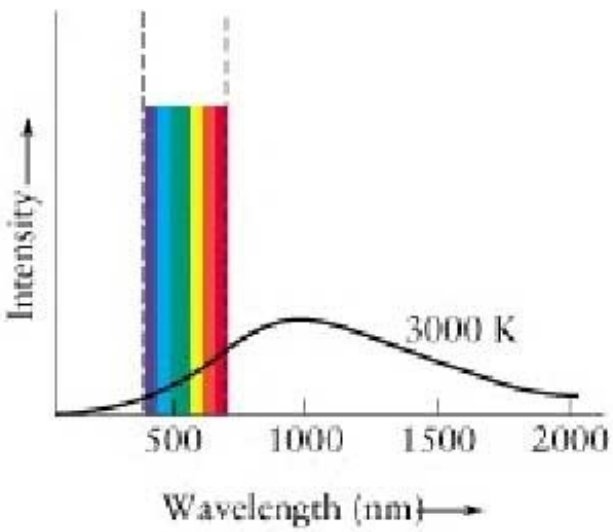
Spectra

- Classifying the spectra stars
- Photons
- Atomic structure
- Elements in stars
- Masses of stars
- Mass-luminosity relation

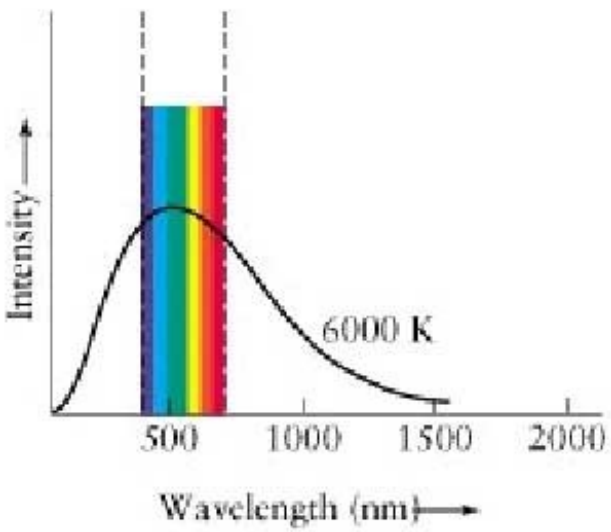
The temperature of the surface of a star can be determined from the stars

A) parallax
B) distance
C) luminosity
D) color
E) number of Oscars

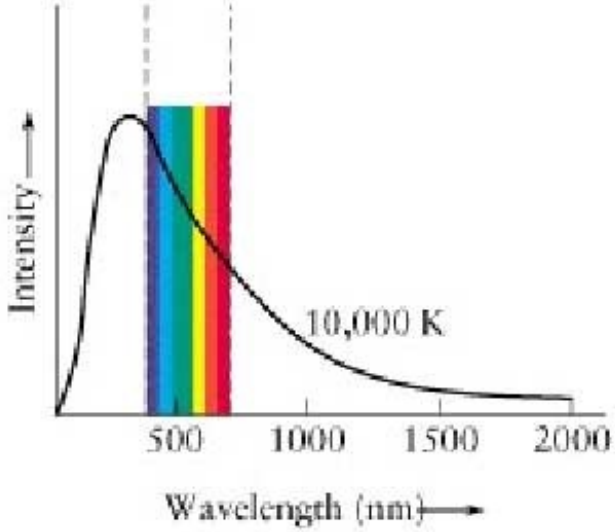
A star's color depends on its surface temperature



