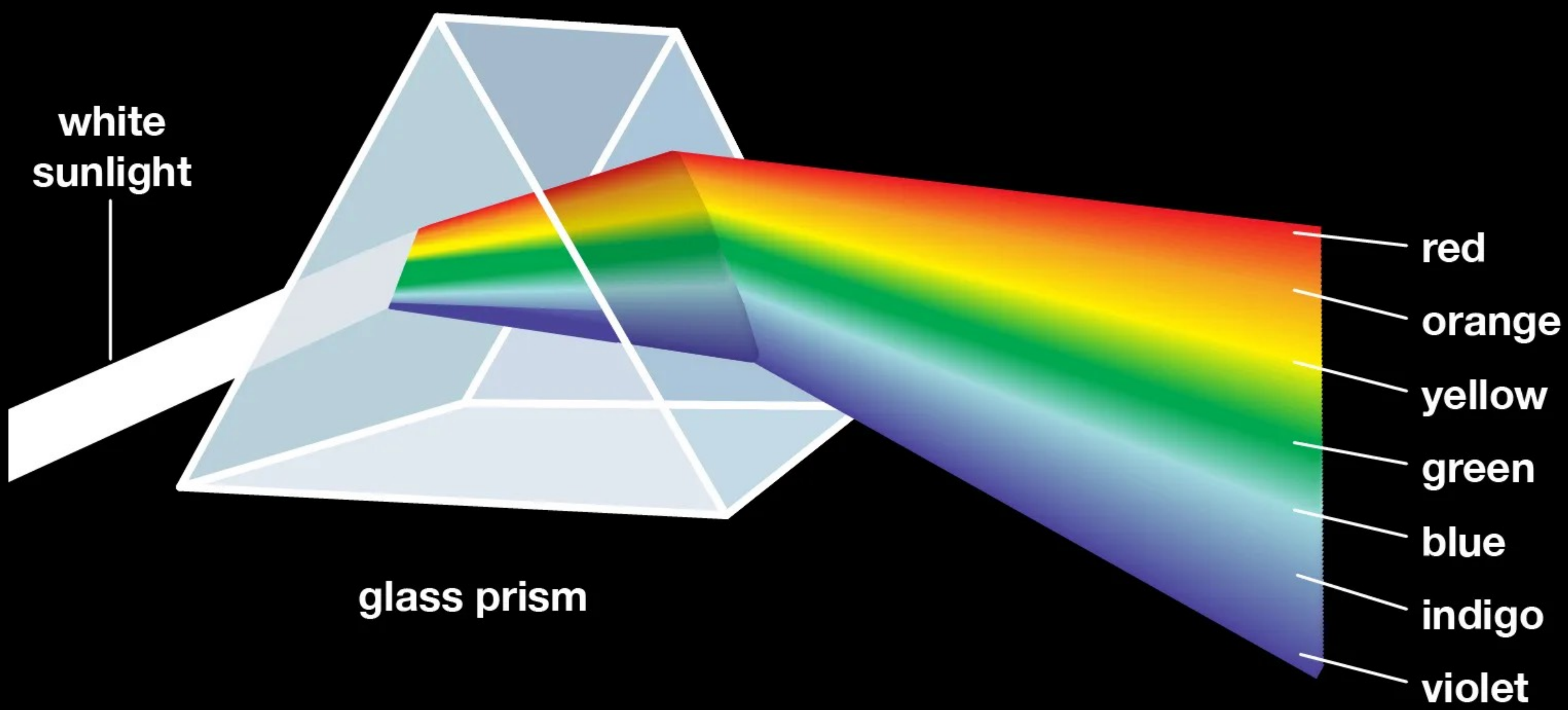
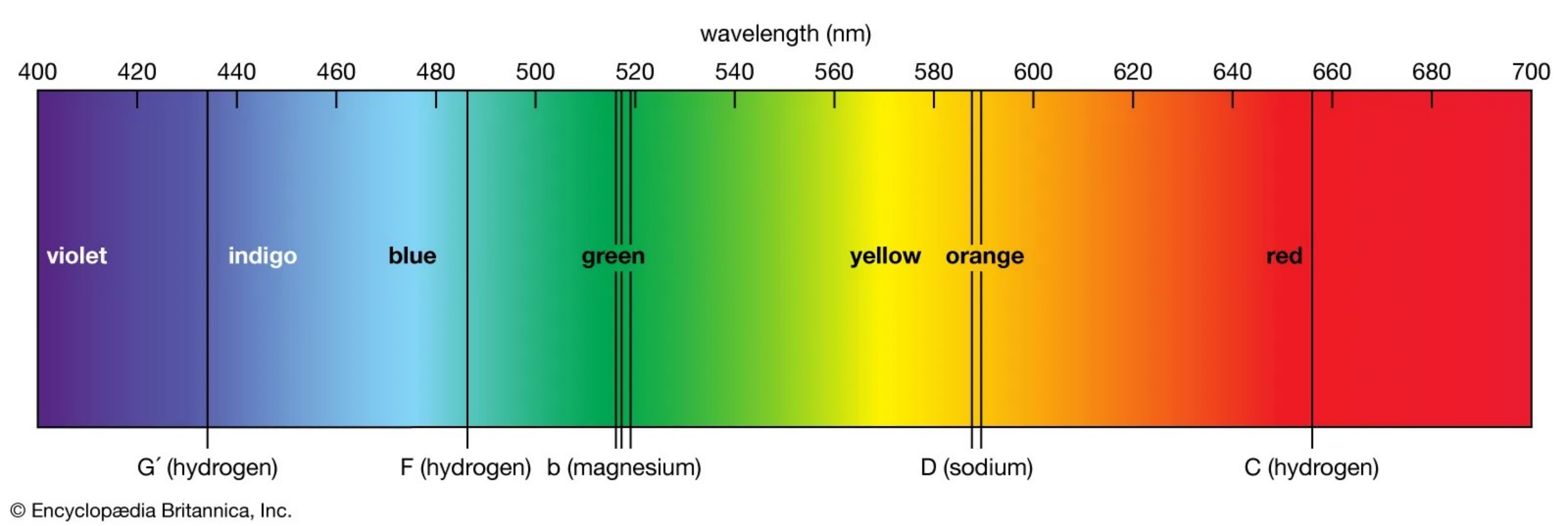
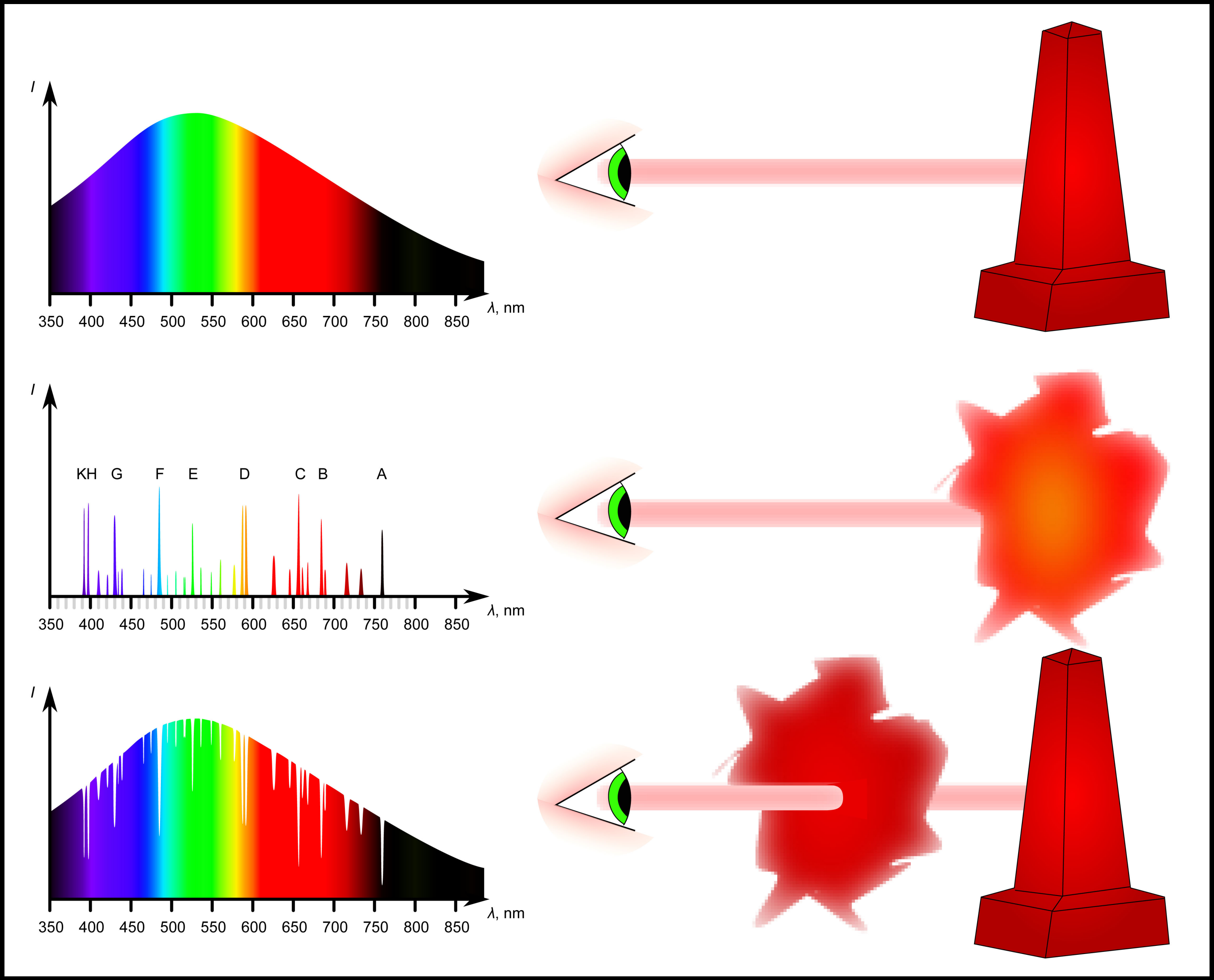


