# Unit 3: Optics
# Chapter 4

## Properties of Light

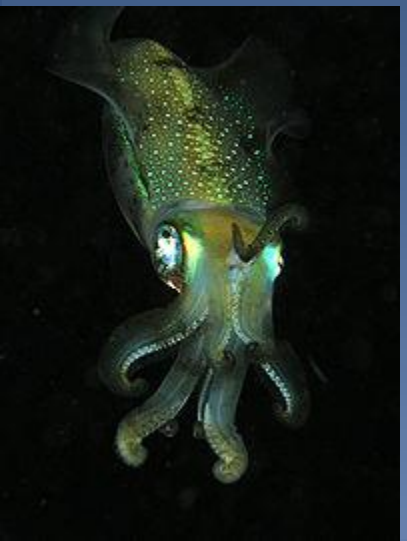
# There are many types of light sources…

- Fluorescence

- Incandescence

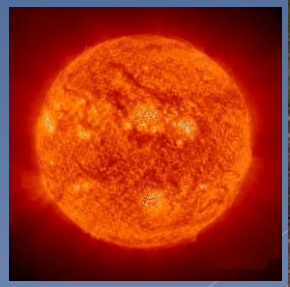
- Electric

- Bioluminescence

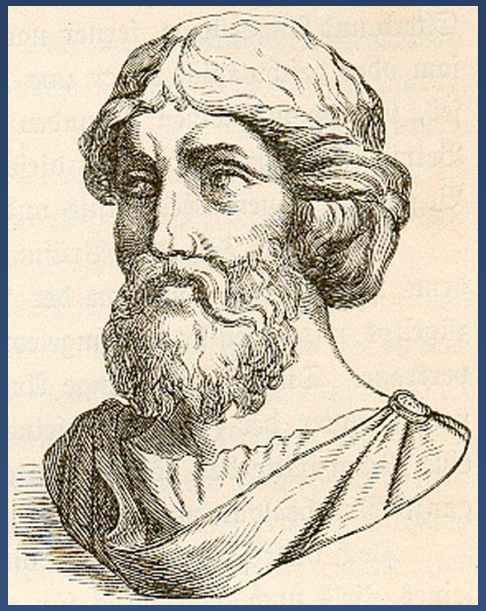


- Chemiluminescence

- Combustion



# The Nature of Light



## Pythagoras

- A Greek philosopher
- Believed light was **beams of tiny particles**
- The eyes could detect these particles and see the object.

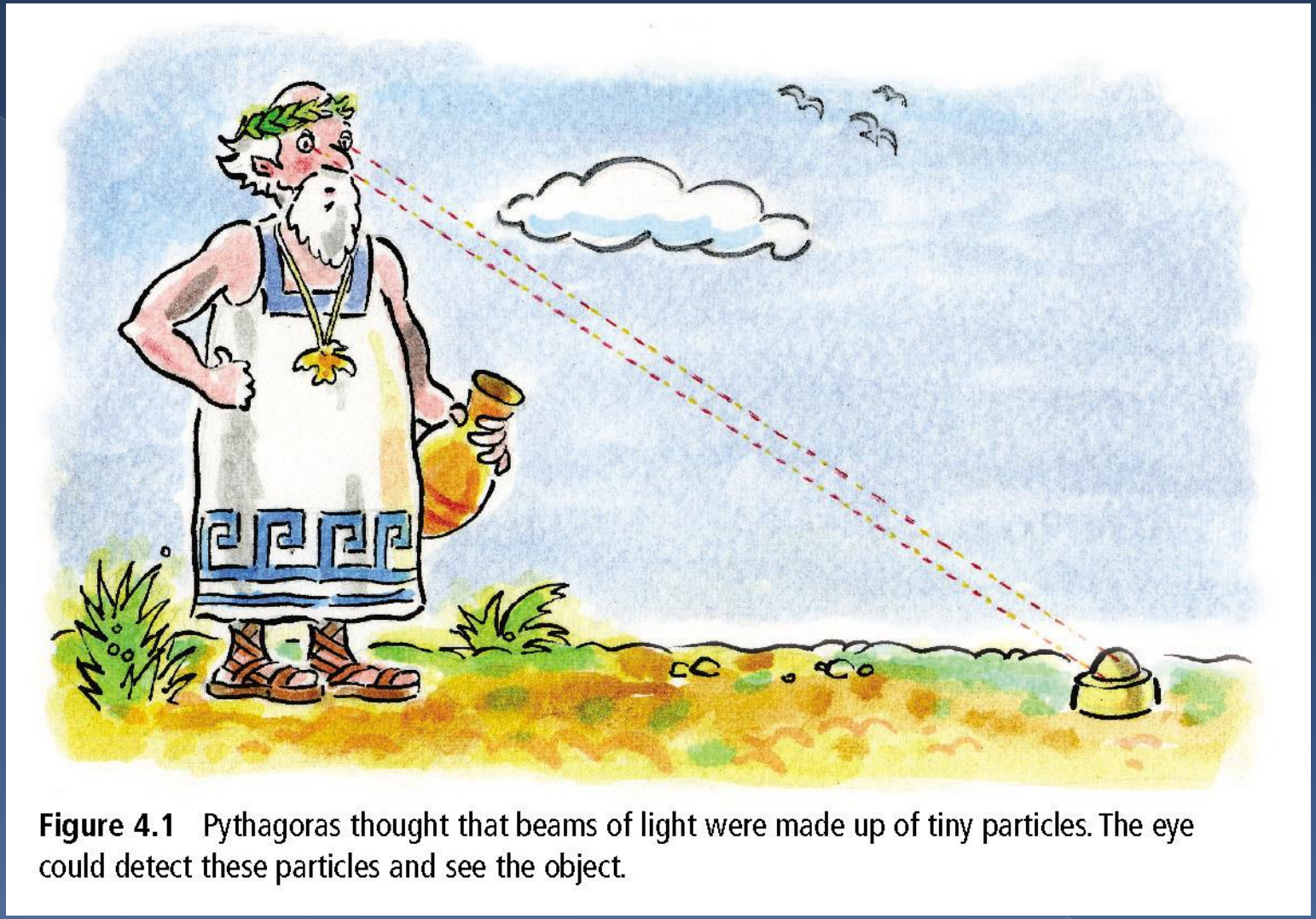


**Figure 4.1** Pythagoras thought that beams of light were made up of tiny particles. The eye could detect these particles and see the object.

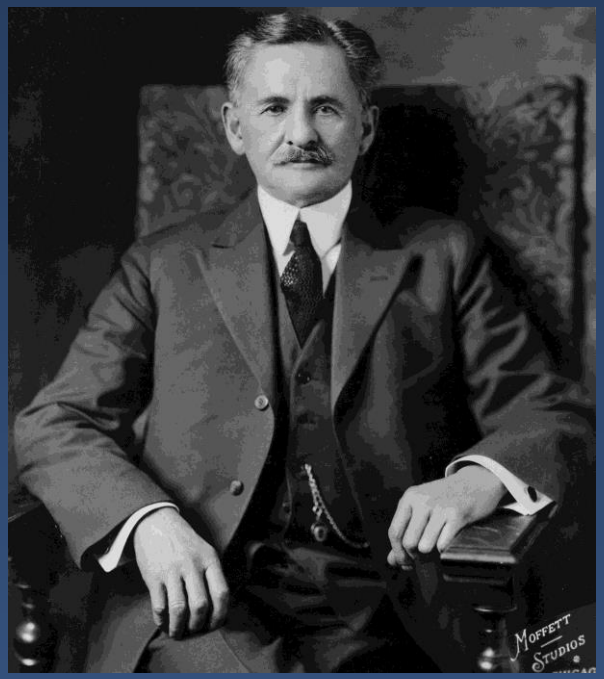
# The Speed of Light

## Galileo

- Tried to measure the speed of light using 2 lanterns 1 km apart.

- Why didn't this work?

# Michelson




- First to measure the **speed of light (3 x $10^8$ m/s)**
- Shone a light on a rotating **mirror** that reflected to a distant **mirror.**
- Used the distance and reflection time to calculate **speed of light.**

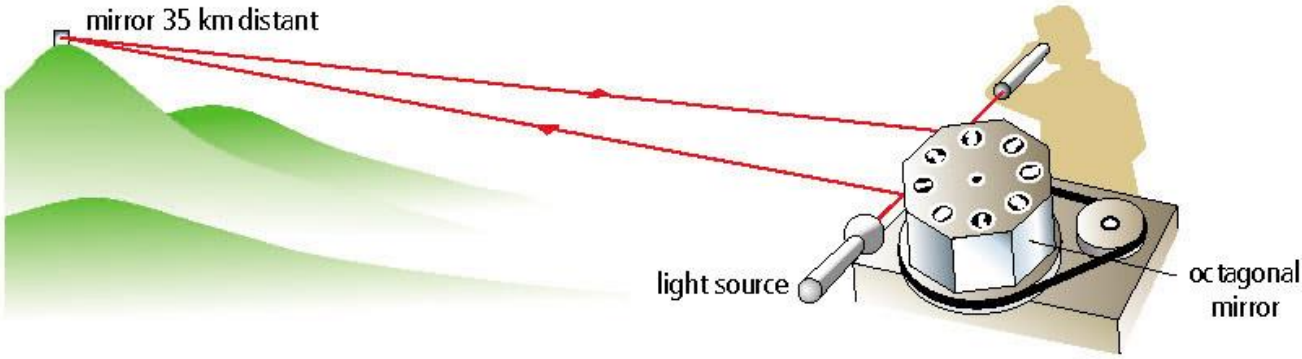



**Figure 4.9** Michelson shone a light on a rotating mirror, which reflected to a large mirror about 35 km away. The returning beam of light reflected off another face of the rotating mirror into the eye of the observer. By precisely measuring the speed of the rotating mirror and the distance to the distant mirror, Michelson calculated the speed of light.

