

Enlightism  
Spreading Inspiration

# IGCSE Physics

## The EM spectrum

Contributed by Mam  
Sheherbano

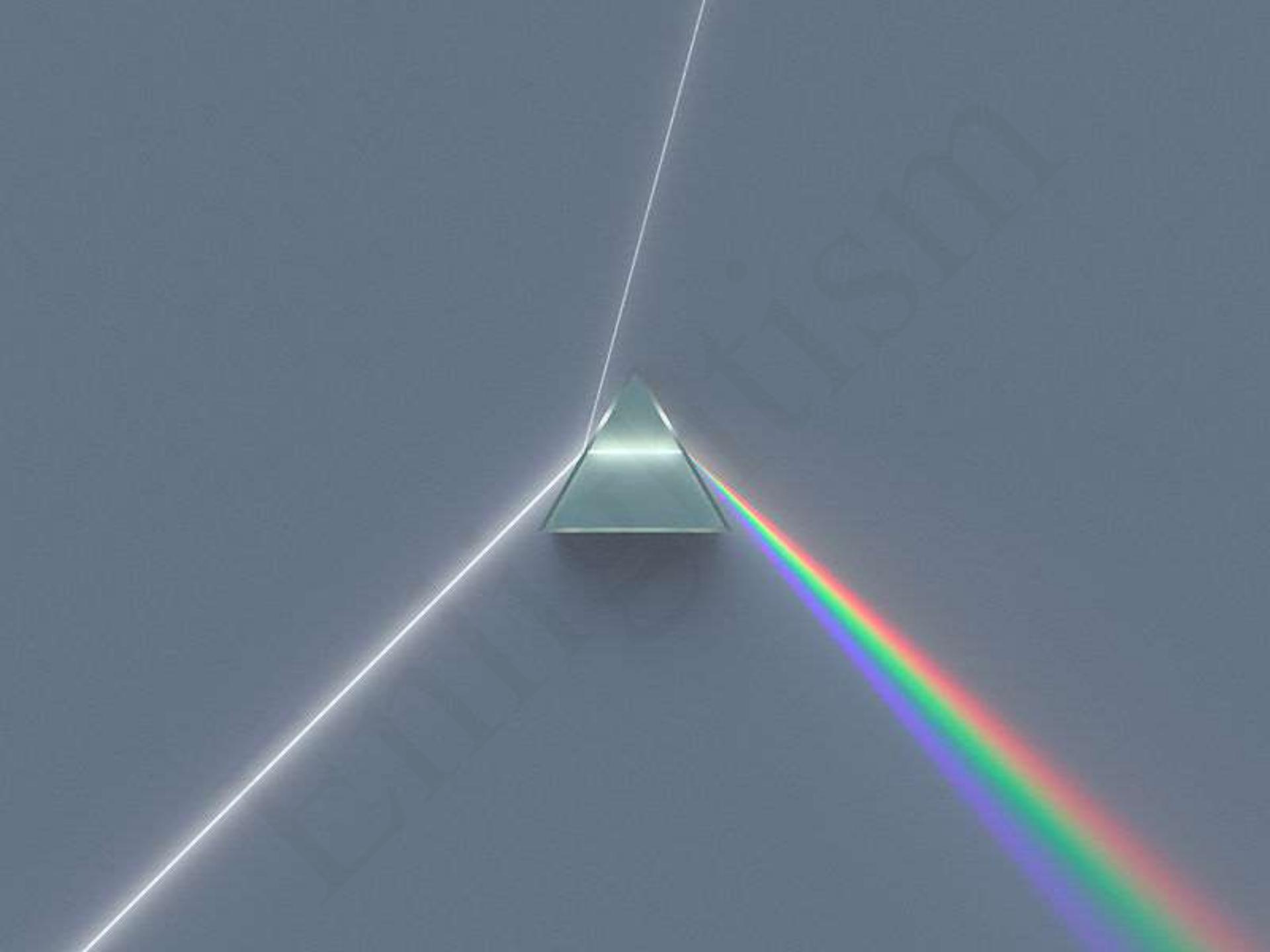
# IGCSE Physics

## Waves

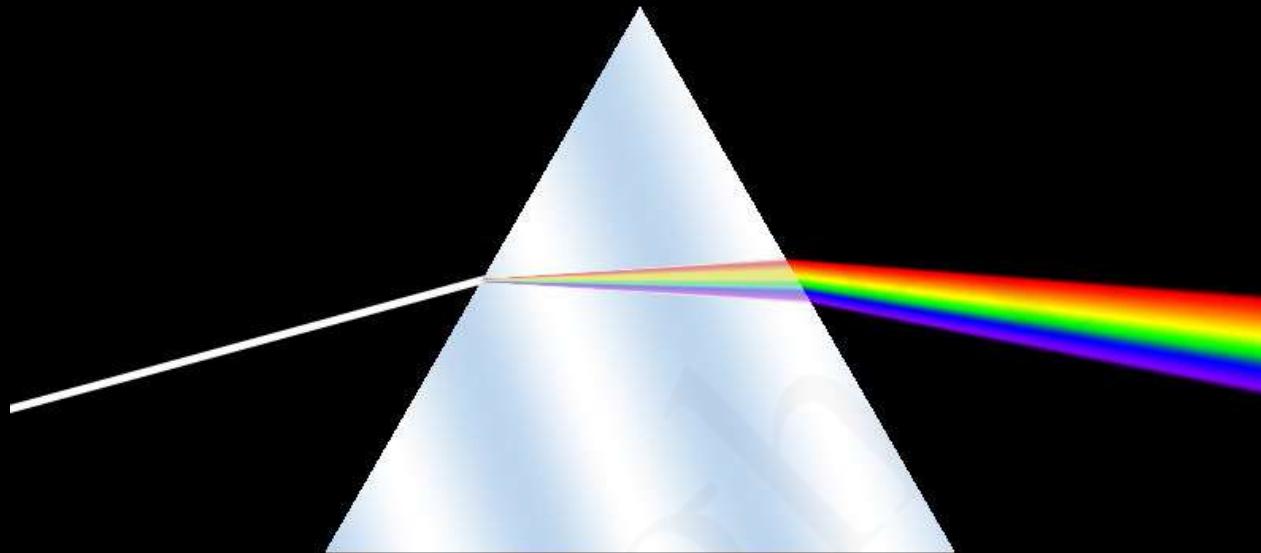
# Lesson– The EM Spectrum

Aims:

- To understand that light is part of a continuous electromagnetic spectrum which includes radio, microwave, infra-red, visible, ultraviolet, X-ray and gamma ray radiations and that all these waves travel at the same speed in free space.
- To recall the order of the electromagnetic spectrum in decreasing wavelength and increasing frequency, including the colours of the visible spectrum.
- To recall some of the uses and dangers of electromagnetic radiations.