The spectroscope is a device that separates white light into component colors called a spectrum.

Elements emit a unique spectrum that has dark lines called absorption features, i.e. produces a unique chemical fingerprint in the spectrum.



These two discoveries are combined to produce a new field called spectroscopy, and allowed astronomers to measure the temperature and chemical composition of stars for the first time.

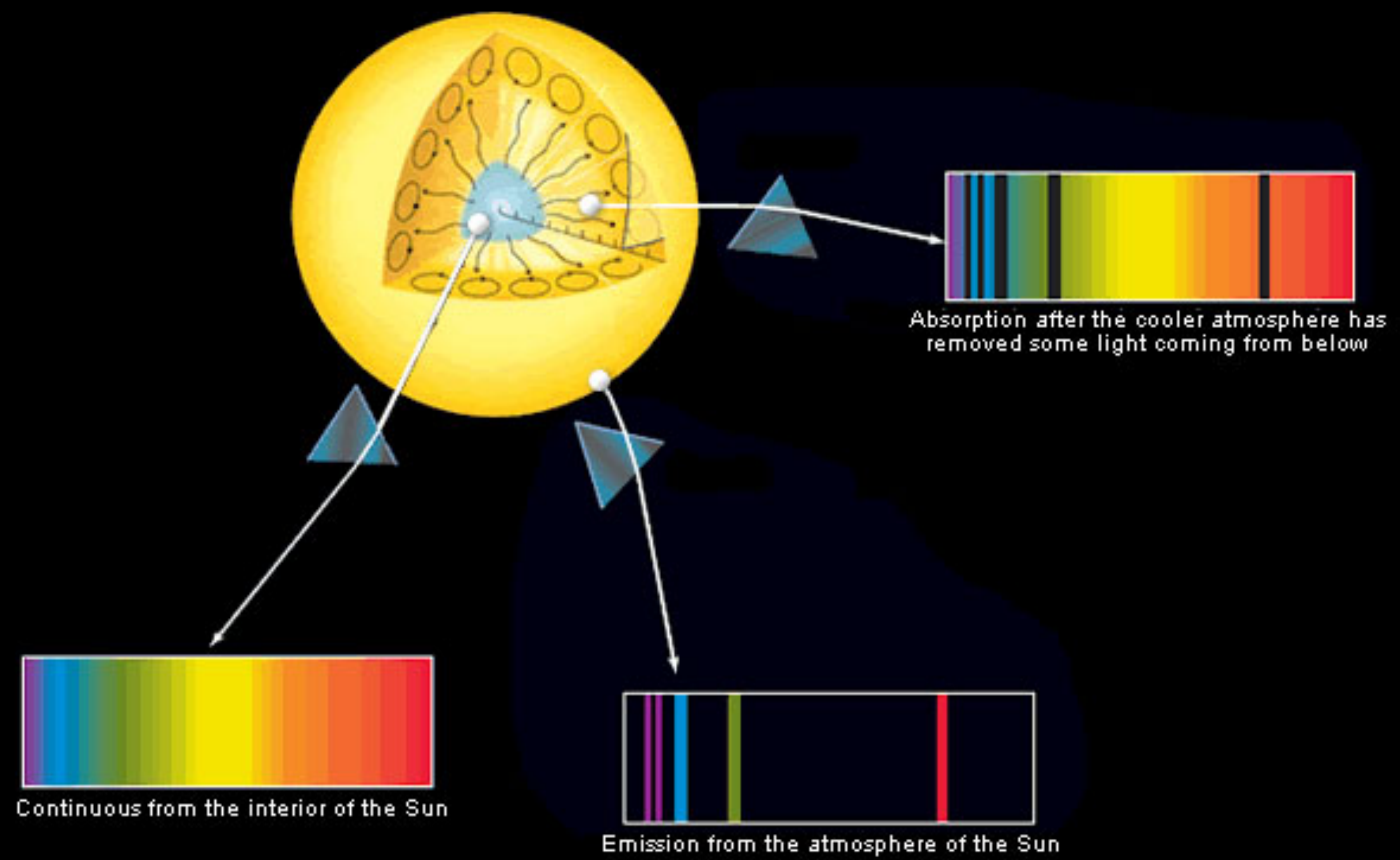


Kirchhoff showed that there are three types of spectra emitted by objects:

1) Continuous spectrum - a solid or liquid body radiates an uninterrupted, smooth spectrum (called a Planck curve)

2) Emission spectrum - a radiating gas produces a spectrum of discrete spectral lines

3) Absorption spectrum - a continuous spectrum that passes through a cool gas has specific spectral lines removed (inverse of an emission spectrum)


Absorption after the cooler atmosphere has removed some light coming from below
Continuous from the interior of the Sun
Emission from the atmosphere of the Sun

Historical facts about Helium

The first evidence of ^{4}**He** was observed on **August 18, 1868** as a bright yellow line with a wavelength of **587.49 nm** in the spectrum of the chromosphere of the Sun. The line was detected by French astronomer **Jules Janssen** during a total solar eclipse in Guntur, India [3], [4]. This line was initially assumed to be **sodium**.