*At this speed it can go around the world*
*7.5 times in one second!!!*

# Speed: Light vs. Sound

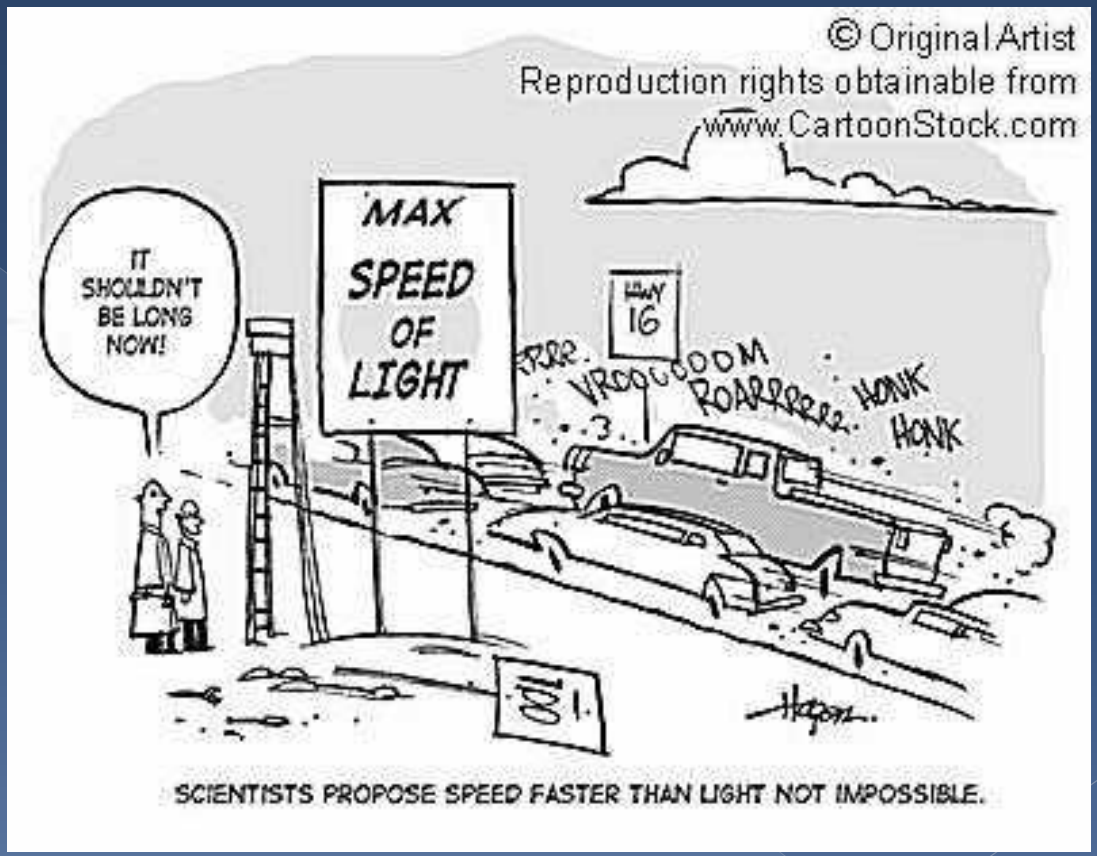
**Light**

**300 000 000 m/s**

**(or 3 x $10^8$ m/s)**

**Sound**

- **343 m/s**



# Example: Thunder & Lightning
(3 seconds for every kilometre)

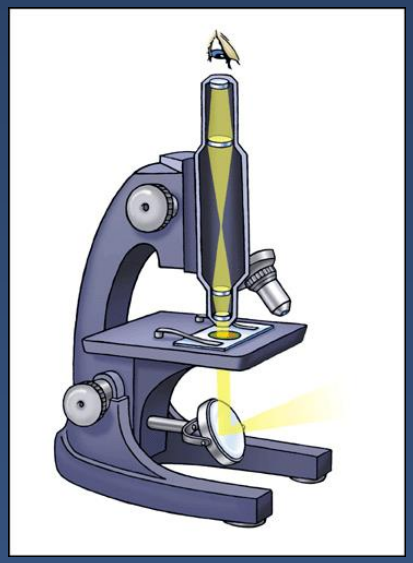
- http://natgeotv.com/ca/ask-the-expert/videos/thunder-bolts-and-lightning

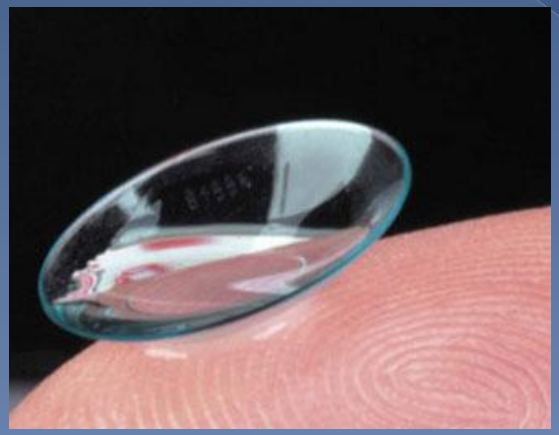
## Supernovae

- http://www.youtube.com/watch?v=q8ZXHYXp7Vs

# Light Technologies Include…

- **Microscope**
- **Telescope**
- Periscope
- Binoculars
- Fibre optics
- Camera
- Prescription contact lenses
- Laser
- Movie projectors
- Overhead projectors





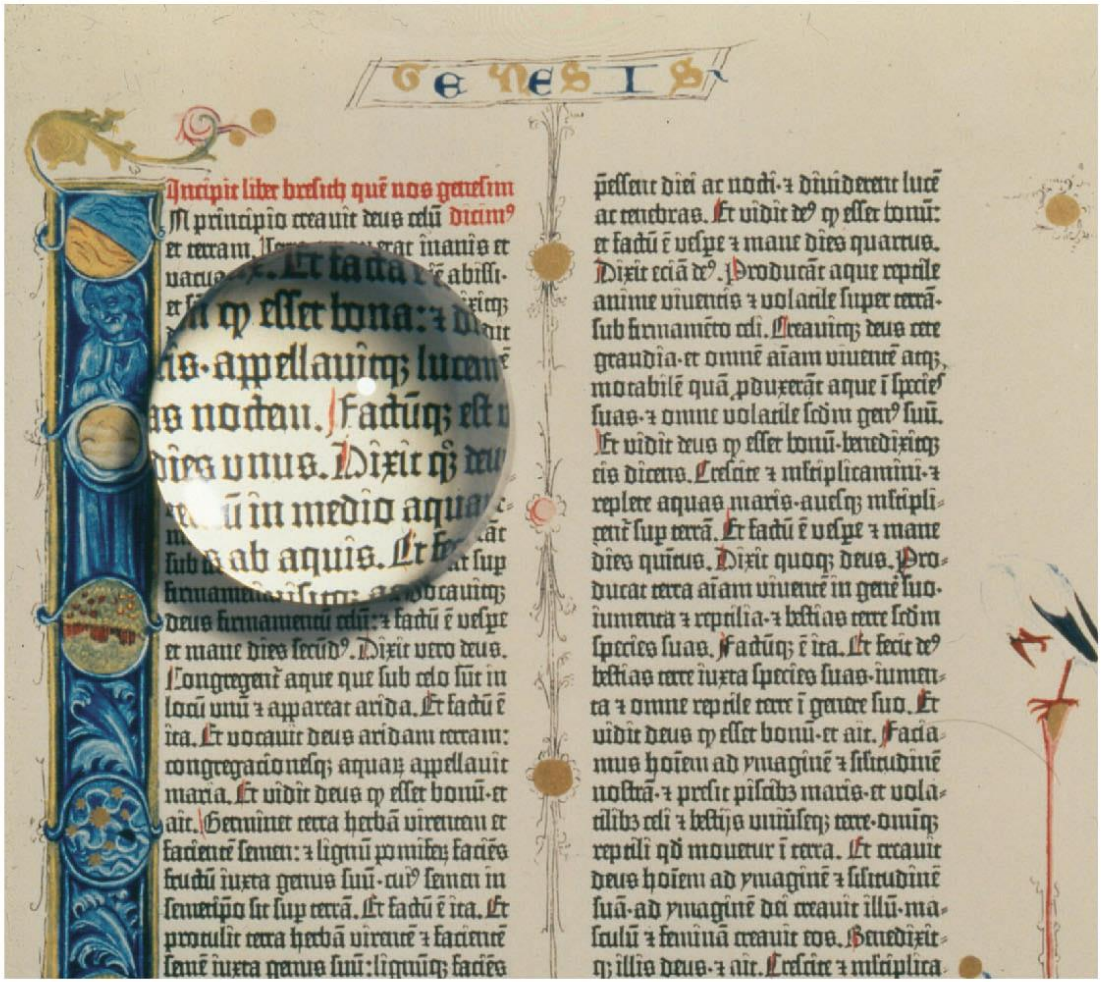



**Figure 4.2** Nearly everyone older than 40 to 50 years old has trouble reading without glasses. Before the 1200s, a reading stone was the only way that older people could magnify the print enough to read it.

**Figure 4.3** The frames of these first spectacles were made of bone, metal, or even leather.

# The microscope

**Figure 4.4** The first compound microscope was just two tubes with lenses in the ends.

- People knew **curved** glass could **magnify** objects
- Father and son experimented with lenses in sliding tubes. When the tubes slide, objects appear **larger.**

