1. THE NATURE OF LIGHT

UNIT 5 – ATOMIC STRUCTURE

CH40S MR. WIEBE

INTRODUCTION

- Atomic structure explains chemical properties and patterns of chemical reactivity.
- Chemical reactions involve electrons. Knowing where the electrons are and how many there are helps explain many chemical phenomena.
- We use different forms of light to explore atomic structure (spectroscopy). Because of this, we start with a discussion of the nature of light.

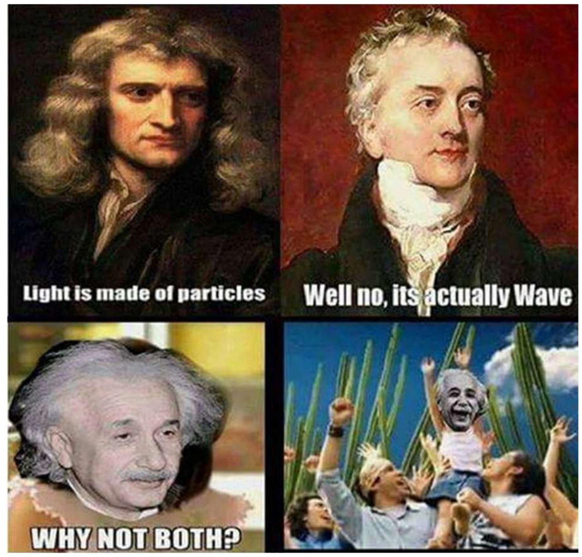
THE NATURE OF LIGHT - PARTICLES OR WAVES??

Isaac Newton: Light must be made of particles because it…

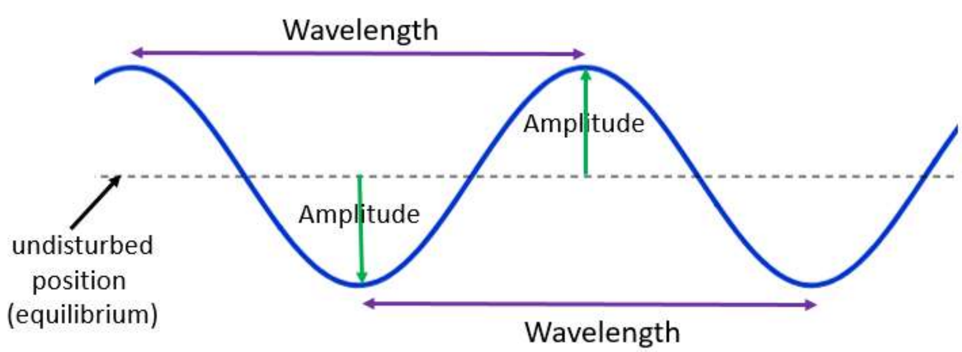
- travels in a vacuum
- reflects off objects
- exerts force (on the tails of comets)

Christiaan Huygens: Light must consist of waves because it…

- reflects like waves
- refracts and diffracts
- exhibits interference



GENERAL CHARACTERISTICS OF WAVES



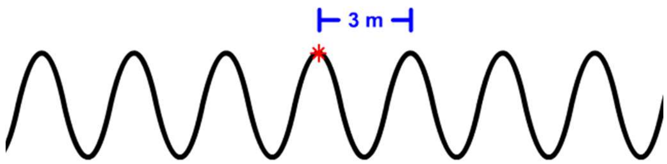
Amplitude: maximum displacement of a point on a wave away from its undisturbed position

Wavelength: distance from a point on one wave to the equivalent point on the adjacent wave.

GENERAL CHARACTERISTICS OF WAVES

Frequency: the number of times a crest passes a fixed point per unit of time.