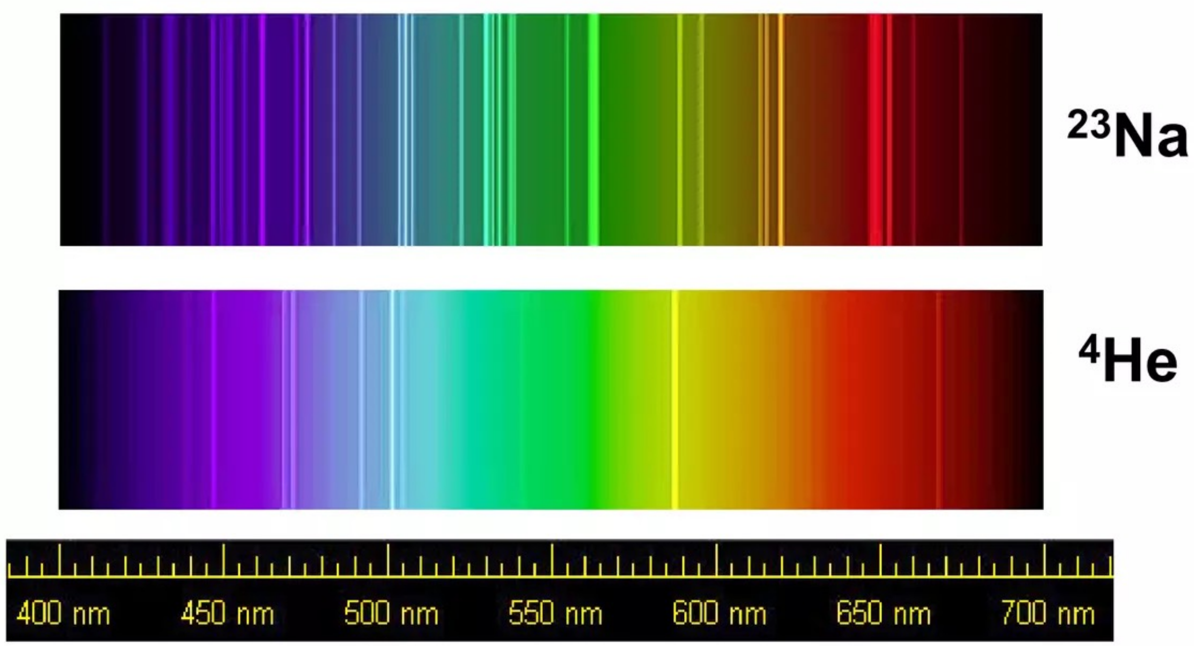
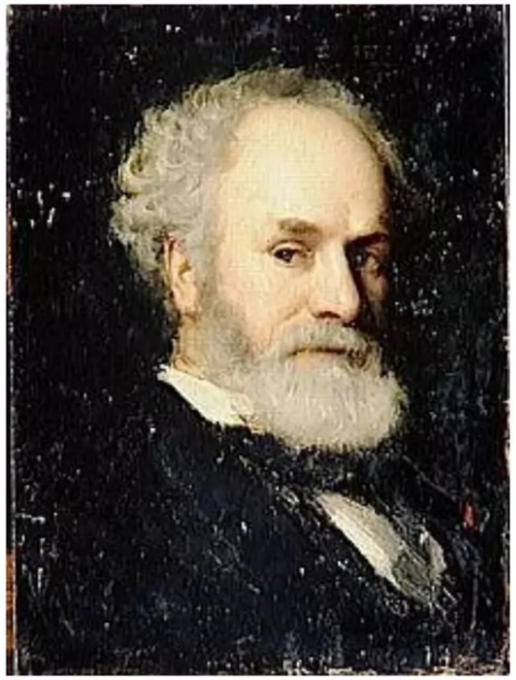
