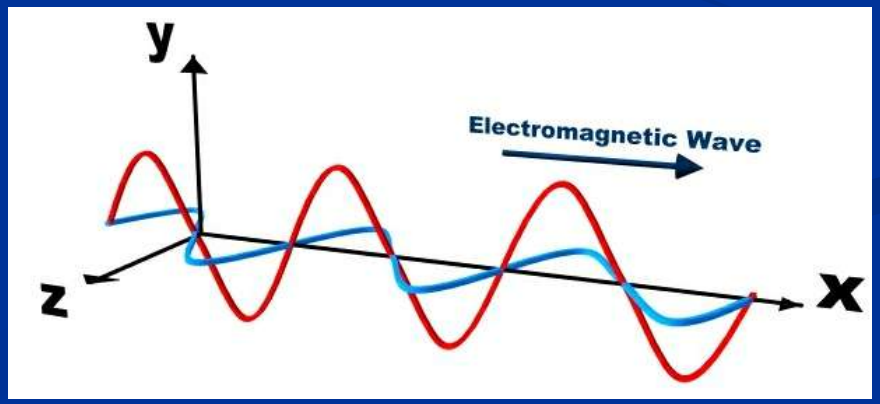
Light can

- Behave as a **particle** called a **PHOTON** – whose energy depends on the frequency of light.
- Behave as a **wave** – whose energy depends on its frequency.



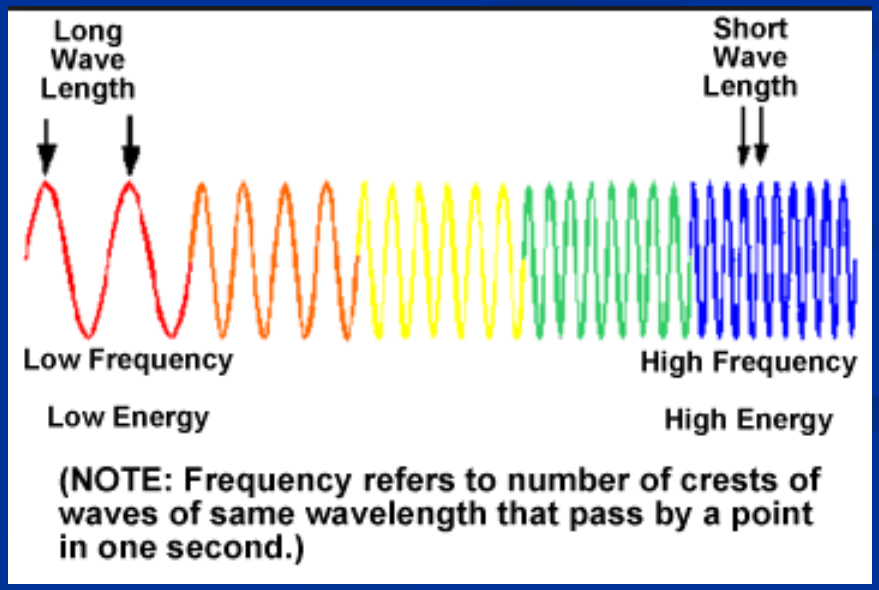
PROPERTIES OF EM WAVES

- Electromagnetic waves have a **wavelength** and a **frequency**.
- One complete **vibration** of the charged particle up and down creates one wavelength.
- The number of wavelengths that pass by a point in **one second** is the frequency of the electromagnetic wave and is measured in **hertz, Hz**.



PROPERTIES OF EM WAVES

- The amount of **energy** carried by an electromagnetic wave is determined by its frequency.
- The **higher** the frequency, the more **energy** the EM wave has.

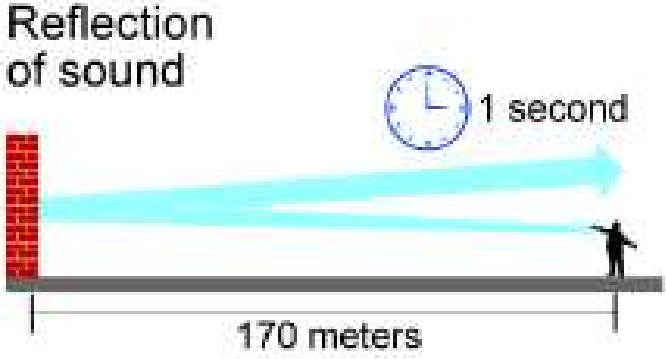


THE SPEED OF LIGHT

- Electromagnetic waves travel at the speed of light, **300,000 km/s**, in the vacuum of space.
- Vacuum means "**empty of matter**".
  - Even though light travels incredibly fast, stars other than the Sun are so far away that it takes **years** for the light they emit to reach Earth.

