Light and Matter

Assignment (due: M, 9/20):

1.) Read Ch. 14

2.) Ch. 4 problems 1 - 12; Ch. 5 problems 29 - 38.

Key Concepts:

1. The Experience of Light
2. The Physical Properties of Light
3. Properties of Matter: Atoms and Molecules
4. Learning from Light
5. Doppler Effect

The Everyday Experience of Light

1. Energy and Power

2. Light and Color

3. Light and Matter Interactions

The Everyday Experience of Light

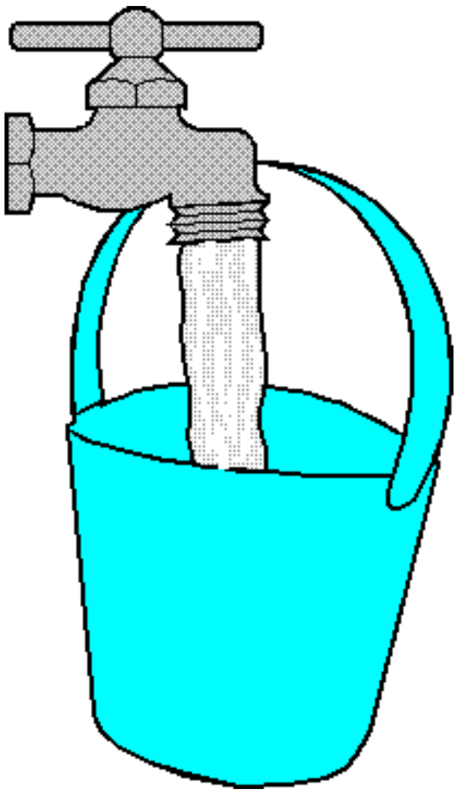
1. Energy and Power

What's the difference?

1. Energy and Power

Power is the *rate* at which energy is delivered or received.

e.g., 1 watt = 1 joule/s

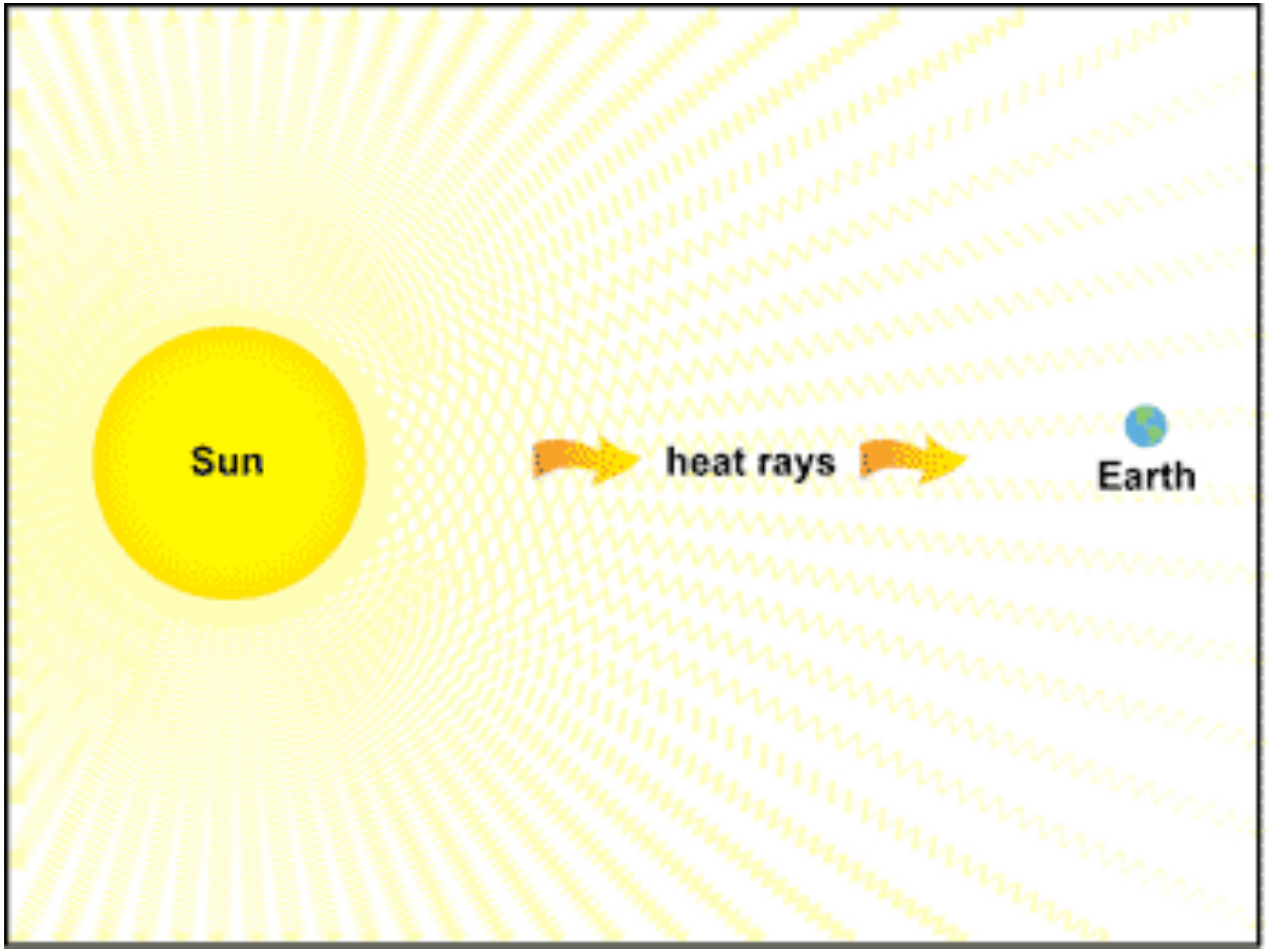


1. Energy and Power

Power is the *rate* at which energy is delivered, received, or transmitted.

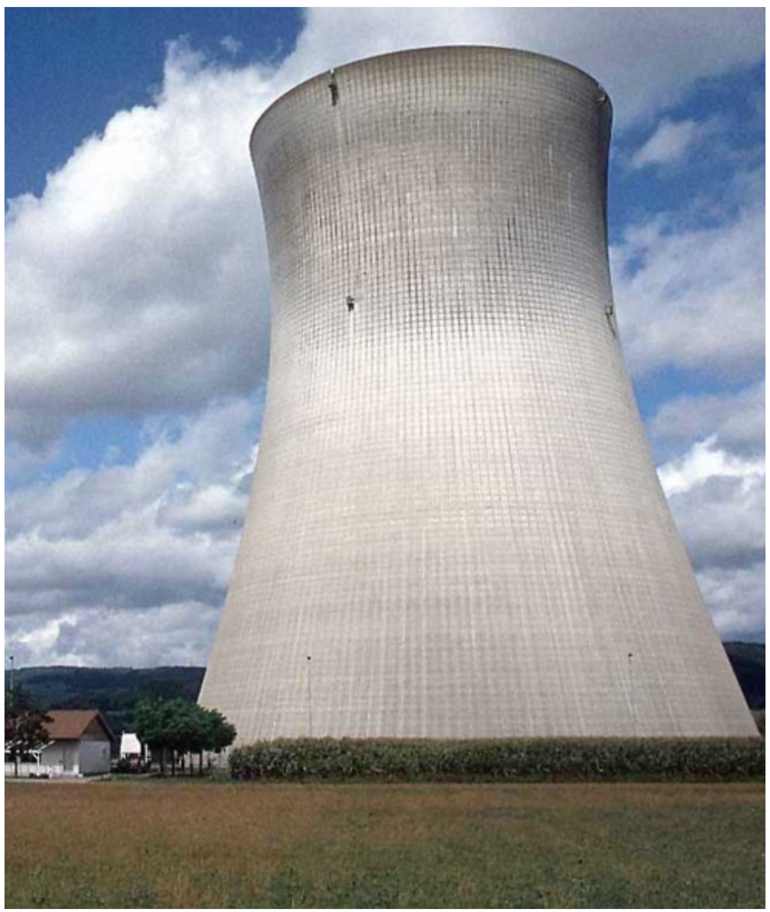
1. Energy and Power

Light *transmits* energy because each photon has a certain energy associated with it.



1. Energy and Power

Home energy usage:
1 kw-h (killo-watt hour = 1 kilo-watt * 1 hour)



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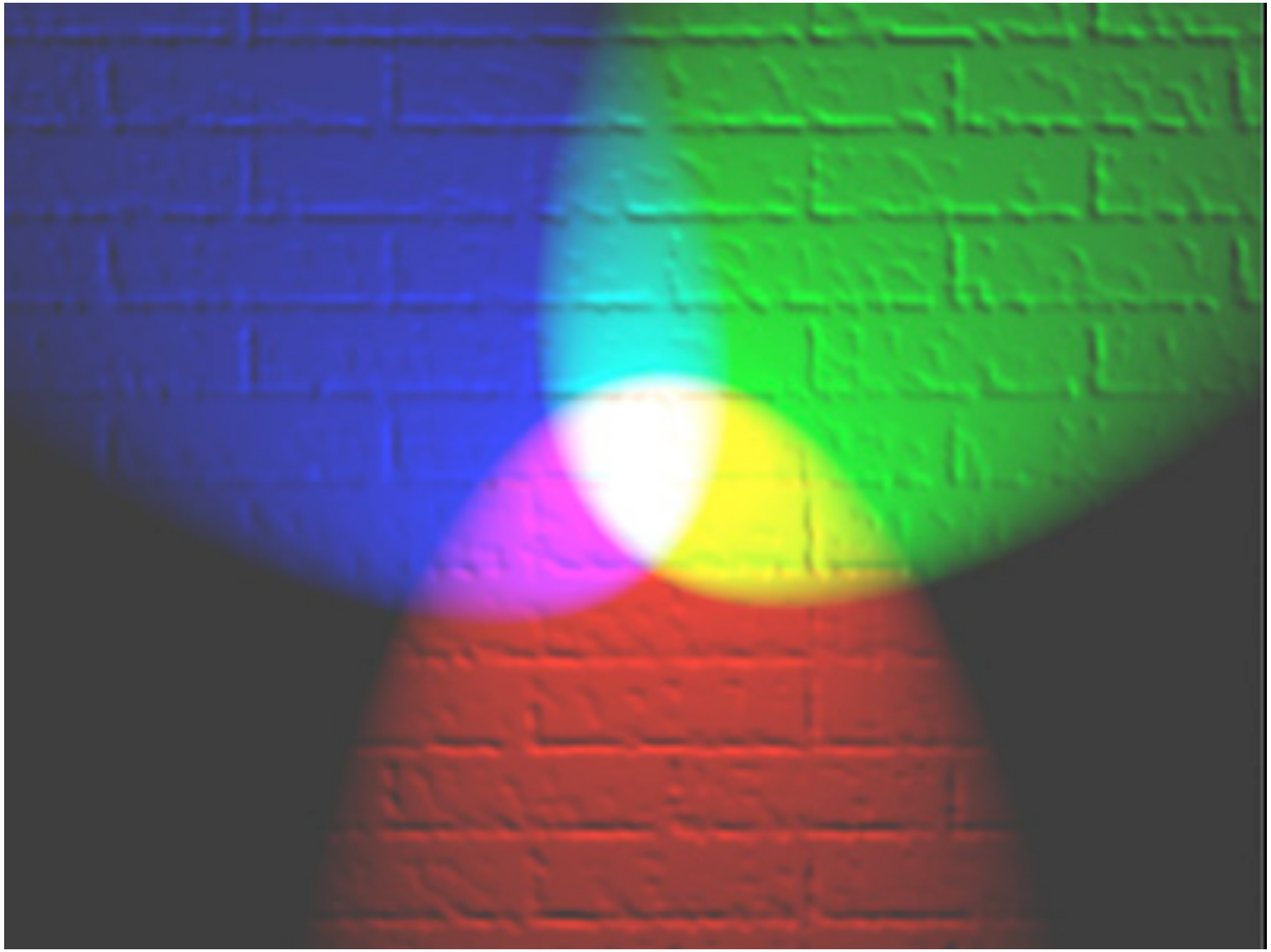
The Everyday Experience of Light