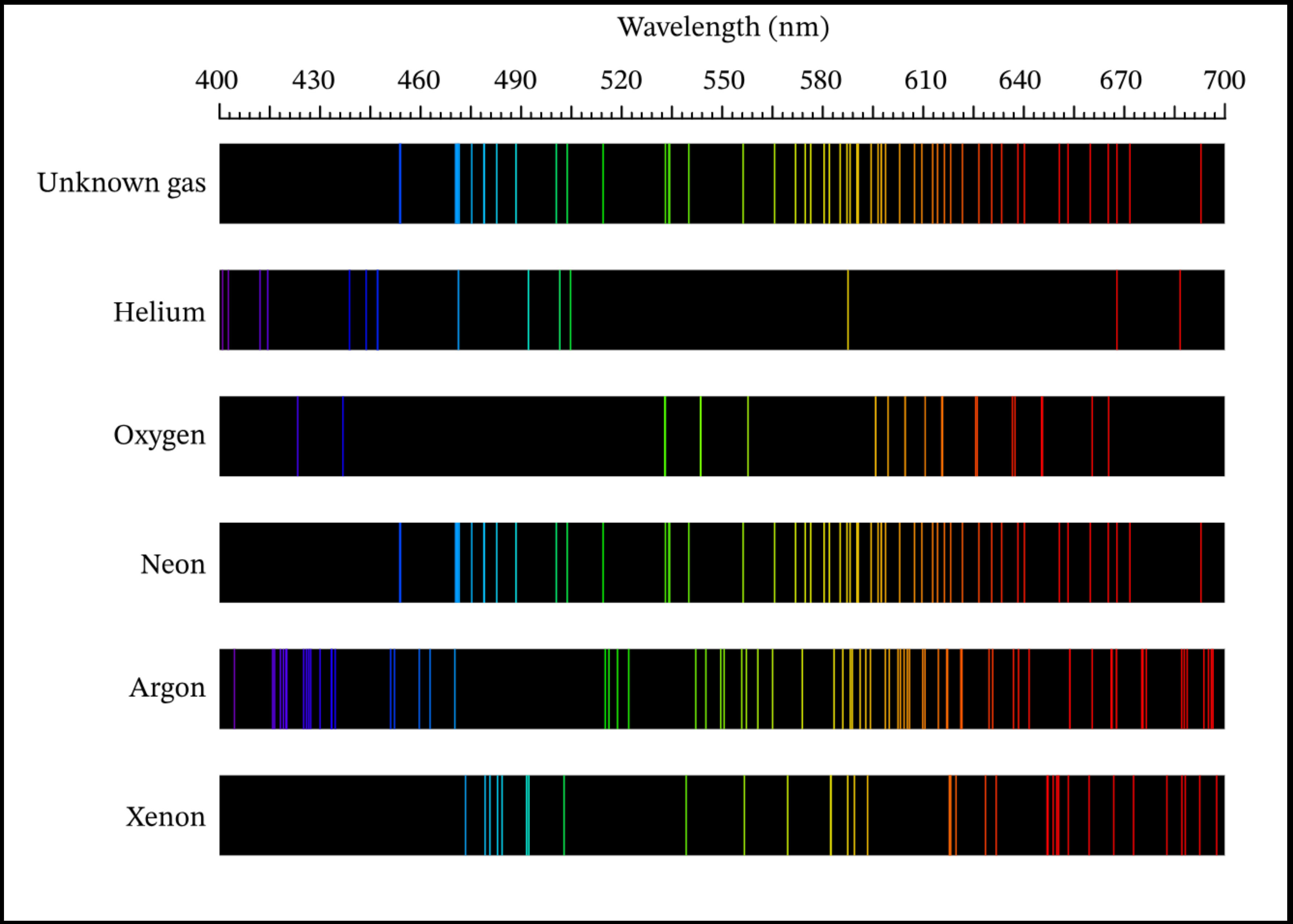
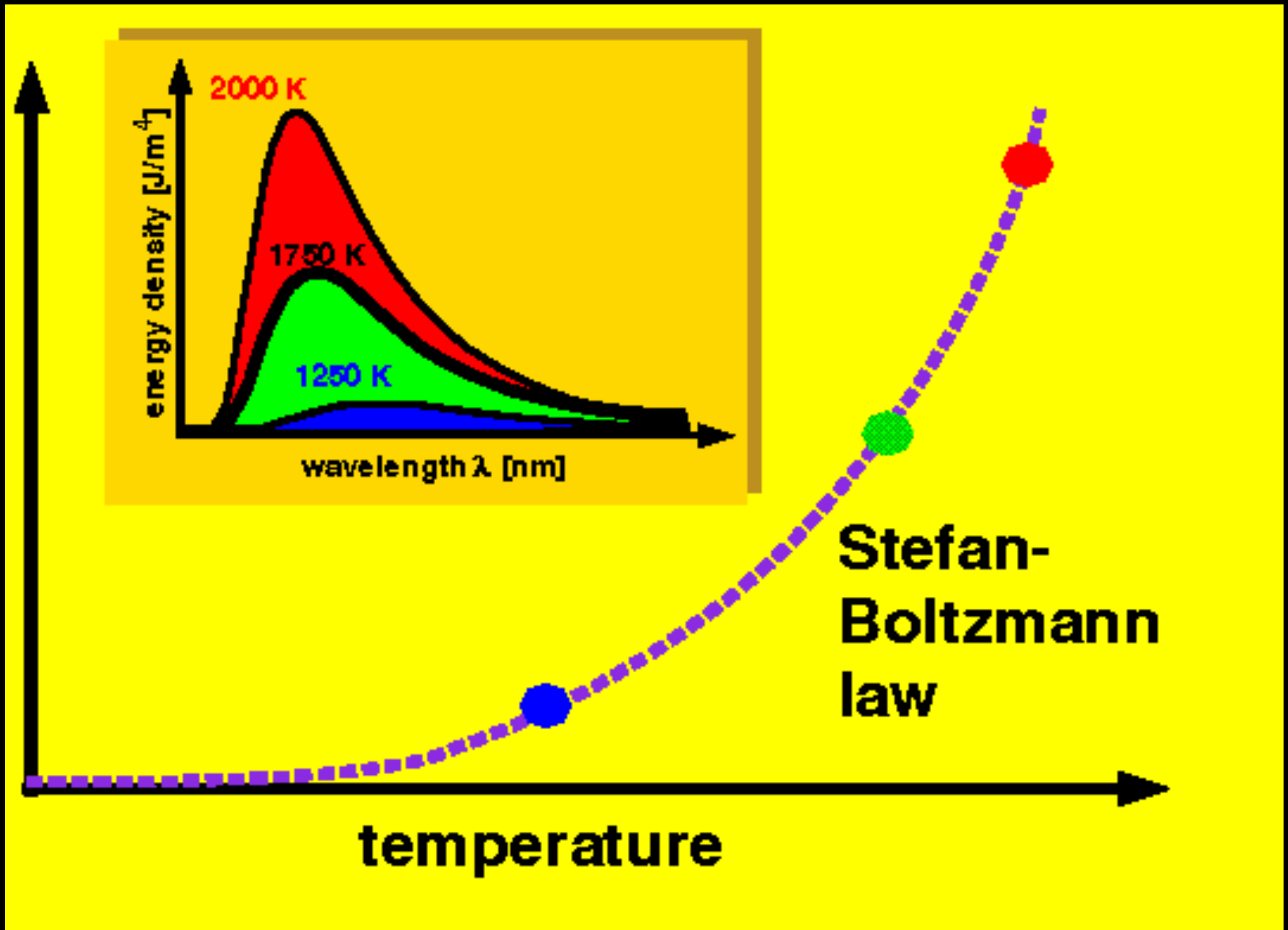