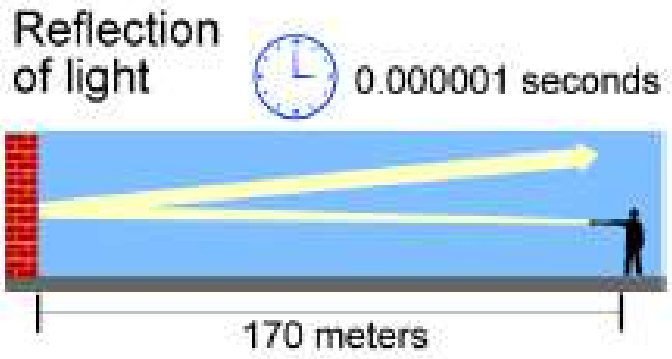
THE SPEED OF LIGHT

- Light travels almost a million times faster than sound.
- The speed of light is so important in physics that it is given its own symbol, a lower case *c*.



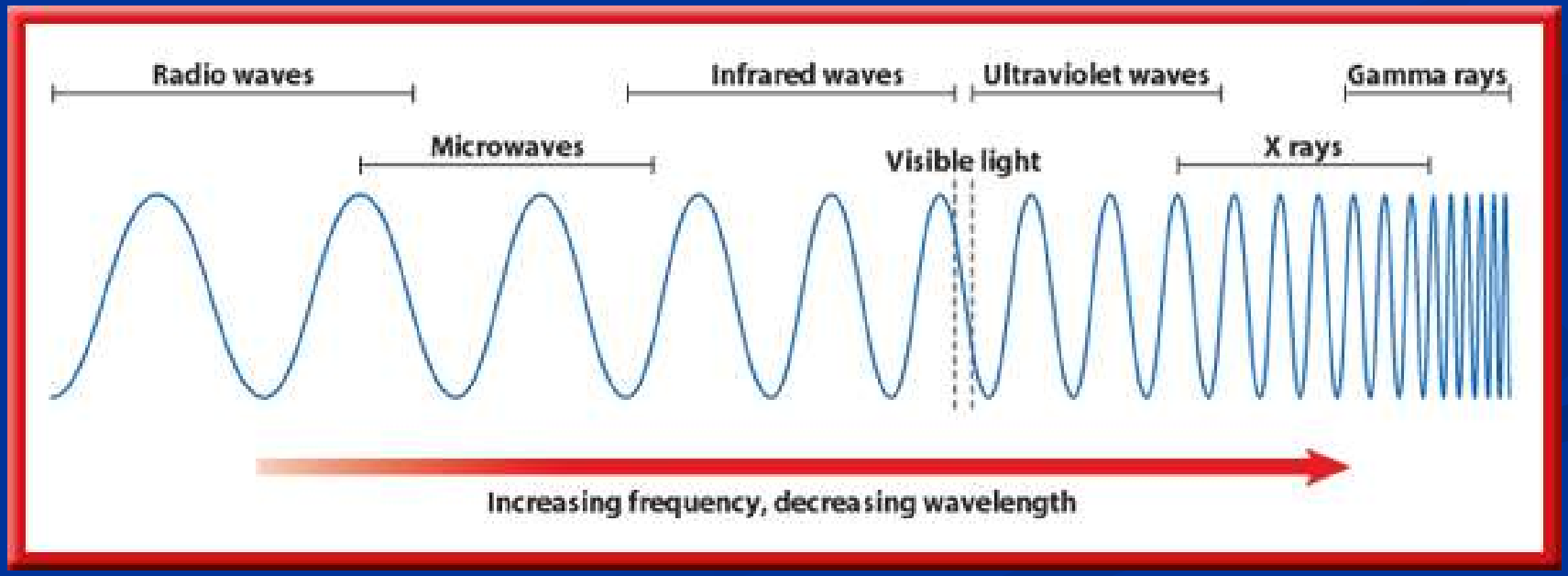
Speed of sound
340 m/sec

Speed of light
300,000,000 m/sec



ELECTROMAGNETIC WAVES

Electromagnetic waves have a series of different frequencies and wavelengths called the **electromagnetic spectrum**.



