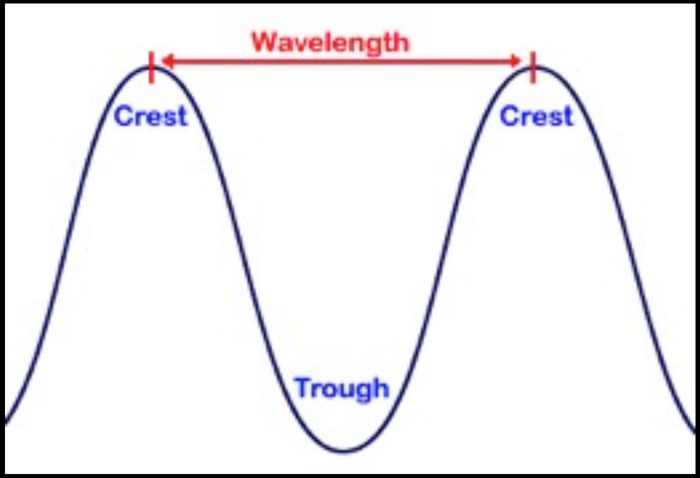
Light
and the
Electromagnetic Spectrum

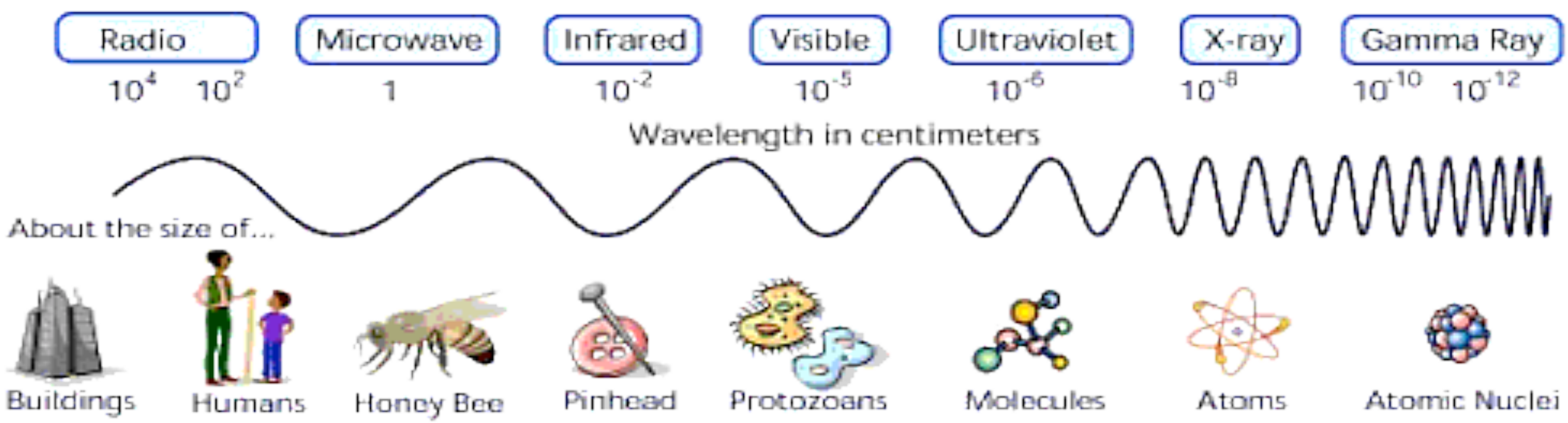
Light Phenomenon

- Isaac Newton (1642-1727) believed light consisted of particles
- By 1900 most scientists believed that light behaved as a wave.



The Electromagnetic Spectrum

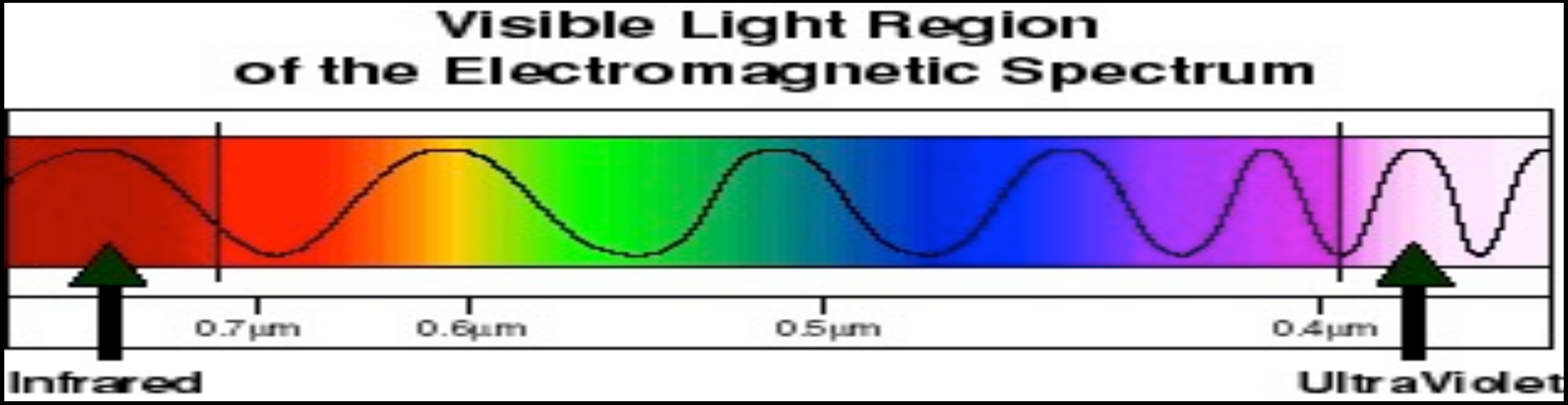
The electromagnetic spectrum represents the range of energy from low energy, low frequency radio waves with long wavelengths up to high energy, high frequency gamma waves with small wavelengths.