Fig. 2. Emission spectra of He and Na.



Jules Janssen
(1824 - 1907)


Wavelength (nm)
400
430
460
490
520
550
580
610
640
670
700
Unknown gas
Helium
Oxygen
Neon
Argon
Xenon

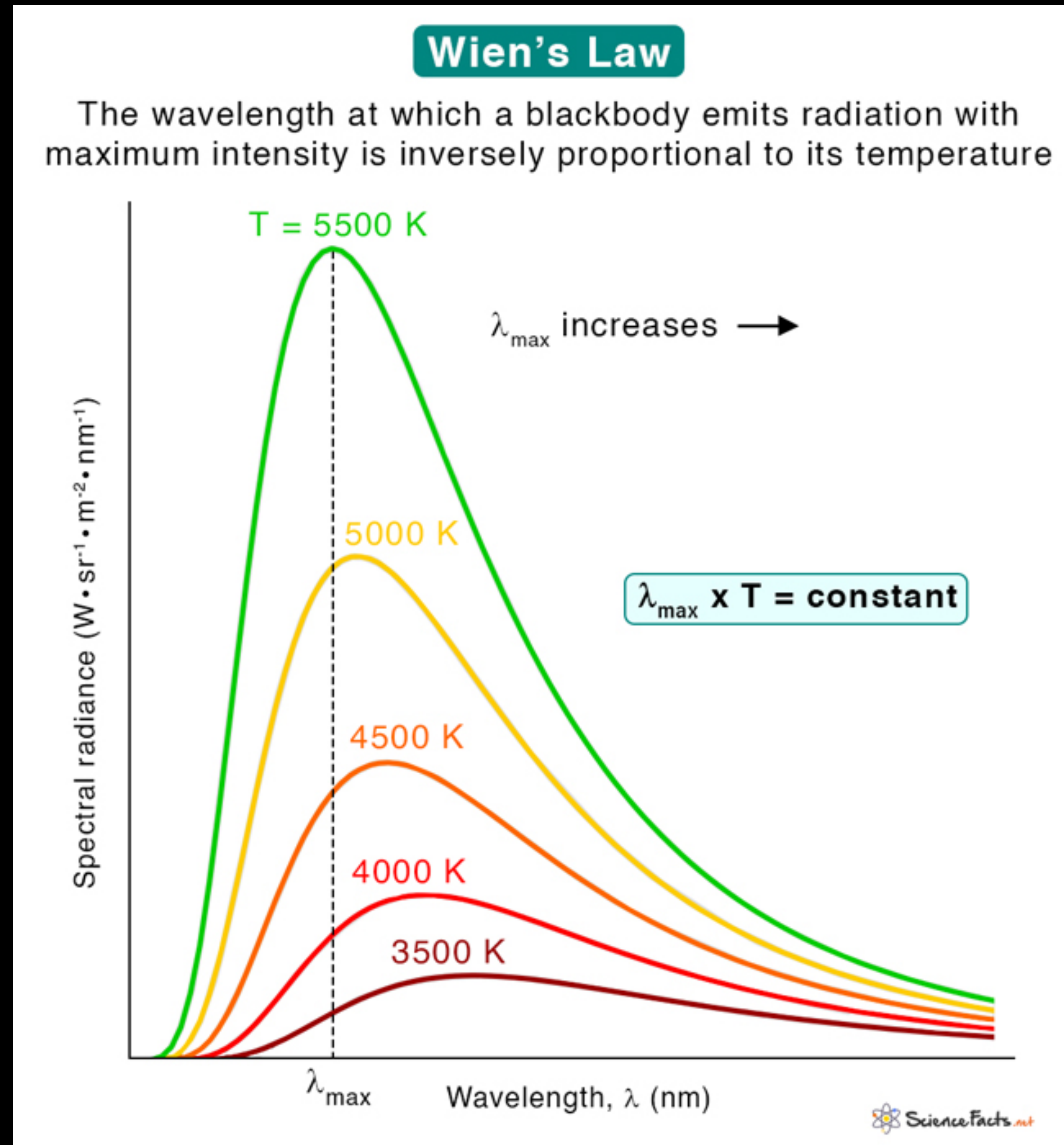


Stefan-Boltzmann law: the amount of energy emitted from a body increases with higher temperature

$$\frac{L}{L_\odot} = \left(\frac{R}{R_\odot}\right)^2 \left(\frac{T}{T_\odot}\right)^4$$

$$\frac{T}{T_\odot} = \left(\frac{L}{L_\odot}\right)^{1/4} \left(\frac{R_\odot}{R}\right)^{1/2}$$

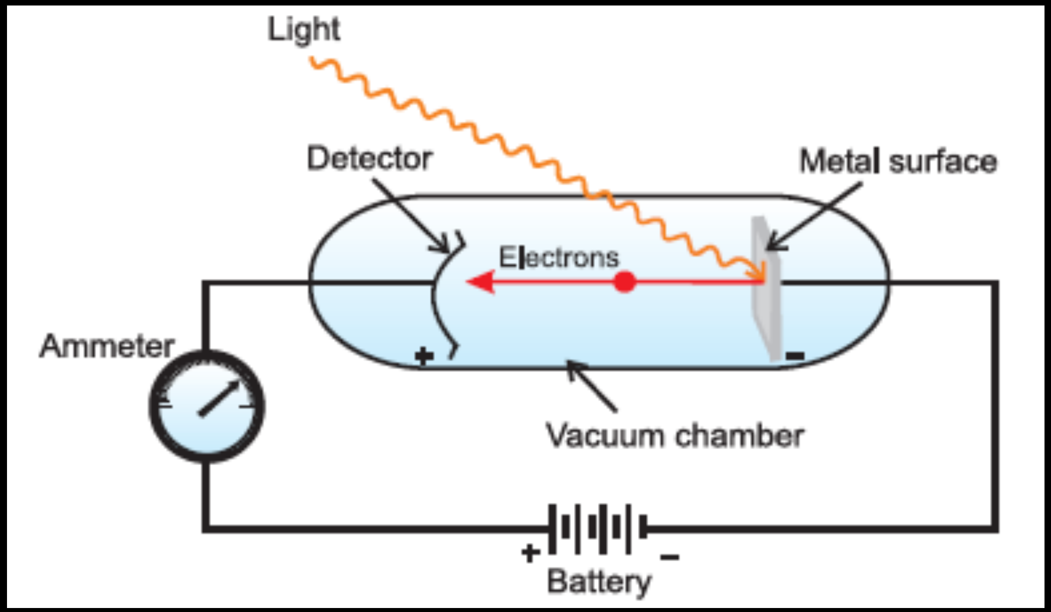
$$\frac{R}{R_\odot} = \left(\frac{T_\odot}{T}\right)^2 \left(\frac{L}{L_\odot}\right)^{1/2}$$



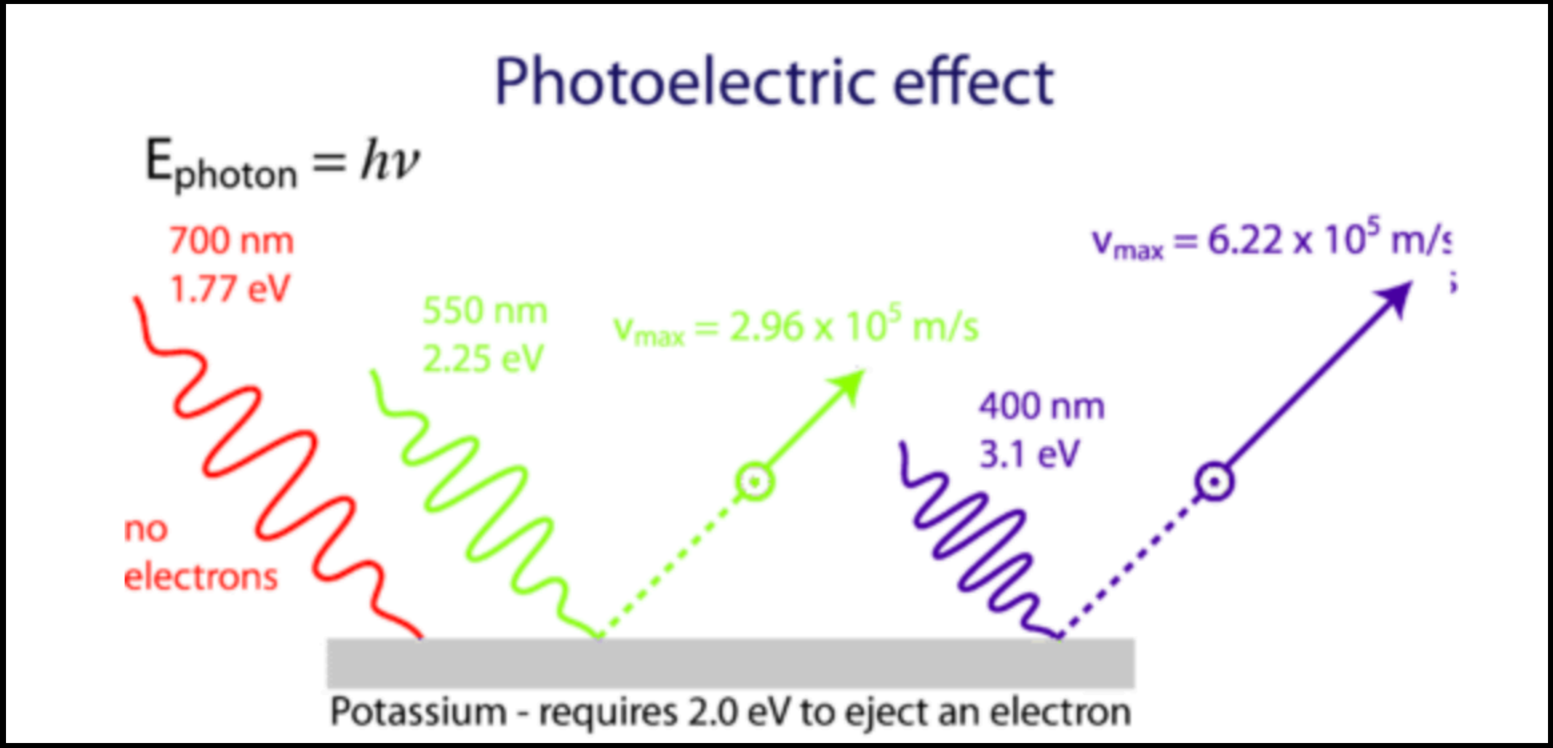
Wien's law: the peak of emission moves to bluer light as temperature increases