ELECTROMAGNETIC WAVES

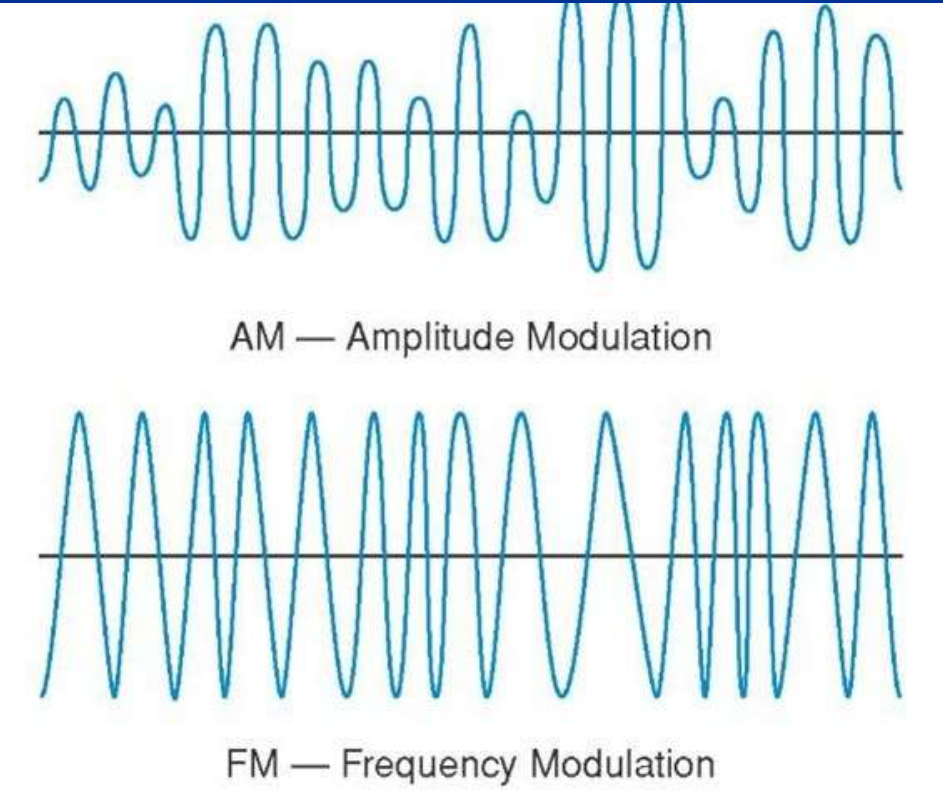
- For waves that travel with the same speed, wavelength **increases** as frequency **decreases**.
- We will look at radio, microwave, radar, infrared, visible, ultraviolet, x-rays, and gamma rays.

RADIO WAVES

- The **lowest** frequency
- The **longest** wavelength (longer than 0.3 m)
- The **least** energy.
  - **AM** and **FM** radio signals and **TV** signals are types of radio waves.
  - they can be sent with radio waves using a transmitting and receiving antenna.

RADIO WAVES

- AM radio waves are "**amplitude** modulated".
- FM radio waves are "**frequency** modulated".



MICROWAVES

- **higher** frequency than radio waves.
- **shorter** wavelength than radio waves (between 0.3 m and 0.001m).
- **More** energy than radio waves.
- they are used for some **phone calls** and to **heat** food.

MICROWAVES

- The idea of using microwave energy to cook food was **accidentally** discovered by Percy Spencer of the Raytheon Company.
- He found that radar waves had **melted** a candy bar in his pocket.
- Experiments showed that microwave heating could raise the internal temperature of many foods far **more rapidly** than a conventional oven.

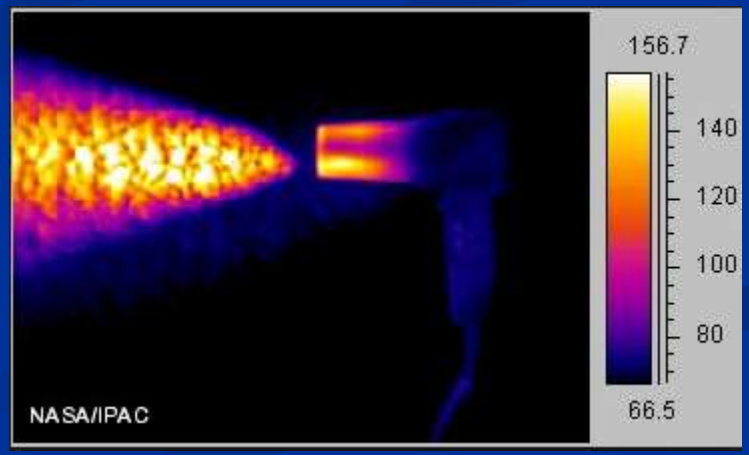
RADAR

- **RA**dio **Detection** **A**nd **R**anging
- **Similar** to microwaves.
- uses electromagnetic waves to **locate objects** by measuring the time it takes for the waves to reach the object, be **reflected**, and return.