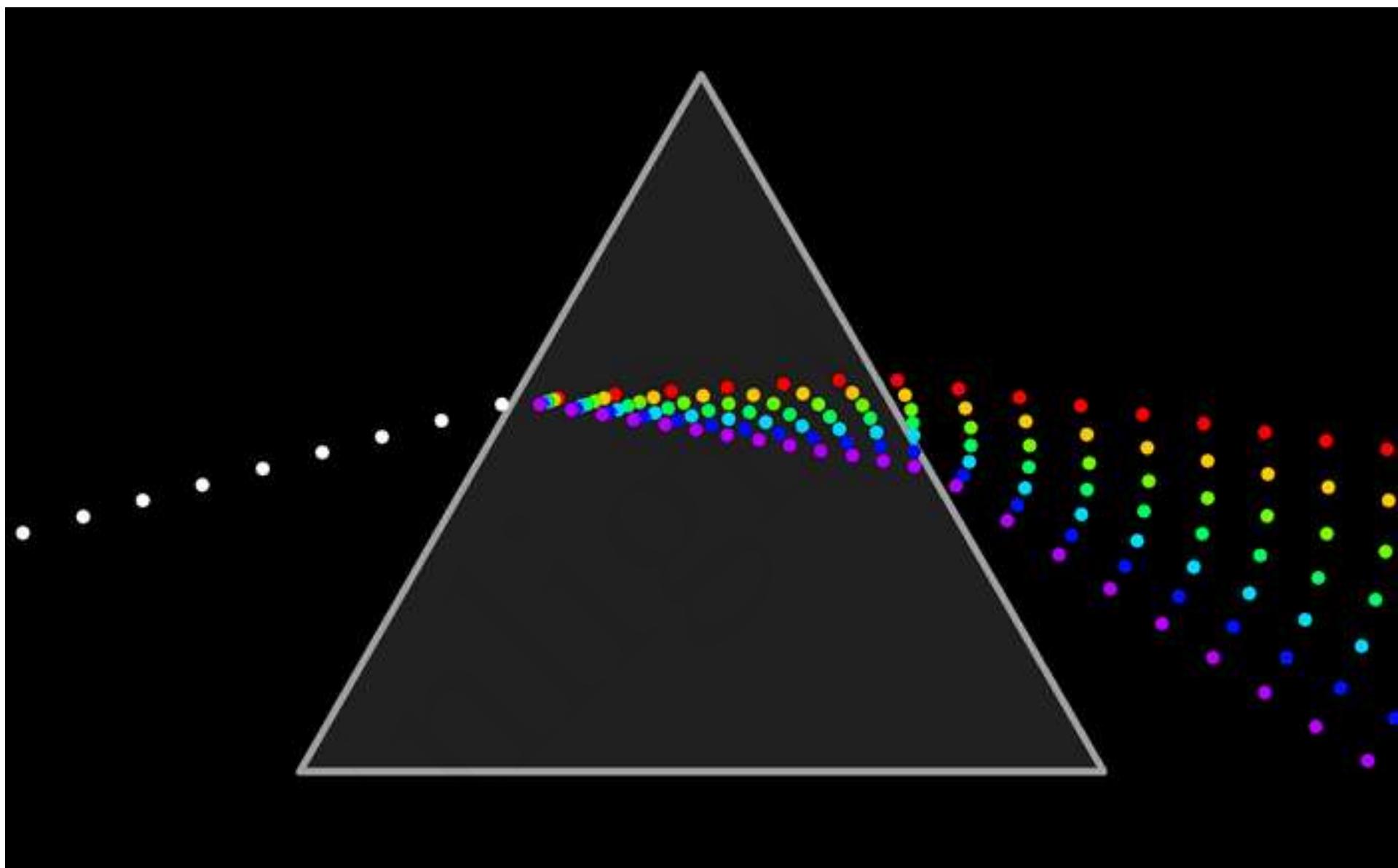


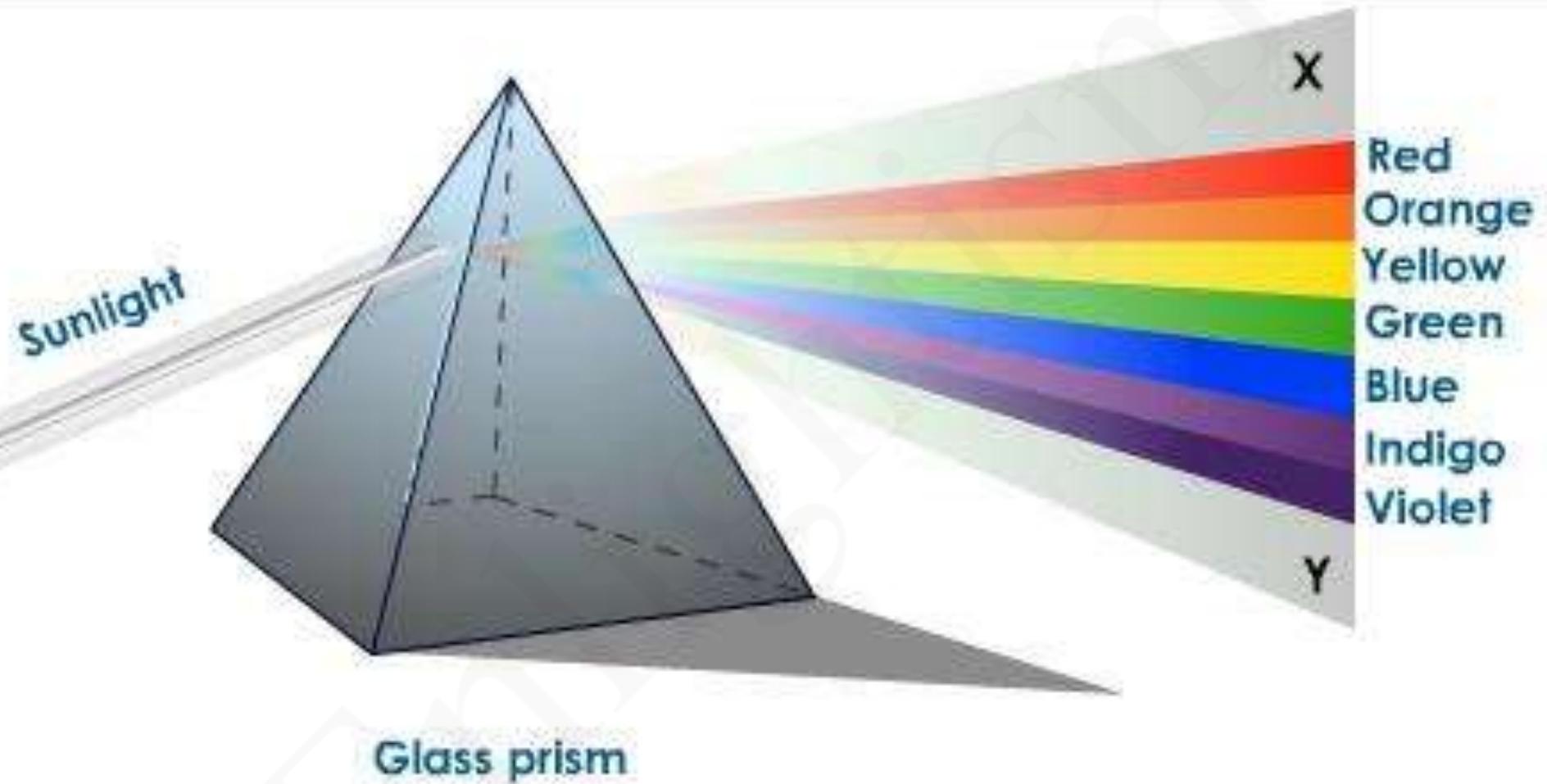
# Dispersion



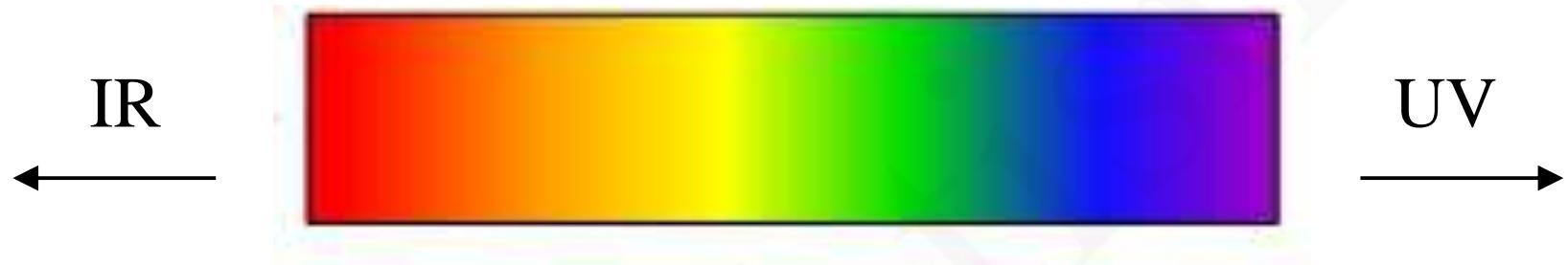
We can split white light into a range of colours using a prism. This process is called dispersion. There are millions of different colours but we normally say that there are just seven.

Red, Orange, Yellow, Green, Blue, Indigo and Violet.