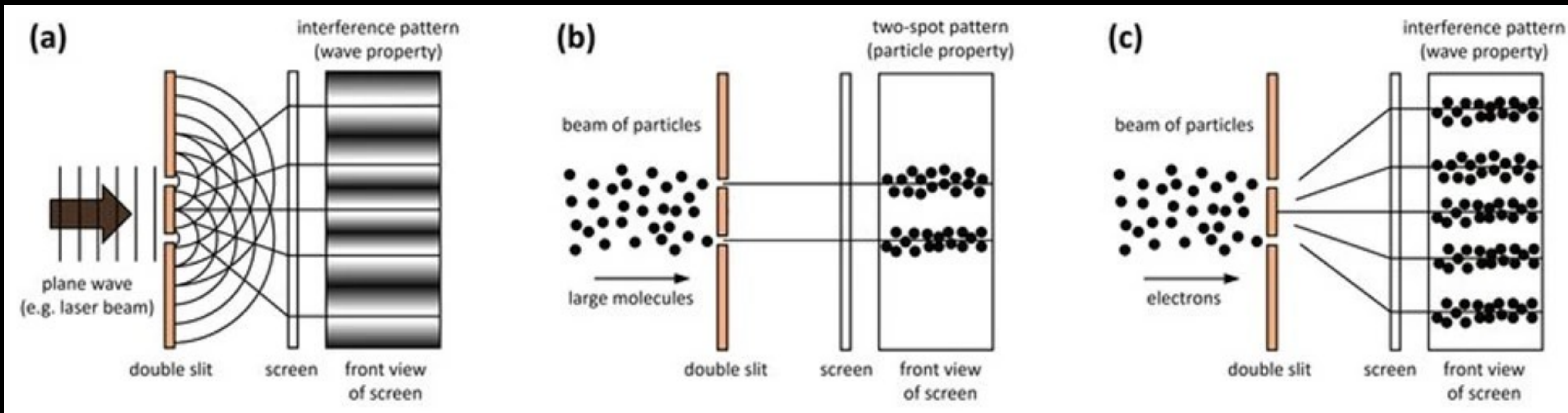
Wien's law

$$\lambda_{max} = \frac{0.0029\ m \cdot K}{T}$$



The wave-like nature of light explains most of its properties. But, the results from spectroscopy (emission and absorption spectra) can only be explained if light has a particle nature. This dualism to the nature of light is best demonstrated by the photoelectric effect,