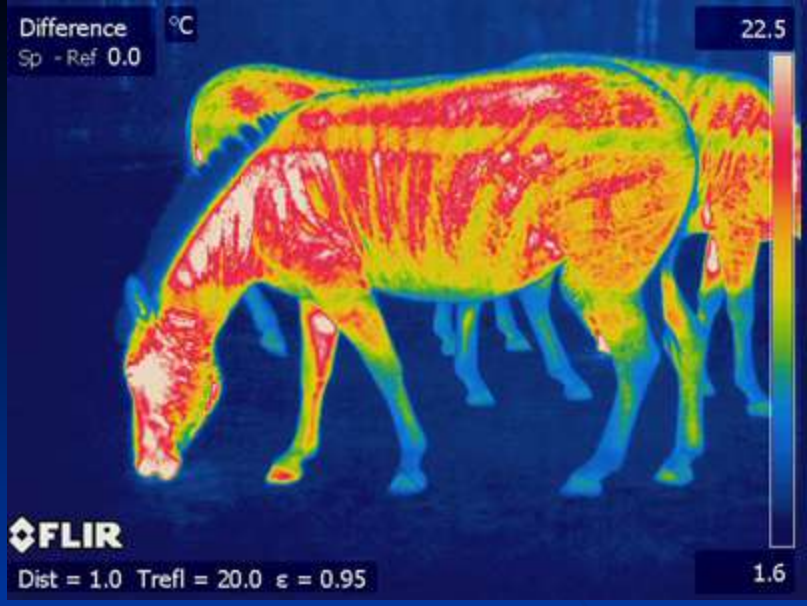
INFRARED, IR

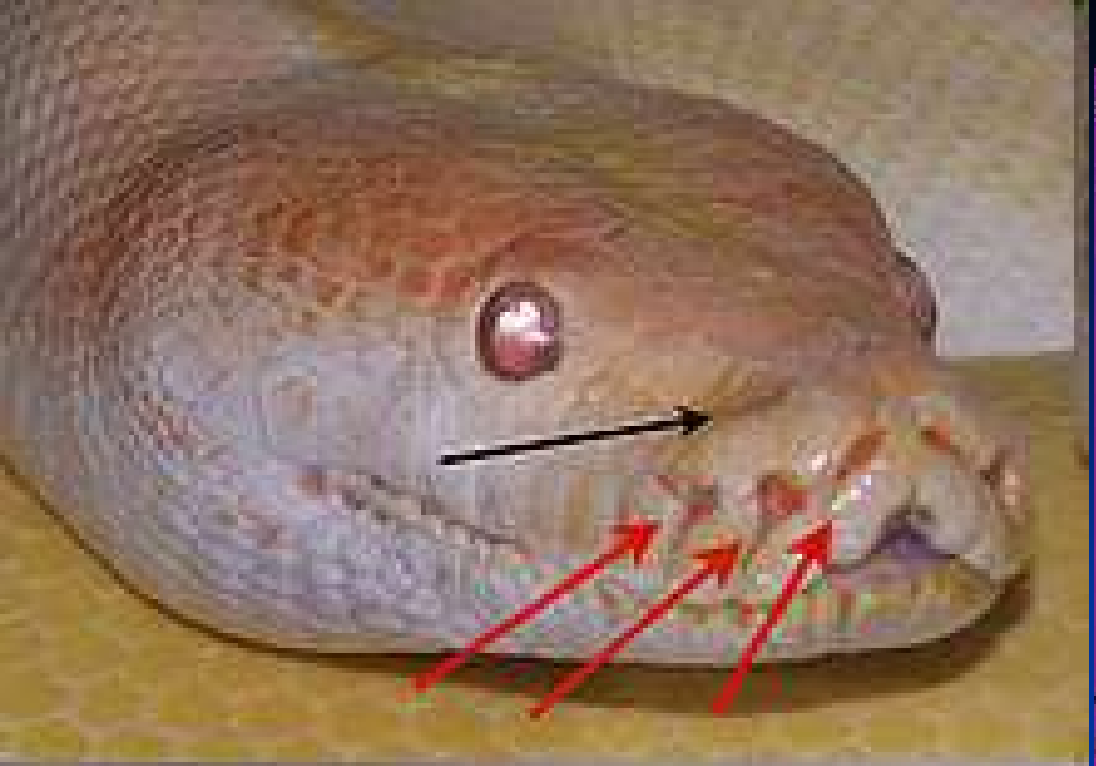
- has a **greater** frequency than microwaves.
- has wavelengths between 0.001m and 0.000007m .
- has more **energy** than microwaves.
- feel **warm or hot**; basically this is **thermal energy.**