2. Light and Color

White Light Spectrum

The Everyday Experience of Light

2. Light and Color



3. Interaction of Light and Matter:

a. Emission

b. Absorption

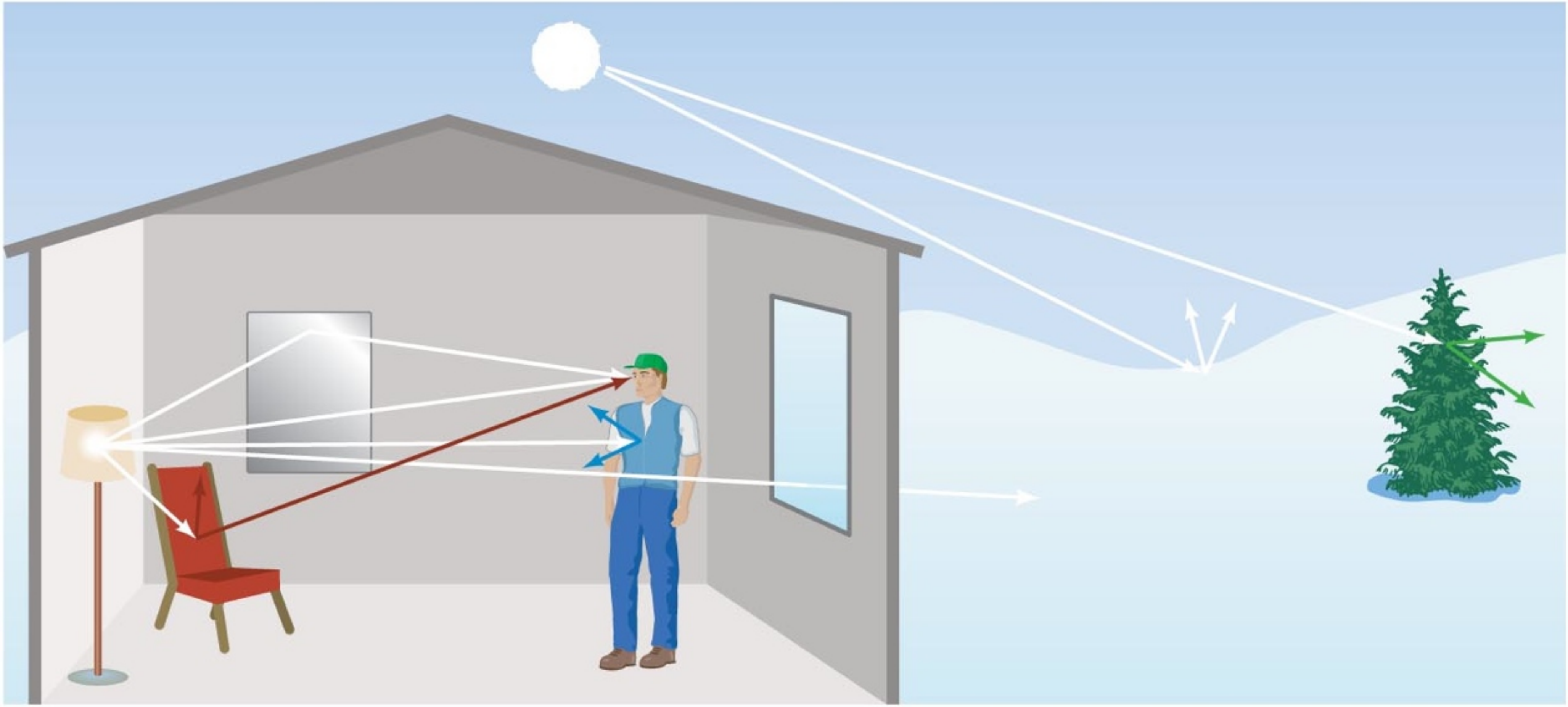
c. Transmission

d. Reflection / Scattering

3. Interaction of Light and Matter

Interaction of Light and Matter:

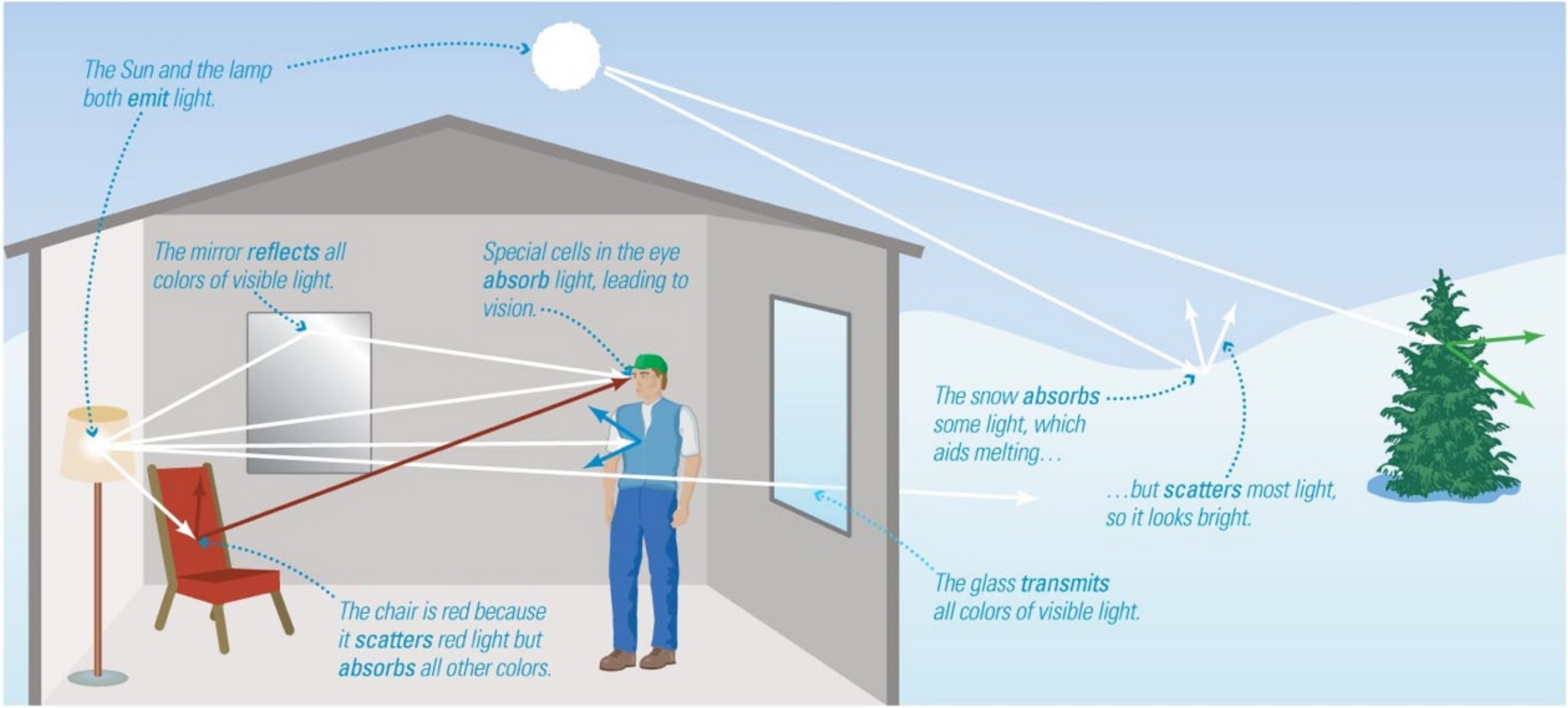
a. Emission, b. Absorption, c. Transmission, d. Reflection / Scattering



3. Interaction of Light and Matter

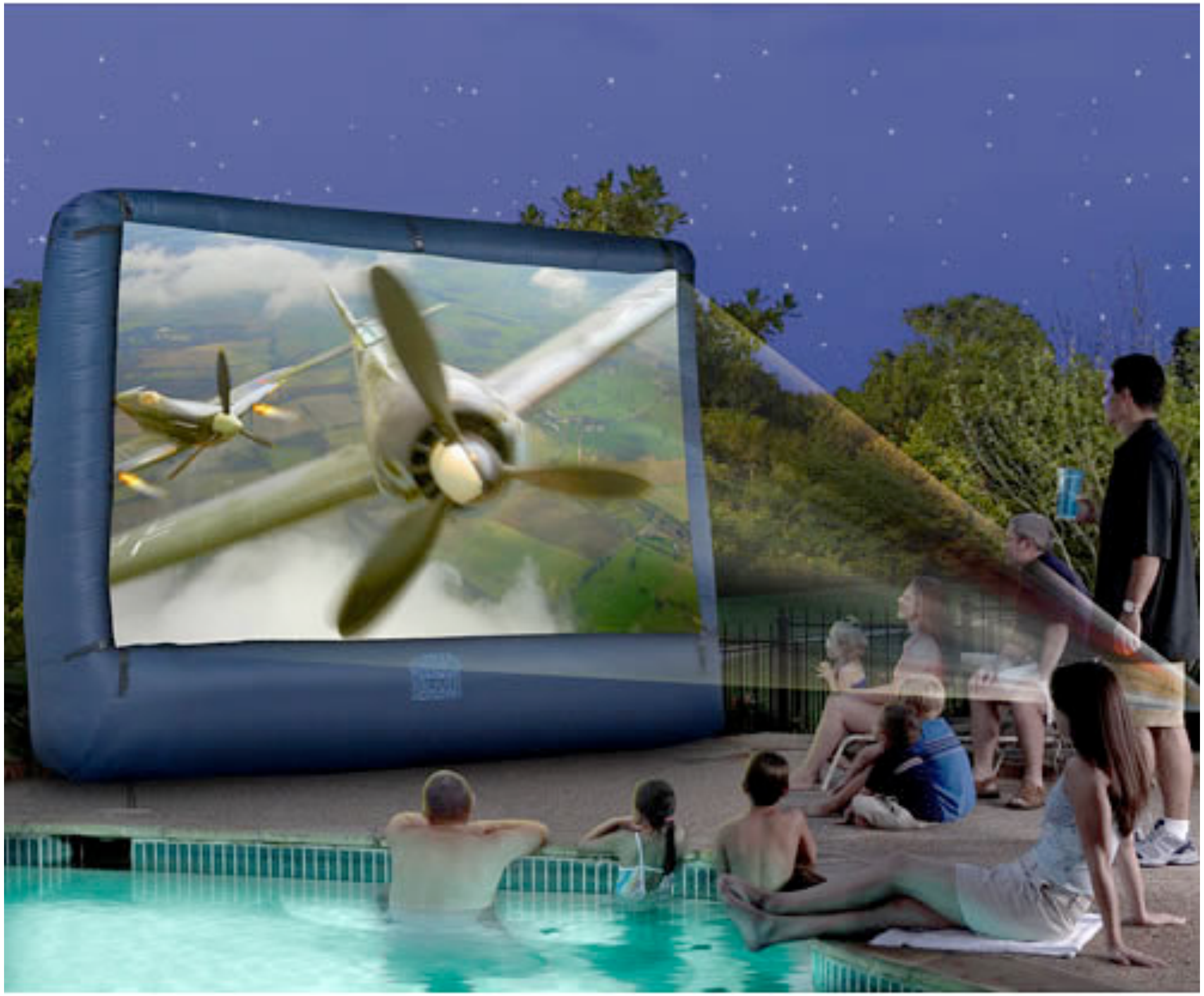
Interaction of Light and Matter:

a. Emission, b. Absorption, c. Transmission, d. Reflection / Scattering



The Everyday Experience of Light

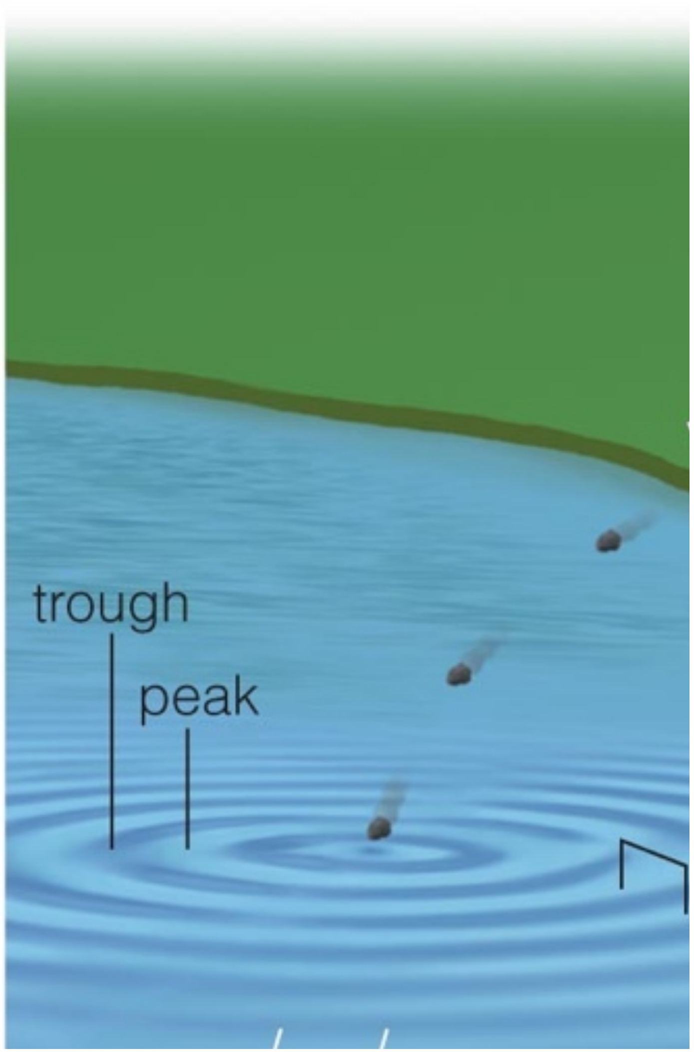
3. Interaction of Light and Matter



The Everyday Experience of Light

3. Interaction of Light and Matter

Physical Properties of Light

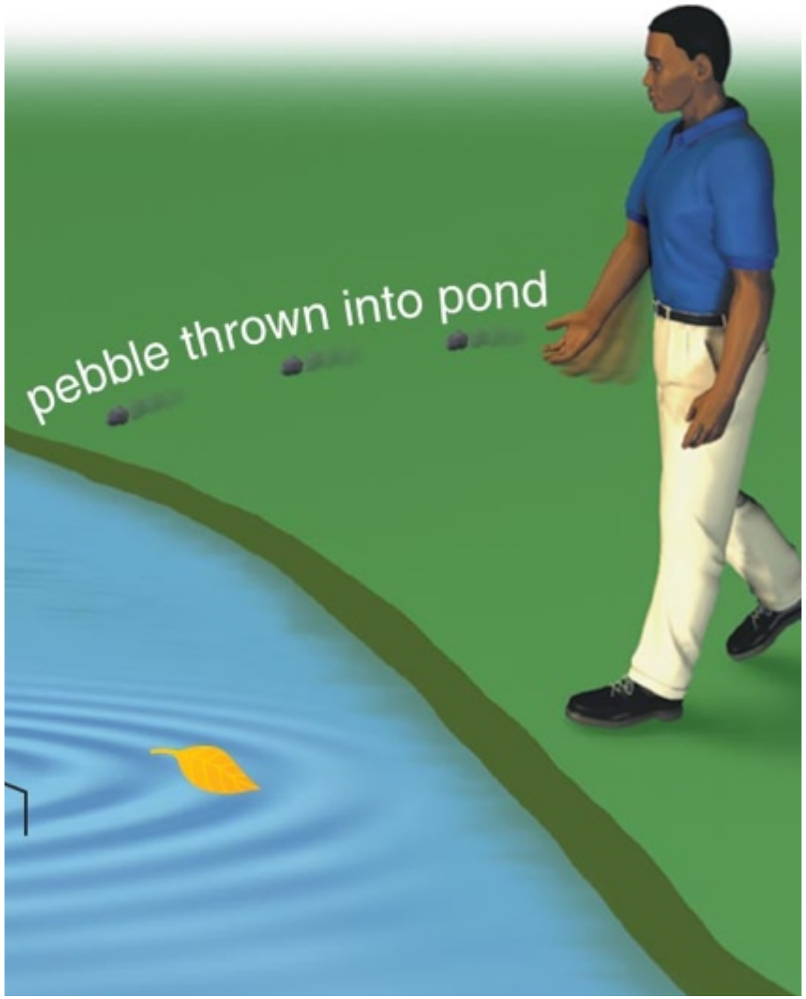


What is light?