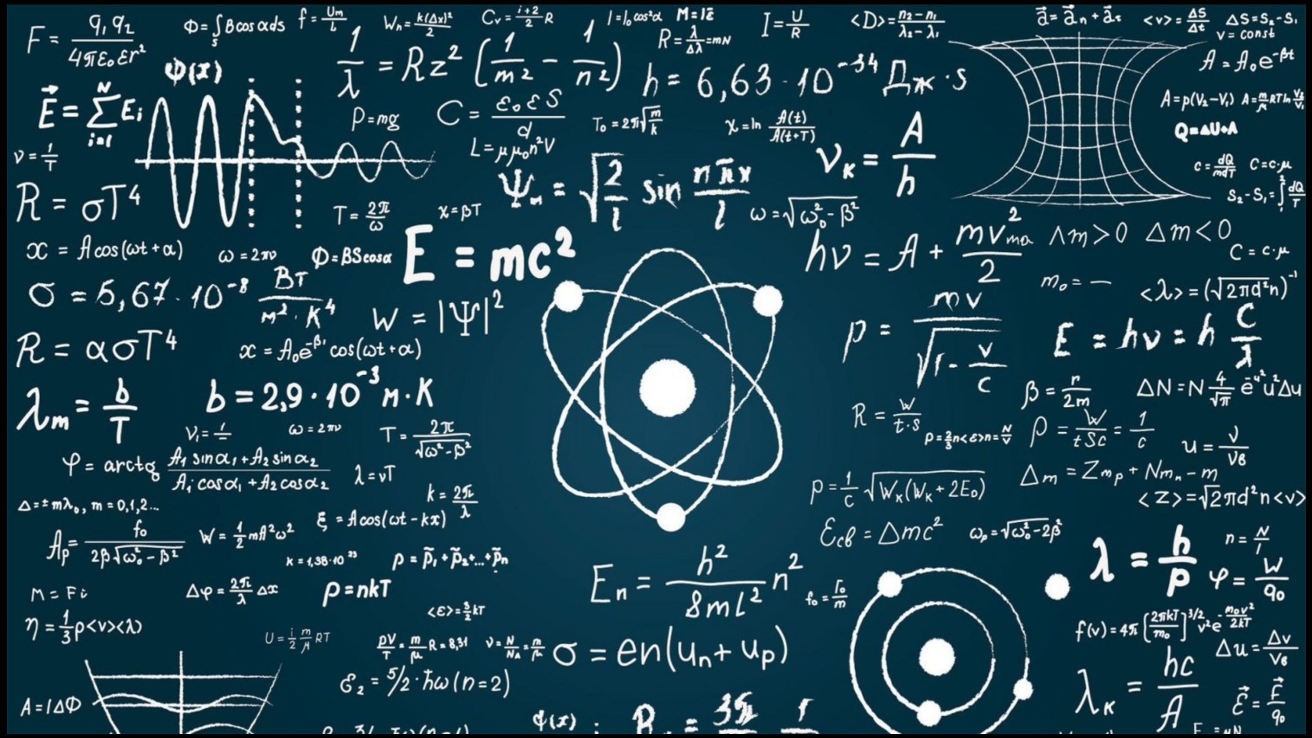




WAVE-PARTICLE DUALITY IN MATTER

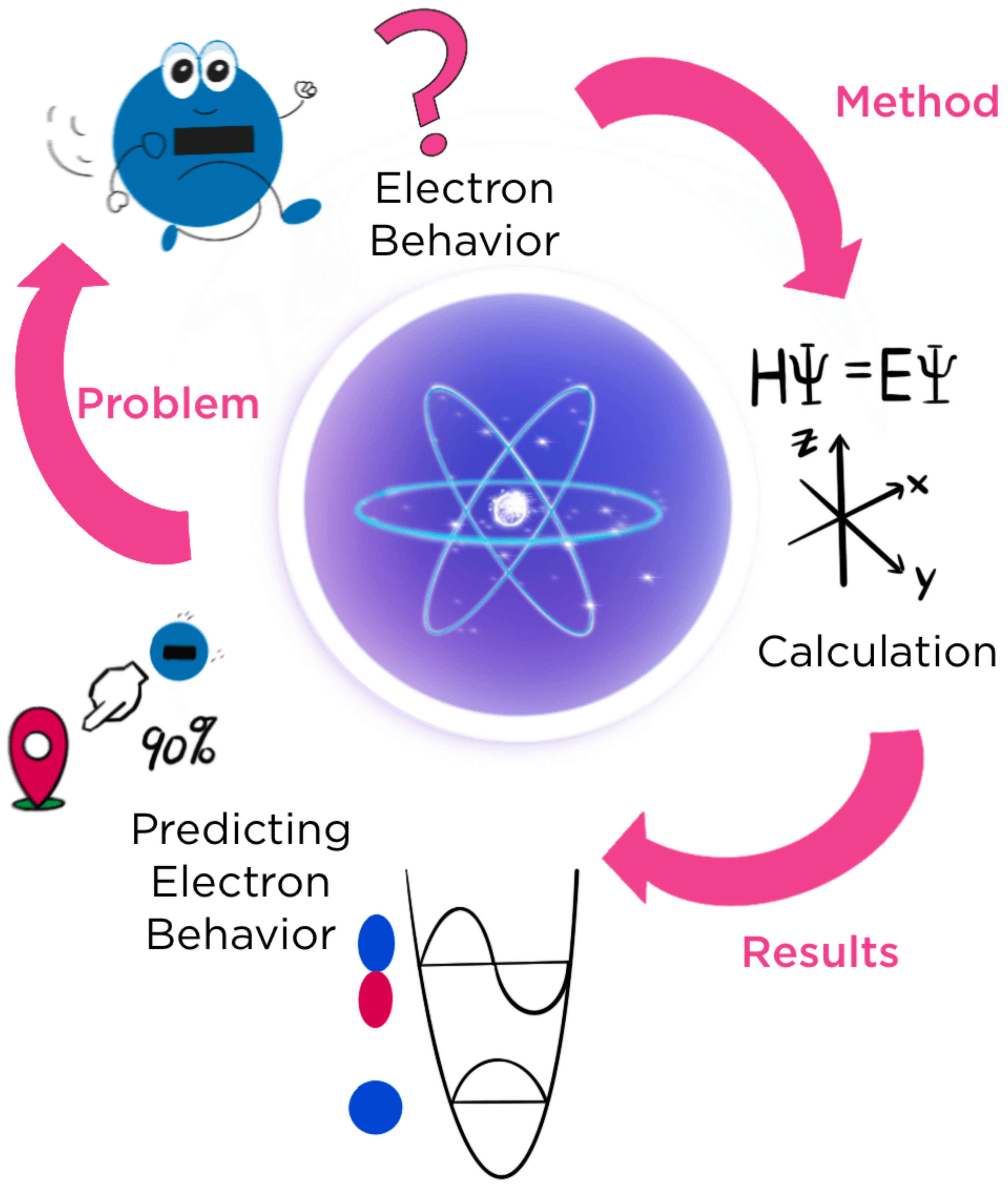
- **Just like light, matter is also capable of exhibiting properties of both wave-lengths and particles.**
- **Massive objects exhibit very small wavelengths, so small in fact that it's rather pointless to think of them in a wave form.**
- **However, in small objects, their wavelength is observable and in some cases significant.**

Quantum Physics



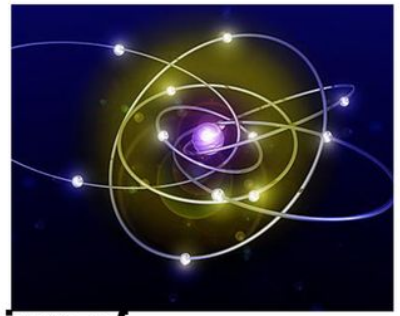
The word quantum derives from quantity and refers to a small packet of action or process, the smallest unit of either that can be associated with a single event in the microscopic world.

Quick Guide to Quantum Mechanics



Quantum?

Quantum mechanics is the study of processes which occur at the atomic scale.

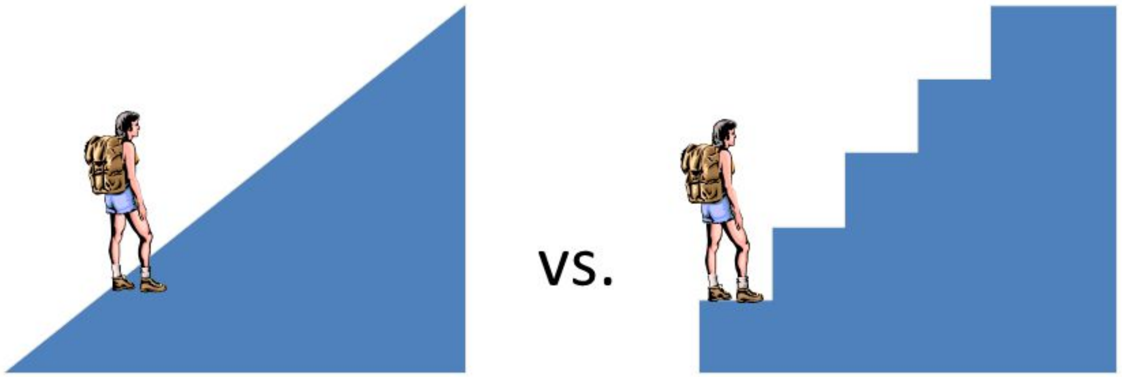


The word "quantum" is derived From Latin to mean *BUNDLE.*

Therefore, we are studying the motion of objects that come in small bundles called *quanta*. These tiny bundles that we are referring to are electrons traveling around the nucleus.