a This star looks red



b This star looks yellow-white



c This star looks blue-white

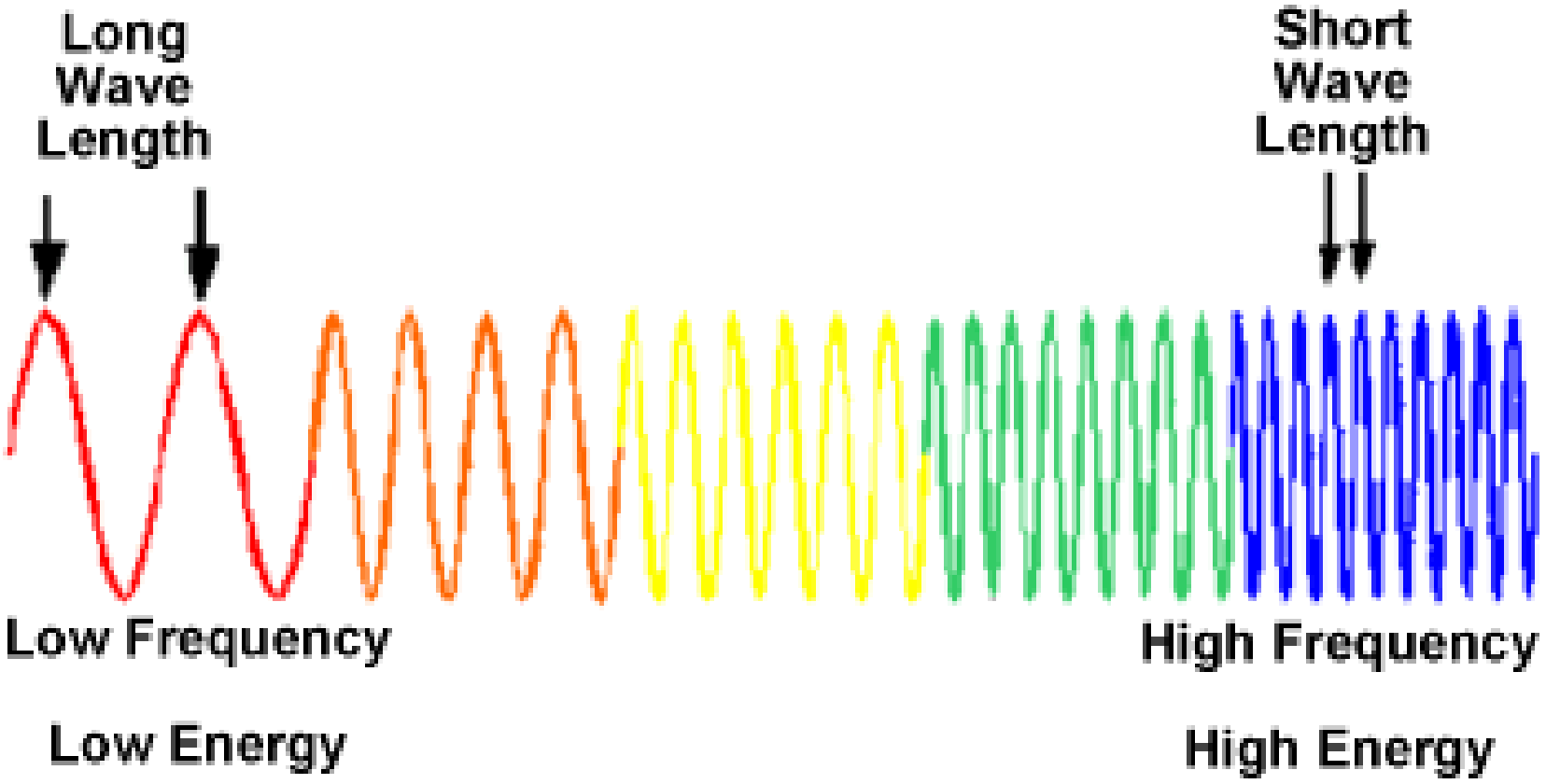
Spectral classification of stars

- The spectral classification essentially sorts stars according to their surface temperature.Sequence is: O B A F G K M
- O type is hottest (~25,000K), M type is coolest (~2500K)
- Star Colors: **O blue** to M **red**
- Sequence subdivided by attaching one numerical digit, for example: F0, F1, F2, F3 … F9 where F1 is hotter than F3 . Sequence is O … O9, B0, B1, …, B9, A0, A1, … A9, F0, …
- Useful mnemonics to remember OBAFGKM:
  - **O**ur **B**est **A**stronomers **F**eel **G**ood **K**nowing **M**ore
  - (Traditional) Oh, Be A Fine Girl, Kiss Me

Photon energy

- Up to now, we have been discussing the wavelength of light as determining it color
- However, light comes in discrete packets called photons and the energy of each photon is set by its color or wavelength
- From Einstein, we known that the photon energy is proportional to frequency and inversely proportional to wavelength