Visible light is a small portion of this spectrum. This is the only part of this energy range that our eyes can detect. What we see is a rainbow of colors.

RedOrangeYellowGreenBlueIndigoViolet

ROY G BIV



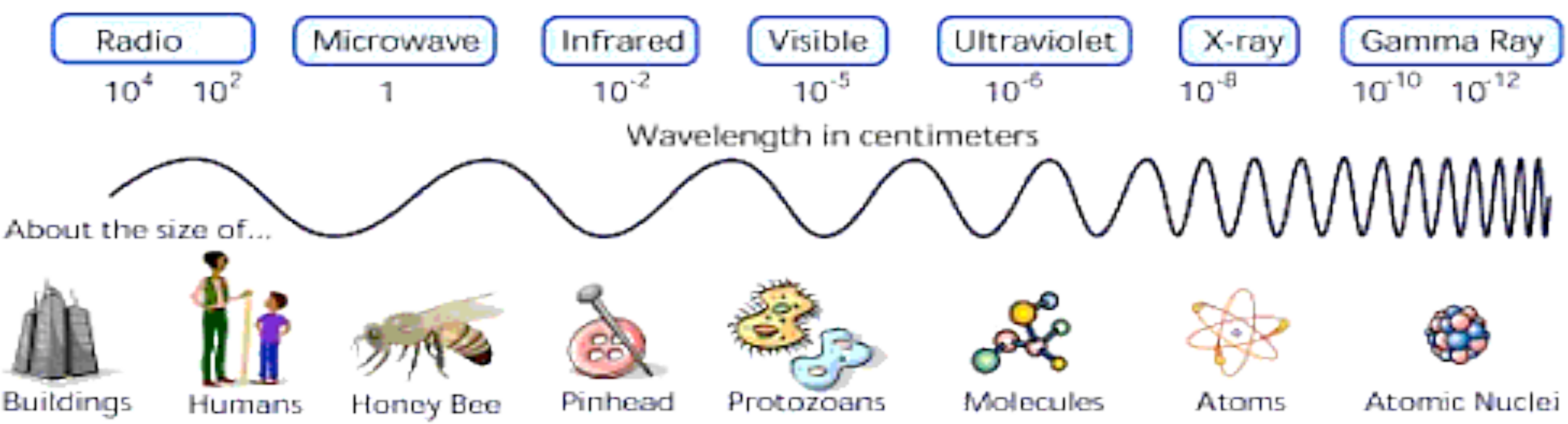
Frequency Ranges

- Wavelengths

10^4 10^1 1 10^{-2} 10^{-5} 10^{-6} 10^{-8} 10^{-10} 10^{-12}

- Frequencies (cycles per sec)