$$v = (\lambda)(f)$$

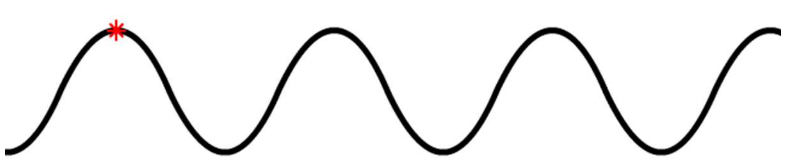


3 meters per wave
2 waves per second

WAVELENGTH AND FREQUENCY

Higher Frequency **Smaller Wavelength**

Wavelength and Frequency are Inversely Proportional

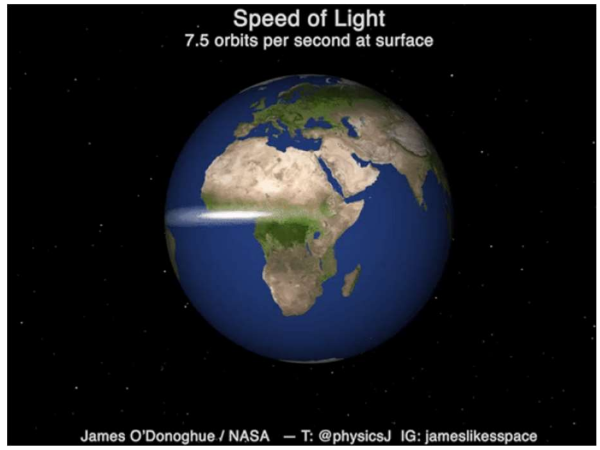


Less Frequency **Bigger Wavelength**

THE WAVE NATURE OF LIGHT

Light travels through space as a wave.

It travels at a constant speed equal to 3.00 x 10^8 m/s or 300 million m/s.



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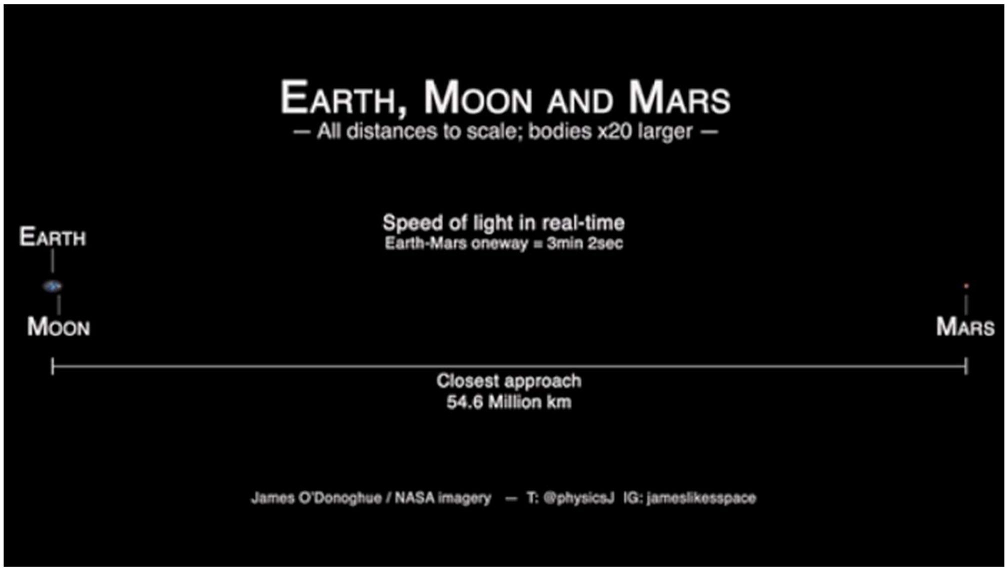
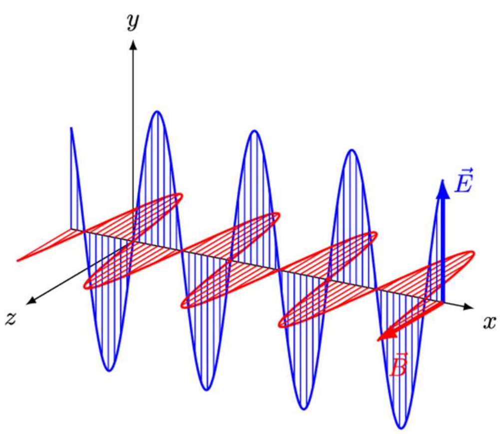
THE SPEED OF LIGHT IS FAST…

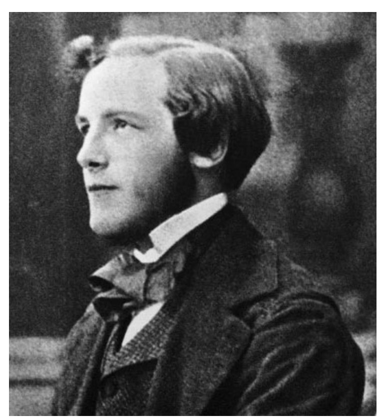
…BUT ONLY RELATIVELY.