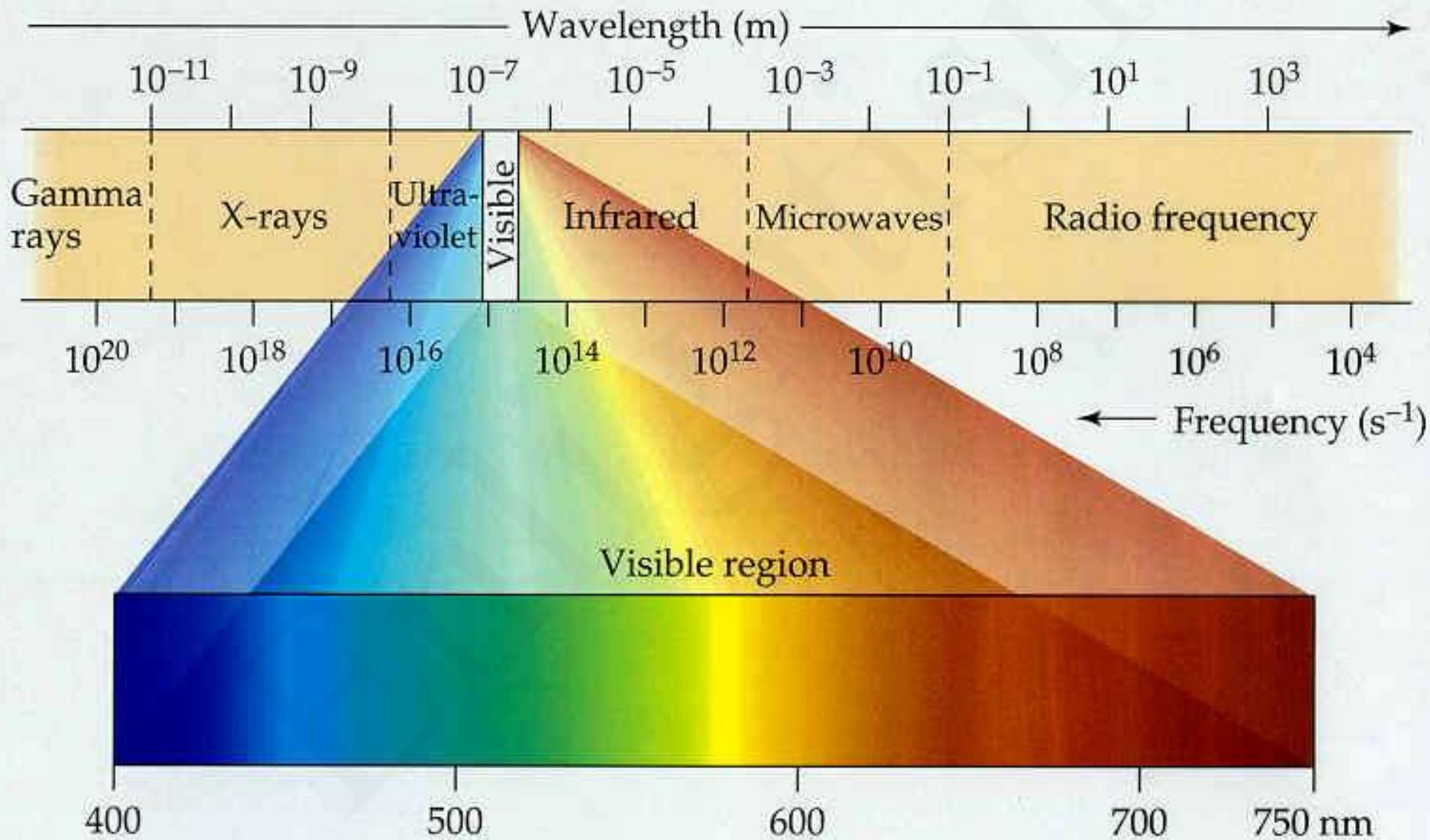


# Above and below

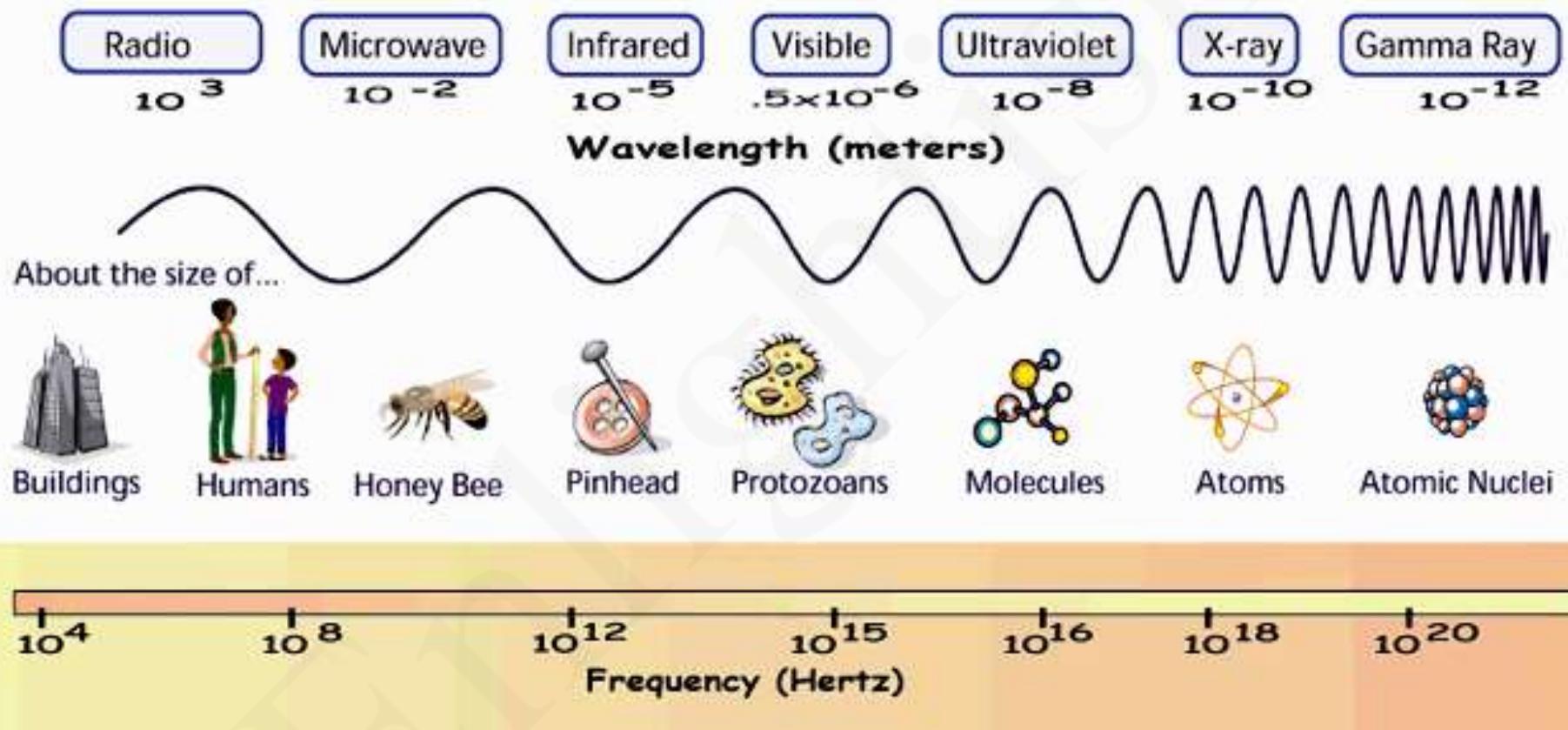


- Colours of light that we cannot see that have frequencies below red are called Infra-Red, infra means ‘below’ or ‘less than’.
- Colours of light that we cannot see that have frequencies above blue are called Ultra-Violet, ultra means ‘beyond’ or ‘above’.
- Some animals can see in the Infra-Red and Ultra-Violet.