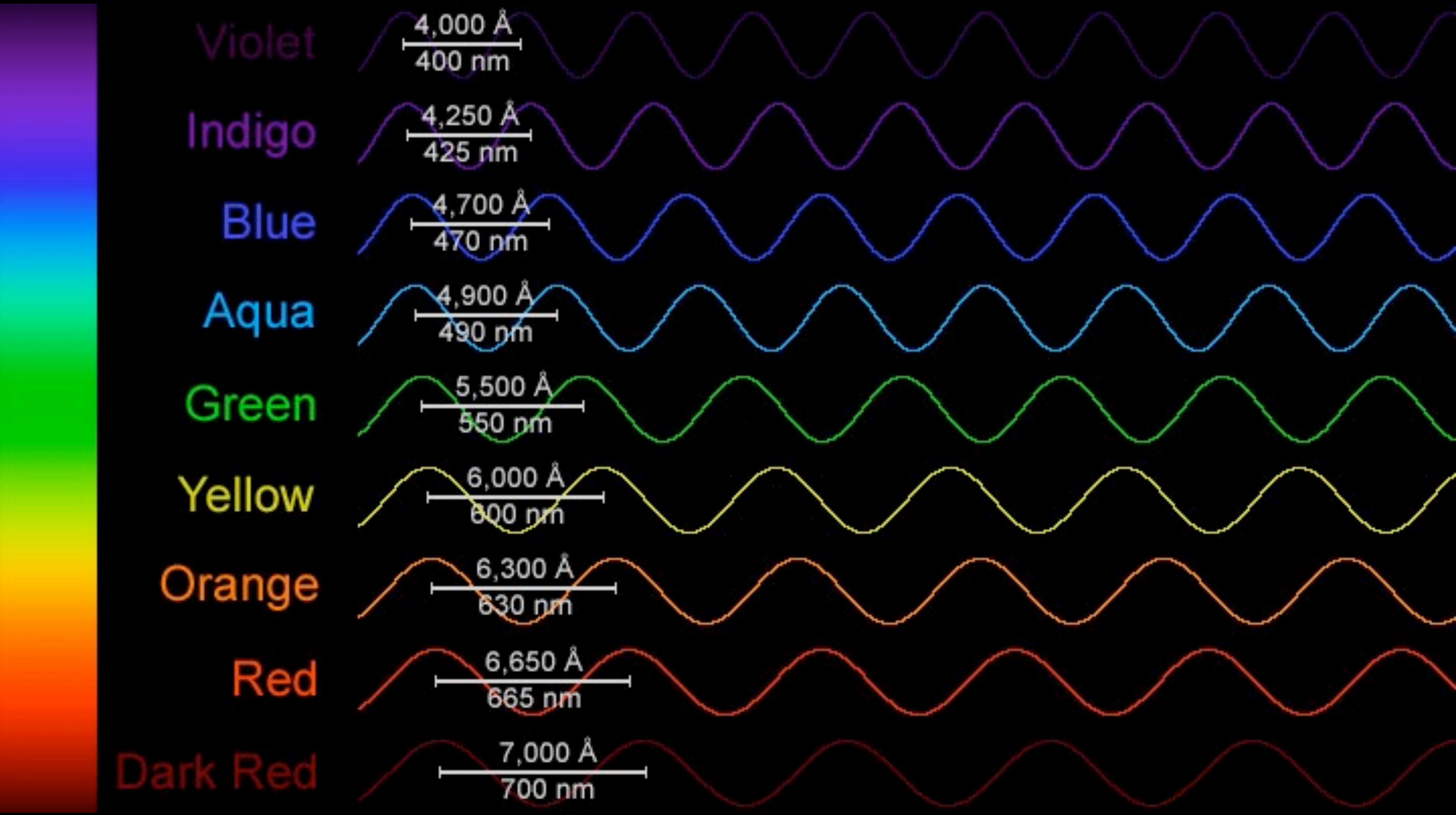
3×10^6 3×10^{10} 3×10^{14} 3×10^{16} 3×10^{18} 3×10^{22}



Frequency Ranges of Visible Light

Red light has a frequency of roughly 4.3×10^{14} Hz, and a wavelength of about 7.0×10^{-7} m (700nm).

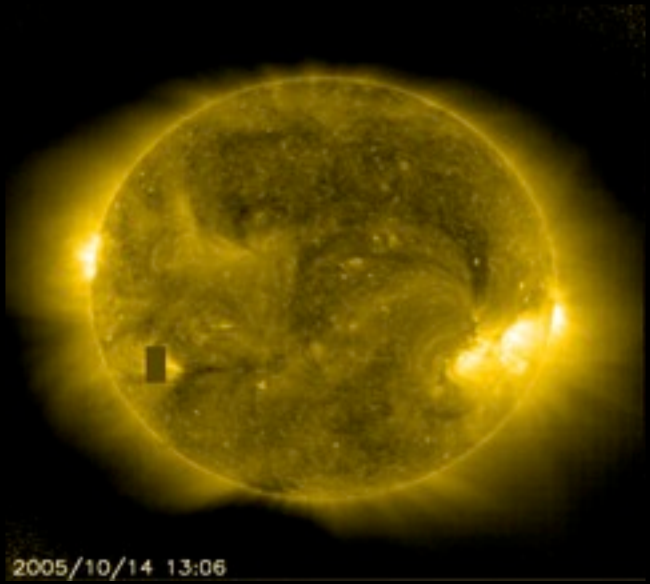
Violet light, at the other end of the visible range, has nearly double the frequency—7.5×10^{14} Hz—and (since the speed of light is the same in either case) just over half the wavelength— 4.0×10^{-7} m (400nm).