BY THE END OF THE 1800's…

Light is an <u>electromagnetic wave</u> composed of continuous wavelengths that form a spectrum. Light and matter are two distinctly different entities.

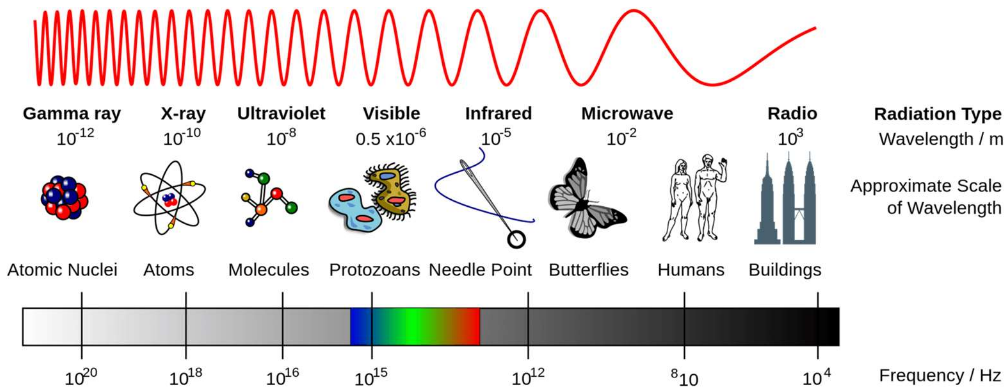




JAMES MAXWELL

<u>**E**</u>LECTRO<u>**M**</u>AGNETIC <u>**R**</u>ADIATION (EMR)

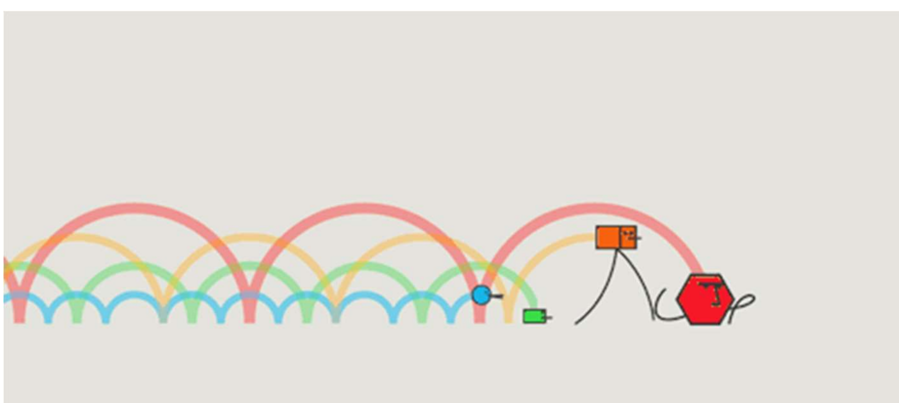
Light can be broken down into <u>7 different types</u>. These types are categorized based on wavelength and frequency.



<u>R</u>aging <u>M</u>artians <u>I</u>nvaded <u>ROY G. BIV U</u>sing <u>X-Ray</u> <u>G</u>uns

SUMMARY

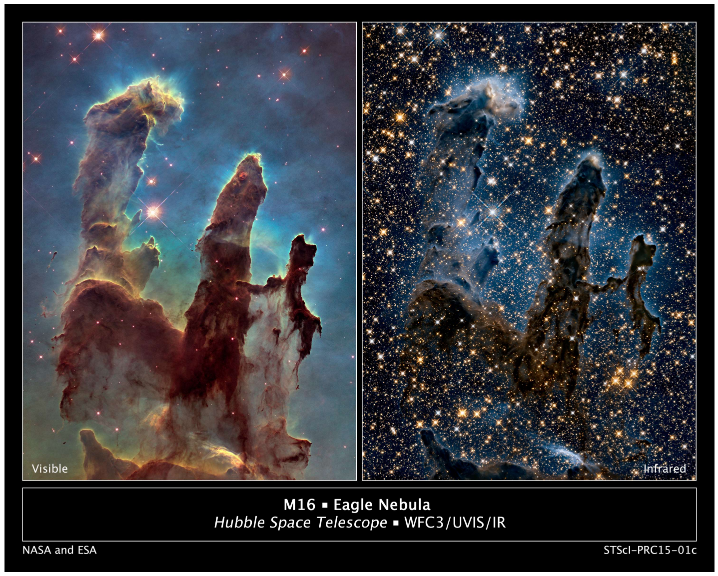
All types of light travel at the same speed.