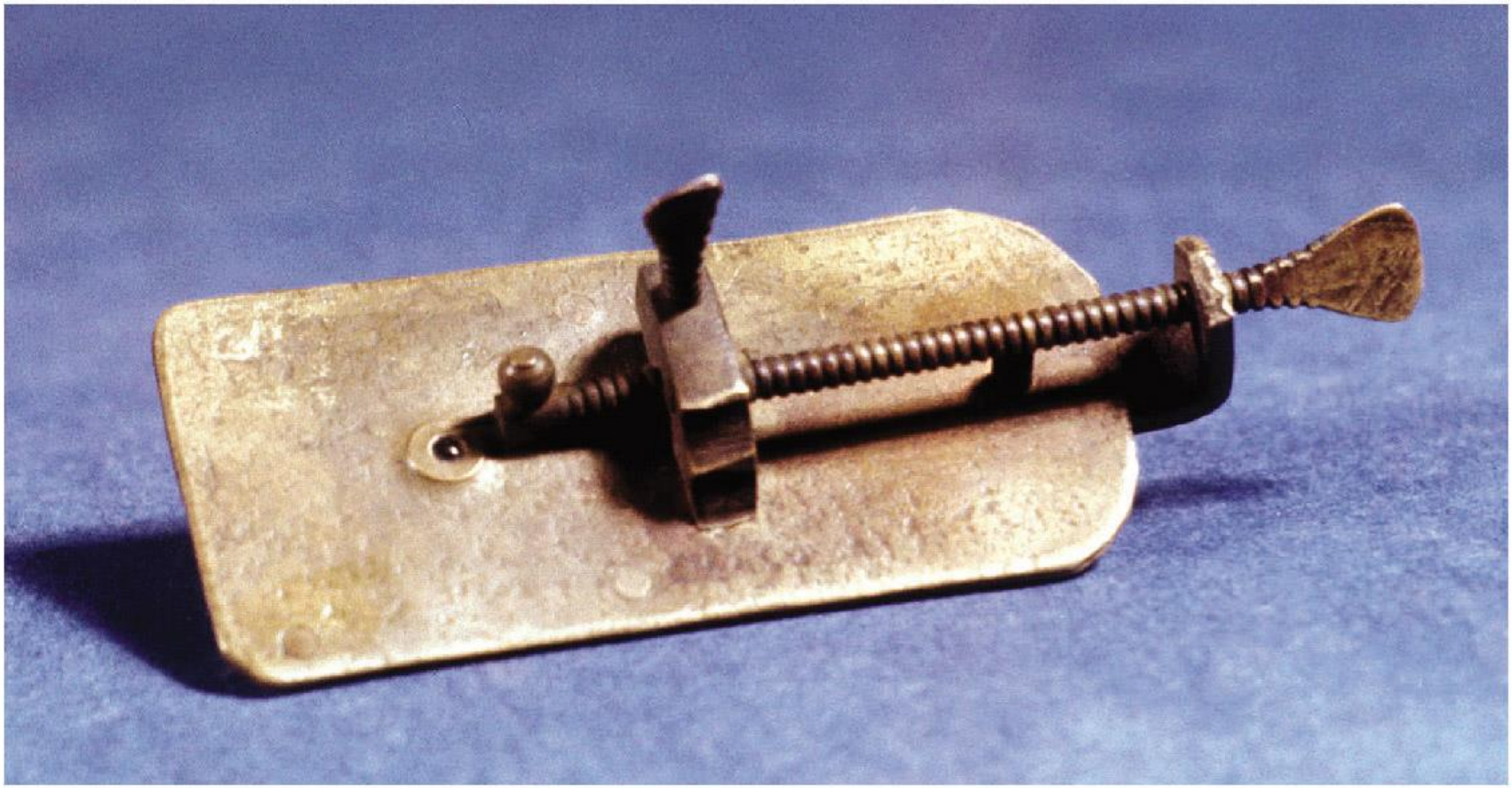


**Figure 4.5** This probably does not look like a microscope but Leeuwenhoek discovered many "wee beasties" with it. The sample was placed on the point of the screw and Leeuwenhoek looked through a lens that was on the other side of the opening.

# The telescope

- Developed by **Galileo**
- Made his own **lenses** to **magnify** objects in space.

**Figure 4.6** Galileo built and used this telescope in the early 1600s.

- Do questions 1-13 on page 137

# Properties of light

- **Visible light** is a form of energy that can be detected by the human eye.

# Properties of light

1. Travels in a straight line (*rectilinear propagation)*

*Example: shadows*

# 2. Light reflects (reflection)

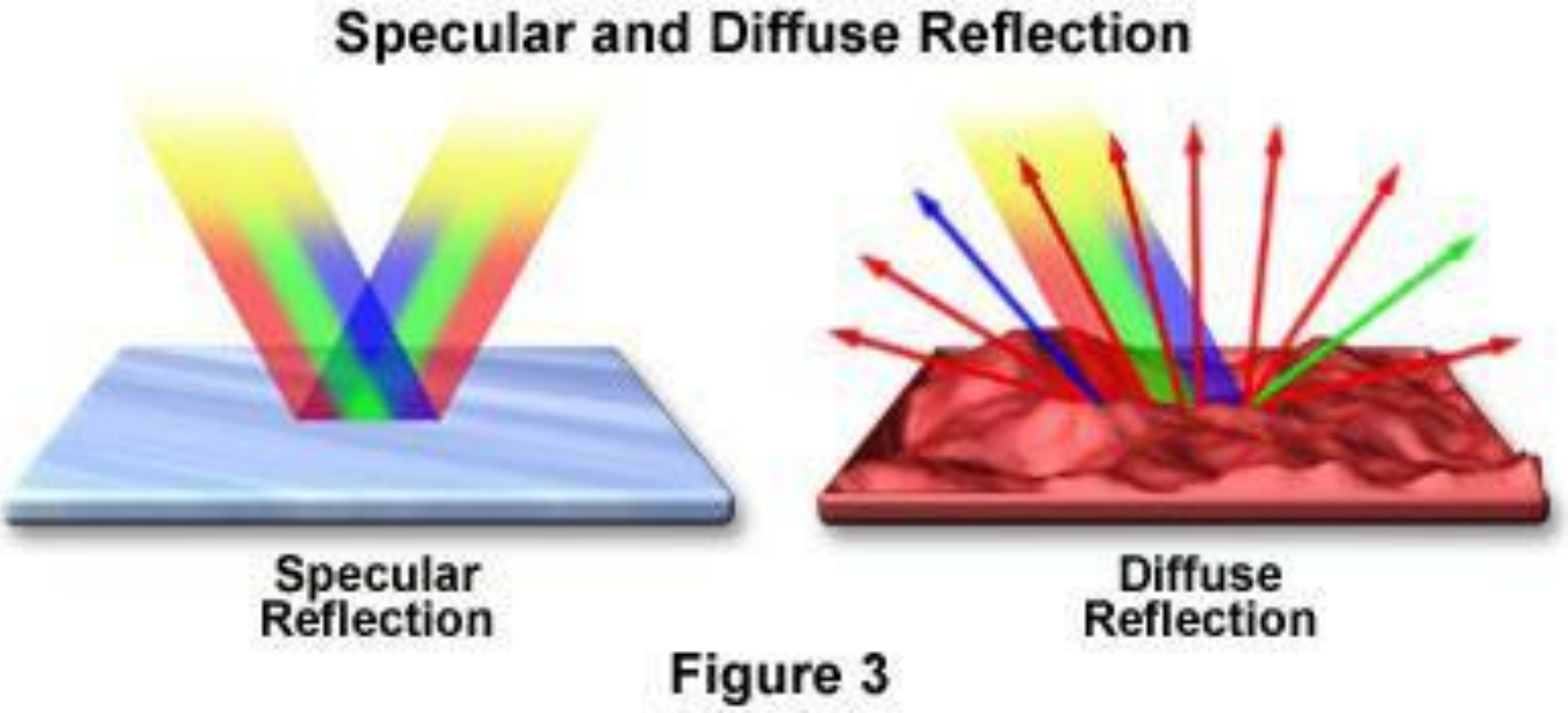



Figure 3

**Mirrors** **Dust**

# Properties of Visible Light

a) ***Specular reflection*:** reflection from a mirror-like surface, which produces an image of the surroundings. (ex: mirrors)

b) ***Diffuse reflection*:** reflection from a **rough** surface, which **does not** produce a clear image but does let you see what is on the surface.

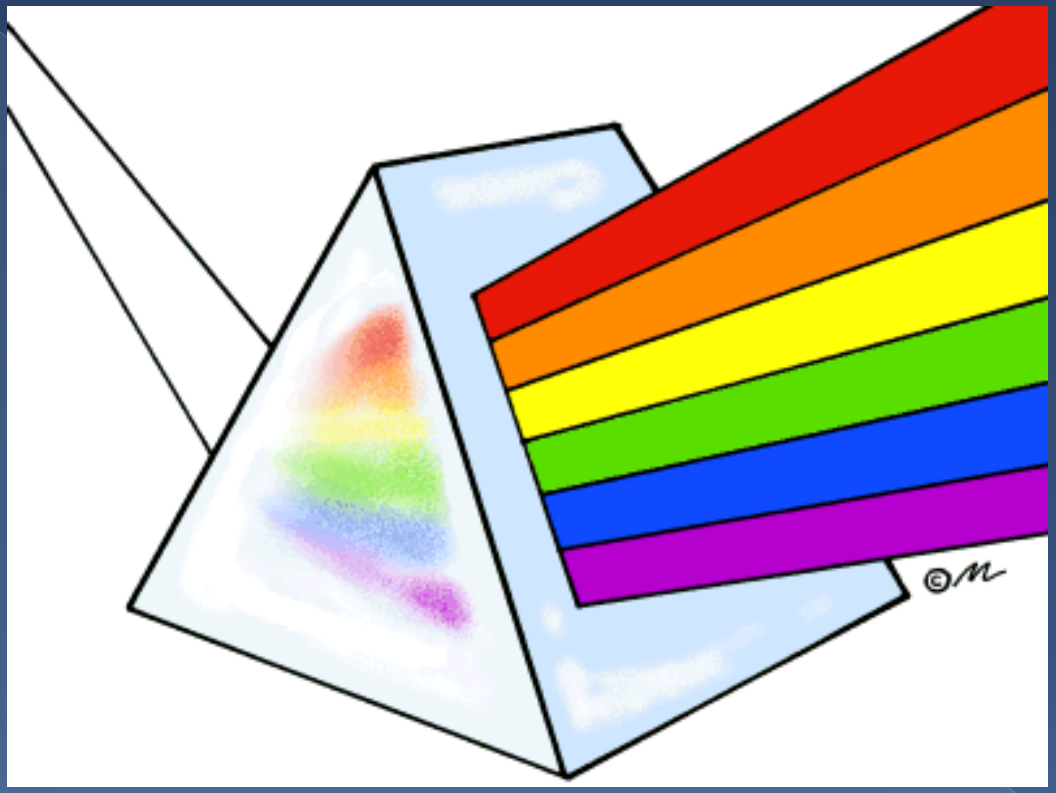
(ex: dust)

3. **Light Refracts (refraction)**

   light **bends** when travelling through different materials

Example: The “bent stick” effect

4. Light disperses (dispersion)

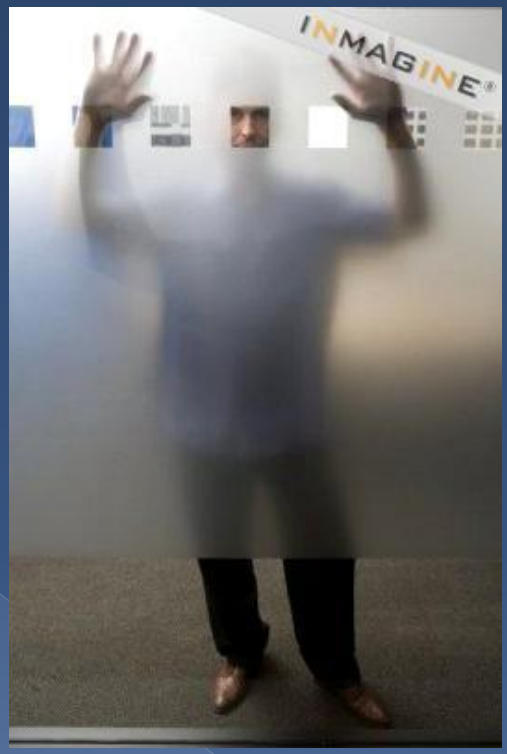


*Example: White light separates into the colours of the rainbow when shone through a prism*

5. **Light travels through a vacuum (empty space)**
   - does not require a medium;
   - no particles are involved