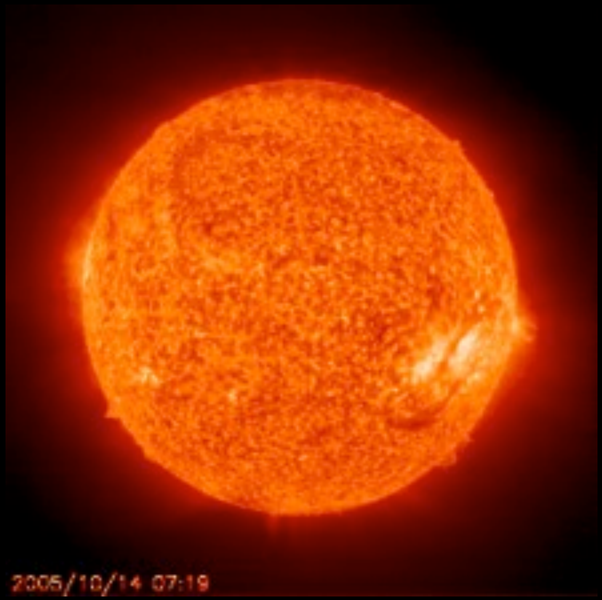

Violet
4,000 Å
400 nm
Indigo
4,250 Å
425 nm
Blue
4,700 Å
470 nm
Aqua
4,900 Å
490 nm
Green
5,500 Å
550 nm
Yellow
6,000 Å
600 nm
Orange
6,300 Å
630 nm
Red
6,650 Å
665 nm
Dark Red
7,000 Å
700 nm

The radiation to which our eyes are most sensitive has a wavelength near the middle of this range, at about

5.5×10^{-7}m (550 nm), in the yellow-green region of the spectrum.

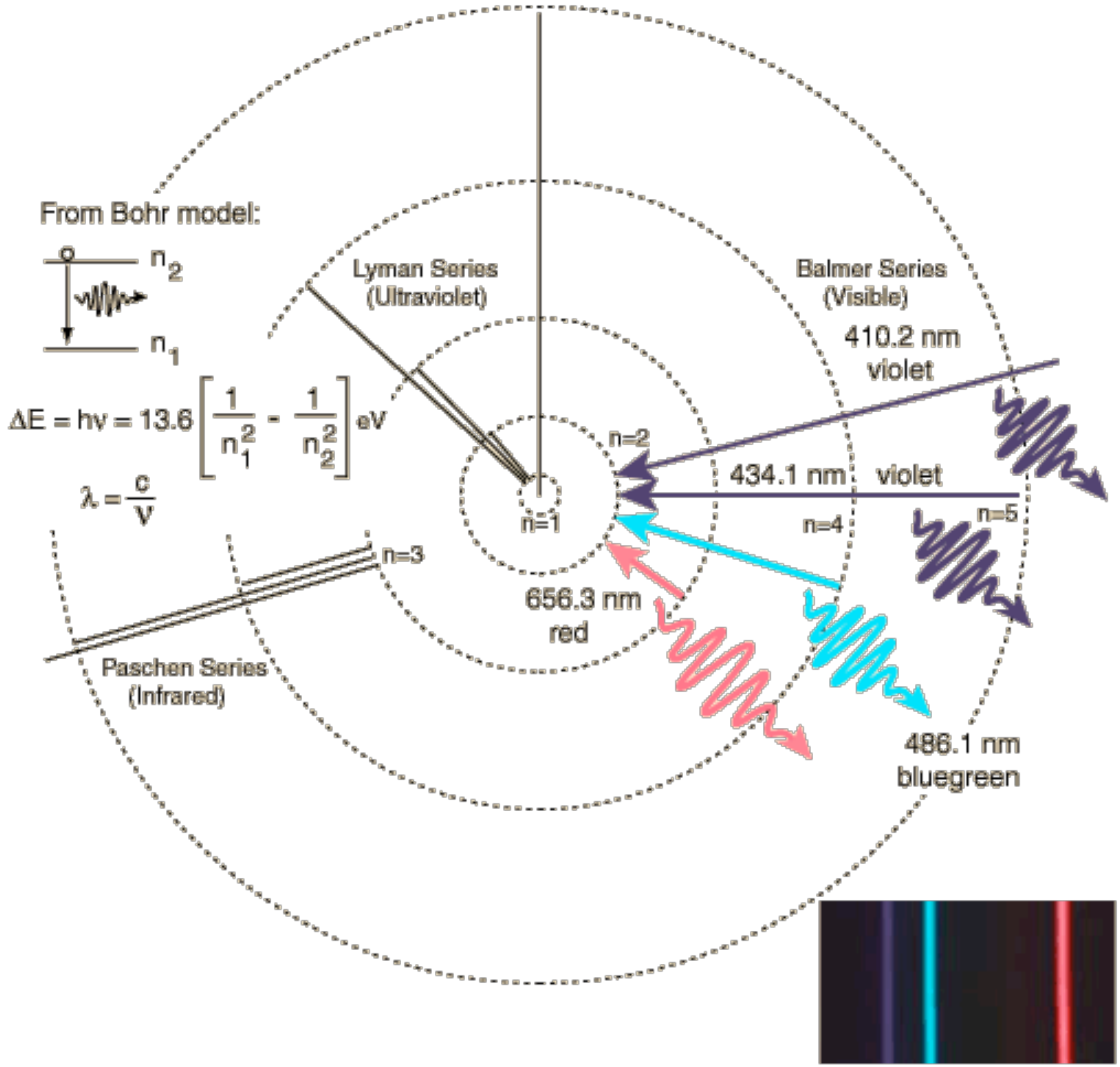
It is no coincidence that this wavelength falls within the range of wavelengths at which the Sun emits most of its electromagnetic energy—our eyes have evolved to take greatest advantage of the available light.