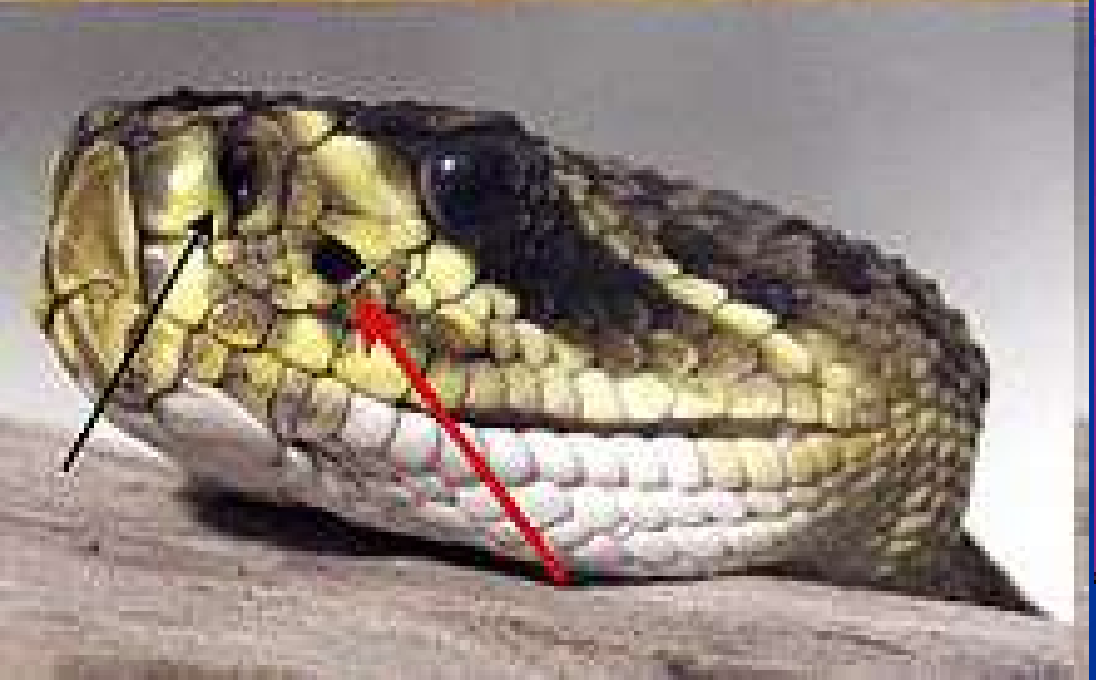
- Infrared detectors sense objects that are **warmer or colder** than their environment; TV and VCR remotes also use IR waves.



Some animals, such as piranhas and rattlesnakes, can **detect** infrared waves, which helps them find prey.