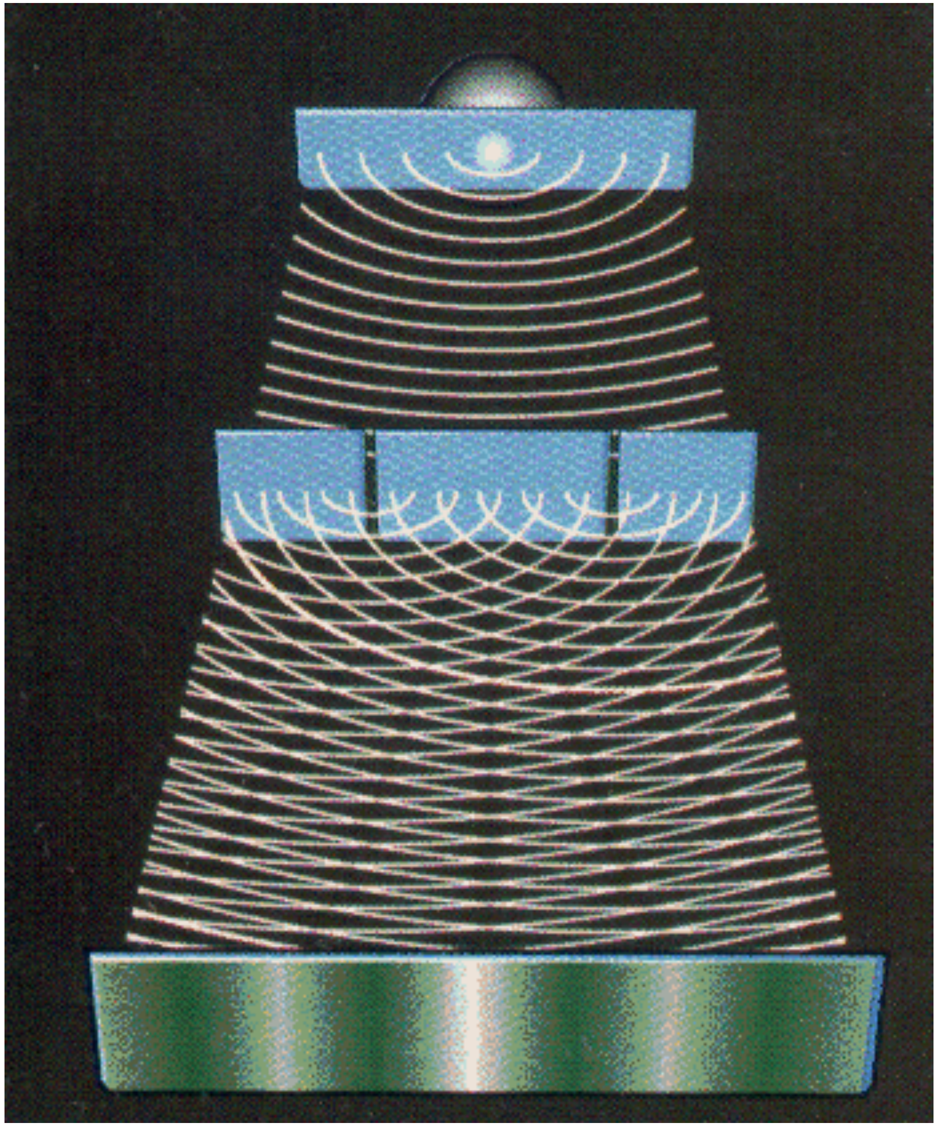
a particle

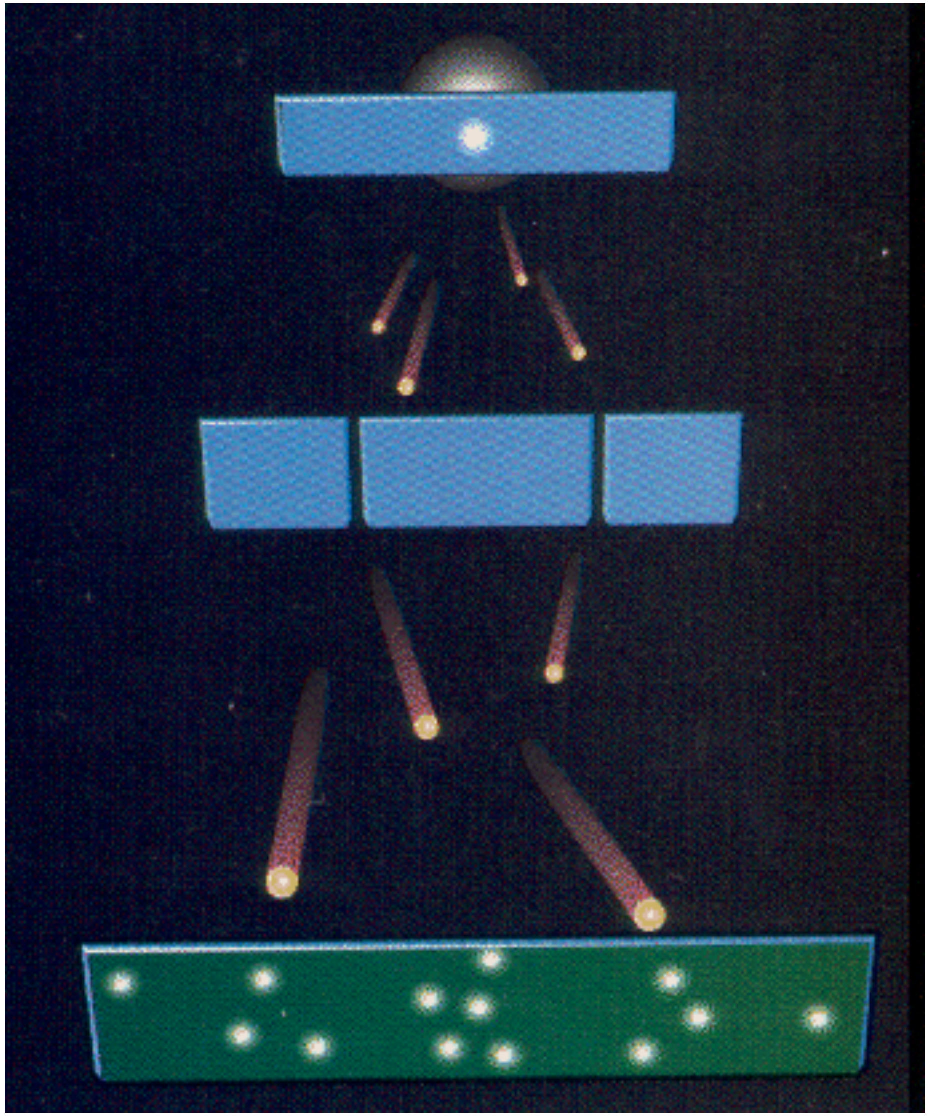
and

a wave



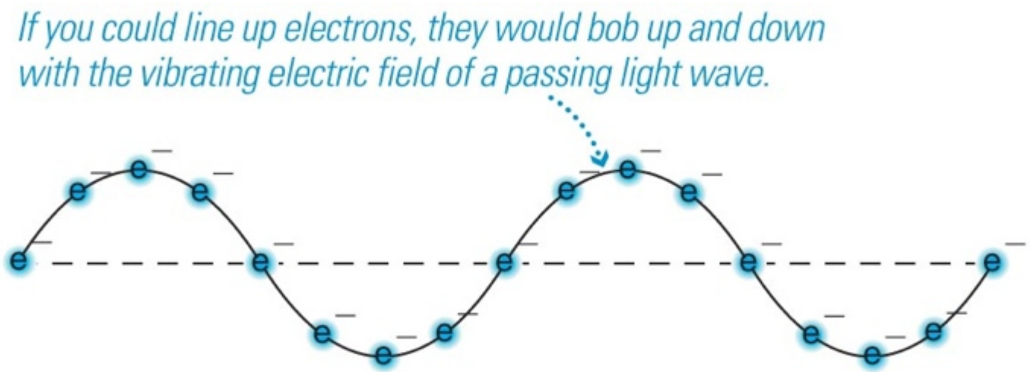
Physical Properties of Light



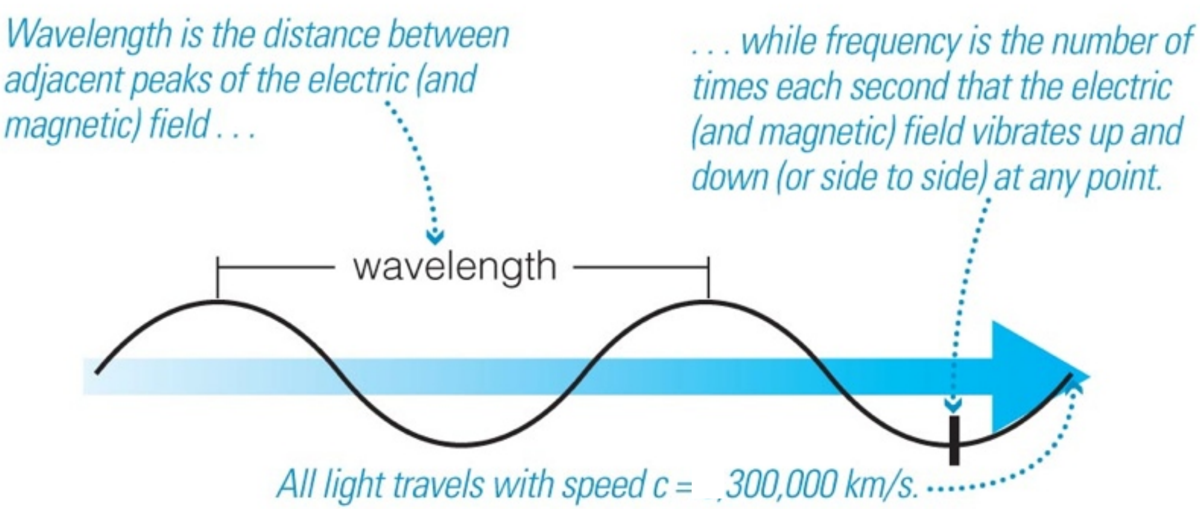


Wave *and* Particle

Physical Properties of Light **Electromagnetic Wave**



a Electrons move when light passes by, showing that light carries a vibrating electric field.