Atoms and Light

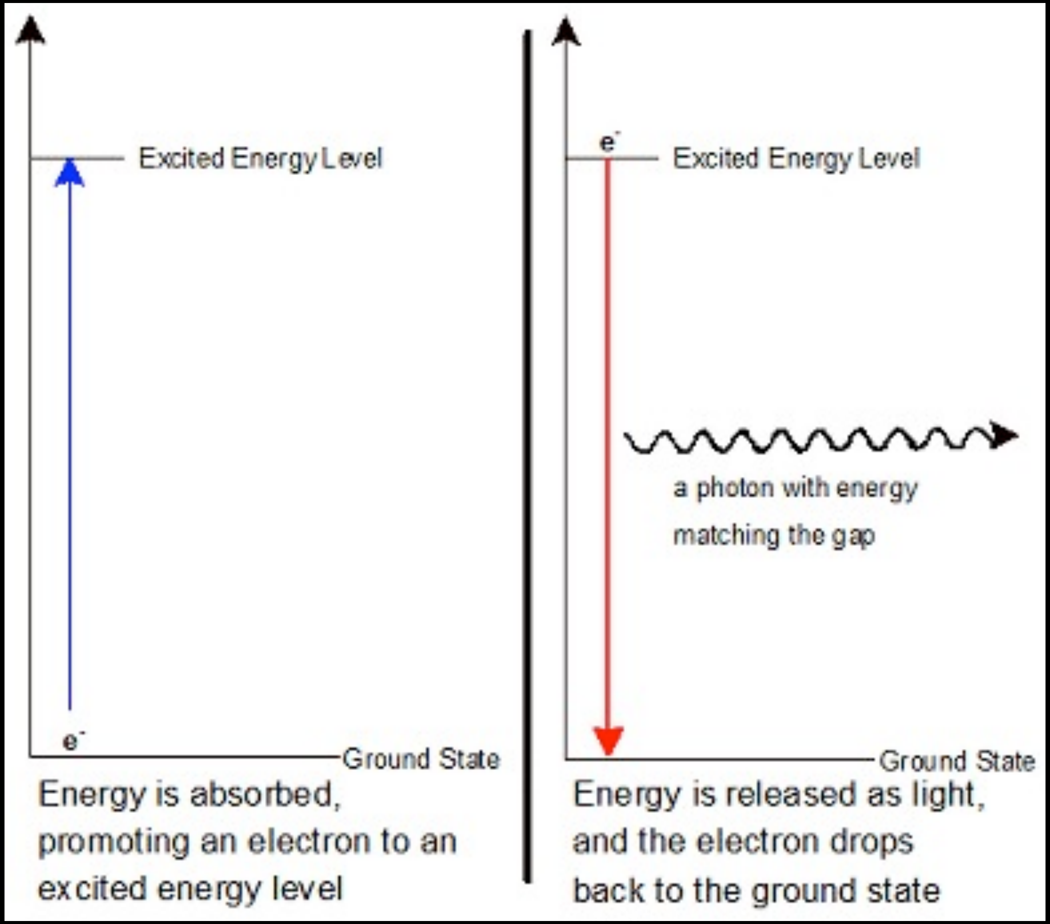
- The movement of electrons inside of atoms produces light and other electromagnetic radiation.
- Sunlight produces every color in the rainbow but…
- Each element gives off only certain frequencies of light, called spectral lines. In effect each element has its own signature of spectral lines allowing us to identify which element we have or what stars are made of.