Photon energy

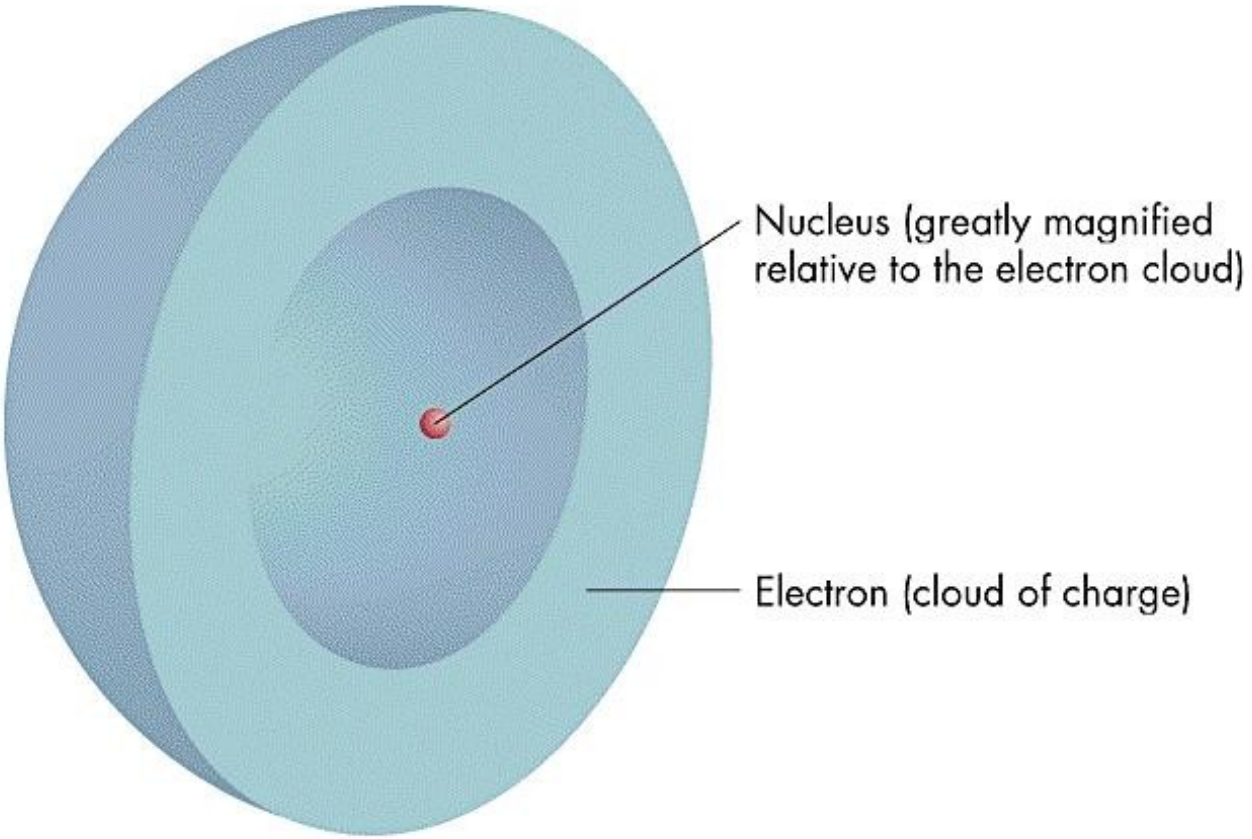


(NOTE: Frequency refers to number of crests of waves of same wavelength that pass by a point in one second.)

Compared to optical light, X-rays have

A) Shorter wavelength, lower energy
B) Shorter wavelength, higher energy
C) Longer wavelength, lower energy
D) Longer wavelength, higher energy
E) Amazing superpowers