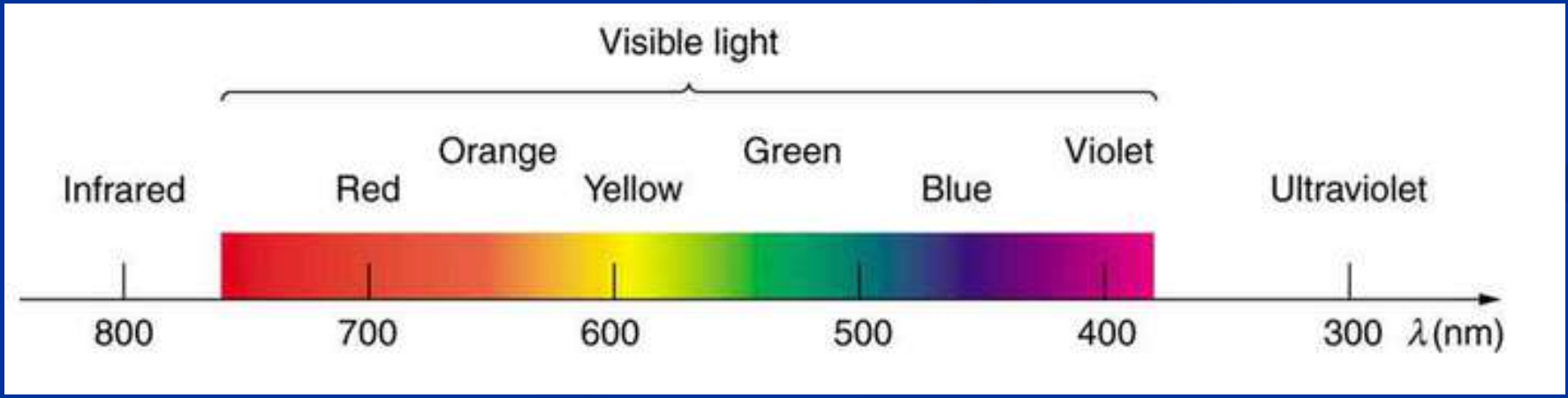



A
MIKRON


B
MIKRON

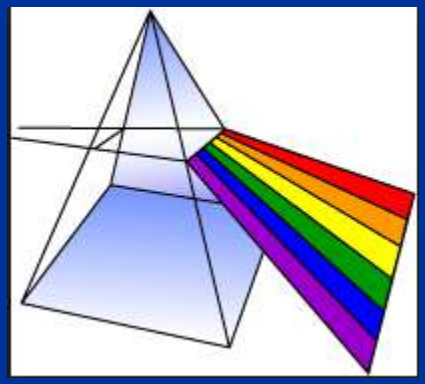
VISIBLE LIGHT

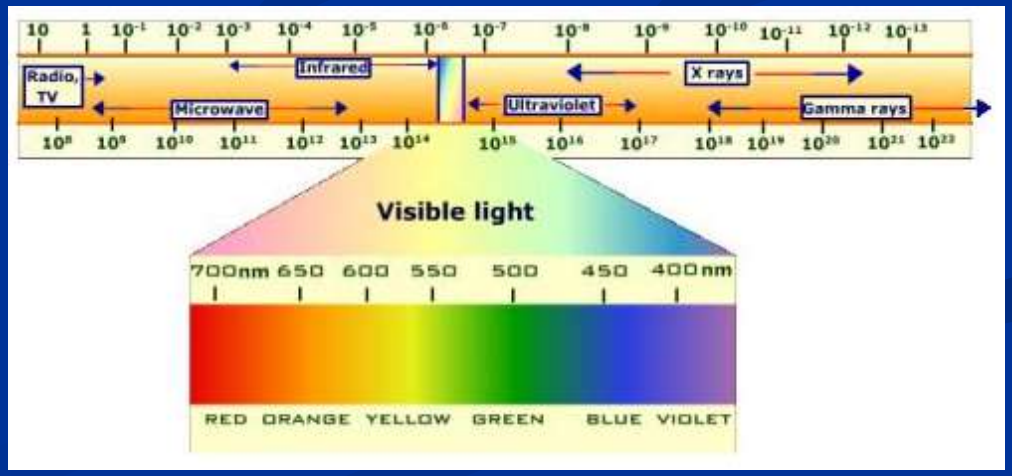
- **Higher** frequency than IR.
- **Shorter** wavelength than IR; between 0.7 and 0.4 millionths of a meter.
- **More** energy than IR
- "infra" means **below** – "below red".



VISIBLE LIGHT

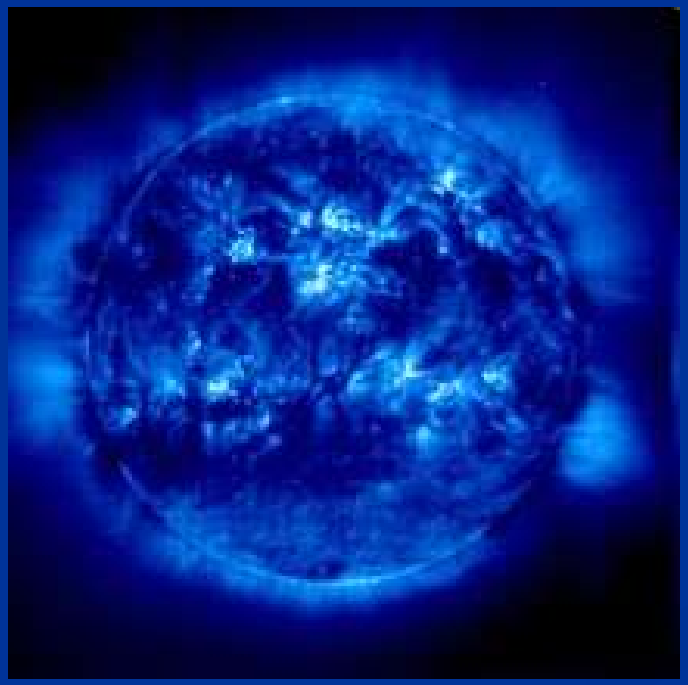
- **ROY G BIV - Red, orange, yellow, green, blue, indigo, violet**
- Red light has the **longest** wavelength and **lowest** frequency.
- Blue light has the **shortest** wavelength and **highest** frequency.