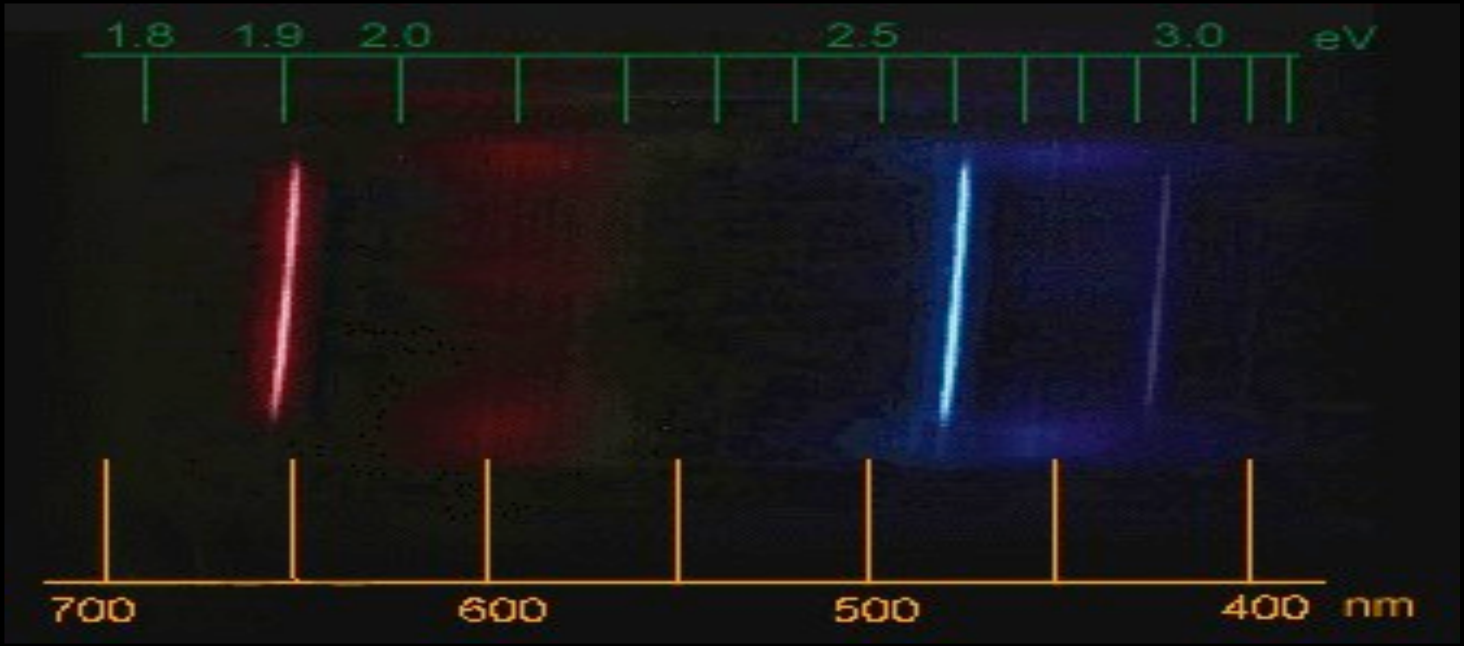
From Bohr model:
n2
n1
ΔE = hν = 13.6 [1/n1² - 1/n2²] eV
λ = c/ν
Lyman Series
(Ultraviolet)
Balmer Series
(Visible)
410.2 nm
violet
434.1 nm
violet
n=1
n=2
n=3
n=4
n=5
656.3 nm
red
486.1 nm
bluegreen
Paschen Series
(Infrared)

Linear Analyzation of Electron's Light

Each electron within their orbital behave differently and gain and release energy differently. This is how we see different colors emitted by each element, and why their spectra show different wavelength frequencies.



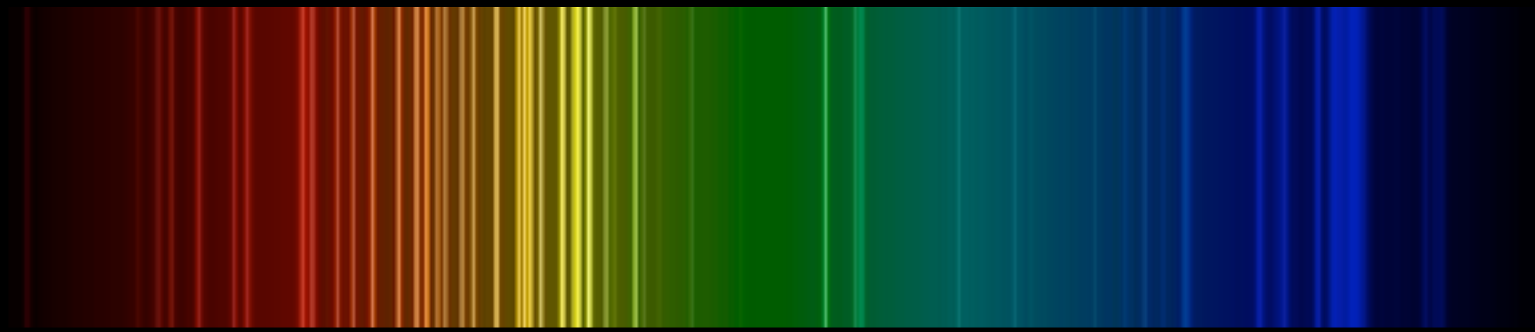
Below is a picture of the spectral lines given off by hydrogen. Note there are 3 different frequencies.