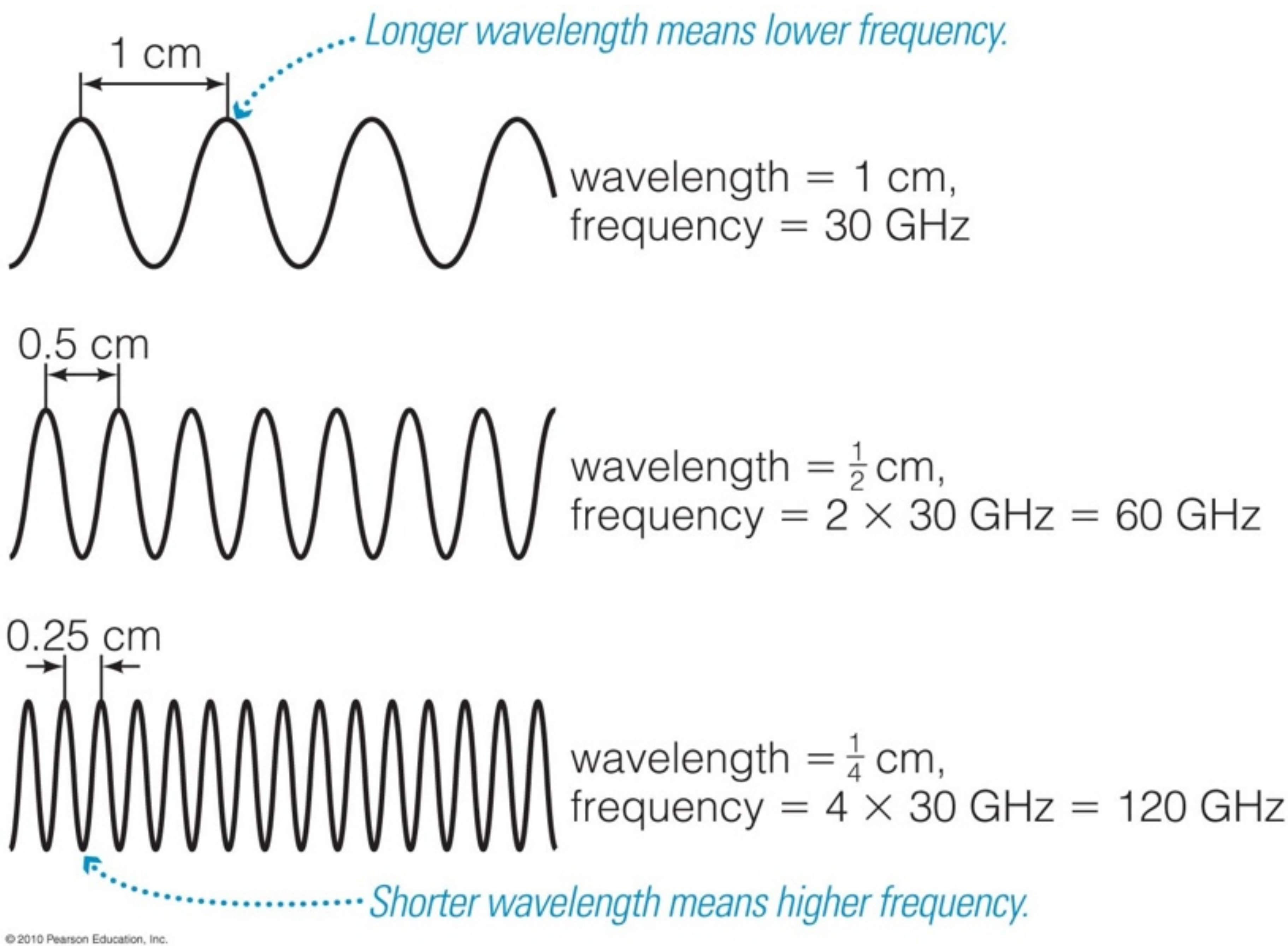
b The vibrations of the electric field determine the wavelength and frequency of a light wave. Light also has a magnetic field (not shown) that vibrates perpendicular to the direction of the electric field vibrations.

Some properties:

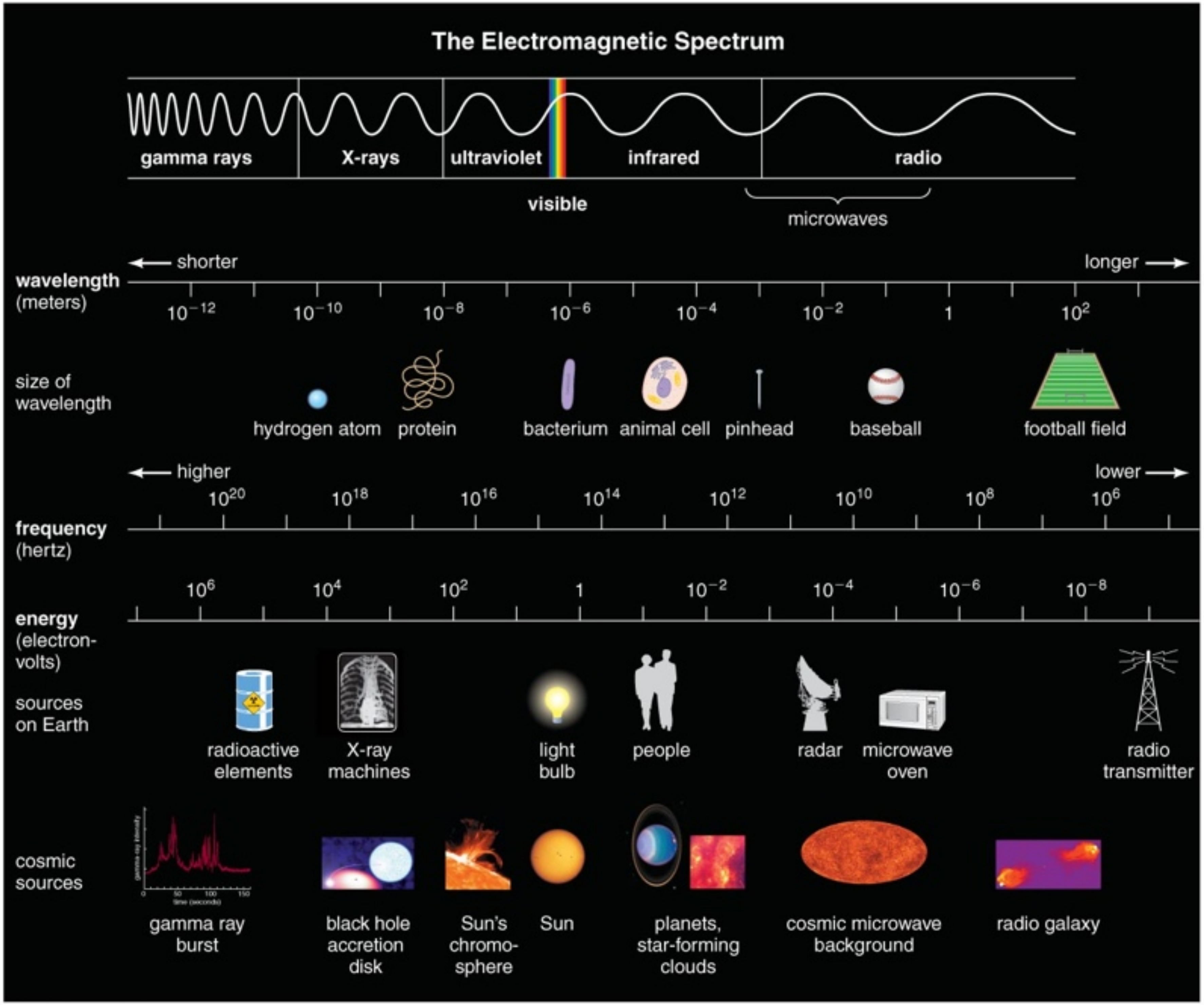
wavelength * frequency = speed = c

energy = h*frequency

Physical Properties of Light **Electromagnetic Wave**

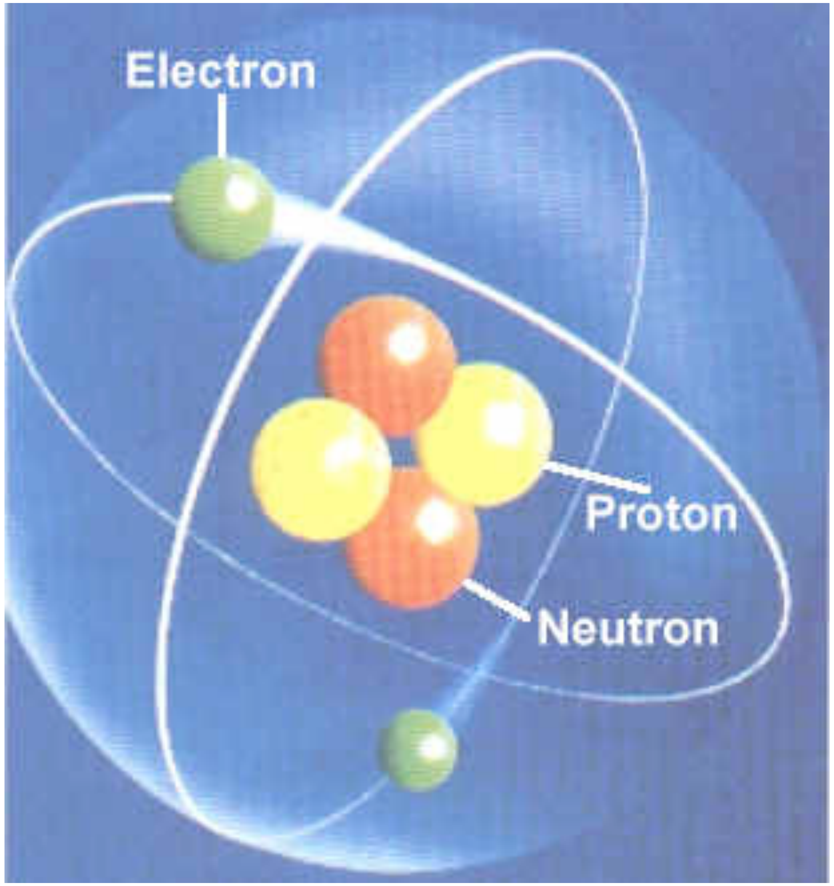


Physical Properties of Light



Properties of Matter

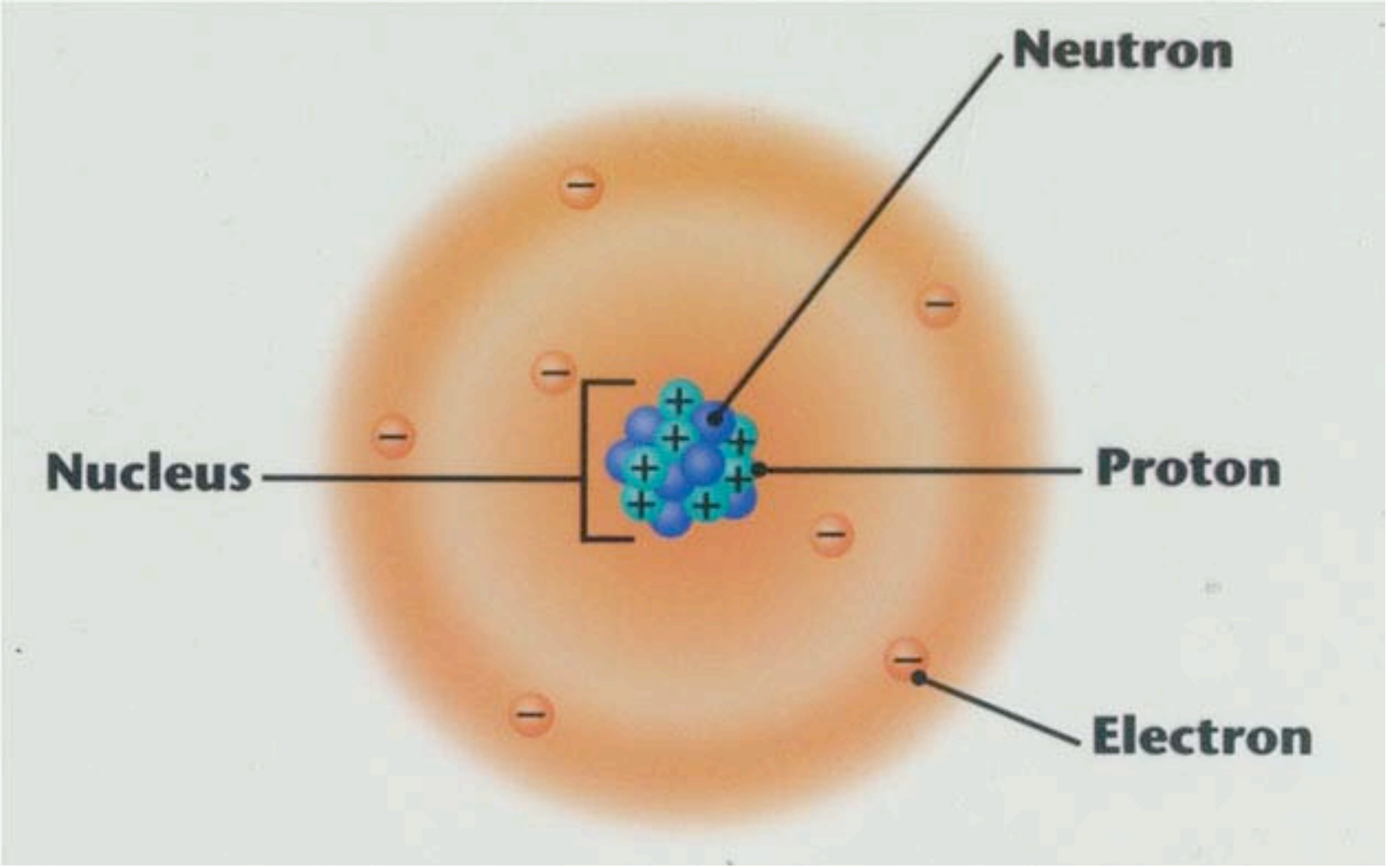
I. The Structure of Matter



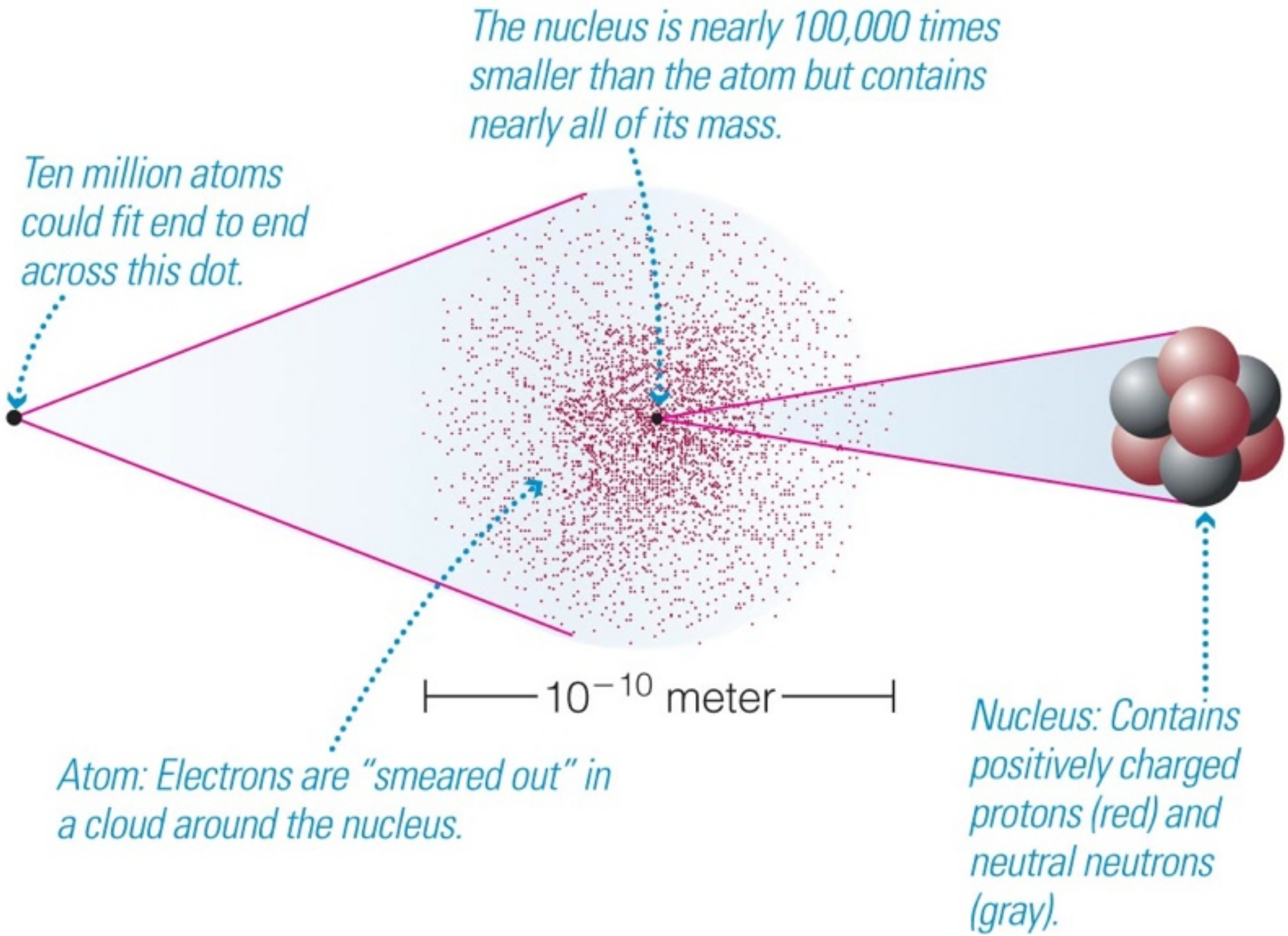
old school picture

Properties of Matter

1. The Structure of Matter



Properties of Matter
1. The Structure of Matter



Properties of Matter

Vocabulary:

Atom

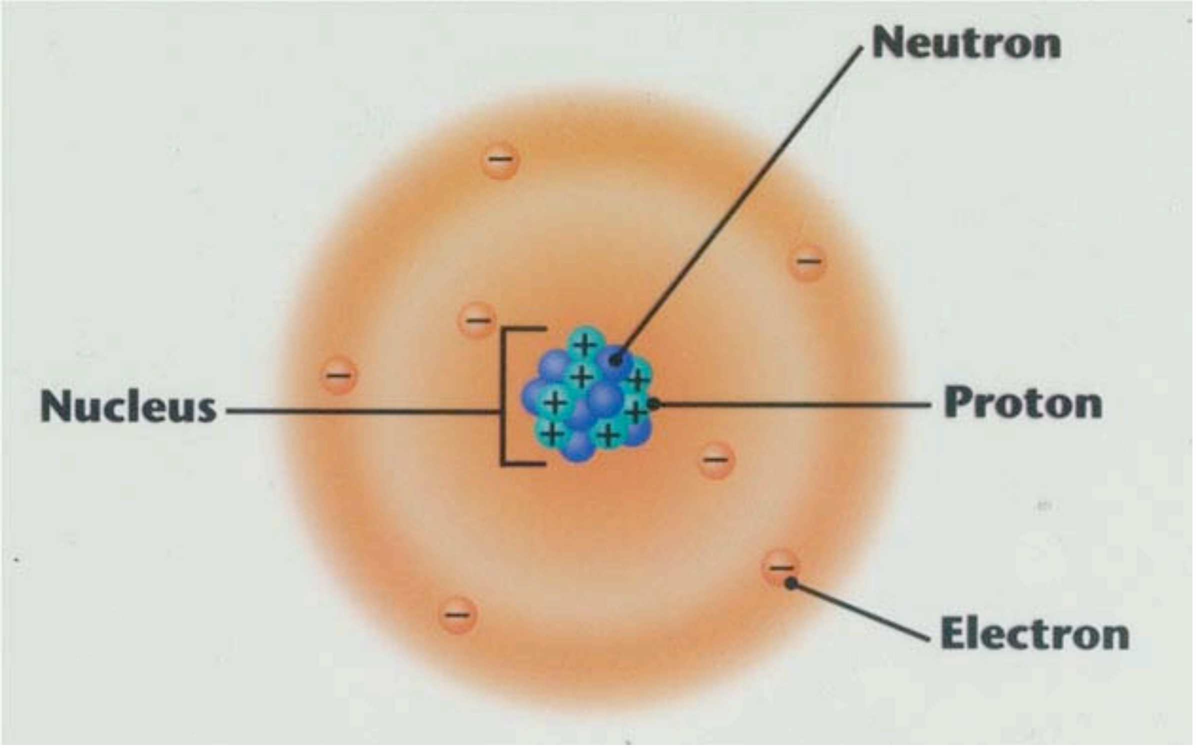
Nucleus

Protons

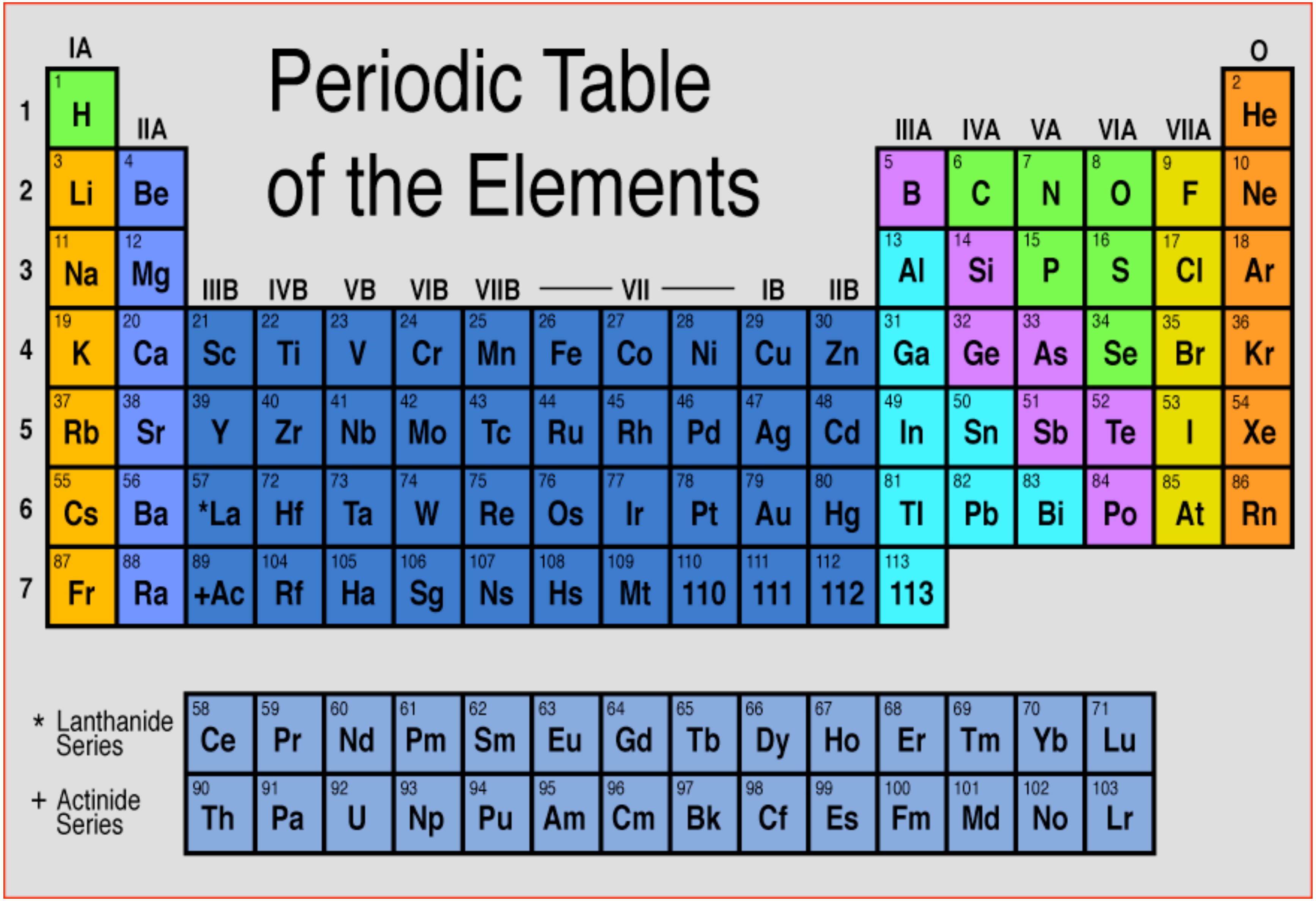
Neutrons

Electrons

The Atom



Properties of Matter



Properties of Matter

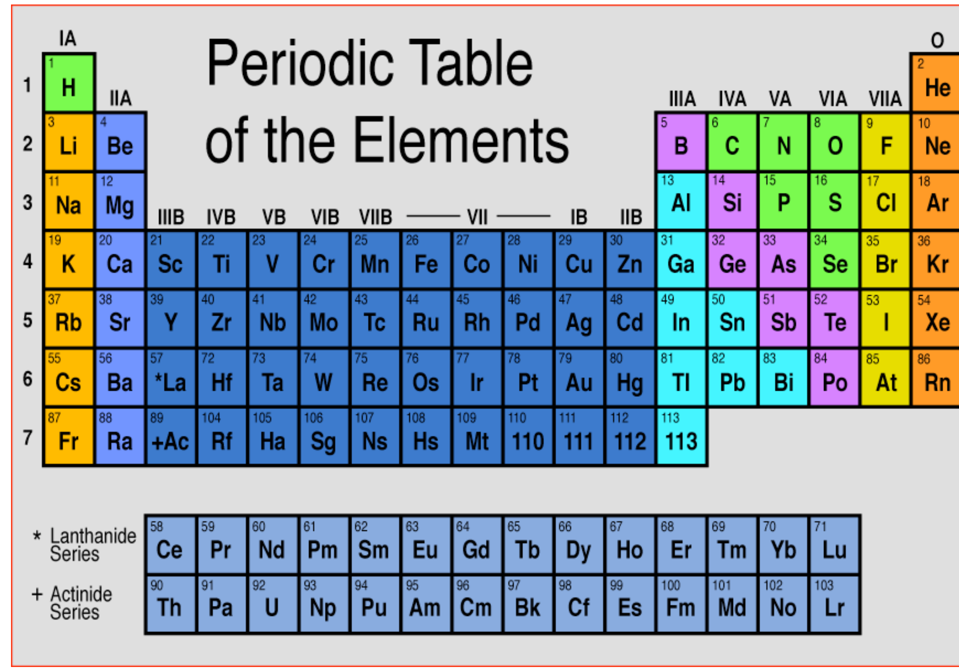
Vocabulary:

Atomic Number, Z

Atomic Mass, A

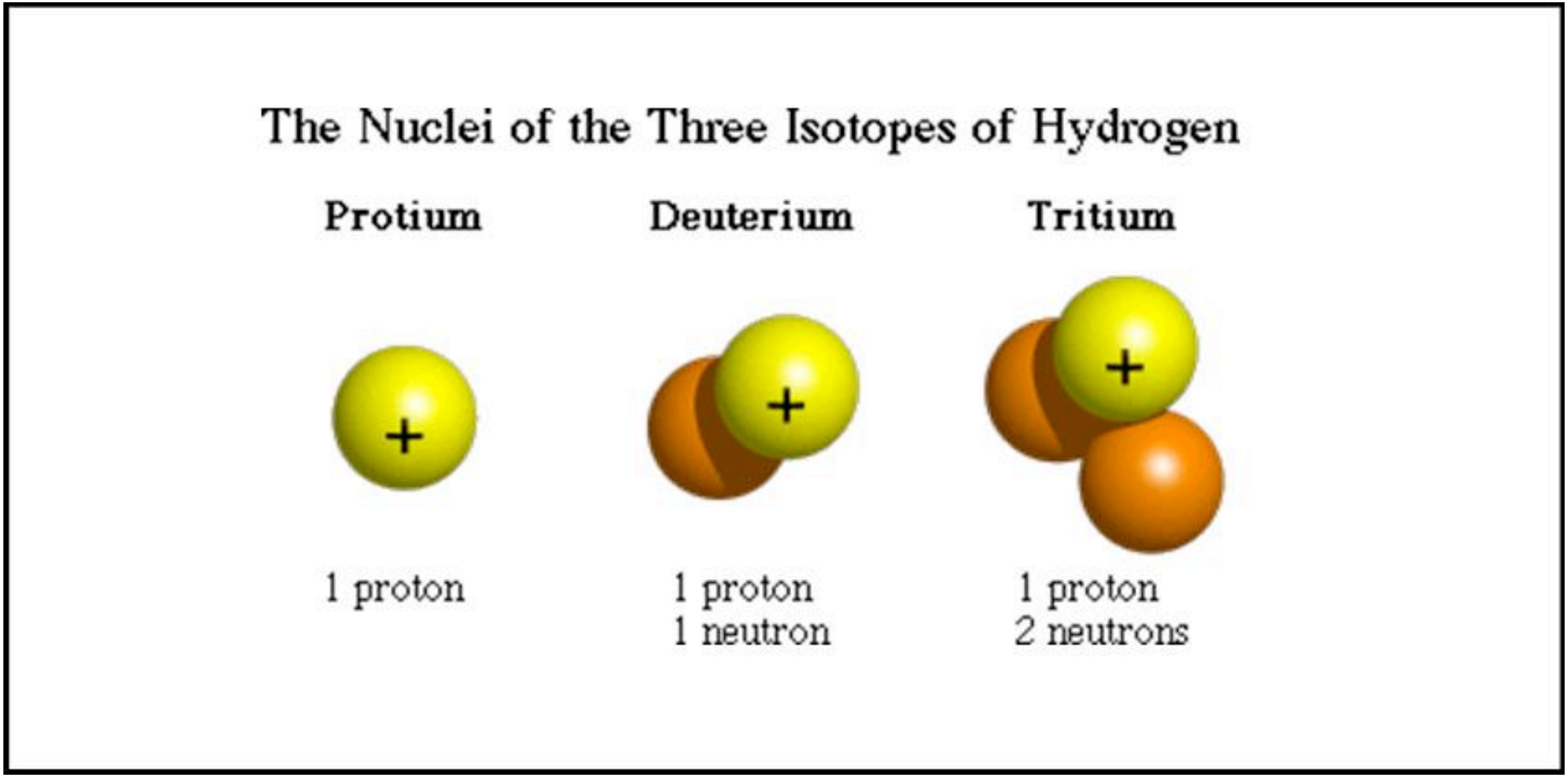
Isotope: Same Z, different A

Examples: C12, C13

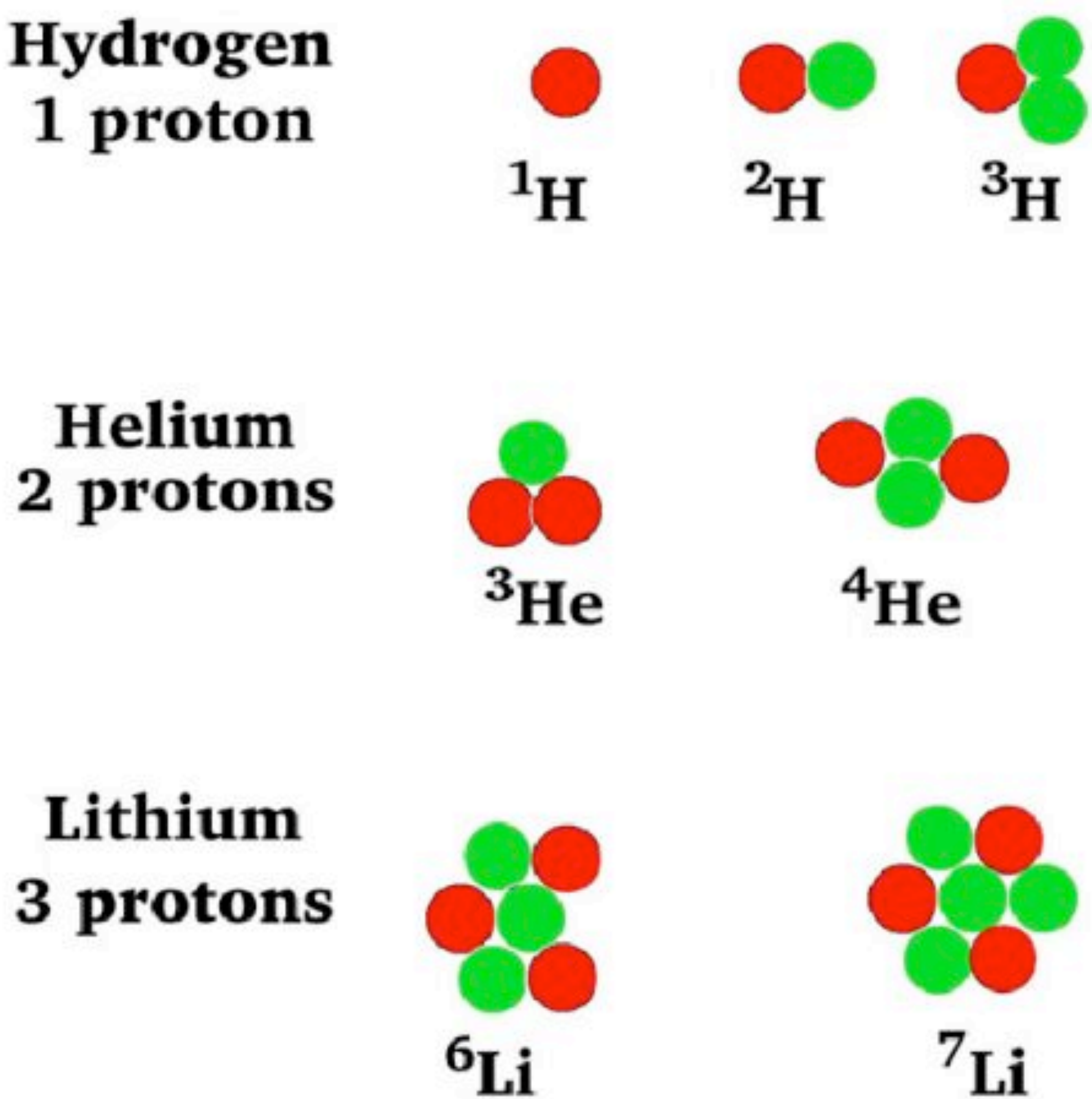


Properties of Matter

Isotopes



Properties of Matter: Isotopes

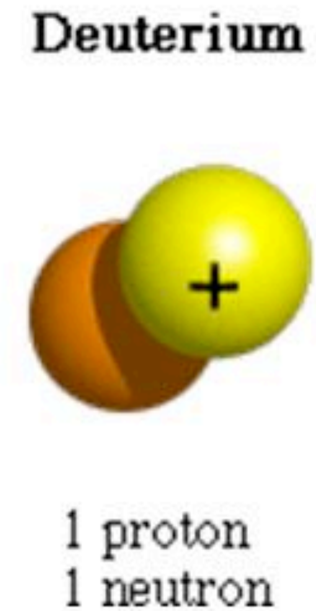


Properties of Matter

Vocabulary:

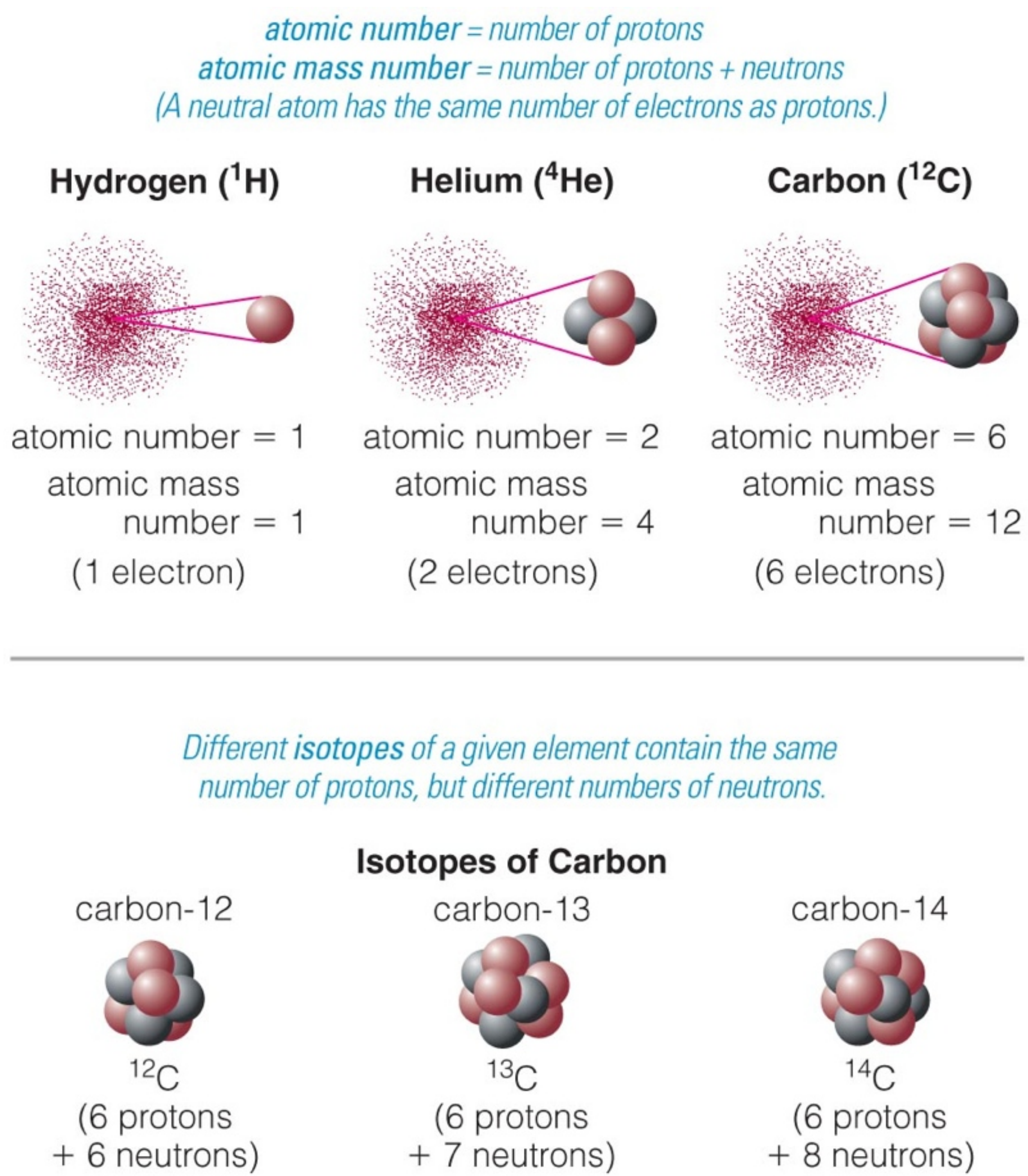
Isotope

Electrical Charge

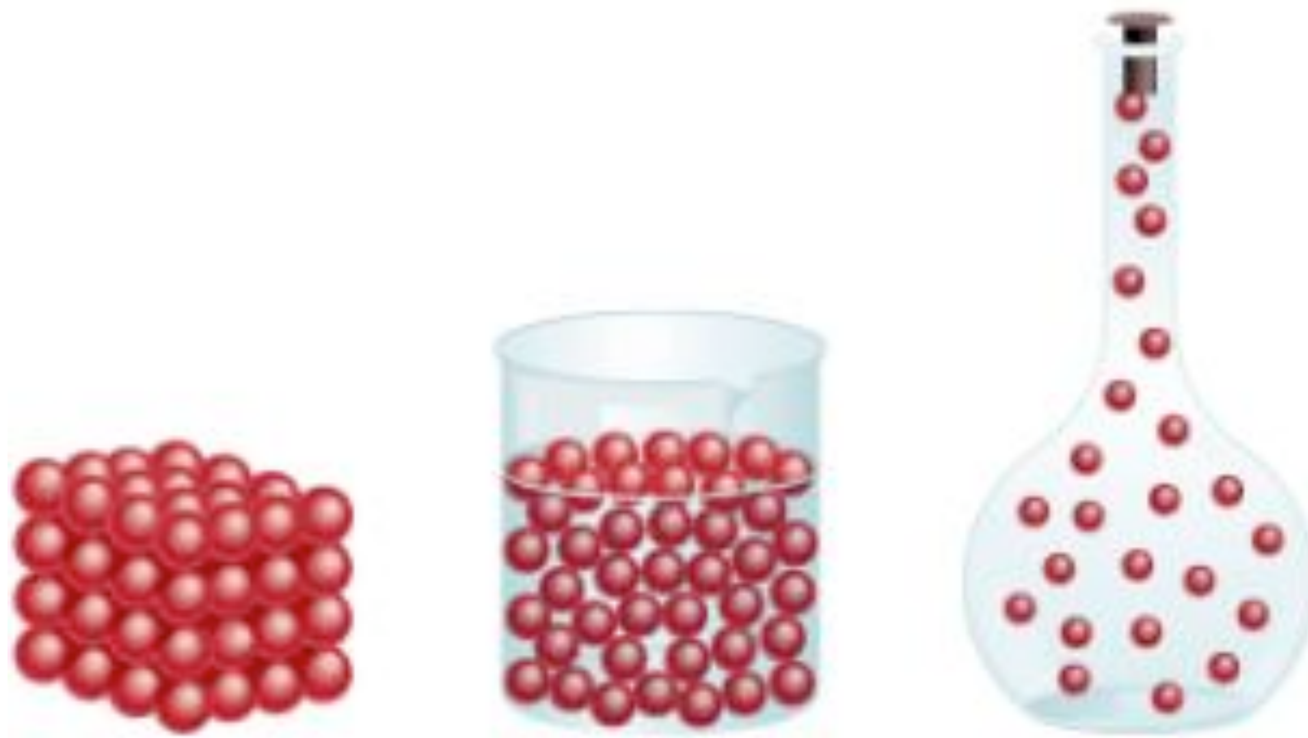


Q: Why isn't matter charged, in general?