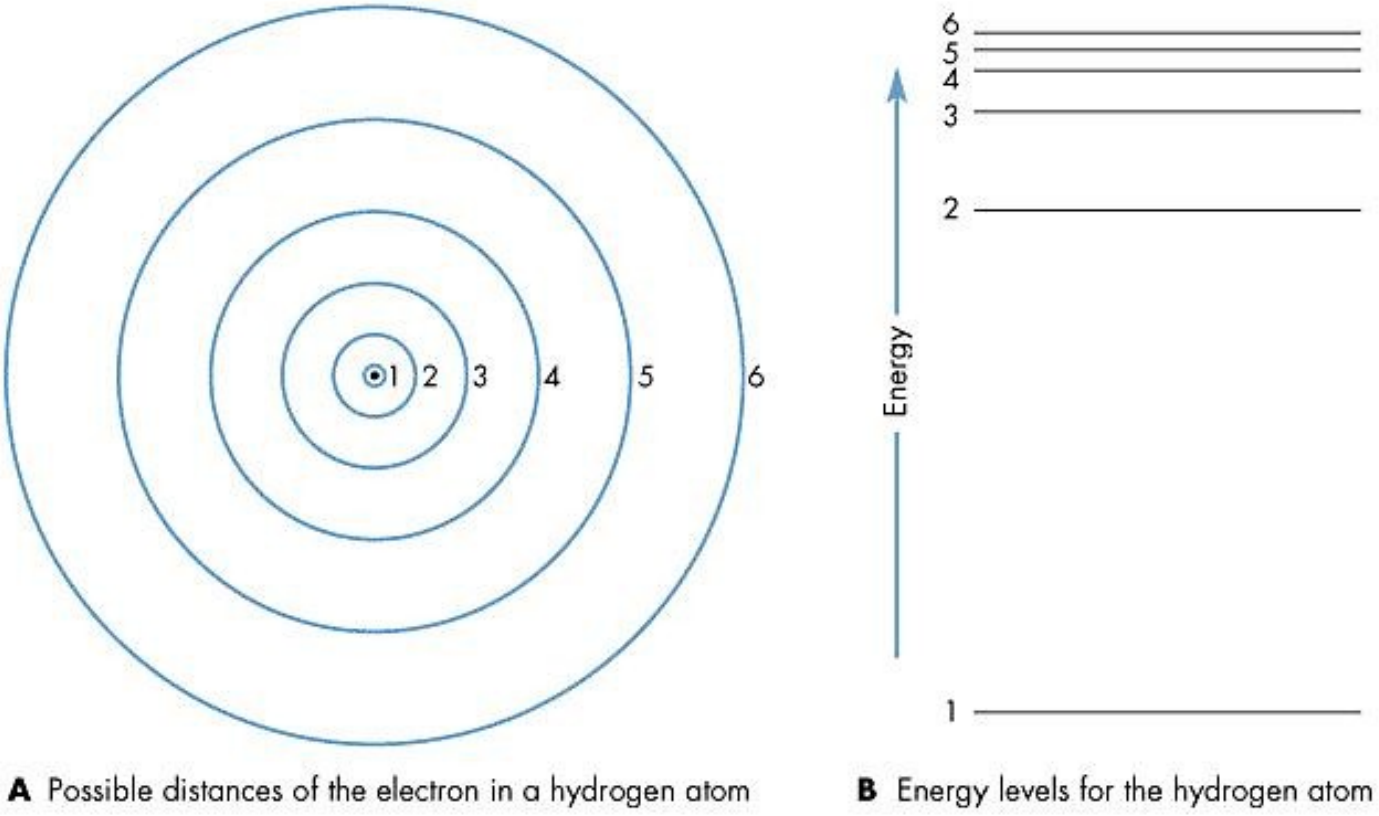
Hydrogen atom



Cross section of a hydrogen atom

Electron orbits around nucleus

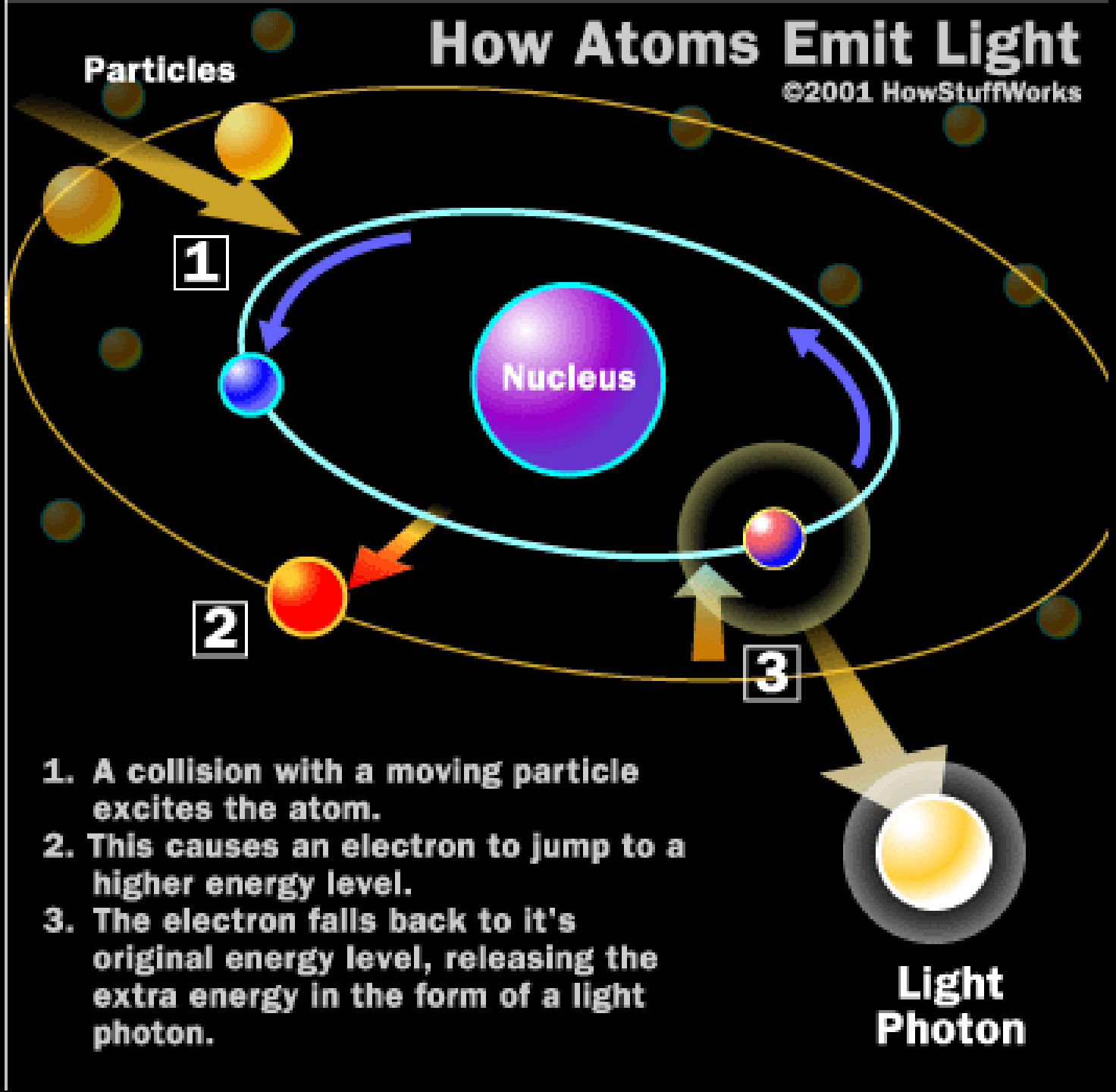
Electron orbits



A Possible distances of the electron in a hydrogen atom

B Energy levels for the hydrogen atom

From quantum mechanics, only certain orbits are allowed. Each orbit has a specific energy. Lowest energy level is called 'ground state'.