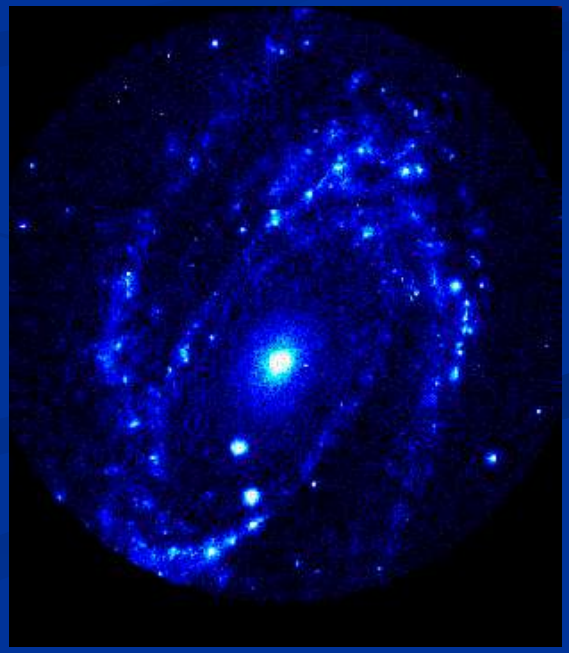


ULTRAVIOLET RADIATION, UV

- **higher** frequency than visible light.
- **shorter** wavelength than visible light.
- **More** energy than visible light.
- "ultra" means **beyond** – beyond violet.
- Enough energy to **penetrate the skin**.



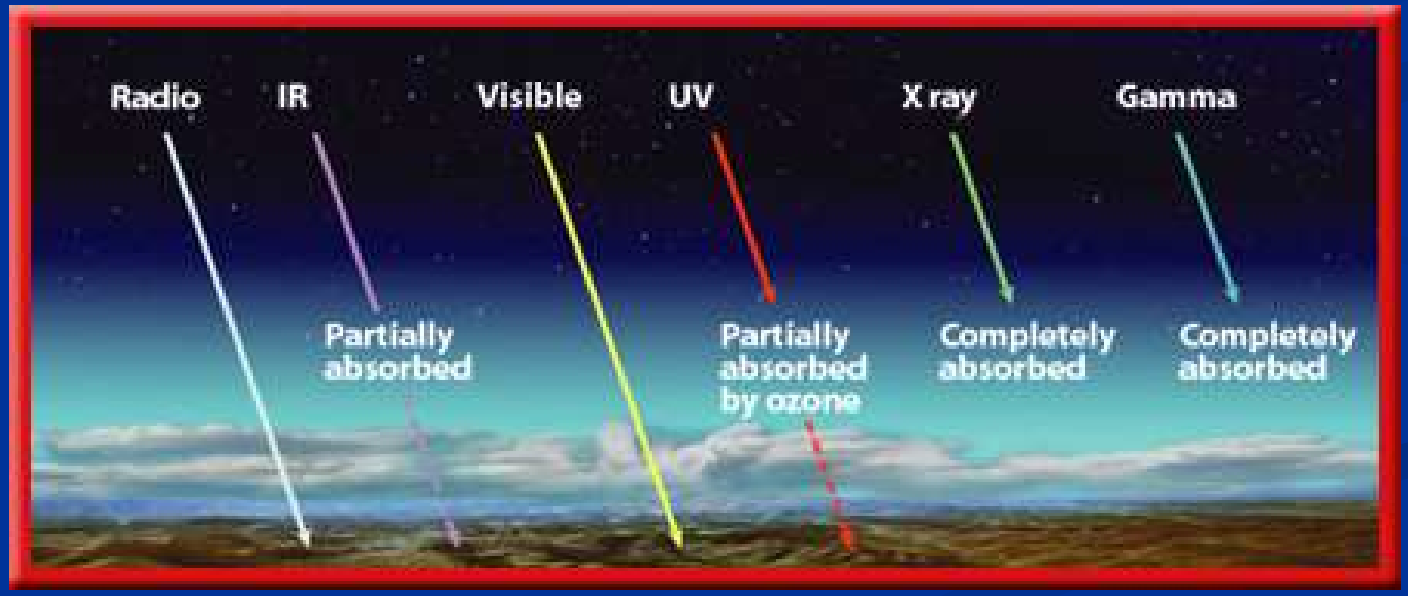
The sun



ULTRAVIOLET RADIATION, UV

- Too much exposure to ultraviolet radiation from the Sun can cause **sunburn** and other health problems.
- Since U.V. radiation can kill cells, it is sometimes used to **sterilize** equipment.
- The **ozone** in Earth's upper atmosphere helps protect the surface by absorbing much of the sun's **U.V. radiation**.

- Much of the ultraviolet radiation arriving at Earth is **absorbed** in the upper atmosphere by ozone.
- Ozone is a molecule that has **three oxygen** atoms and is formed high in the Earth's atmosphere.
- Chemical compounds called **CFCs**, which are used in air conditioners and refrigerators, can react with ozone molecules and **break** them apart.