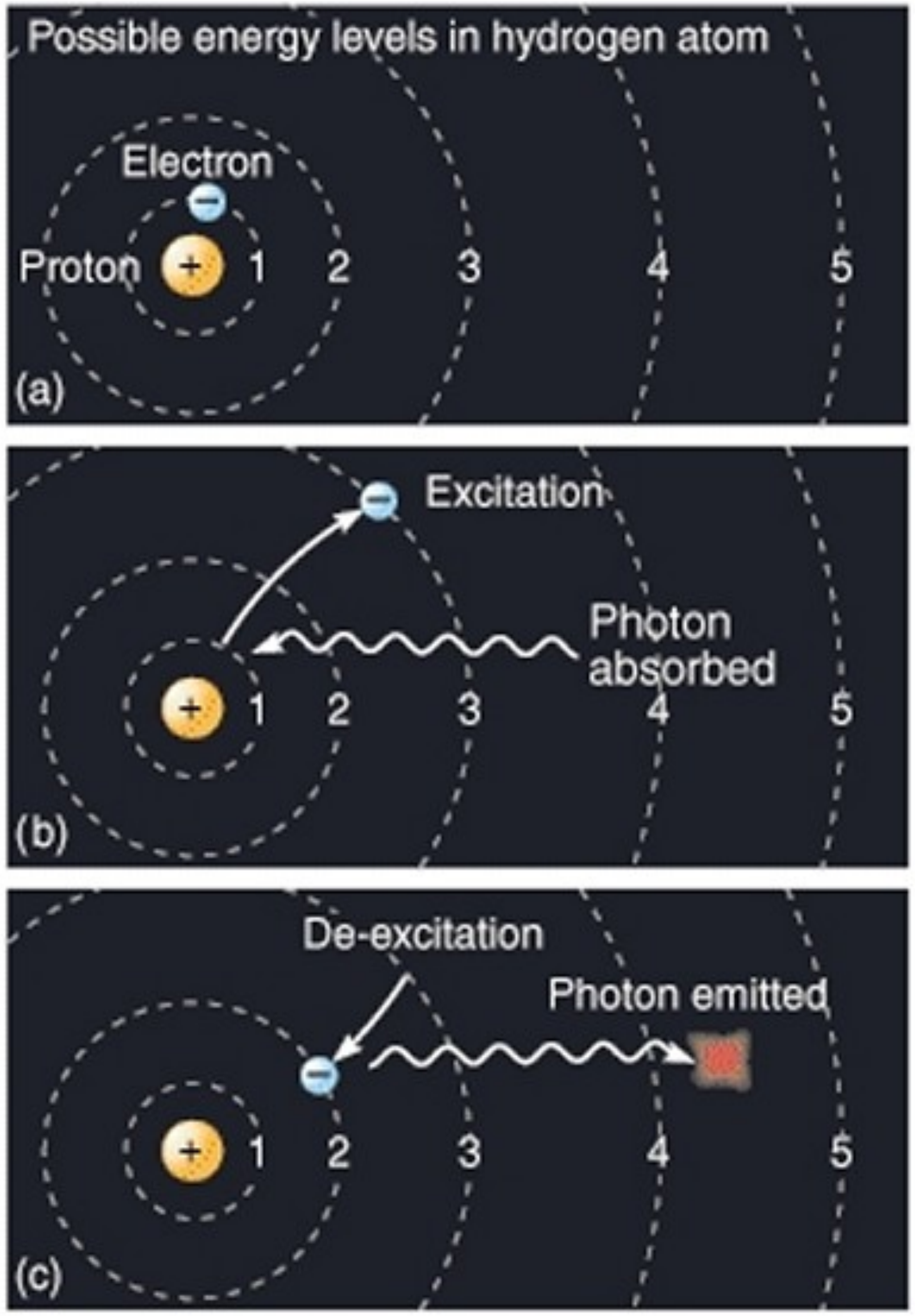
Quantum Theory

- **Planck** (1900)

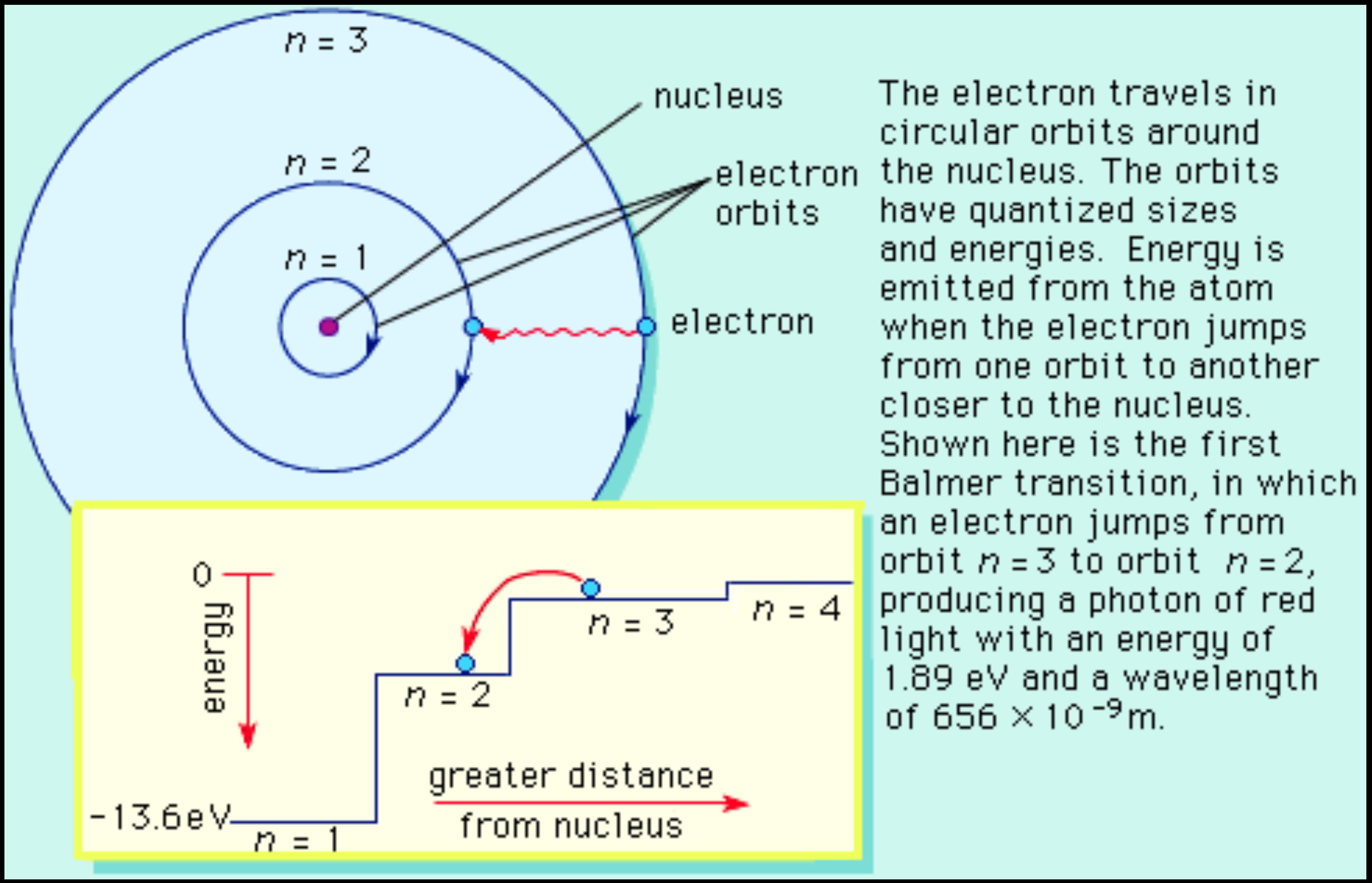


Classical Theory Quantum Theory

Courtesy Christy Johannesson www.nisd.net/communicationsarts/pages/chem



Bohr developed a different model of the atom to account for quantum physics, and the spectra of elements. The Bohr atom is similar to Rutherford atom, except the electrons moved in fixed or quantized orbits.



The quantized orbits of the electrons allows for a simple explanation of the origin of photons, and the spectrum of light. Photons are produced by the transition of electrons downward in their orbits. A downward transition releases potential energy in the form of a light particle, a photon. Likewise, photons could be absorbed by electrons, and they move upward in their orbits.

Models of atomic structure