*Example: Light from the sun and stars*

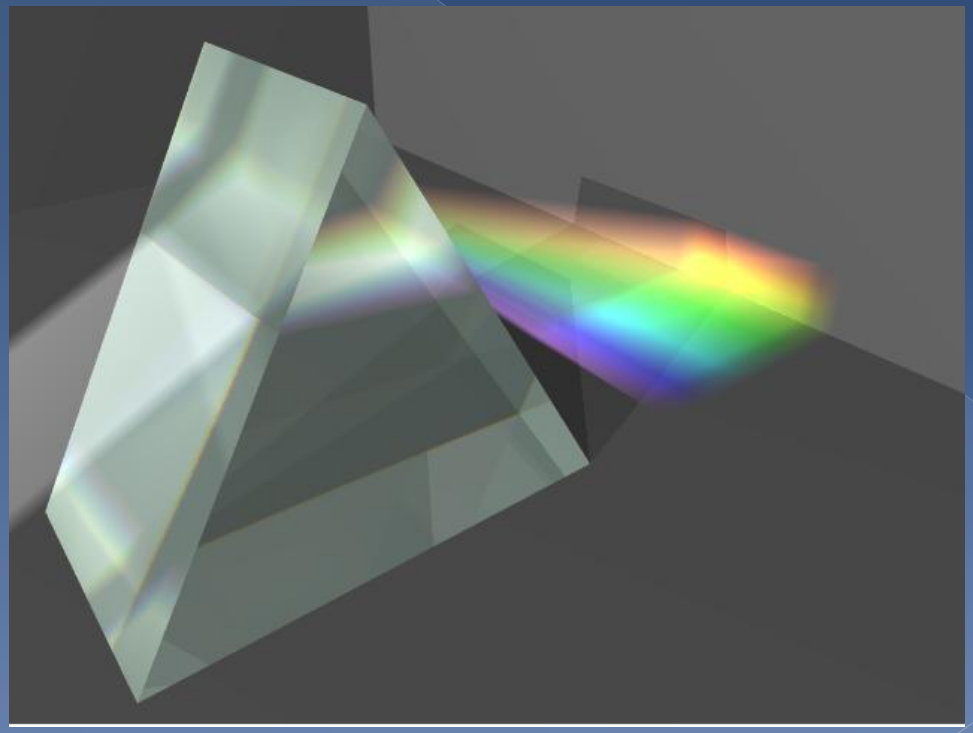
6. **Travels through transparent, translucent, and opaque materials to different degrees**




*Example: window pane (transparent)*
*frosted window (translucent)*
*wall (opaque)*

# Visible Light Spectrum

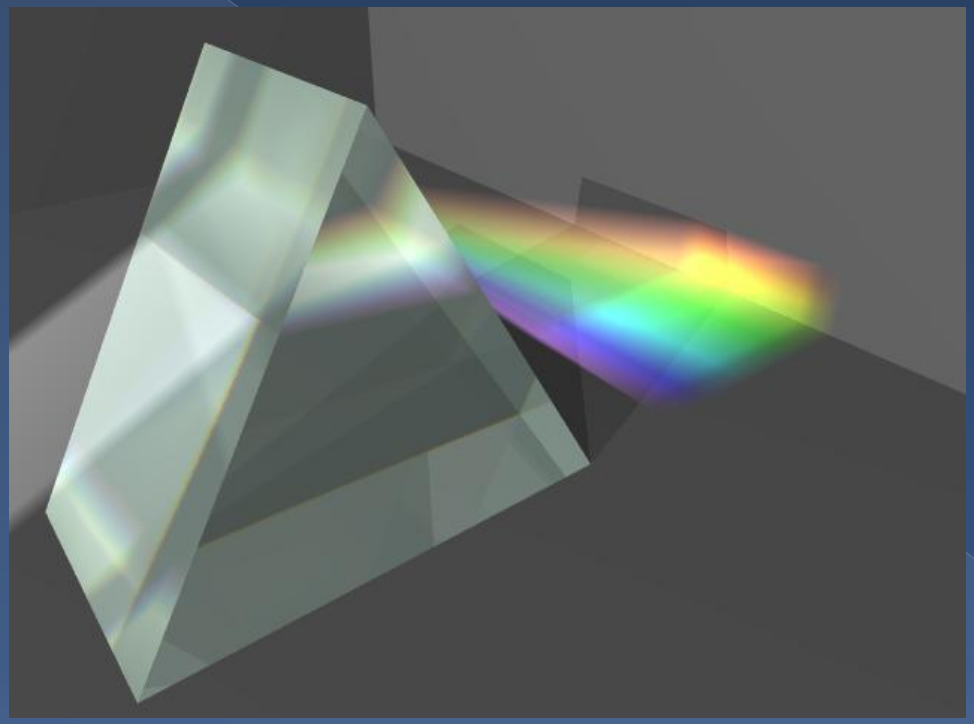
- A form of **energy** our eyes can detect
- Can be seen due to the **dispersion of light** through a prism.



# The constituent colors of white light are:

**R**ed (smallest refraction)
**O**range
**Y**ellow
**G**reen
**B**lue
**I**ndigo
**V**iolet (greatest refraction)

"**ROY G BIV**"



Since each colour **refracts** differently, we can see all the colours that make up light when a beam of white light is **refracted** through a prism.