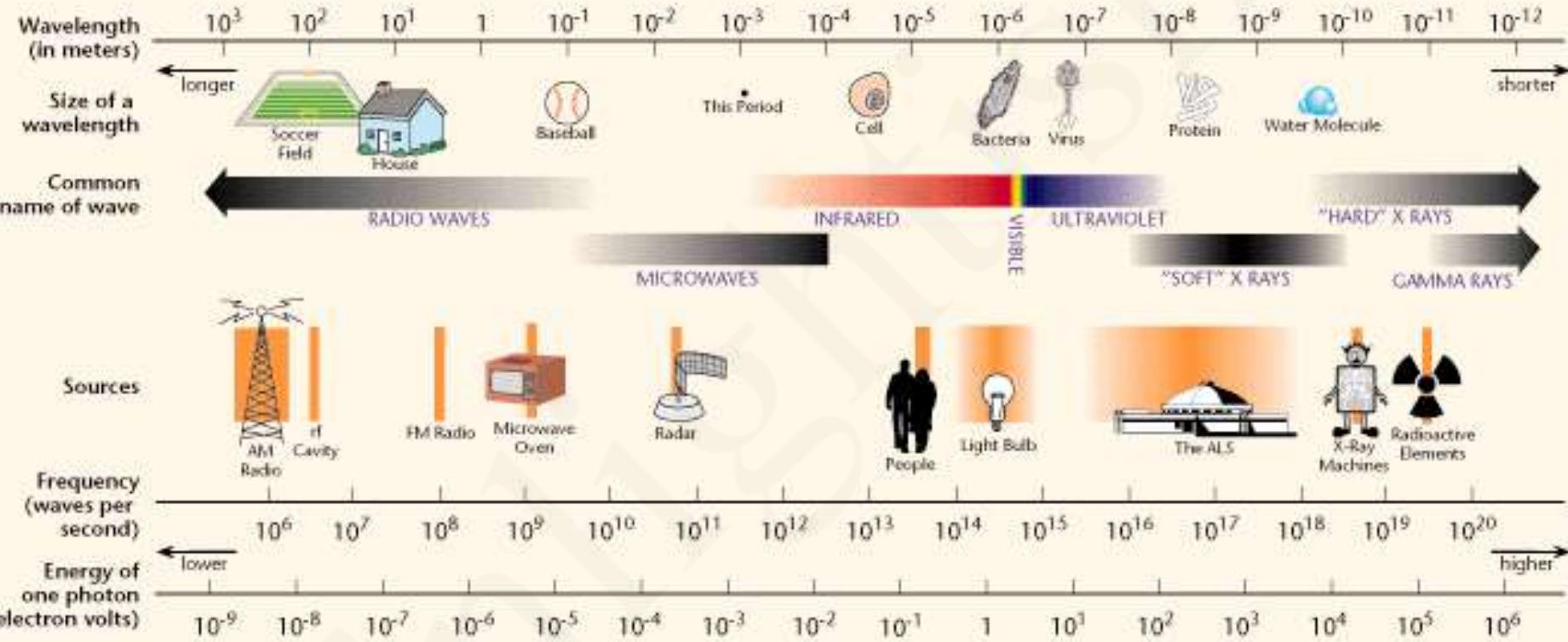
# The Electromagnetic Spectrum



# The size of the EM spectrum



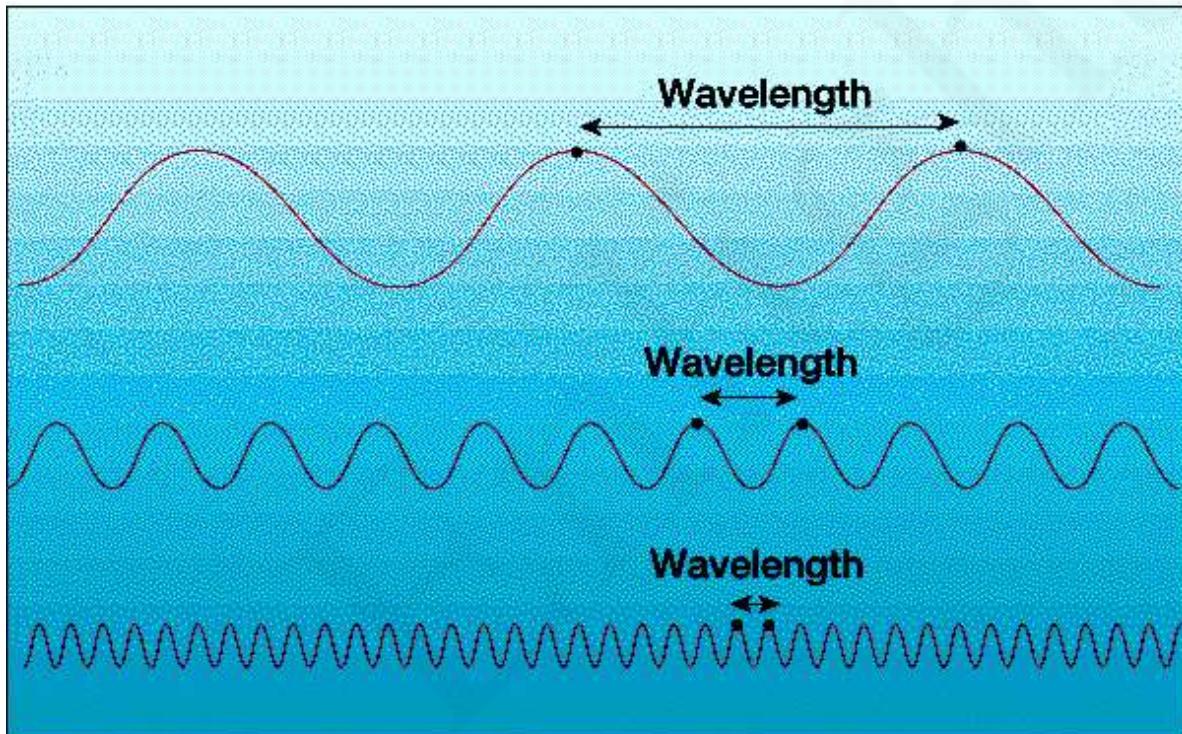
# THE ELECTROMAGNETIC SPECTRUM

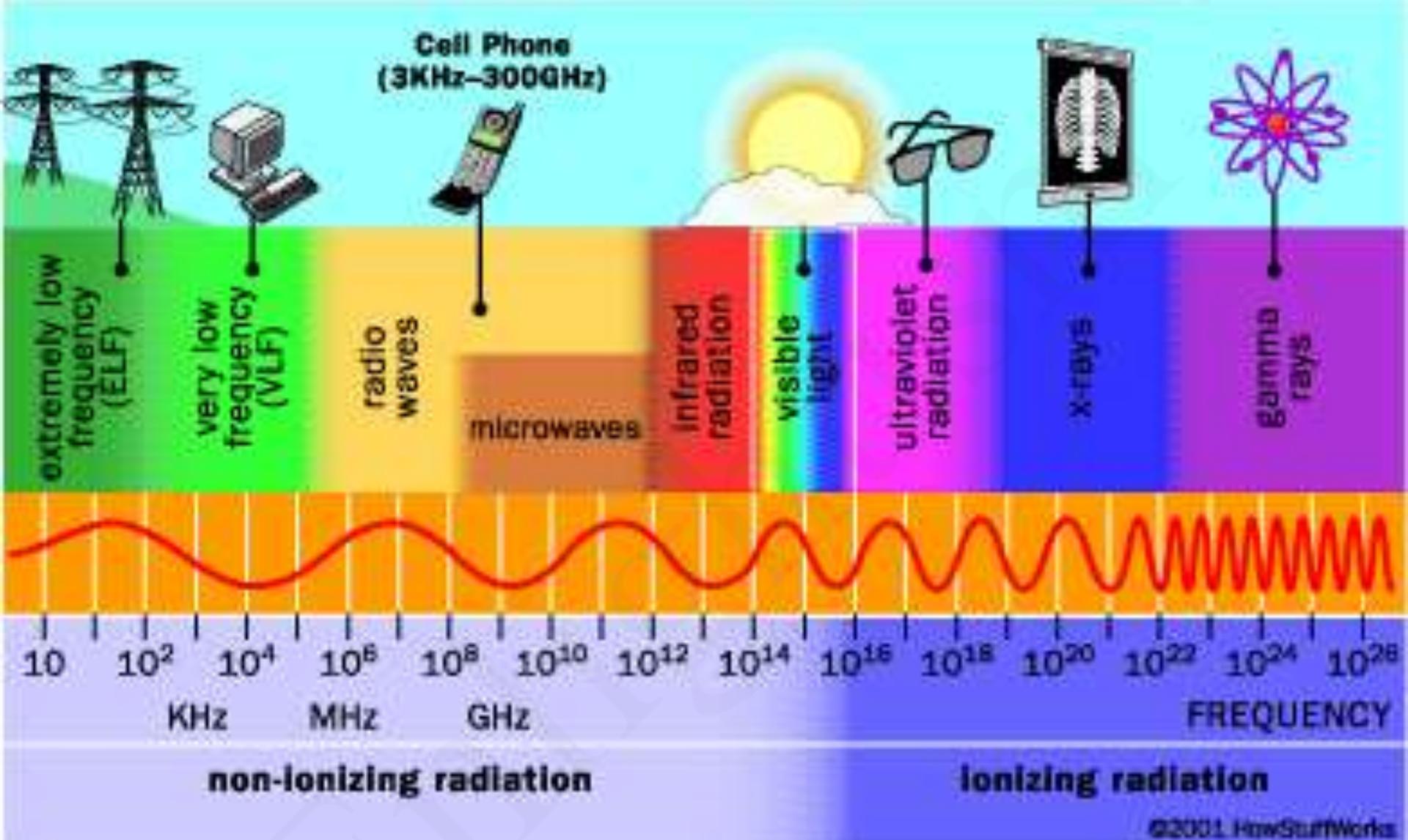


Long Wavelength  
Low Frequency  
Low Energy

# EM Radiation

Shorter wavelength  
means more danger.