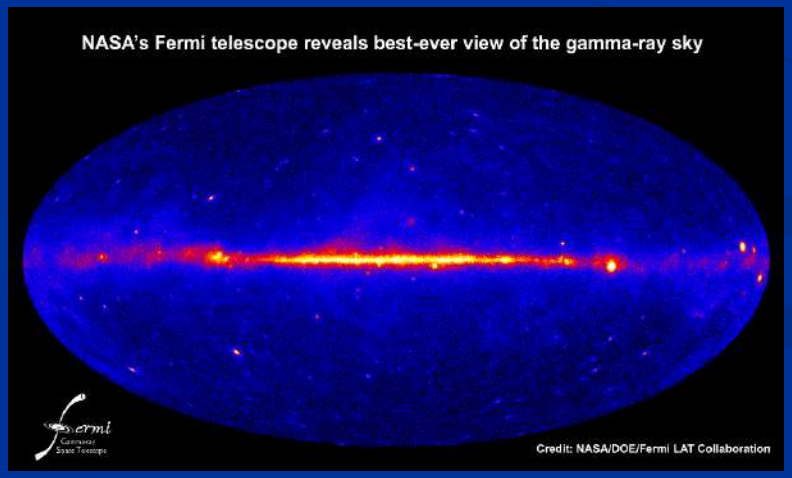


X RAYS

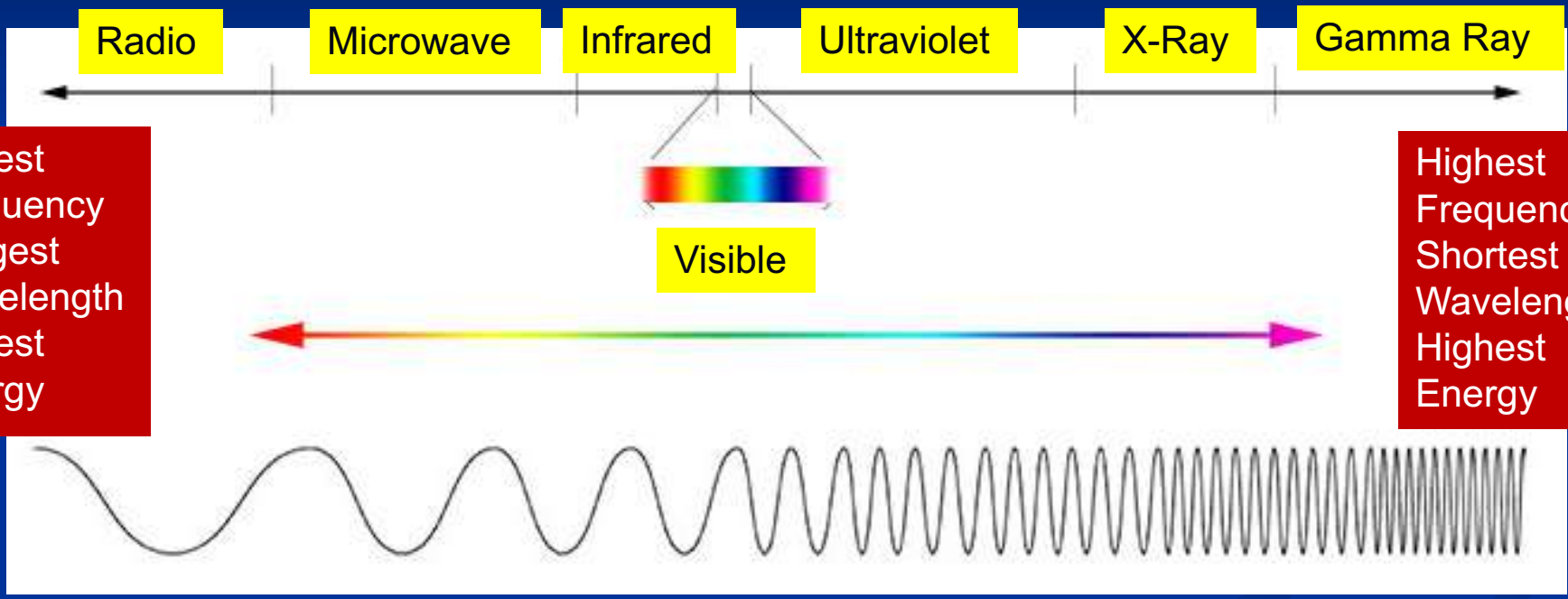
- **Higher** frequency than UV.
- **Shorter** wavelength than UV.
- **Higher** energy than UV.
- Enough energy to go through **soft tissue**.
- Too much exposure to X-rays can **damage or kill** cells.
- X-rays are useful in **medical diagnosis** if used with appropriate precautions.

GAMMA RAYS

- **Higher** frequency than UV.
- **Shorter** wavelength than UV.
- **Higher** energy than UV.
- Enough energy to go through **all tissue**.
- Too much exposure to gamma rays can **damage or kill cells.**
- Gamma rays, which have the highest frequency, can be used to treat **cancer** and to **kill** bacteria in food.



YOUR SPECTRUM



TO DO

- Handout due tomorrow.