How Atoms Emit Light
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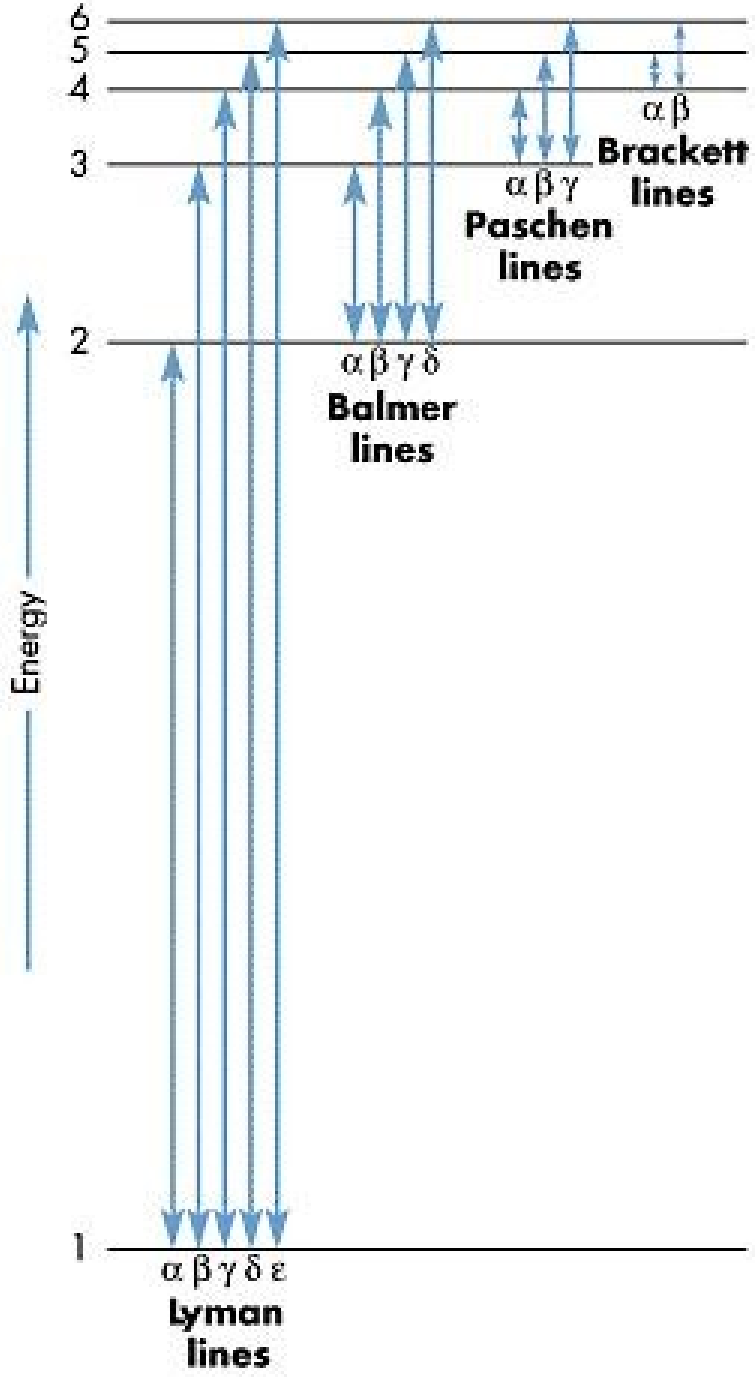
Particles
1
Nucleus
2
3
1. A collision with a moving particle excites the atom.
2. This causes an electron to jump to a higher energy level.
3. The electron falls back to it's original energy level, releasing the extra energy in the form of a light photon.
Light Photon

How atoms emit light

- The emitted photon has an energy which is exactly the energy difference between the orbits that the electron had before and after.
- Because only certain energies are allowed for the electron orbits, only certain energies of photons can be produced. We call these the spectral lines.



Spectral lines of hydrogen

The length of each arrow determines the energy of the photon emitted.

Which of the following statements about electrons is **not** true?

A) Electrons orbit the nucleus rather like planets orbiting the Sun.

B) Within an atom, an electron can have only particular energies.

C) Electrons can jump between energy levels in an atom only if they receive or give up an amount of energy equal to the difference in energy between the energy levels.

D) An electron has a negative electrical charge.

E) Electrons have very little mass compared to protons or neutrons.