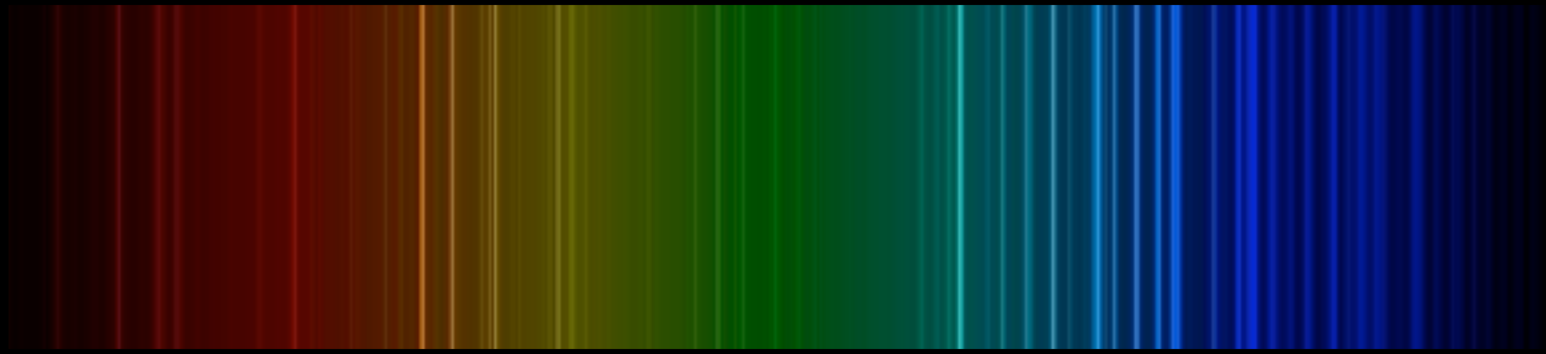
- The emission spectra makes it possible to identify inaccessible substances. Most of our knowledge of the universe comes from studying the emission spectra of stars.
- Below is the spectra of a few more elements.

Helium

- Neon



- Argon



Why Is This Important?

- Knowledge from analyzing different elements has allowed us to analyze stars.
- Different combinations of elements and other chemical knowledge has led to fireworks.

- In a star, there are many elements present. The way we can tell which are there is to look at the spectrum of the star.
- From **spectral lines** astronomers can determine not only the element, but the temperature and density of that element in the star
- Emission lines can also tell us about the magnetic field of the star. The width of the line can tell us how fast the material is moving

- If the lines shift back and forth, it means that the star may be orbiting another star - the spectrum will give the information to estimate the mass and size of the star system and the companion star.