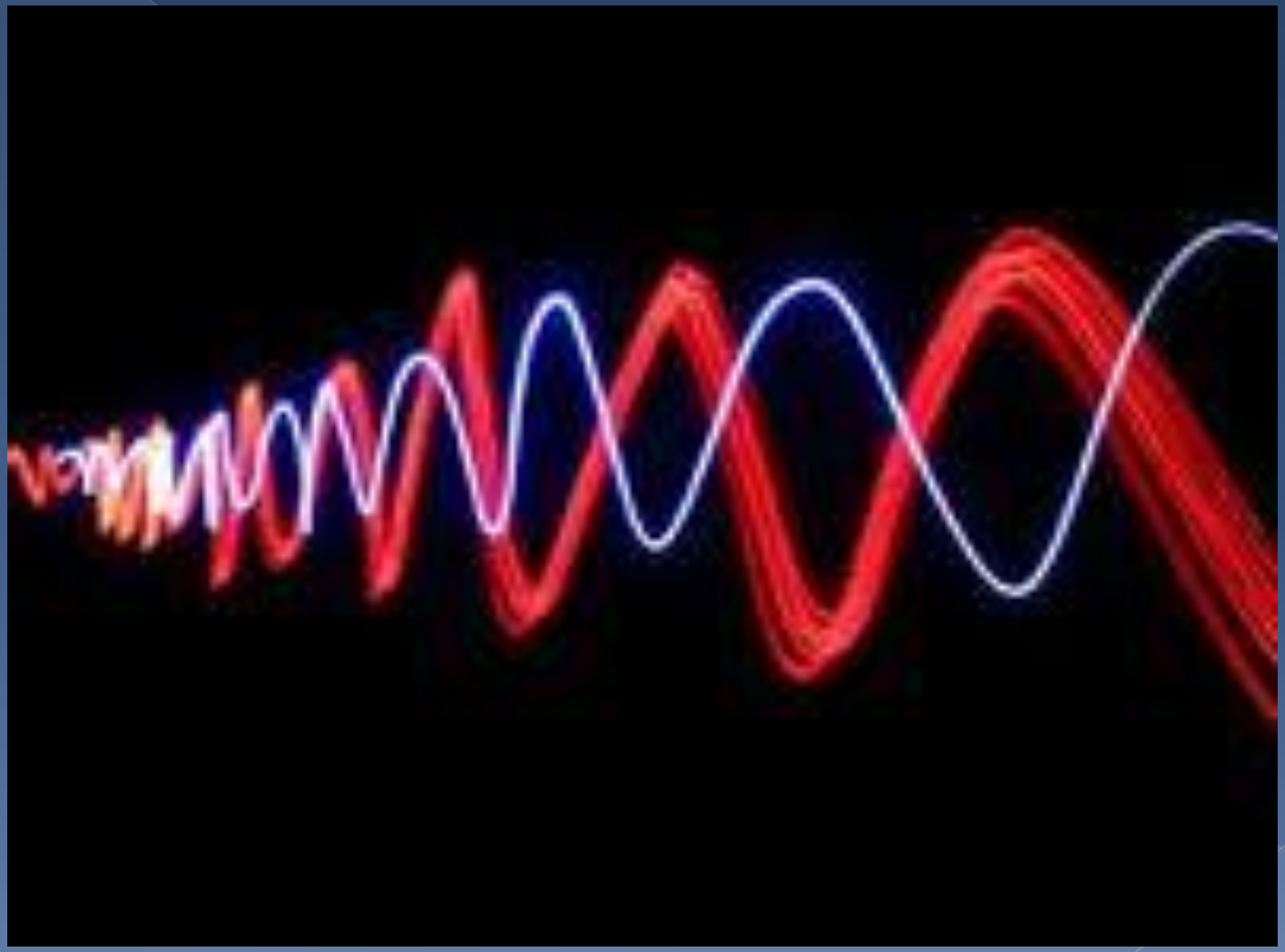
# Colour

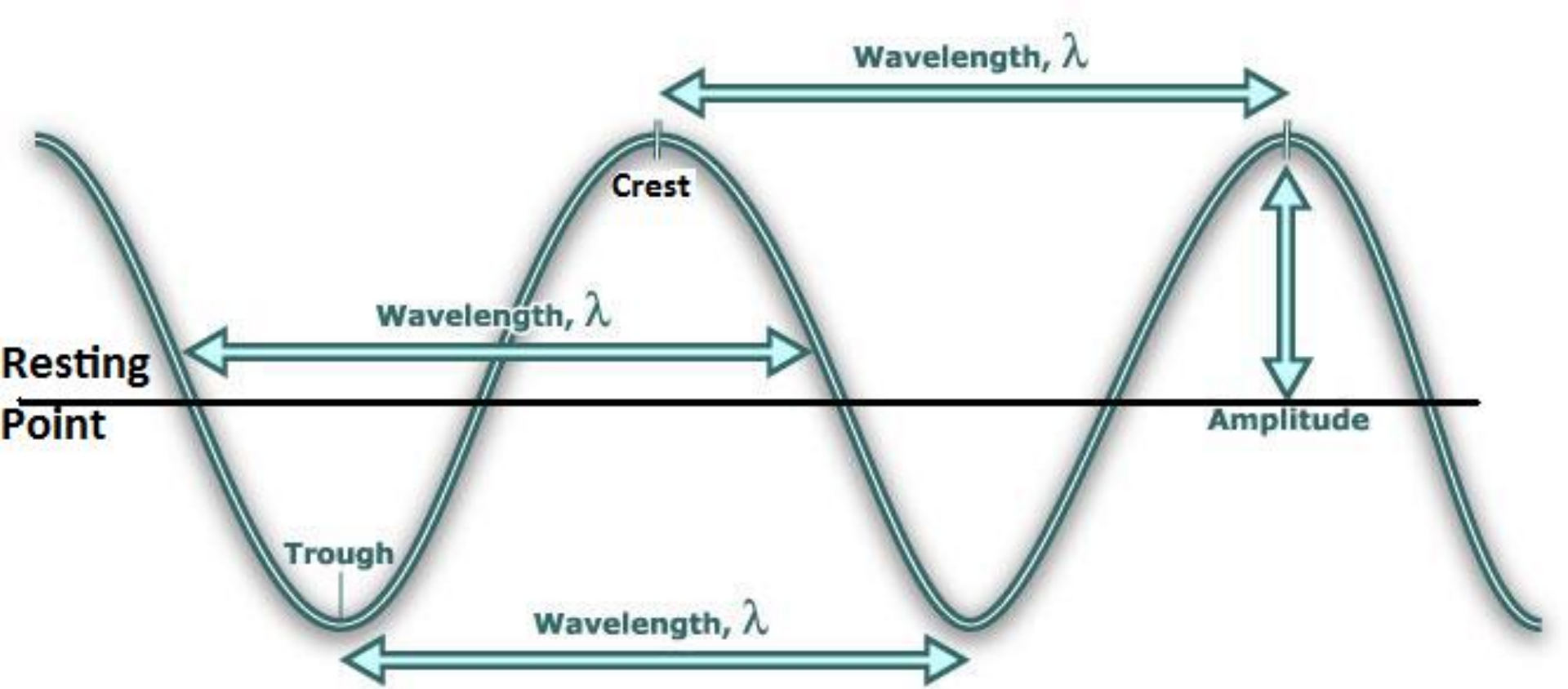
- The colour we see is the colour that is being **reflected**. All other wavelengths are **absorbed**.
- Example: a red shirt is **absorbing** all colours except for red. Red wavelengths are being **reflected.**

# Homework

- On page 155, do questions 2-7
- On page 187, do questions 1, 4, 5, and 6.

# Light travels in the form of a wave



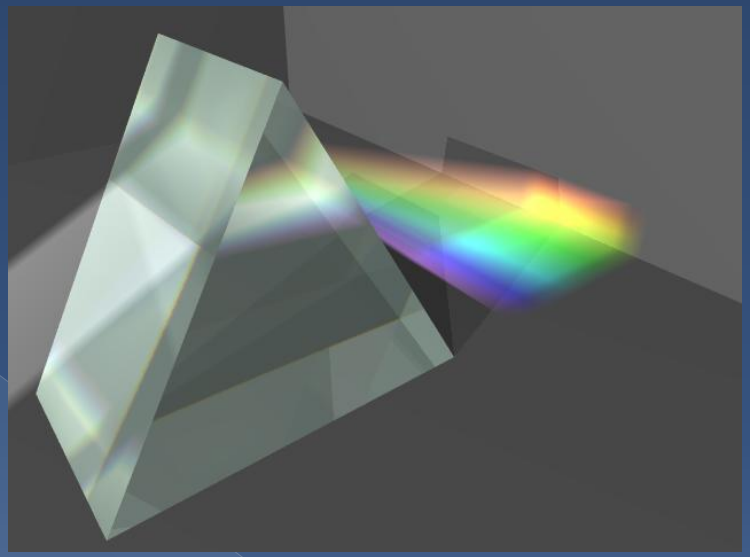

Wavelength, λ
Crest
Wavelength, λ
Resting Point
Amplitude
Trough
Wavelength, λ

# Frequency

- #of wave cycles that occur in a given time.
- The **higher** the frequency, the **faster** the wave.
- Frequency = $\frac{\textbf{\# cycles}}{\textbf{seconds}}$
- Measured **in Hertz**

# Wavelength

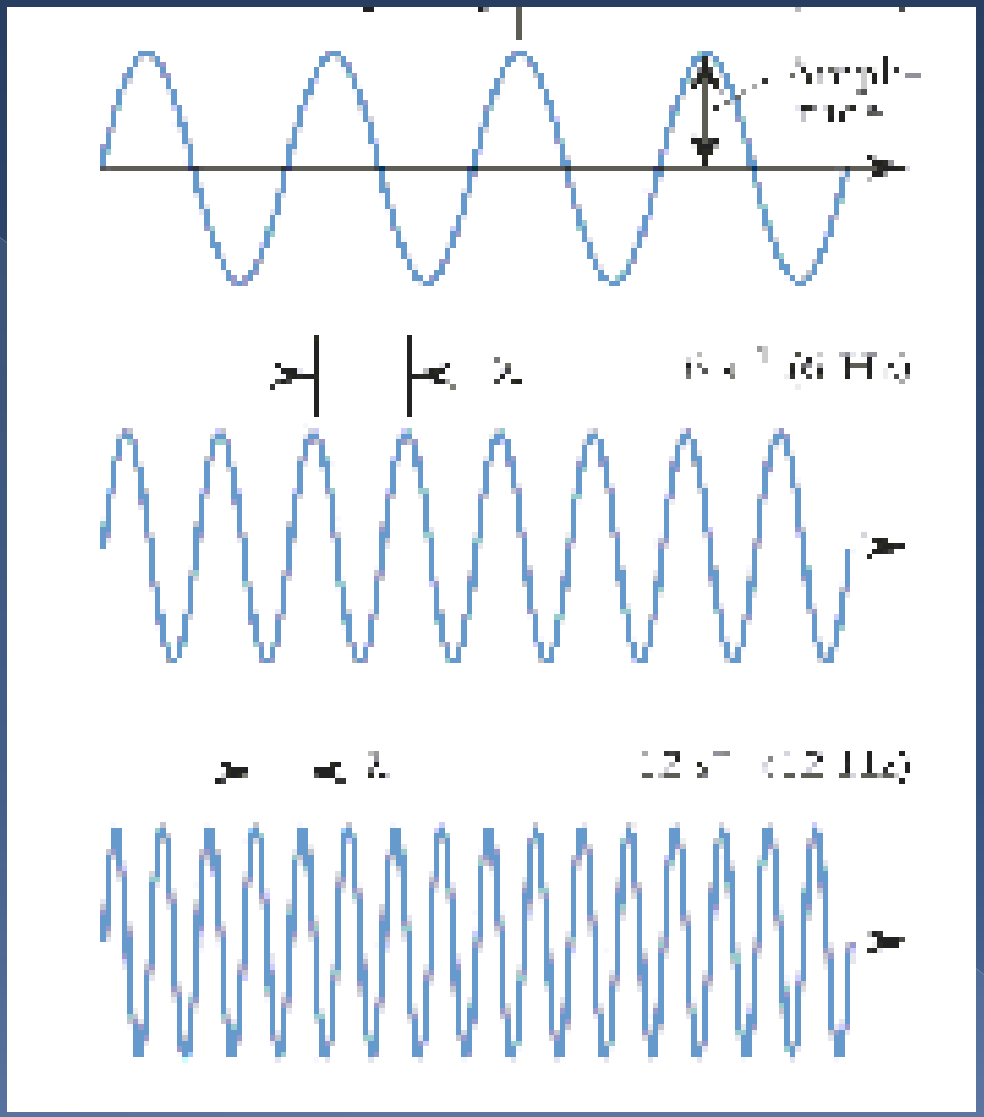
- The distance from **crest to crest** or **trough to trough** in a wave.
- Longer wavelengths **refract** the least (red light)
- Shorter wavelengths **refract** the most (blue light)



# Frequency and Wavelength

- High frequency waves have **short** wavelengths (blue light)

- Low frequency waves have **long** wavelengths (red light)



http://phet.colorado.edu/sims/wave-on-a-string/wave-on-a-string_en.html

# HOMEWORK

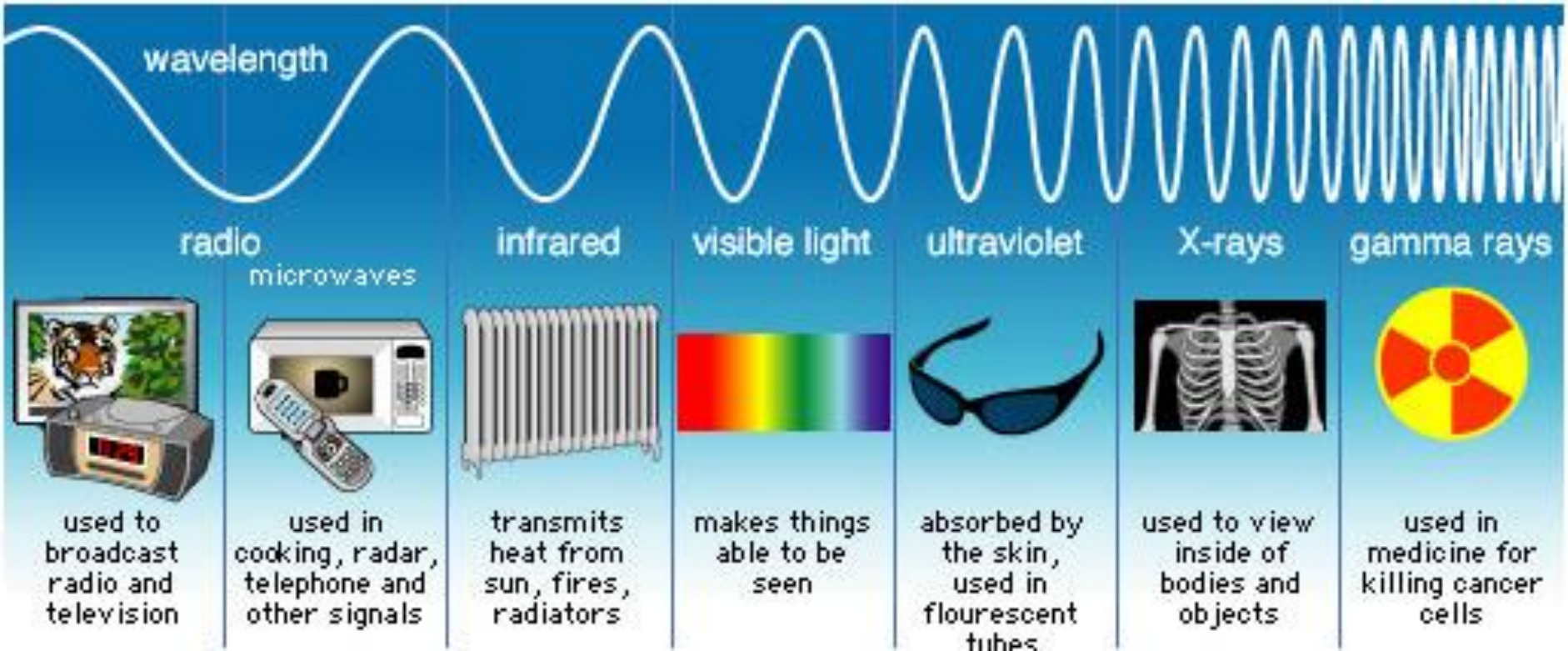
- P. 147, #s 1, 2, 4, 5, 8, 9
- P. 155, #s 9, 10, 13

# Assignment

- Waves & Frequency

# Electromagnetic Radiation

- The transmission of energy in the form of waves that extend from radio waves (longest) to gamma rays (shortest).