Ionizing electromagnetic radiation can be dangerous to our health.

# Speed of Light

- Light and all other Electromagnetic waves travel at the same speed, called the **speed of light!**
- In free space (a vacuum like outer space), light travels at **300,000,000 m/s.**
- When light or other EM waves pass through the **air** they move only a **tiny bit slower.**
- Light can travel round the equator of the Earth eight times in a second.

$$c = 3 \times 10^8 \text{ m/s} = 186,000 \text{ miles/s}$$

# The electromagnetic spectrum

- Light, a type of radiation, is part of the electromagnetic spectrum.
- The electromagnetic spectrum is made up of different types of radiation.
- The different types of radiation have different properties and behaviour.
- All electromagnetic waves can travel through space.
- All electromagnetic waves travel at the same speed in a vacuum (300,000,000 m/s).

~~TRUE/FALSE~~

~~TRUE/FALSE~~

~~TRUE/FALSE~~

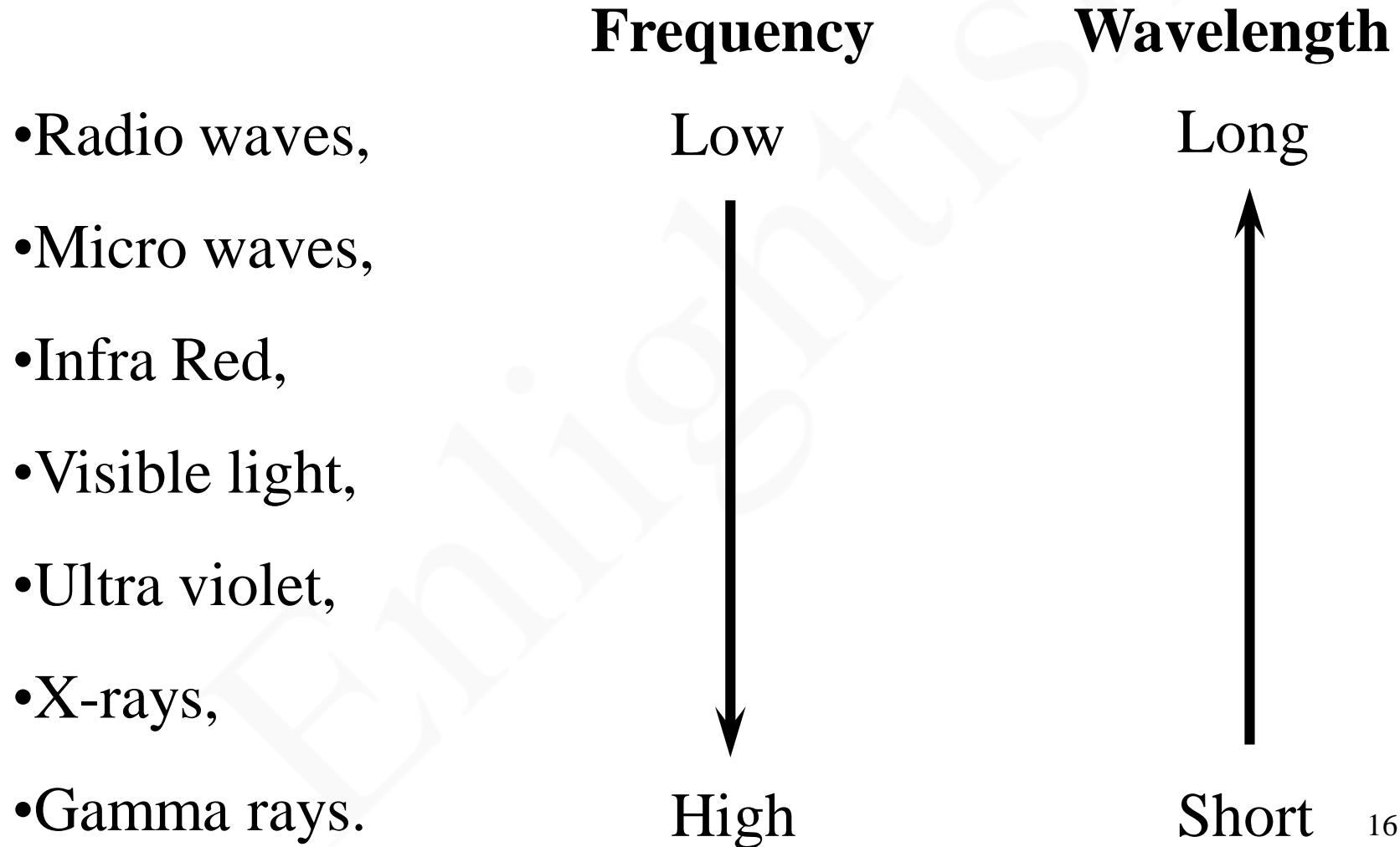
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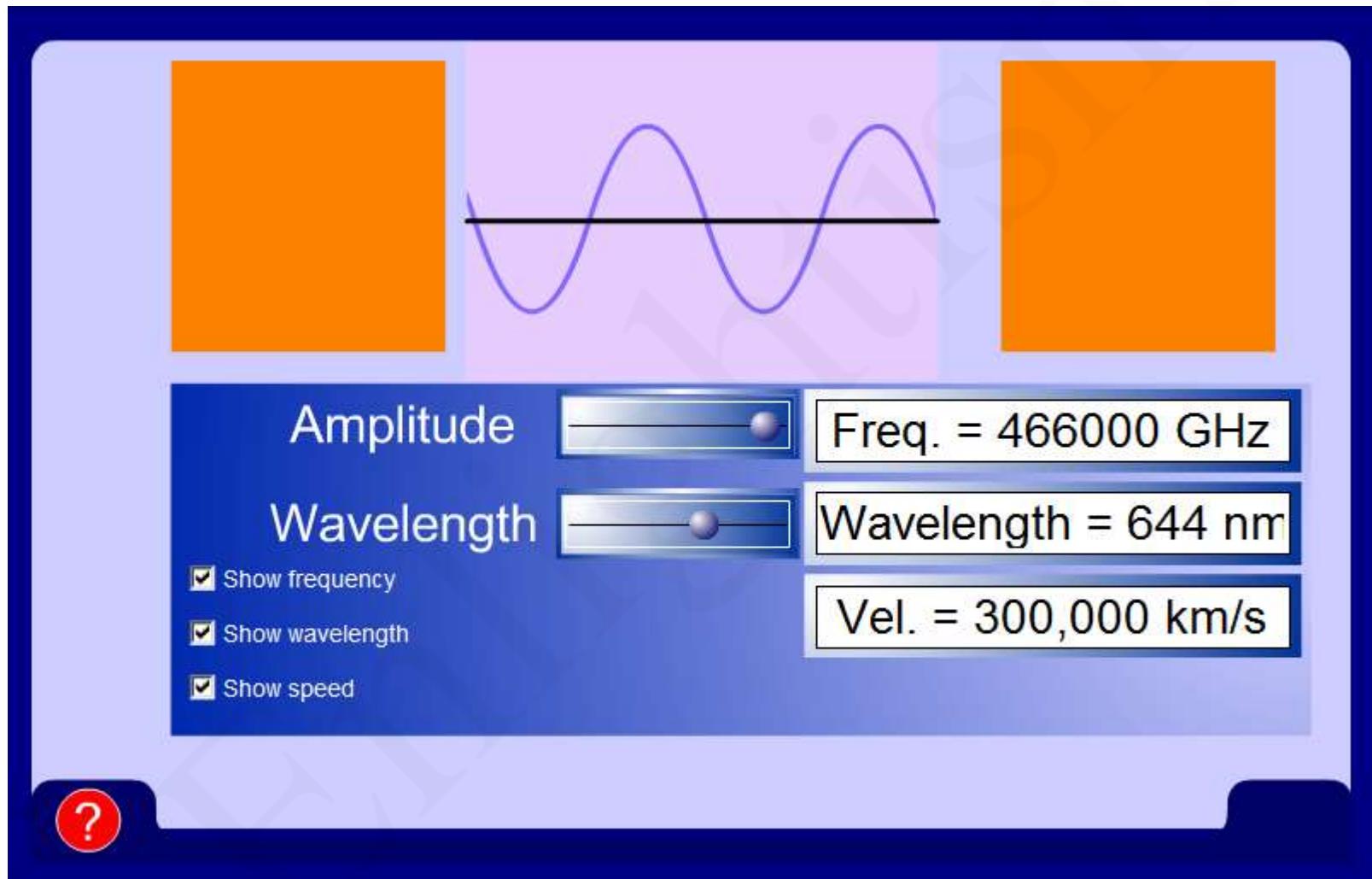
# Mnemonics