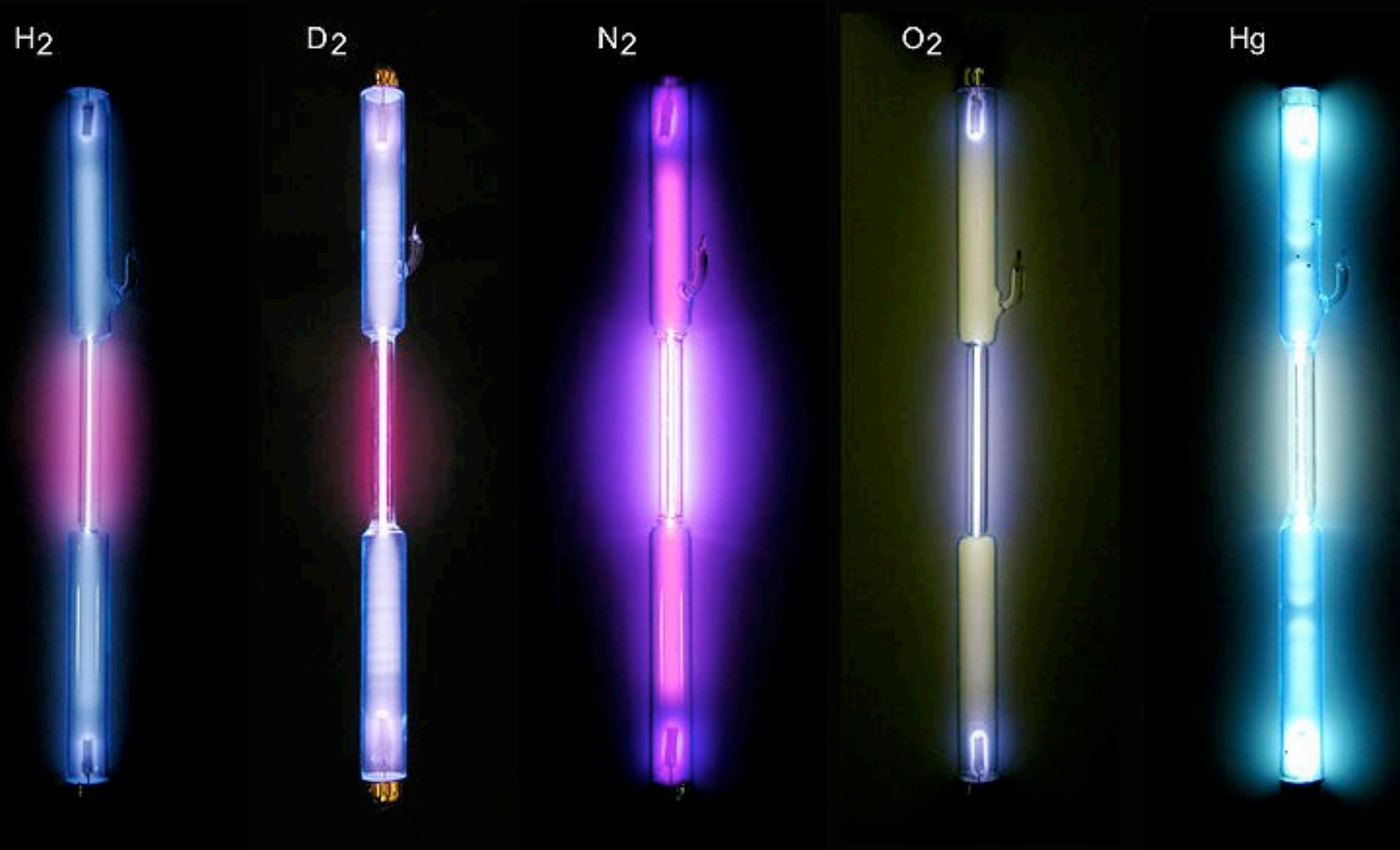
Our Lab

- We are going to analyze the different flame test colors from 5 metal elements, and 4 gaseous elements that have been "excited" by electricity.

Procedure

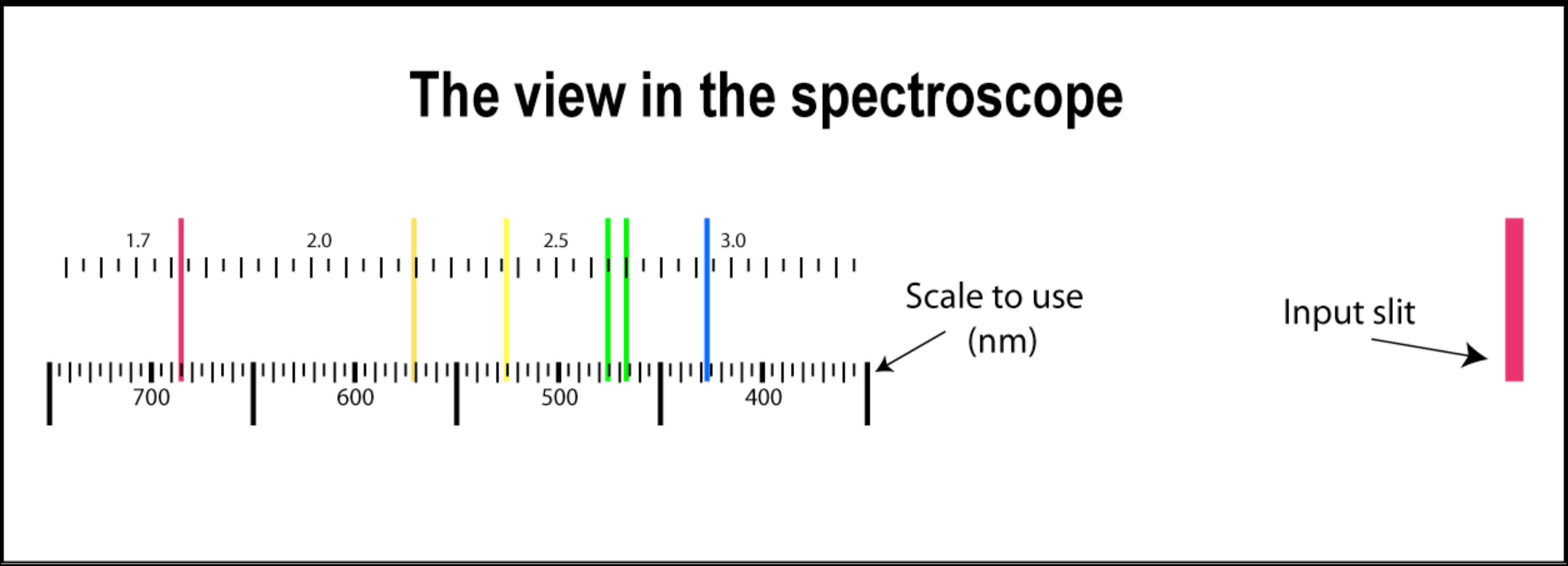
- The first four stations on your handout are for the **gas tube** stations.
  - You will be analyzing the wavelength of light given off by the element using spectrometers.
- The last five stations on your handout are for the **flame tests**.
  - There are six metals to choose from, but you can only record 5. There are 2 choices at each bunsen burner. **DO NOT MIX THE SALTS!!**
- Use the provided wavelength key to help guide where you should be drawing in **your lines (gas tubes)** or **range (flame tests)** on your lab sheet.
- You will have approximately **5 minutes** at each station.

Before Electricity



After Electricity

Spectrascope



Top view of the setup