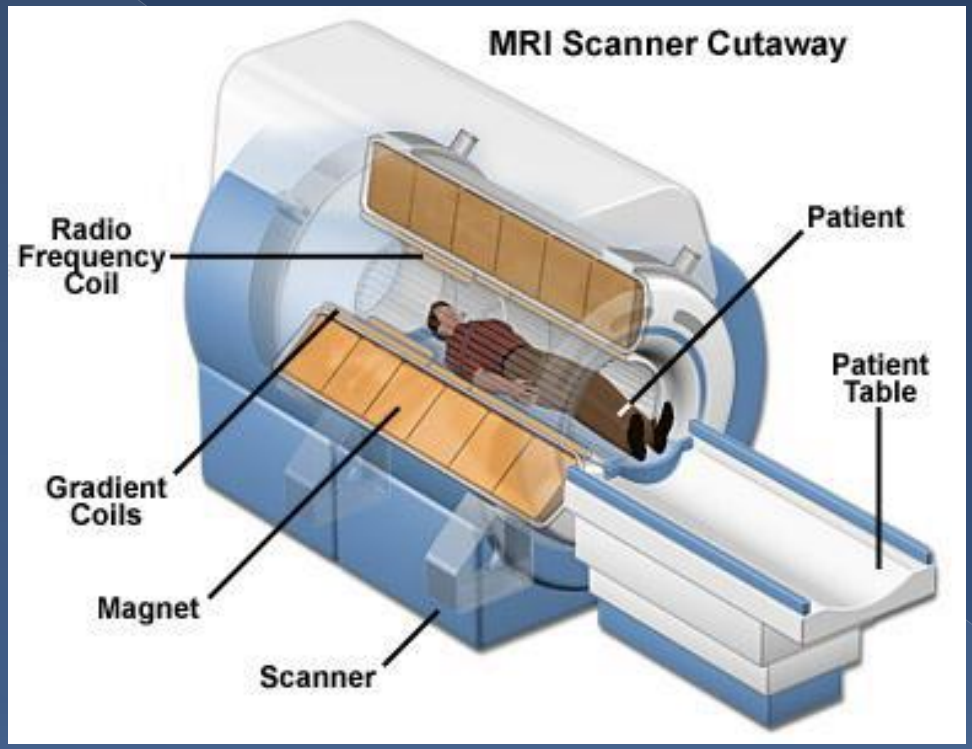
- http://phet.colorado.edu/en/simulation/radio-waves

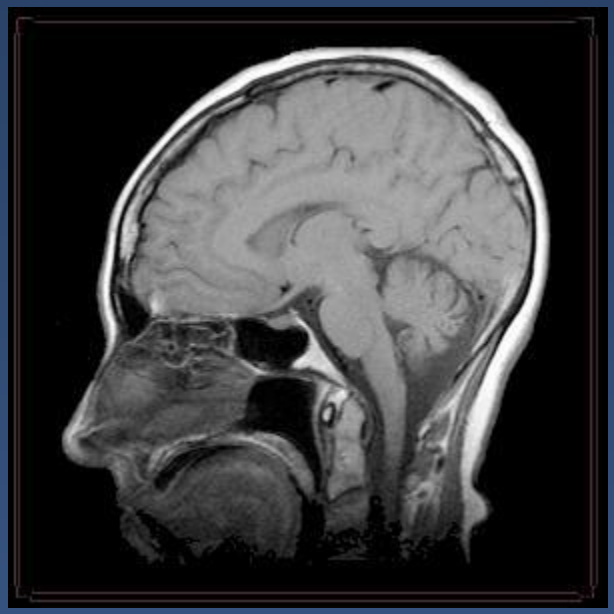

SCIENCEphotoLIBRARY

# Types of Electromagnetic Radiation

1. **Radio waves**
   - **Longest wavelength** (several kilometres to one millimetre)
   - **Lowest frequency**
   - **Lowest energy**

- Uses: MRI
  Radio and television broadcasting
  Microwaves
  Radar



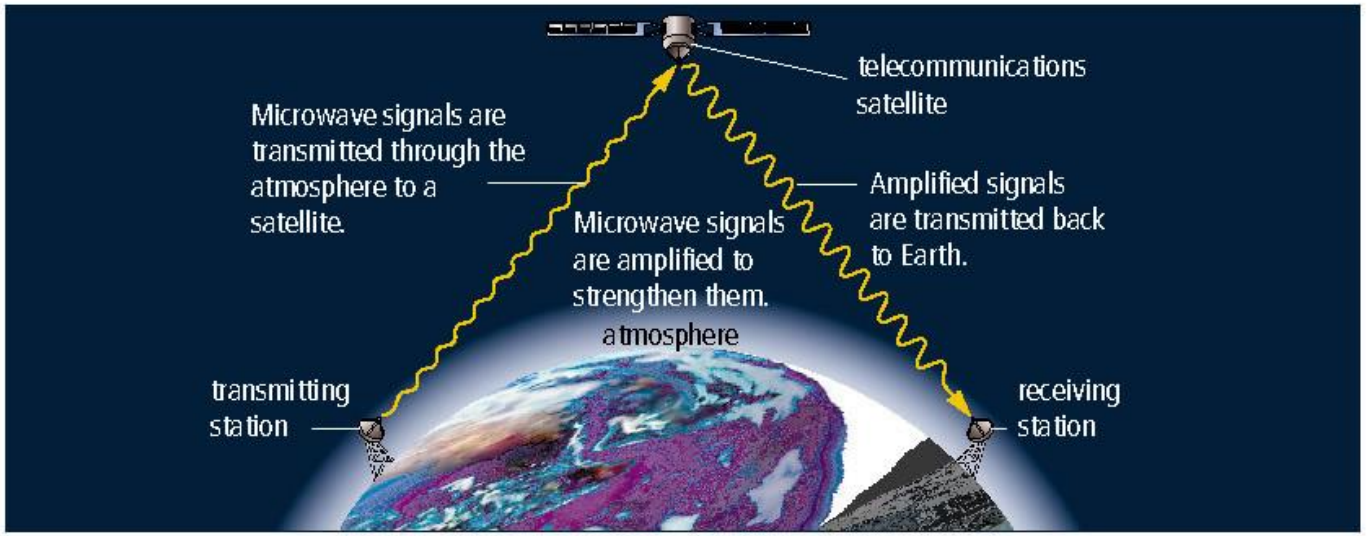



# Magnetic Resonance Imaging

Video Clip

## 2. Microwaves

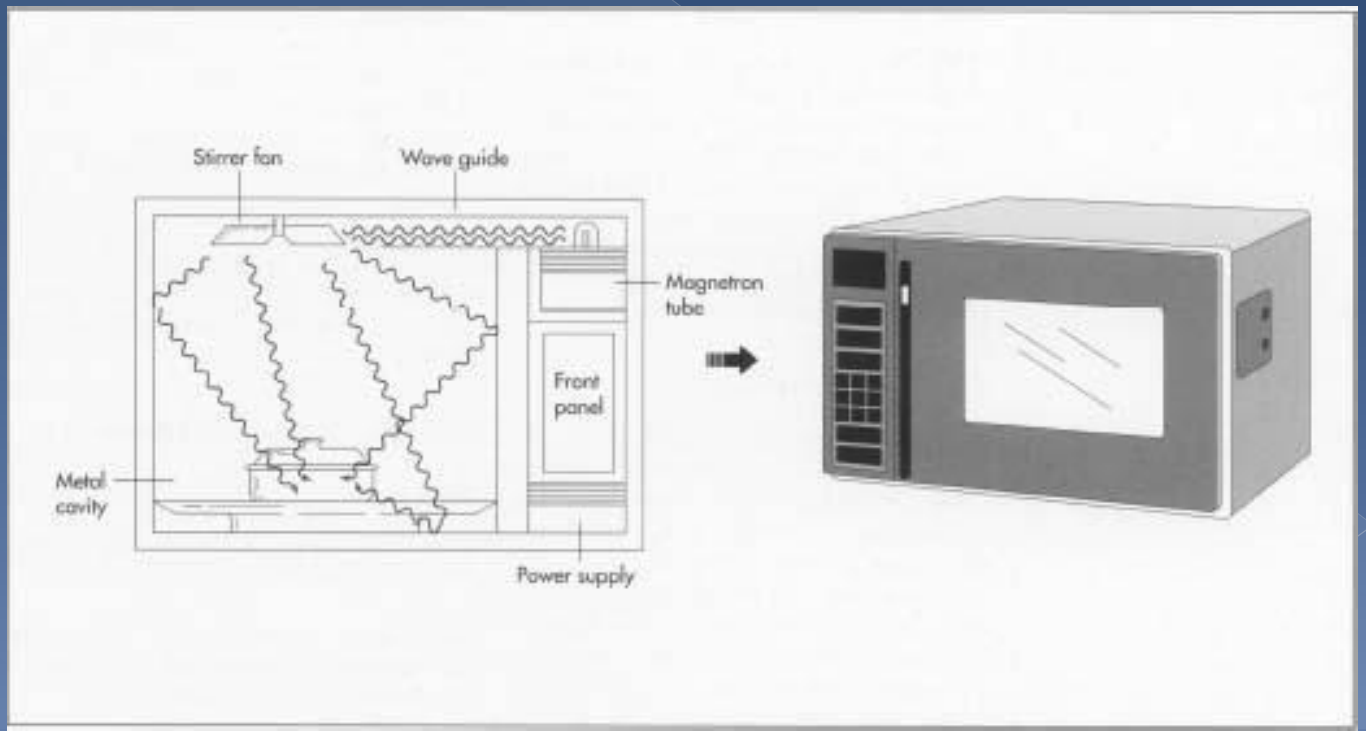
- Type of **radio** wave that is the shortest wavelength (between one millimetre and one meter) and highest frequency.
- Examples:
  - Microwave ovens
  - Telecommunications
  - Radar (remote sensing)



# How a microwave works

- Microwave ovens use a specific frequency that is strongly absorbed by water molecules in food.