- Radio waves,
- Micro waves,
- Infra Red,
- Visible light,
- Ultra violet,
- X-rays,
- Gamma rays.
- Rich
- Men
- In
- Love
- Use
- Xtra
- Gel

# Frequency and wavelength



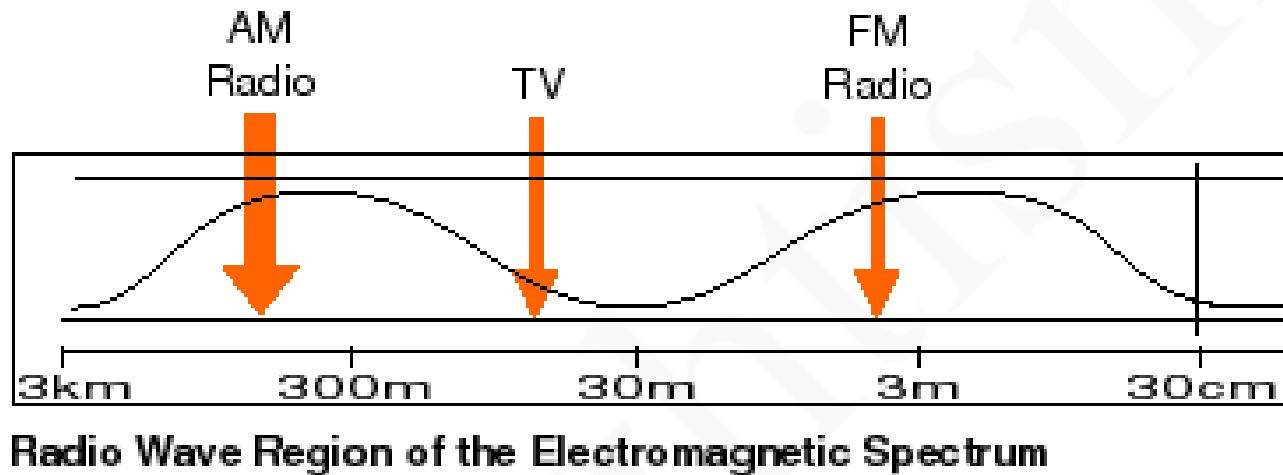
# Colour, wavelength and amplitude



# Uses and Dangers

While there are many uses and dangers associated with electromagnetic waves we only need to learn a few.

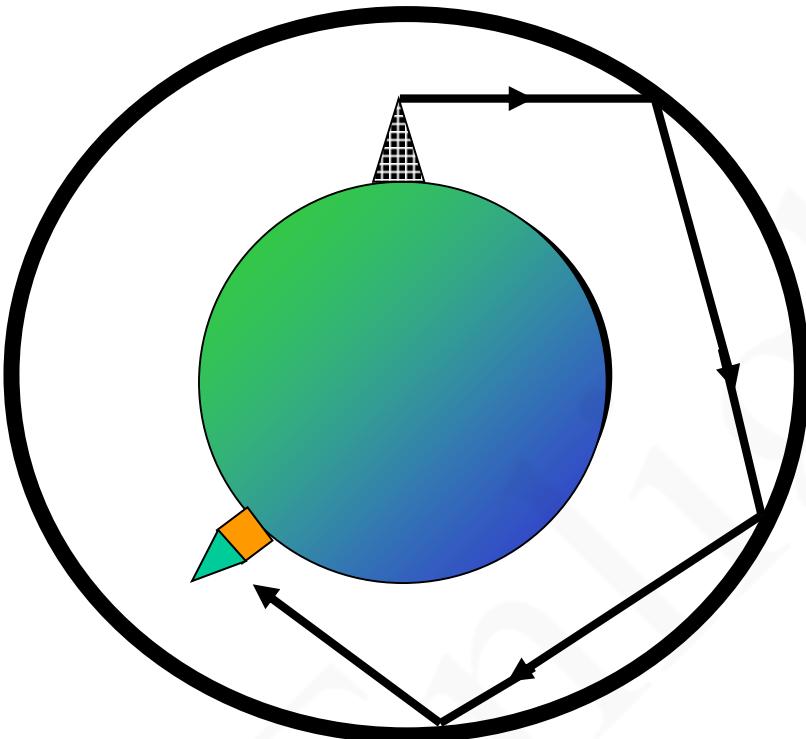
# Radio waves



Radio waves are used for broadcasting sound and television. They are very useful as they bounce off the ionosphere and can therefore travel long distances.

Radio waves can be transmitted and received by cheap and reliable antennas.

# Radio waves



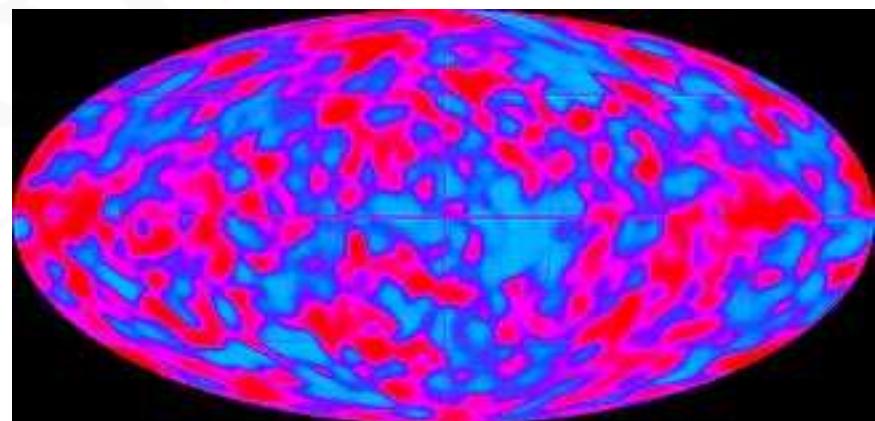
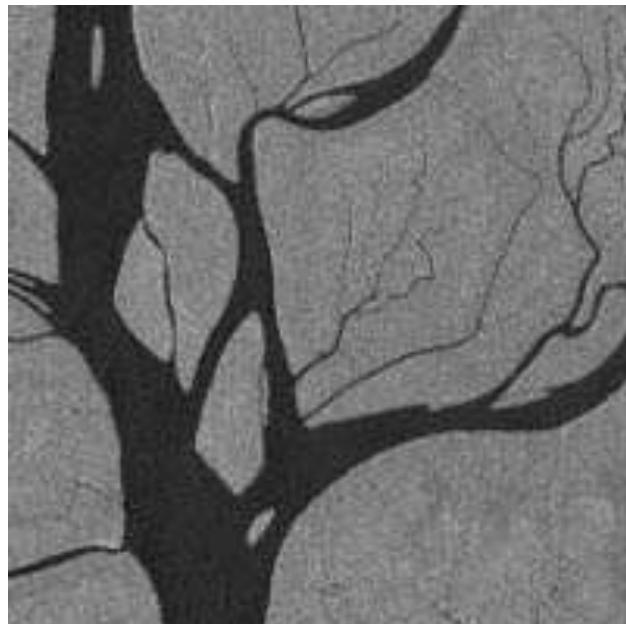
How do radio signals from the UK reach around the globe?

Radio waves of different frequencies behave in different ways.