Spectral lines

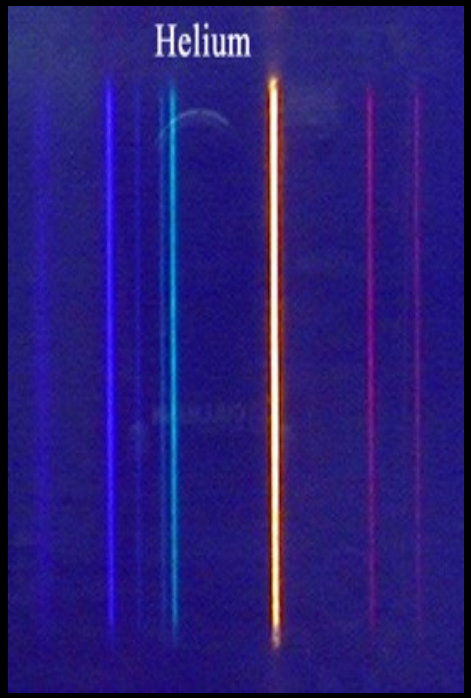
- Each element (hydrogen, helium, neon, mercury, iron, …) has its own particular set of energy levels and its own set of spectral lines.

- Do demonstration (7B10.10)

Spectra

A

B



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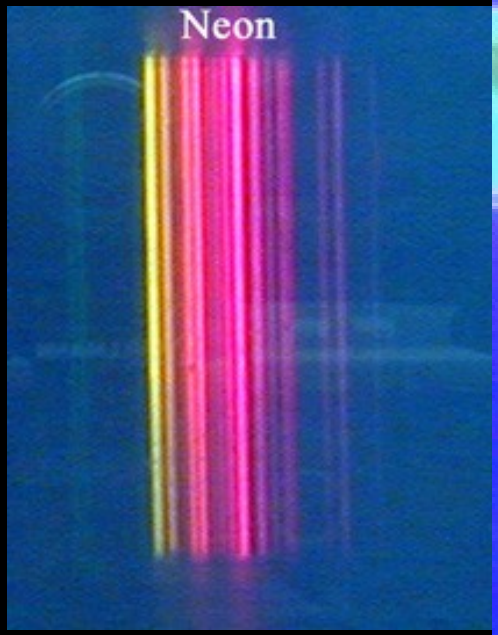
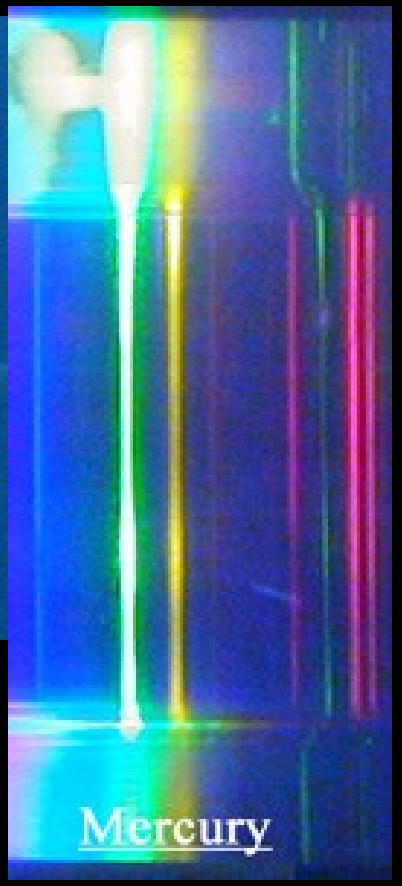