Video Clip



# 3. Infrared Waves

Compared to visible light:

- **longer wavelength**

( between 700 and 300 000 nanometres)

- **lower energy**
- **lower in frequency**

- Also called heat radiation

- Ex. Motion sensors
- Video Clip

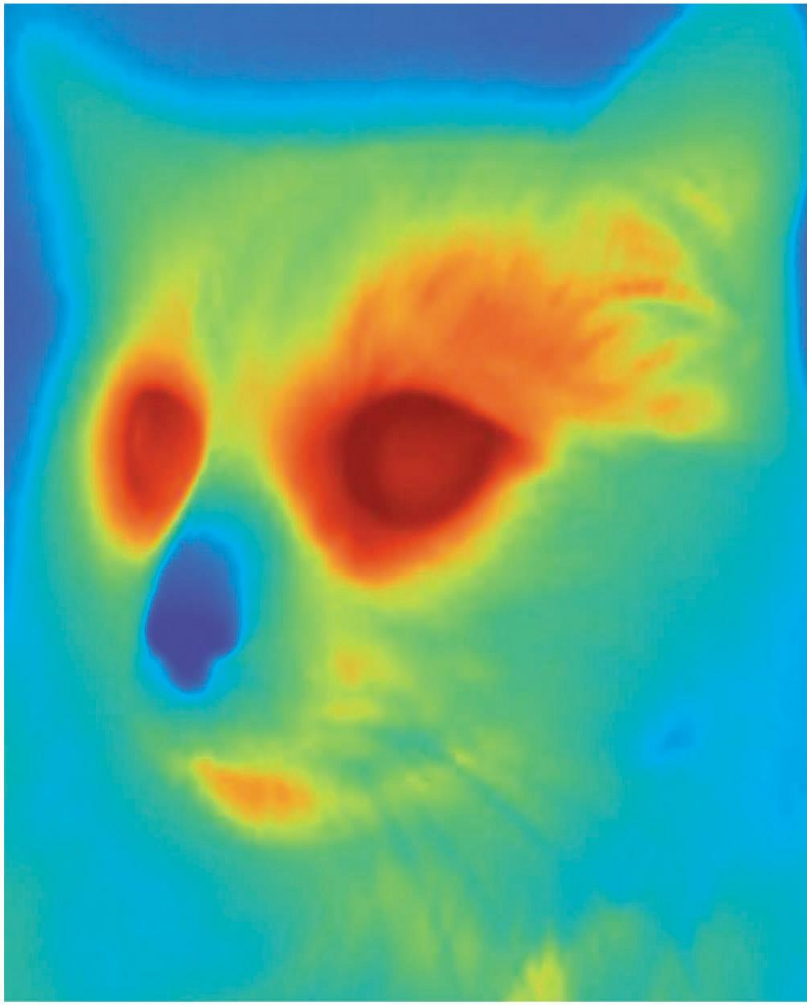
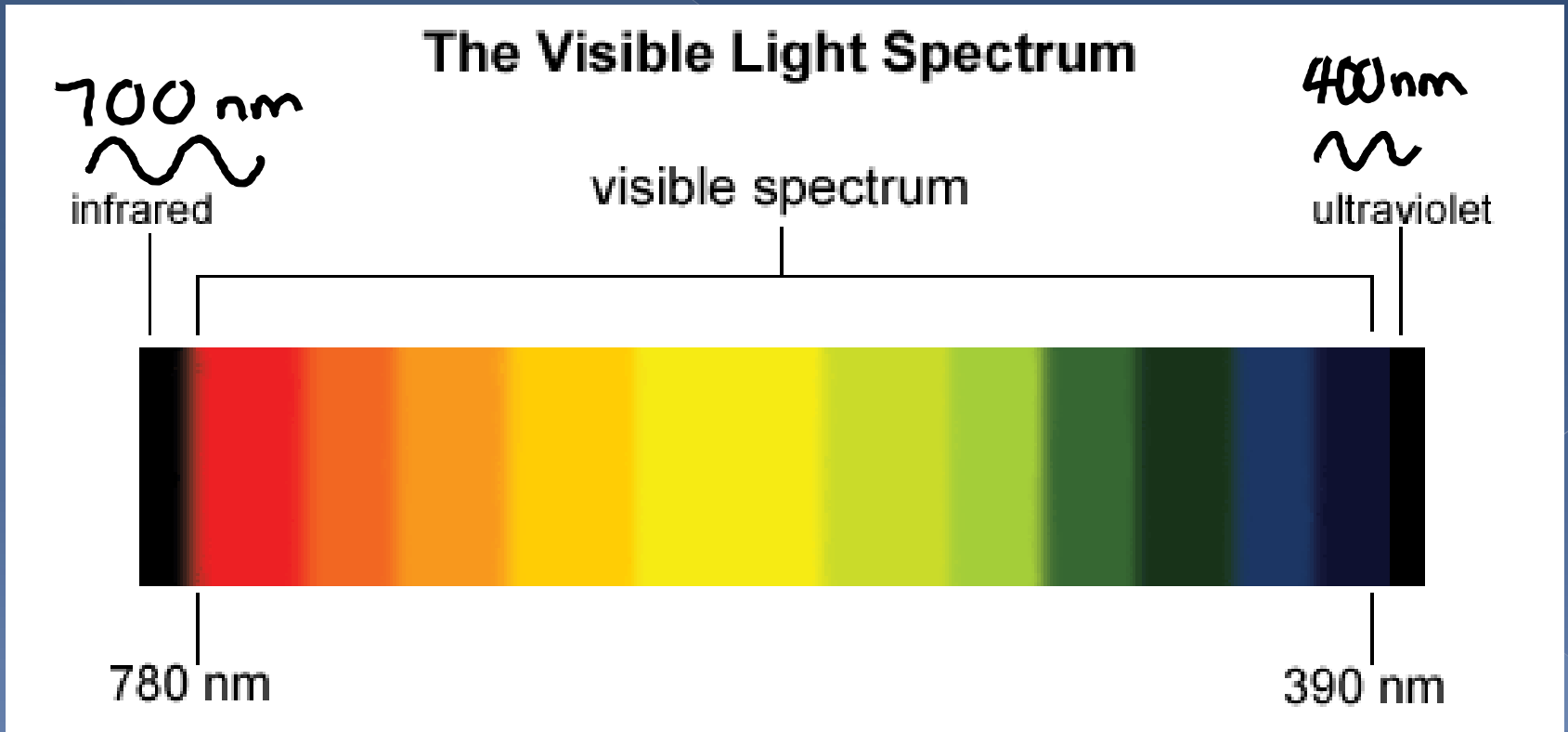


**Figure 4.35** An infrared camera and film detect differences in temperature and assign false colours to different brightnesses. The resu is information that we could not get from a visible light photograph.

4. **Visible light**
   - Can be detected by our eyes
   - Wavelengths are between 400 (violet light) and 700 (red light) nanometres.



# 5. Ultraviolet

Compared to visible light:

- **Shorter** wavelength (between 10 and 400 nm)
- **Higher** energy
- **Higher** frequency

- Ex. Sun tanning
  - Your Body uses UV light to make vitamin D, but too much can cause skin cancer.

**Figure 4.37** You can prevent damage to your skin from ultraviolet radiation by wearing sunscreen and covering up exposed skin. Sunglasses that block ultraviolet radiation can help protect your eyes.

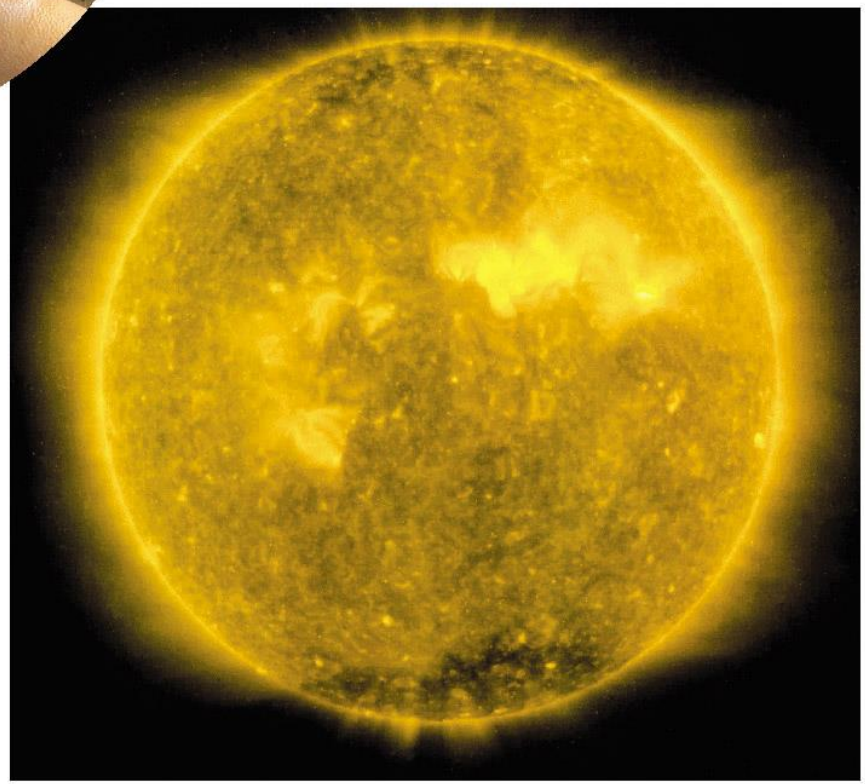


**Figure 4.37** Earth's atmosphere absorbs some of the ultraviolet radiation emitted by the Sun.

**Figure 4.38** The detective is shining ultraviolet light on fingerprints dusted with fluorescent powder.

6. **X-Rays**

Compared to visible light:

- **Shorter** wavelength
- **Higher** energy
- **Higher** frequency

- Ex. Medical uses

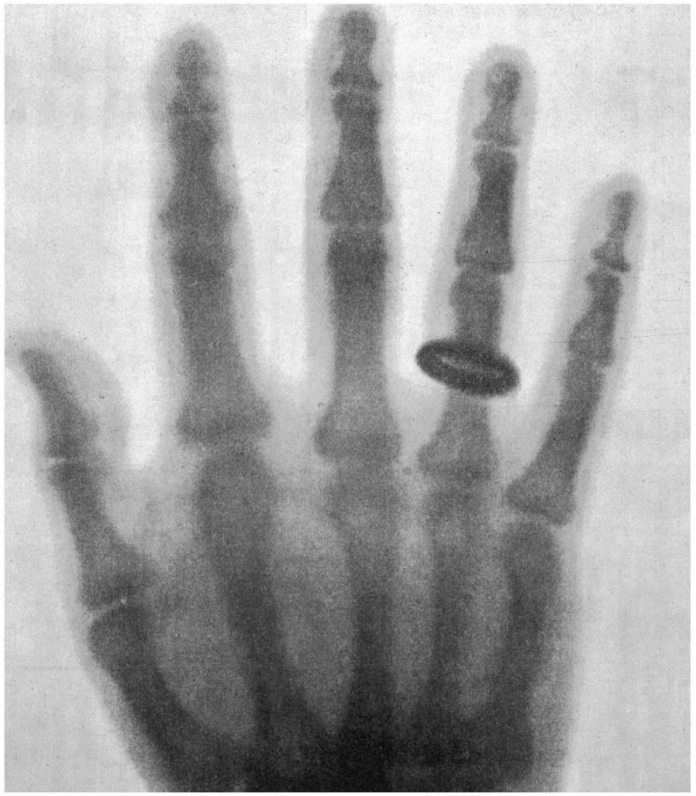


**Figure 4.39** X rays pass easily through tissue such as skin and muscle. However, X rays are absorbed by bone.

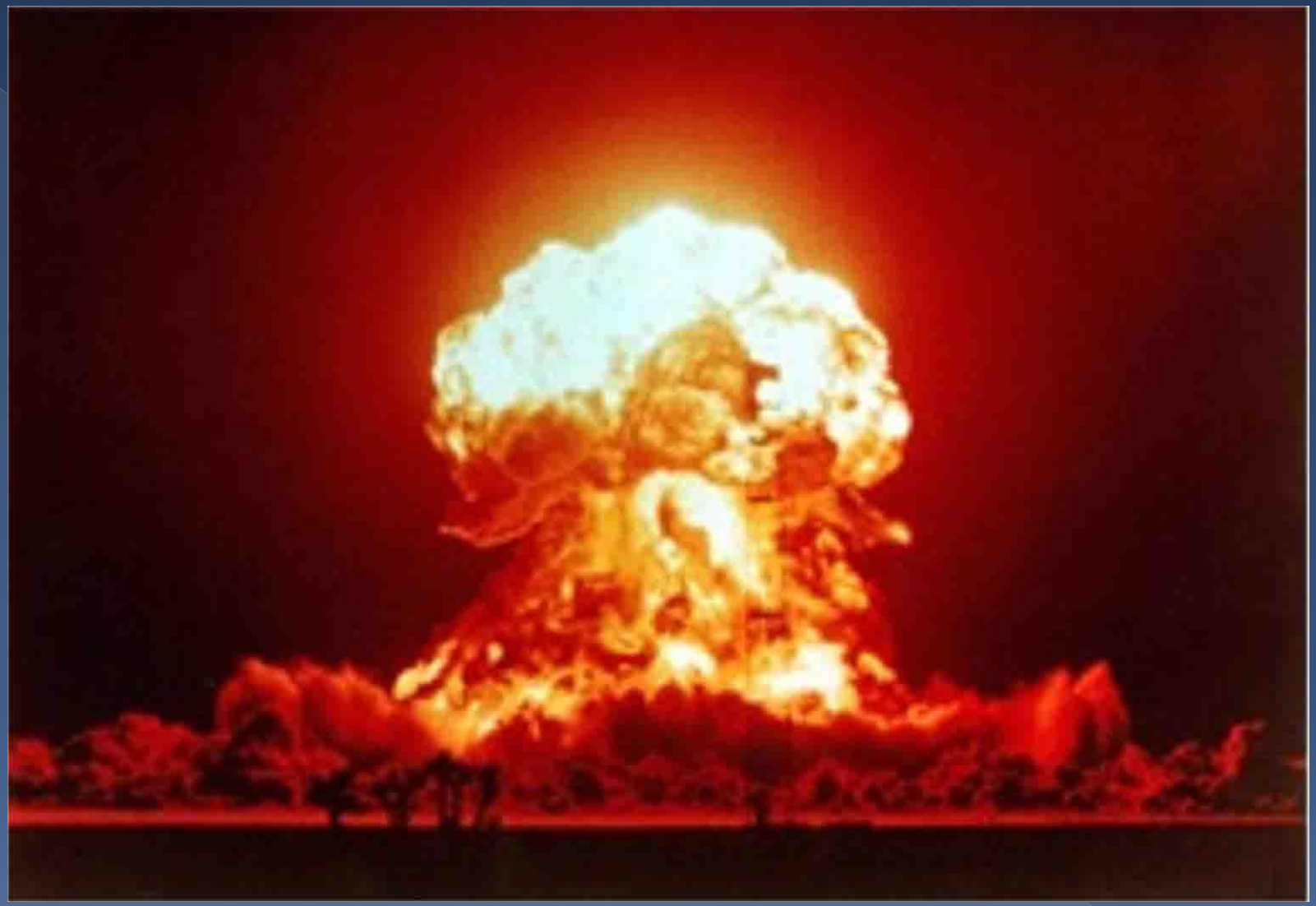
**Figure 4.40** X rays are commonly used to locate a break in a bone, such as this forearm fracture.

- Video Clip

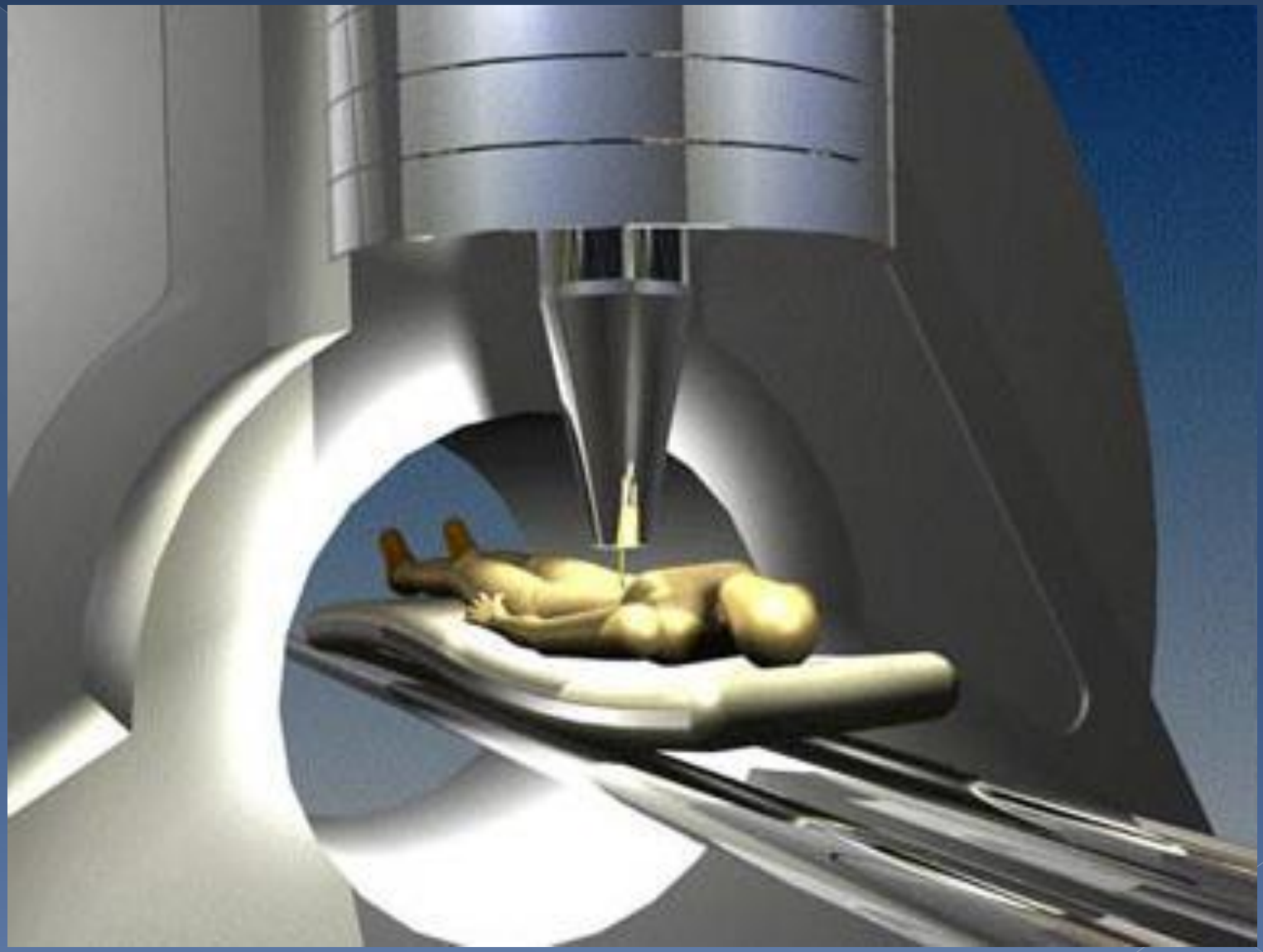
## 7. Gamma Rays

- **Shortest** wavelength
- **Highest** energy
- **Highest** frequency

- Result from nuclear reactions
- Used to kill cancer cells



Video Clip



# In order of:

Longest wavelength
Lowest energy
Lowest frequency

Shortest wavelength
Highest energy
Highest frequency

Radio, microwave, infrared, visible, ultraviolet, x-ray, gamma

http://natgeotv.com/ca/known-universe/videos/emitting-light

# Compare the Different Types of Electromagnetic Radiation

Complete the following table comparing the different types of electromagnetic radiation (copy it into your notebook). Use your notes to help you.

| Type of Electro-magnetic Radiation | Radio Waves | Microwaves (radio waves) | Infrared Waves | Visible Light | UV Waves | X-Rays | Gamma Rays |
|---|---|---|---|---|---|---|---|
| Wavelength | | | | | | | |
| Energy | | | | | | | |
| Frequency | | | | | | | |
| Example | | | | | | | |

# Is electromagnetic radiation dangerous?

- **Higher** energy electromagnetic radiation (gamma rays) is more harmful than **lower** energy (radio waves).

- The atmosphere protects us by reflecting **higher** energy radiation

# Electromagnetic Radiation Positive or Negative?

- Page 166

| Type of Radiation | Positive effects | Negative effects |
|---|---|---|
| Radio Waves | | |
| X-rays | | |
| Ultraviolet rays | | |
| Gamma rays | | |

| Type of Radiation | Positive effects | Negative effects |
| --- | --- | --- |
| Radio Waves | Telecommunications | Uncertain of long term exposure |
| X-rays | Medical detection | Over-exposure can lead to cancer |
| Ultraviolet rays | Treats jaundice<br>Produces vitamin D | Over-exposure can cause skin cancer |
| Gamma rays | Kills cancer cells | Over-exposure can cause cancer, death. And other serious health issues |

# Homework

- Do questions 1-12 on page 167

# Assignment

- Electromagnetic Radiation

# Tanning Bed Project

- Project Outline Handout
- Intro Video Clip

https://www.youtube.com/watch?v=jyAwGlRnnNk