Some radio waves reflect off the ionosphere of the atmosphere.

# Microwaves

Microwaves are useful for cooking food but are also used for communications. Microwaves can pass through clouds without being affected. They are used for mobile phones and satellite communications.



The Amazon and the background radiation of space.

# Microwave heating

- The microwaves used in a cooking machine are about 12 cm long. They **vibrate water** and fat particles to make them **hot**. Microwaves cannot go very far into food which is why big turkeys cannot be cooked in a normal microwave oven.
- Microwaves given off by a cooker or a mobile phone can cause the **heating of internal body parts**. A cooker has a **shield** on it to stop this happening. Mobile phones only cause a tiny amount of heating and are not really very dangerous. Just don't phone for a long time or when you are on your bike.

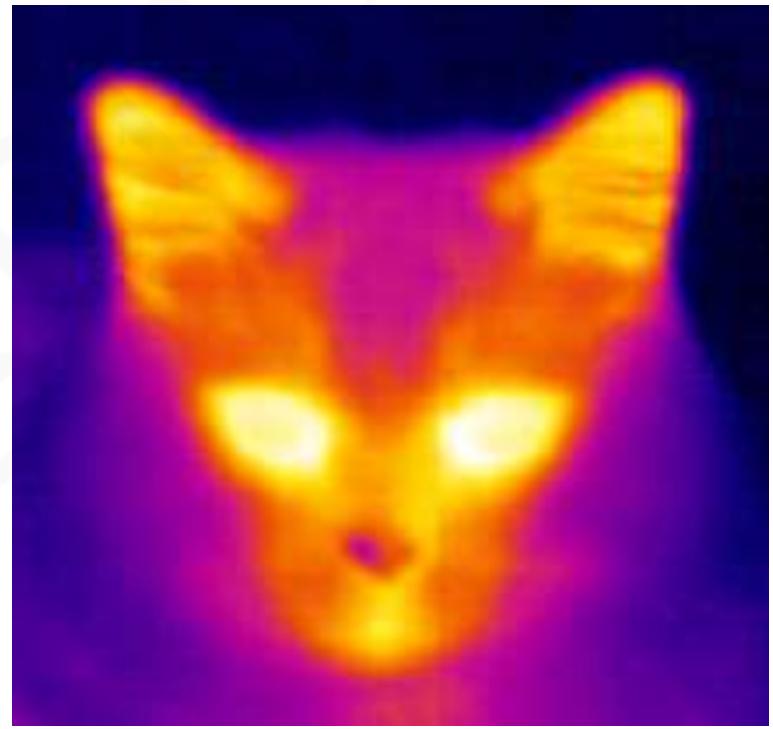
# Infra Red

- All objects that have a temperature give off some Infra Red (IR) radiation. Unless something is much hotter than us we cannot feel this radiation.
- A heater or grill or toaster uses IR radiation to heat a room or cook some food.
- Special cameras can be used to change IR into visible light so that we can see hot objects.
- Too much IR radiation, such as sticking your hand under a grill, can cause burns to our skin.

# Infra red images



A man with a match

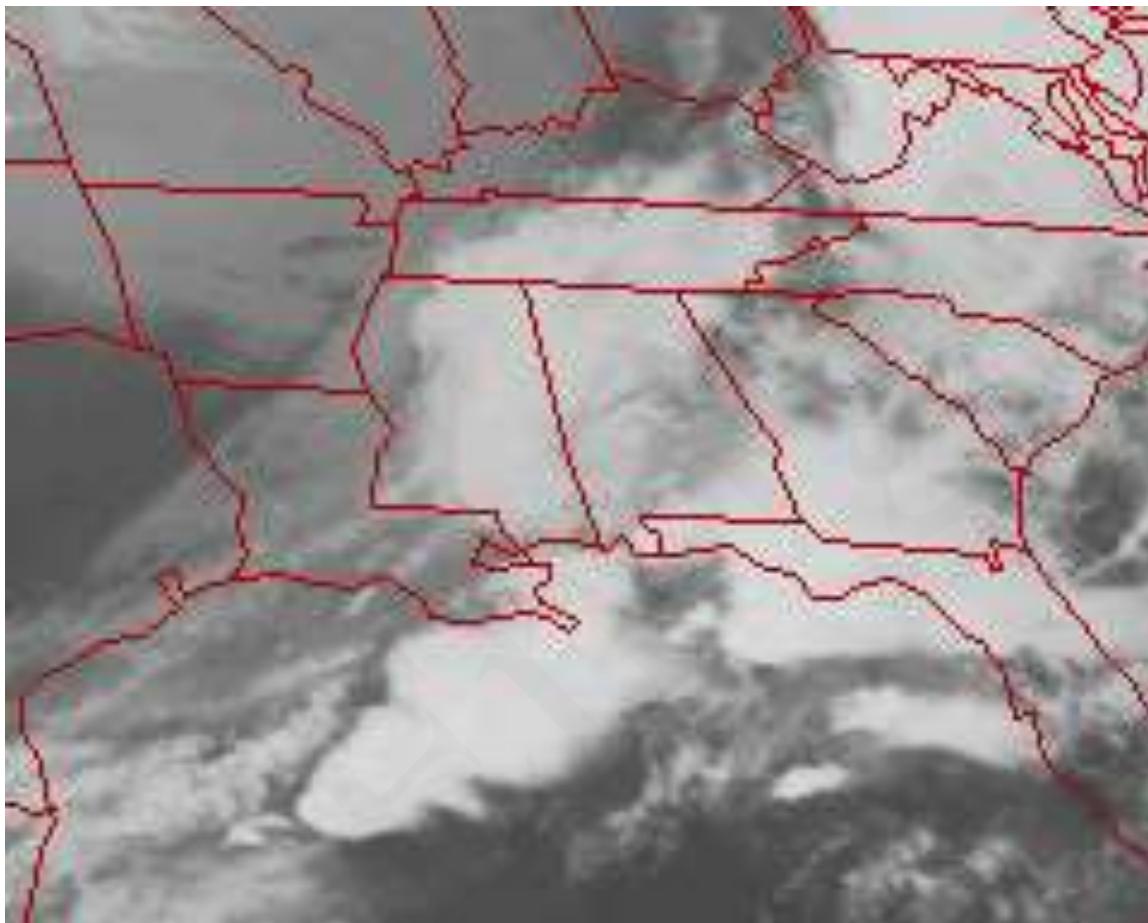


The eyes of a cat

# Night vision



# Infra red satellite images



## Infra red

- Images based on heat radiation,
- Cool places seen as white,
- Hot places seen as dark,
- May be viewed day and night.

# Ultra Violet

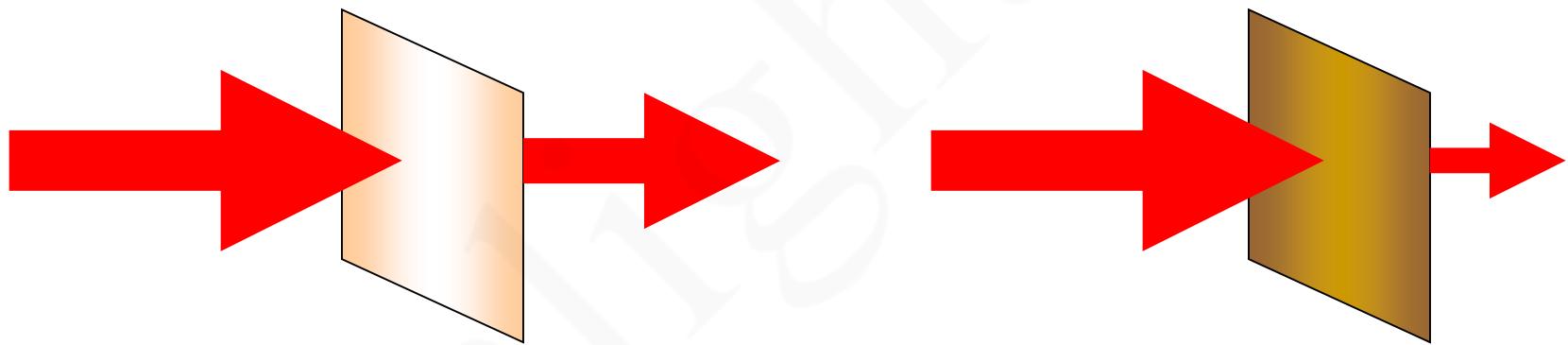
- Ultraviolet light can come from the Sun or artificial lamps. 10 % of the Sun's light is UV.
- An ultraviolet sunbed can be used to change the colour of our skin.
- Ultraviolet lamps are used to prevent crime by detecting chemicals that we cannot see and checking to see whether a bank note is forged or real.