Different types of light have different wavelengths and frequencies that are inversely proportional.

INFRARED SPECTROSCOPY

NASA's Hubble Space Telescope has cameras that can capture different wavelengths of light, resulting in images that show different perspectives of the same object.



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THERMAL IMAGING

Thermal (infrared) imaging is very useful. It can be used to detect abnormal heat signatures in electrical circuits as well as in animals.

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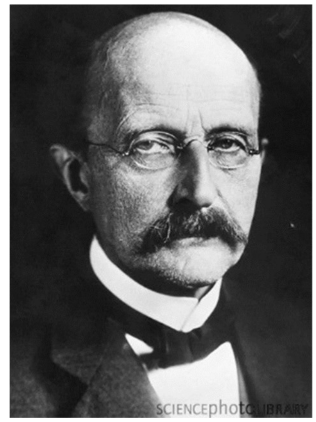
PARTICLE THEORY OF LIGHT

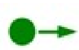


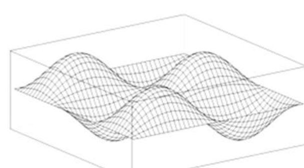
- In the early 1900's, new evidence was discovered by Max Planck, Albert Einstein, and others that resurrected the particle theory of light.
- Light is now thought to be composed of particles (quanta) each carrying a fixed amount of energy. These particles are called photons.
- The amount of energy per photon is directly proportional to the frequency of the light:

$$\boxed{E = h\nu \quad \text{or} \quad E = \frac{hc}{\lambda} \quad , h = 6.626 \times 10^{-34}\ J \cdot s}$$

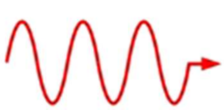
PHOTONS = WAVICLES?

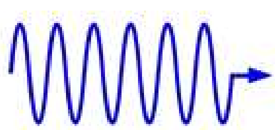
Particle + Wave =





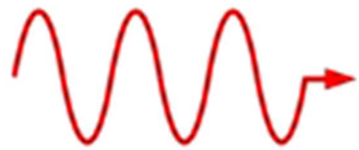
PHOTONS!



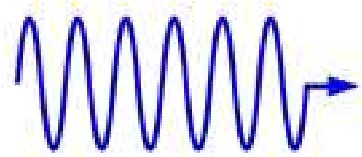


IN OTHER WORDS…

<u>LARGE</u> Wavelength = <u>SMALL</u> Frequency = <u>SMALL</u> ENERGY PHOTON



<u>SMALL</u> Wavelength = <u>LARGE</u> Frequency = <u>LARGE</u> ENERGY PHOTON



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CONVERTING BETWEEN WAVELENGTH & FREQUENCY

$$c = \lambda v$$

λ = wavelength in **<u>meters</u>**

v = frequency ($\frac{1}{s}$ **becomes s^{-1} or Hz**)

c = speed of light (**<u>3.00×10^8 m/s</u>**)

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ENERGY OF A PHOTON

$$E = h\nu \quad \text{or} \quad E = \frac{hc}{\lambda} \quad , h = 6.626 \times 10^{-34}\ J \cdot s$$

E = energy of photon (**J**oules)

h = Planck's Constant

V = frequency of wave (Hz or s^{-1})

DON'T FORGET SI UNITS!

Multiplication Factor	Prefix	Symbol
1,000,000,000 = 10^9	giga	G
1,000,000 = 10^6	mega	M
1,000 = 10^3	kilo	k
100 = 10^2	hecto	h
1 = 1		
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000001 = 10^{-6}	micro	µ
0.00000001 = 10^{-9}	nano	n

Gigantic Megaphones Killed 1 Million Microscopic Nanobots

CALCULATIONS INVOLVING EMR

The wavelength of maximum visual acuity in humans is 550 nm.
(green light)

What is the frequency of a **single** photon having this wavelength?

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$1{,}000{,}000{,}000 = 10^{9}$	giga	G
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$0.001 = 10^{-3}$	milli	m
$0.000001 = 10^{-6}$	micro	µ
$0.000000001 = 10^{-9}$	nano	n

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CALCULATIONS INVOLVING EMR

The wavelength of maximum visual acuity in humans is 550 nm.
(green light)

What is the energy of a **single** green photon having this wavelength?

What is the energy of a **mole** of green photons?

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