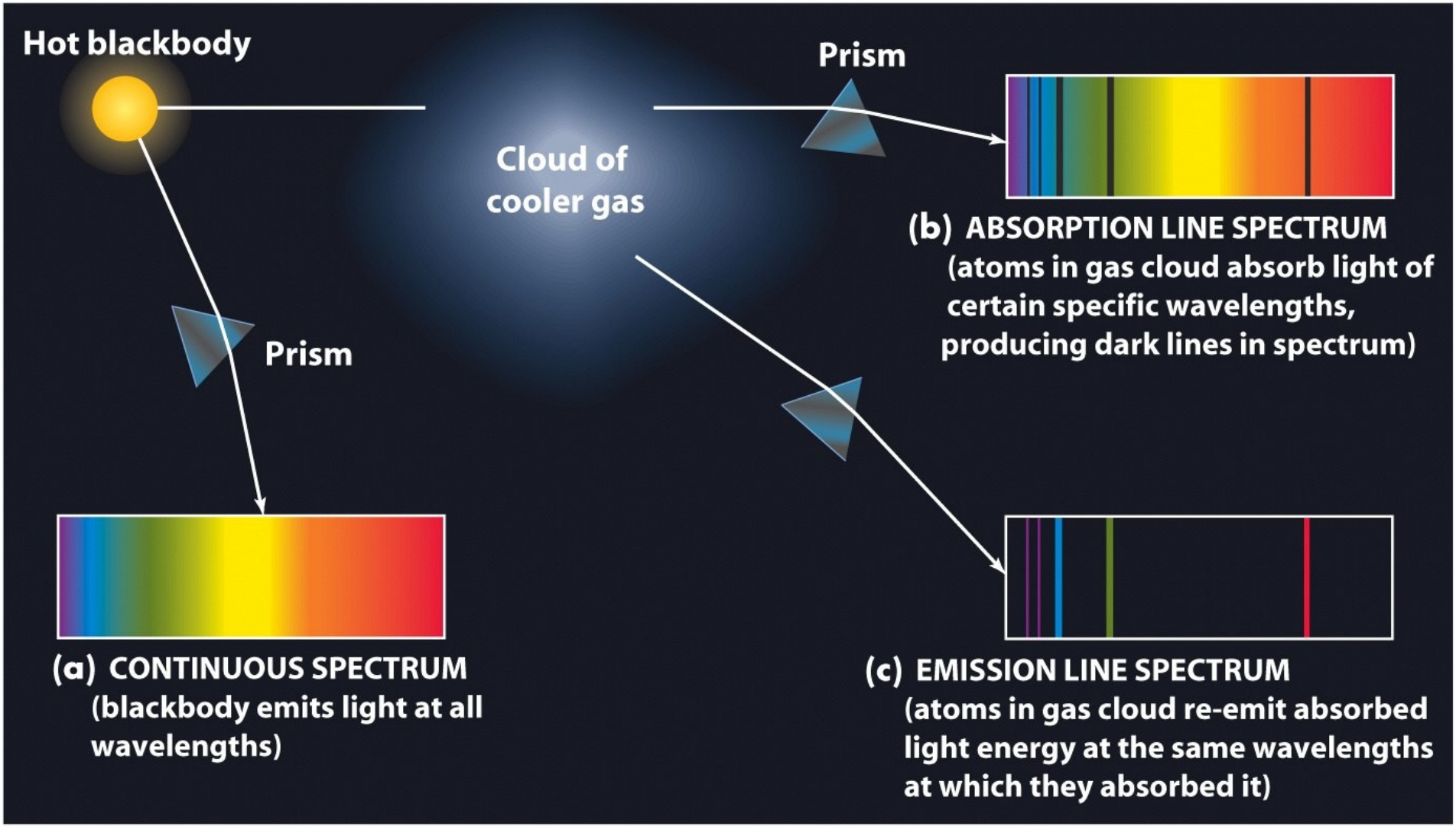
D



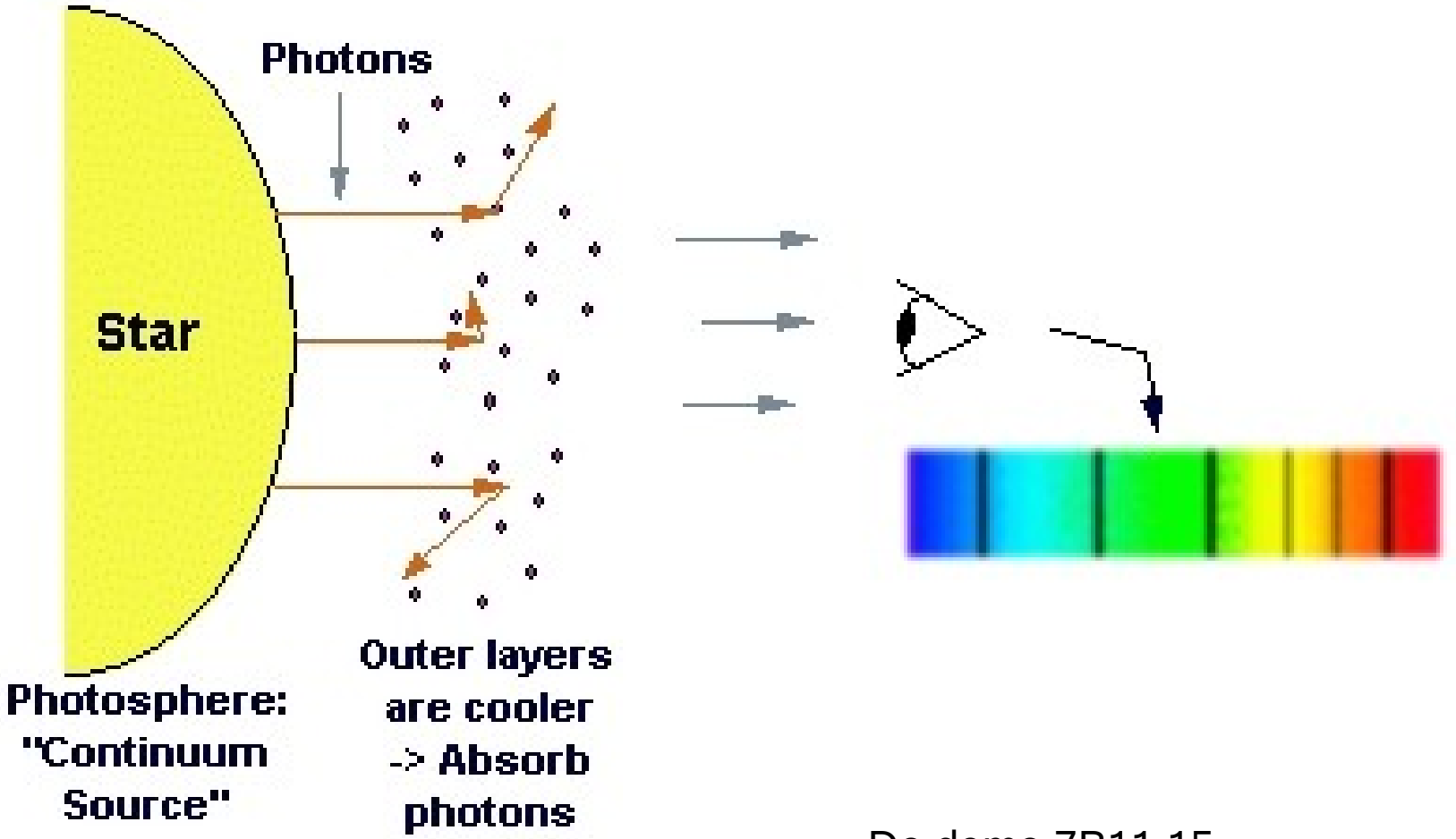
Uses of spectral lines

- Because each element has it own unique pattern of spectral lines, the spectral lines from stars can be used to determine the composition, or the relative number of atoms of each elements, of the stars

Kirchhoff's Laws

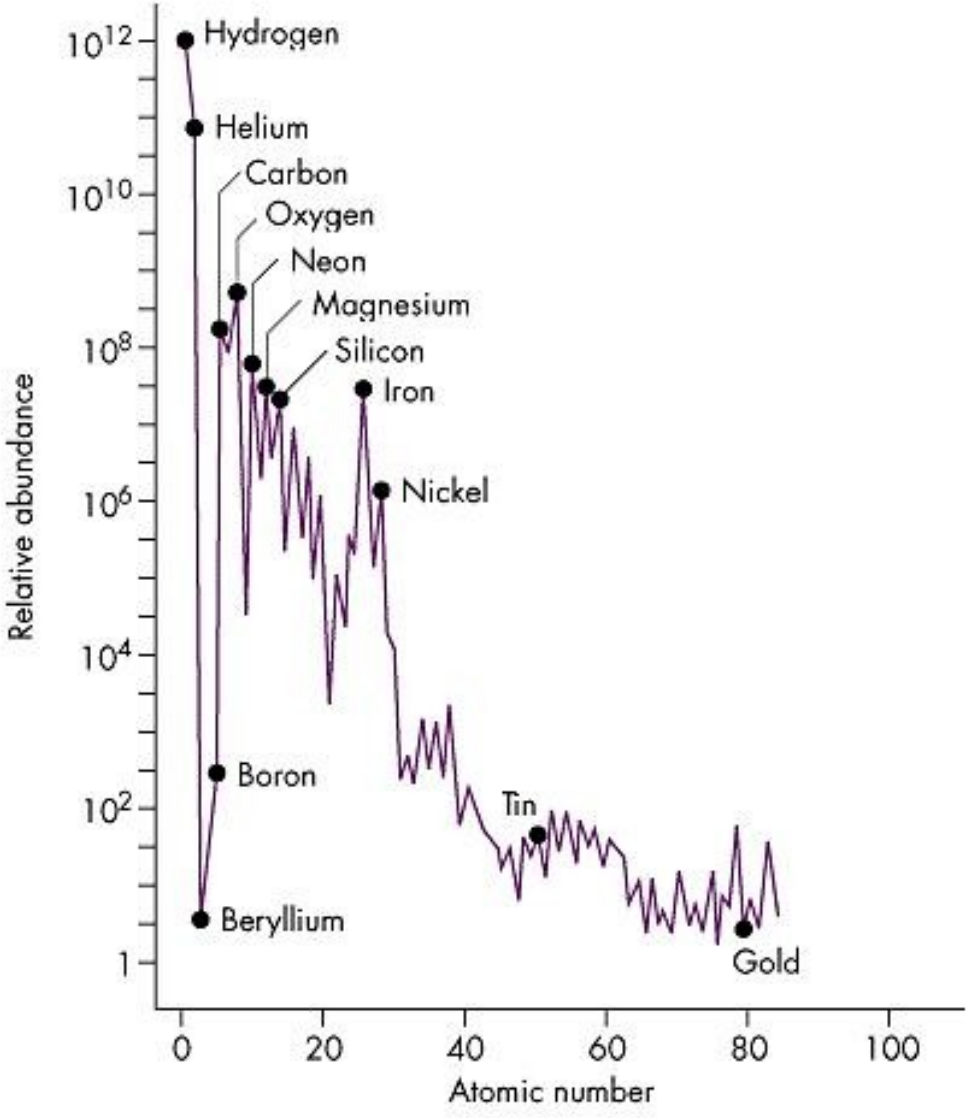


Absorption spectrum of a star



Do demo 7B11.15

Composition of a typical star



Masses of stars

- Spectral lines also allow us to measure the velocities of stars via the Doppler shift that we discussed in searching for extra-solar planets. Doppler shift measurements are usually done on spectral lines.
- Essentially all of the mass measurements that we have for stars are for stars in binary systems – two stars orbiting each other.

Mass-Luminosity relation