# Damaging UV

- Unfortunately UV light is damaging to our eyes and skin. Frequent exposure can lead to eye problems and even blindness (Galileo).
- UV light can also cause skin cancer, which is why you should wear sun block even if your skin does not burn.
- The Earth is protected from a lot of UV light by the ozone layer; unfortunately chemicals from air con, fridges and other industries have made a big hole in the layer.

Ultraviolet radiation can pass through skin to deeper tissues.

What effect do you think the colour of the skin has on the amount of radiation that passes through it?

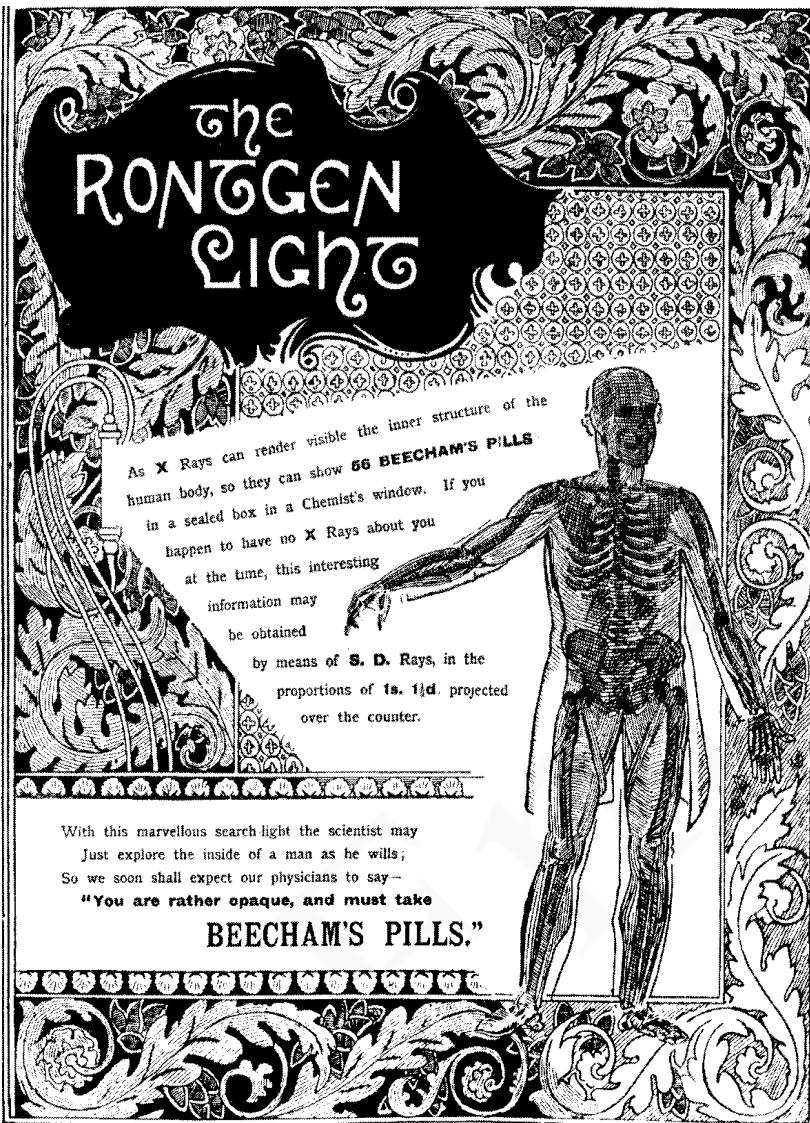


The darker the skin, the more ultraviolet radiation is absorbed, and the less can reach into deeper soft tissues.

# X-rays

- X-rays are very small waves that can pass through our bodies. Some X-rays can pass through flesh but not bone, this lets us see shadows of our bones.
- X-rays are very dangerous and can cause cancer. In small doses they are less likely to cause cancer and are very useful for looking for broken bones.
- X-rays are also very useful for looking inside all sorts of objects. They are used to find cracks in pipes and aircraft parts. They are also useful for looking inside suitcases without having to open them.

# Old X-rays



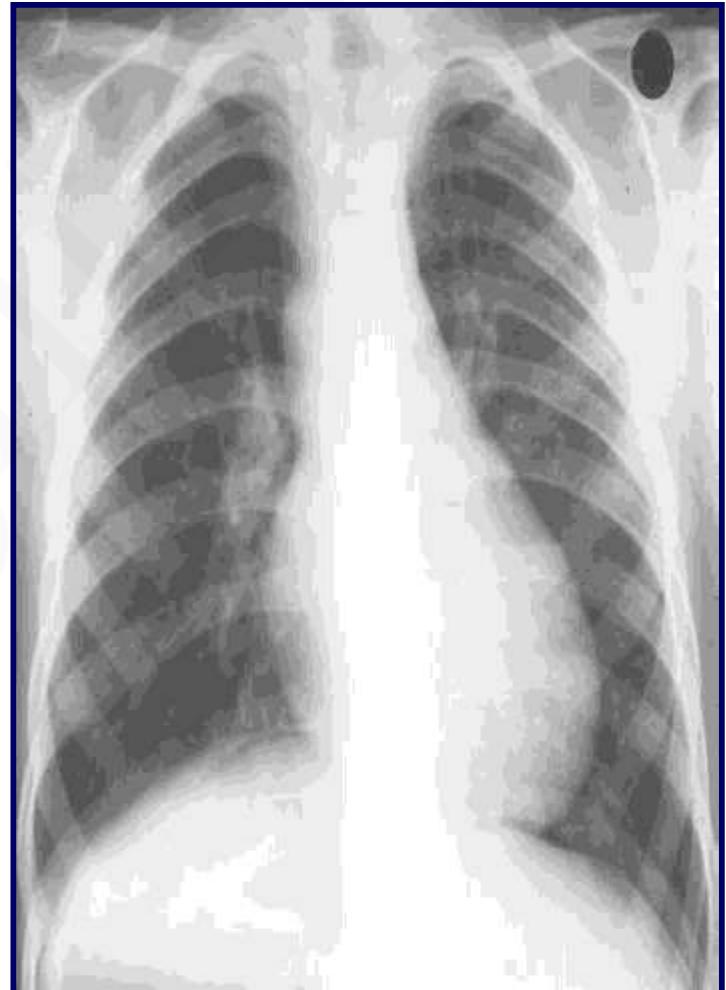
- Discovered in 1895 by William Roentgen, he took this photo of his wife.
- At first people did not know they were dangerous and held X-ray shows!

# How are X-ray slides formed?

X-rays can penetrate soft tissue but not bone.

X-rays are absorbed more by some materials than others.

Photographic film is used to detect X-rays.



# Using Gamma rays



Gamma rays are **very penetrating** and can be very dangerous to living cells.

But there are times when we want to kill living cells, gamma rays can be used to **kill bacteria**.

# Using Gamma rays



Gamma rays can be used to kill bacteria living on **fruits**, such as strawberries, so that they last longer before becoming rotten.

The gamma irradiation does not affect the quality of the fruit. Many **meats**, such as chicken and pork, are also irradiated. Gamma radiation saves thousands of lives each year.

# Sterilisation



Gamma rays can be used to **sterilise** all sorts of **medical equipment** to make sure that patients do not become infected by bacteria. Even a tiny amount of bacteria can grow to become a life threatening illness for a post operative patient.

# Gamma Medicine

- Small amounts of gamma emitting chemicals can be placed inside the body to detect defects and problems. While they cause some damage they may save someone's life.
- Gamma rays can also be used to **treat cancer** by focussing beams of gamma rays onto cancer cells. This treatment can be dangerous and painful but may prolong or save someone's life. X-rays are also used to treat cancer by this method.

# Gamma camera



# Summary – The EM spectrum

- Light is one of many waves in the electromagnetic spectrum.
- In order of decreasing wavelength (increasing frequency) they are: Radio waves, Microwaves, Light waves, Ultra violet, X-rays and gamma rays.
- Red light has a longer wavelength than blue light.
- EM waves can be dangerous but are used in many different ways in our everyday lives.



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