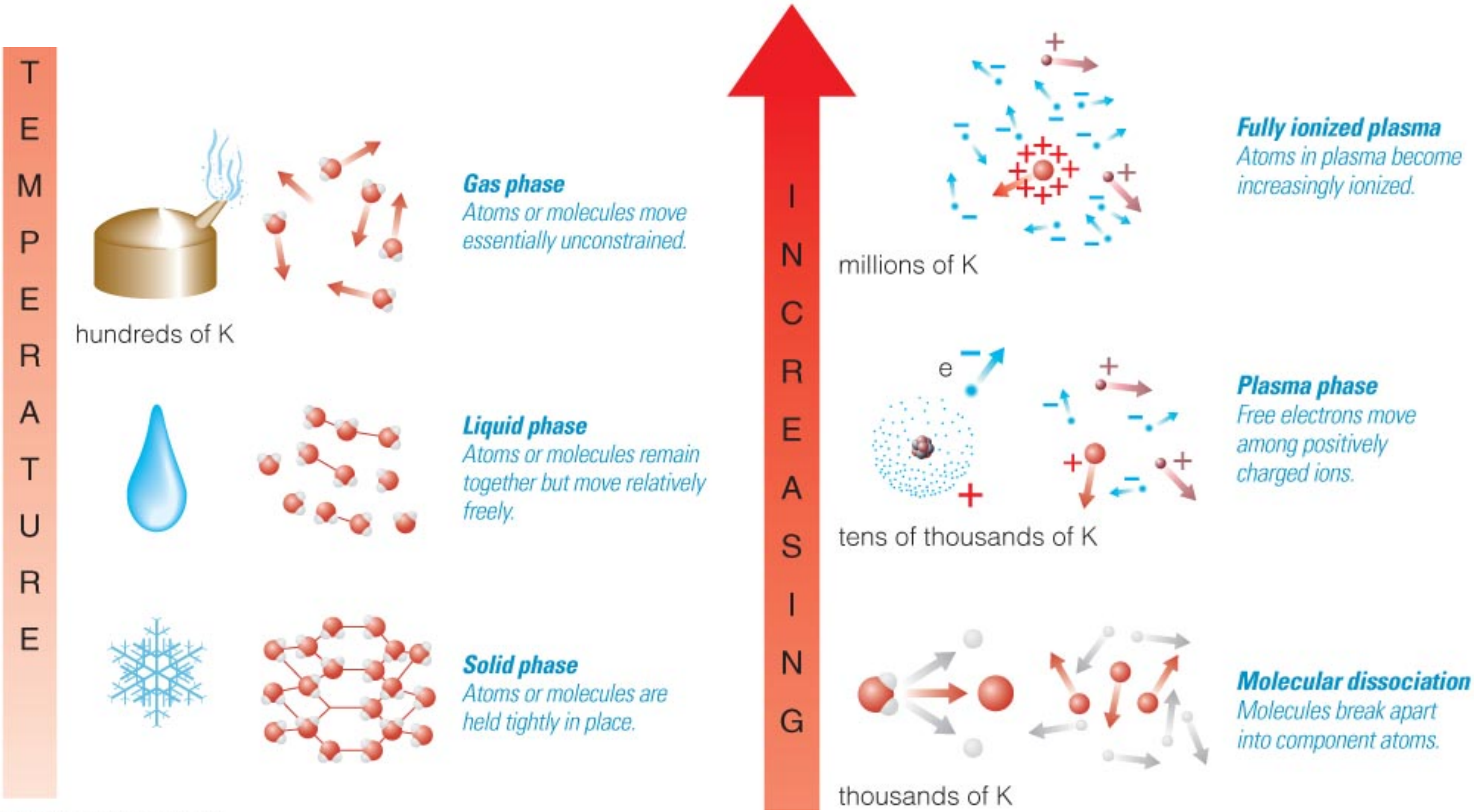
Properties of Matter



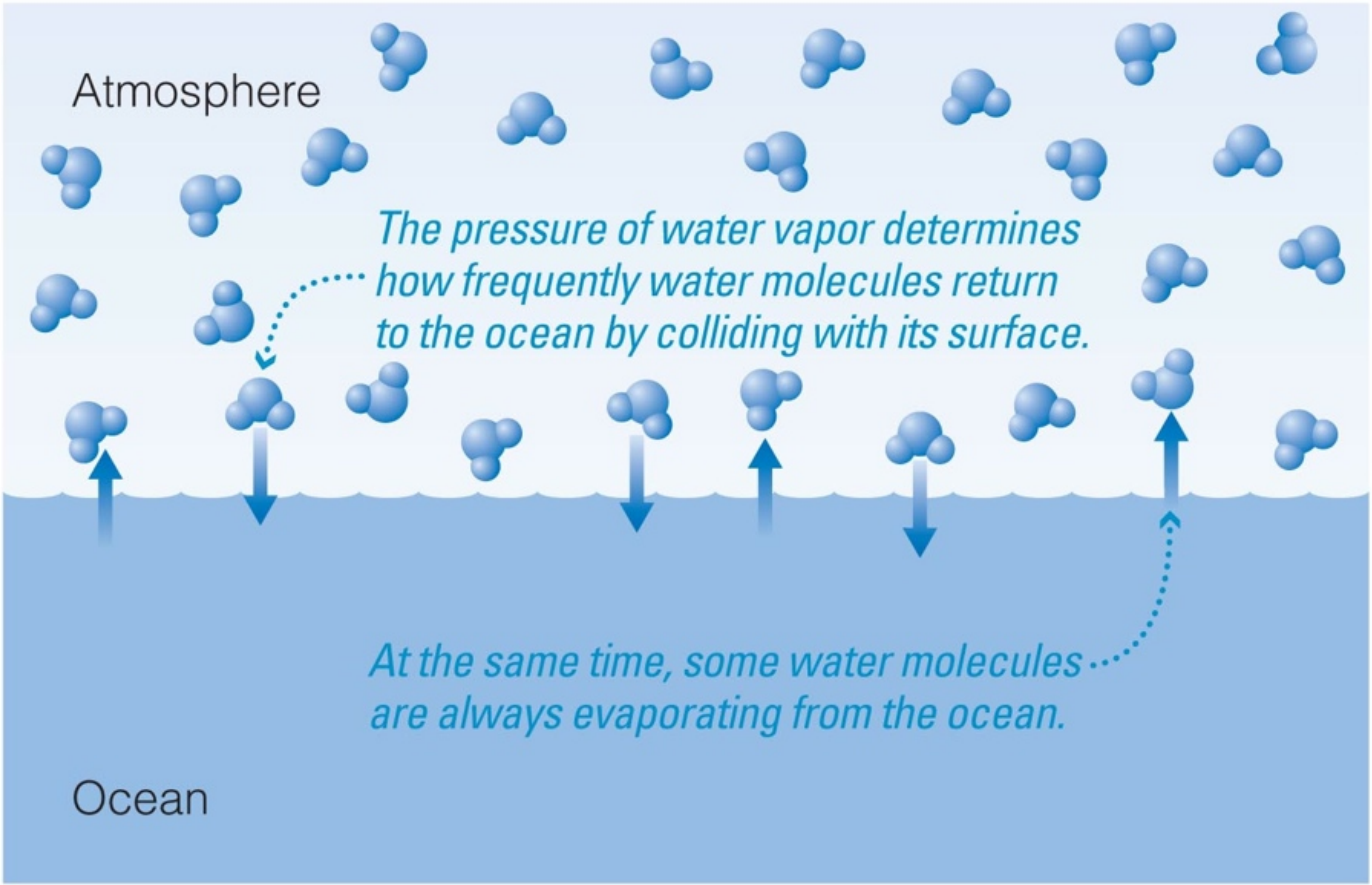
Properties of Matter: **Phases**



Properties of Matter: **Phases**

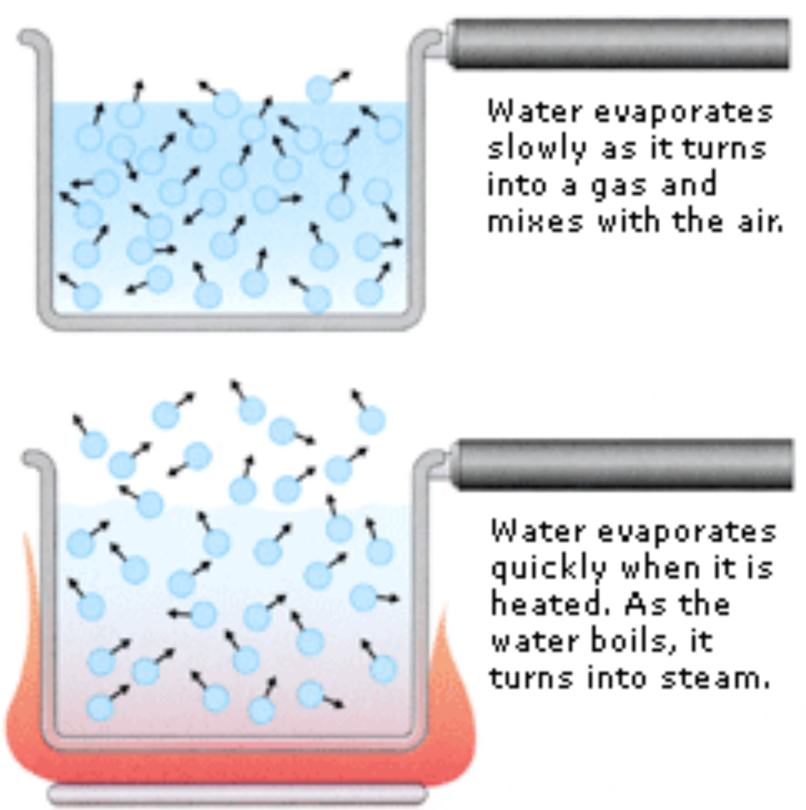


Properties of Matter: **Phases**



Properties of Matter: **Phases**

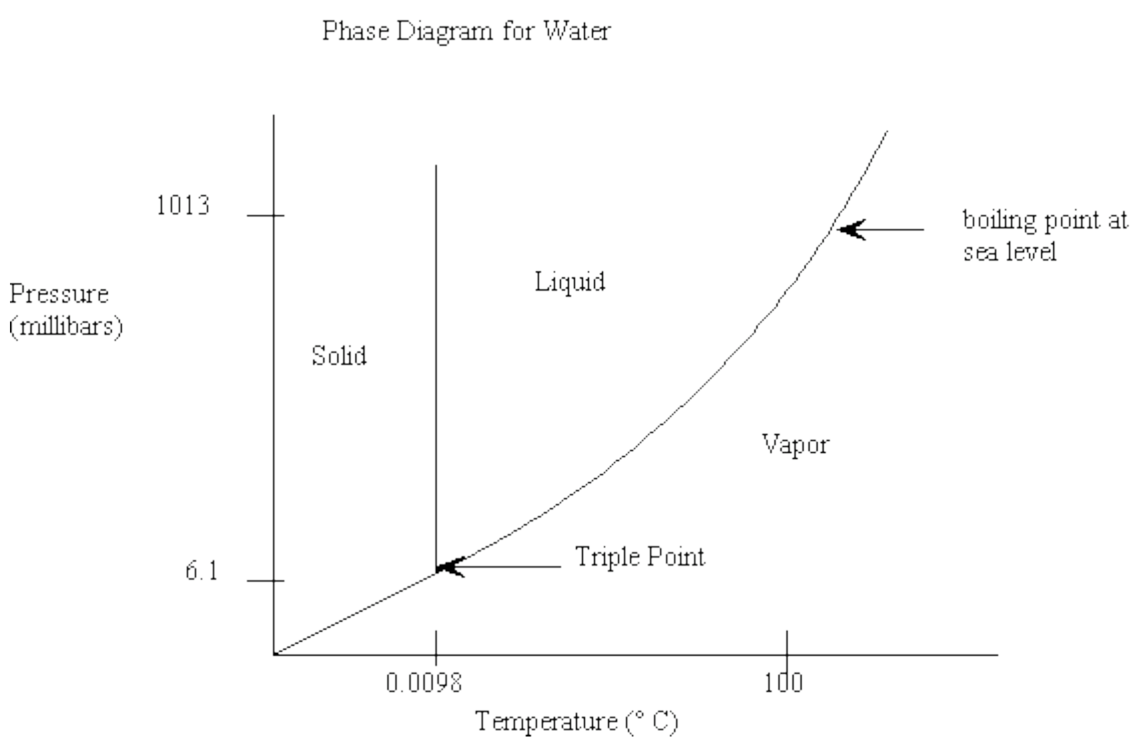
Evaporation



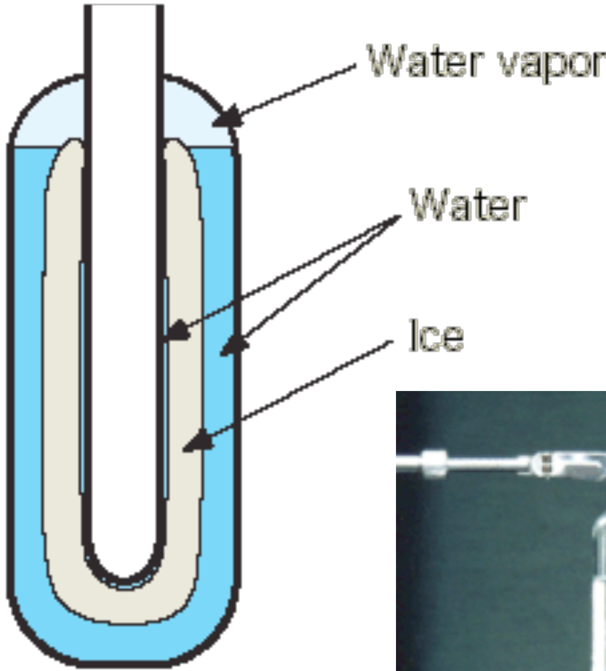
Sublimation

Properties of Matter: **Phases**

Triple Point of Water: Phase Coexistence



Phase depends on:
Temperature and **Pressure**



Properties of Matter: **Phases**

Vocabulary:

Ion

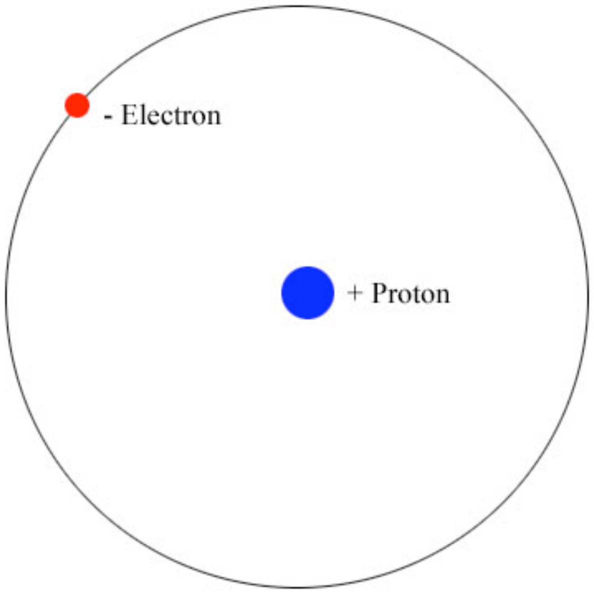
Ionization

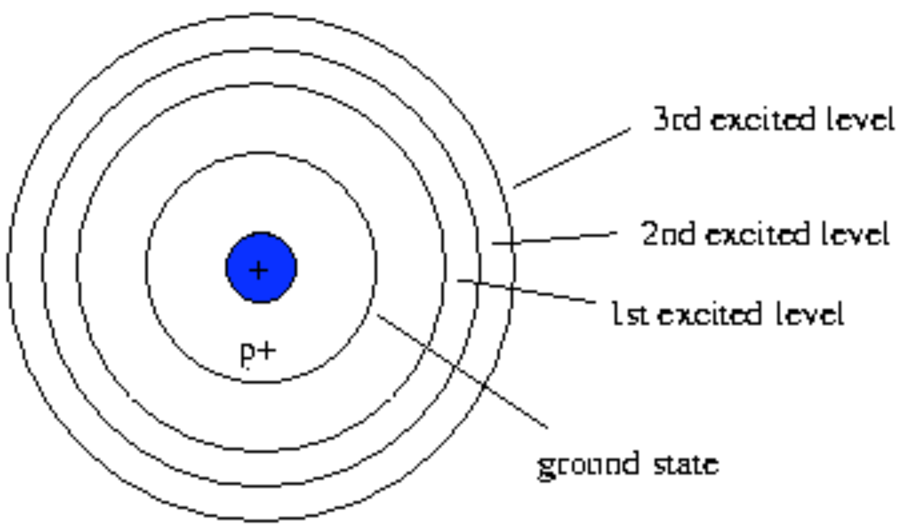
Molecular Dissociation

Plasma

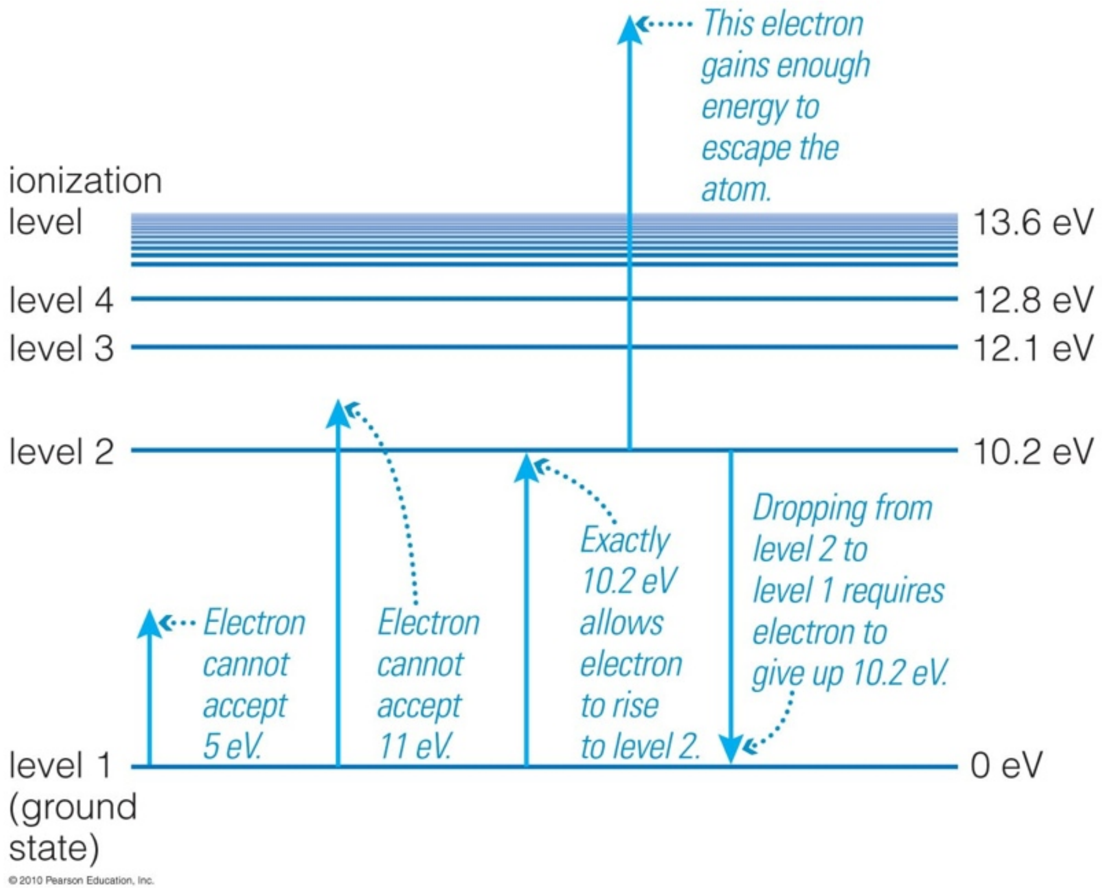
Pressure

Properties of Matter: **Energy** *and* **Energy Levels**

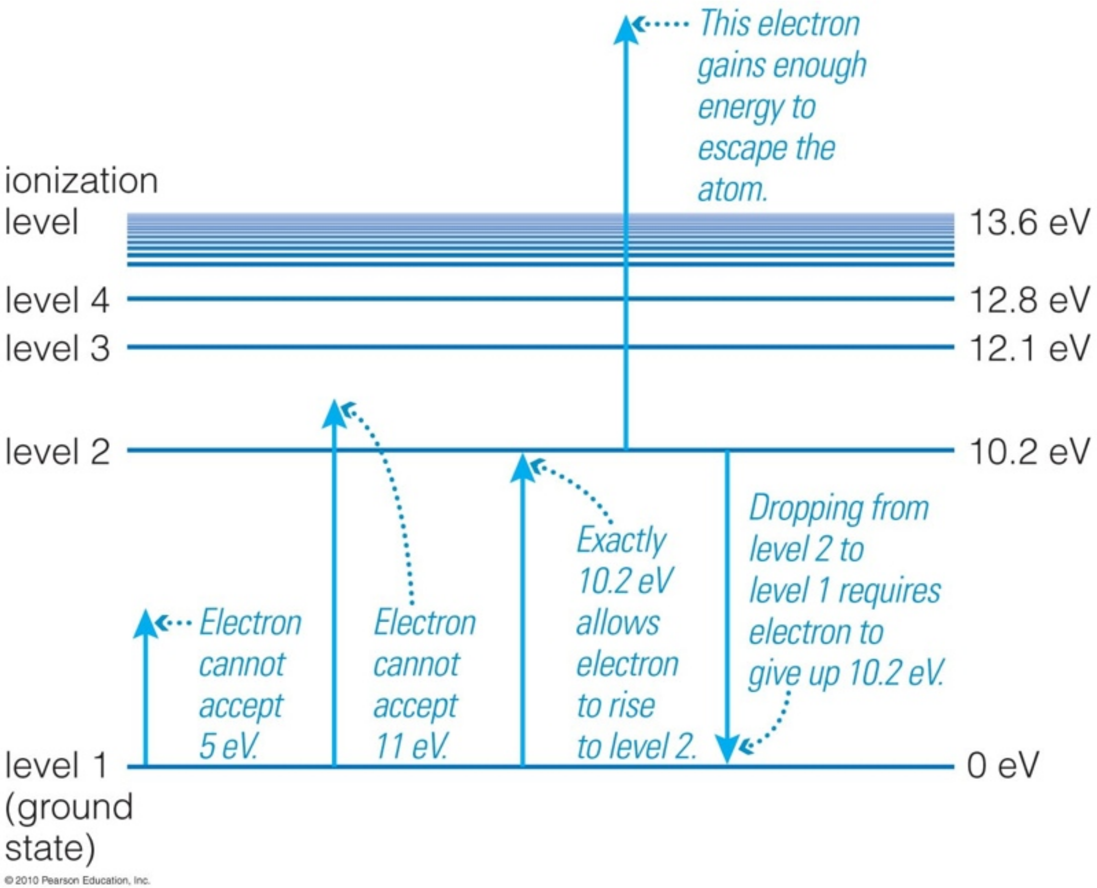




Hydrogen Atom -- lowest four "allowed" energy levels

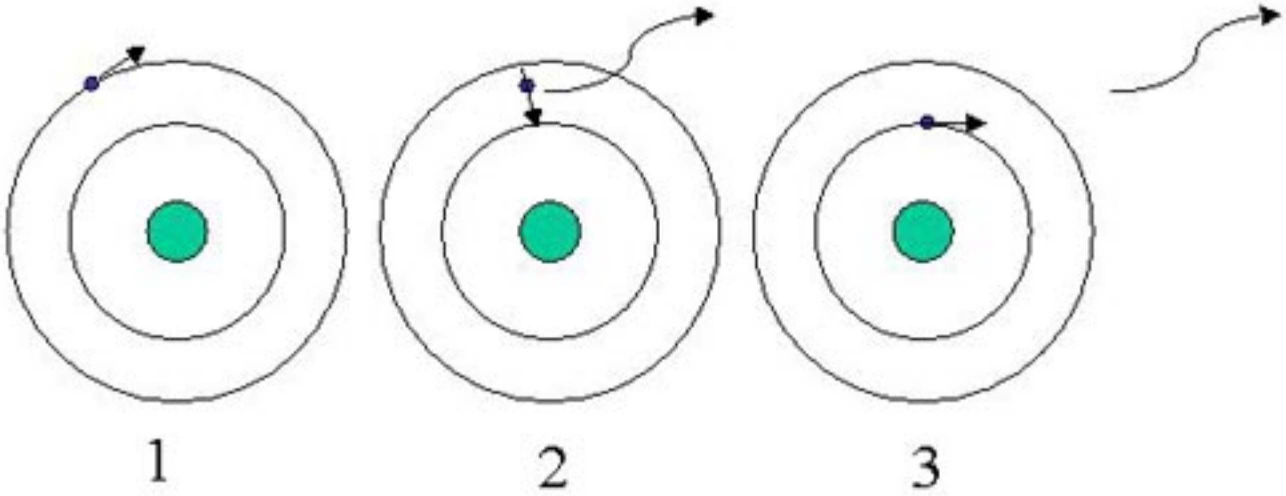


Properties of Matter: **Energy** *and* **Energy Levels**



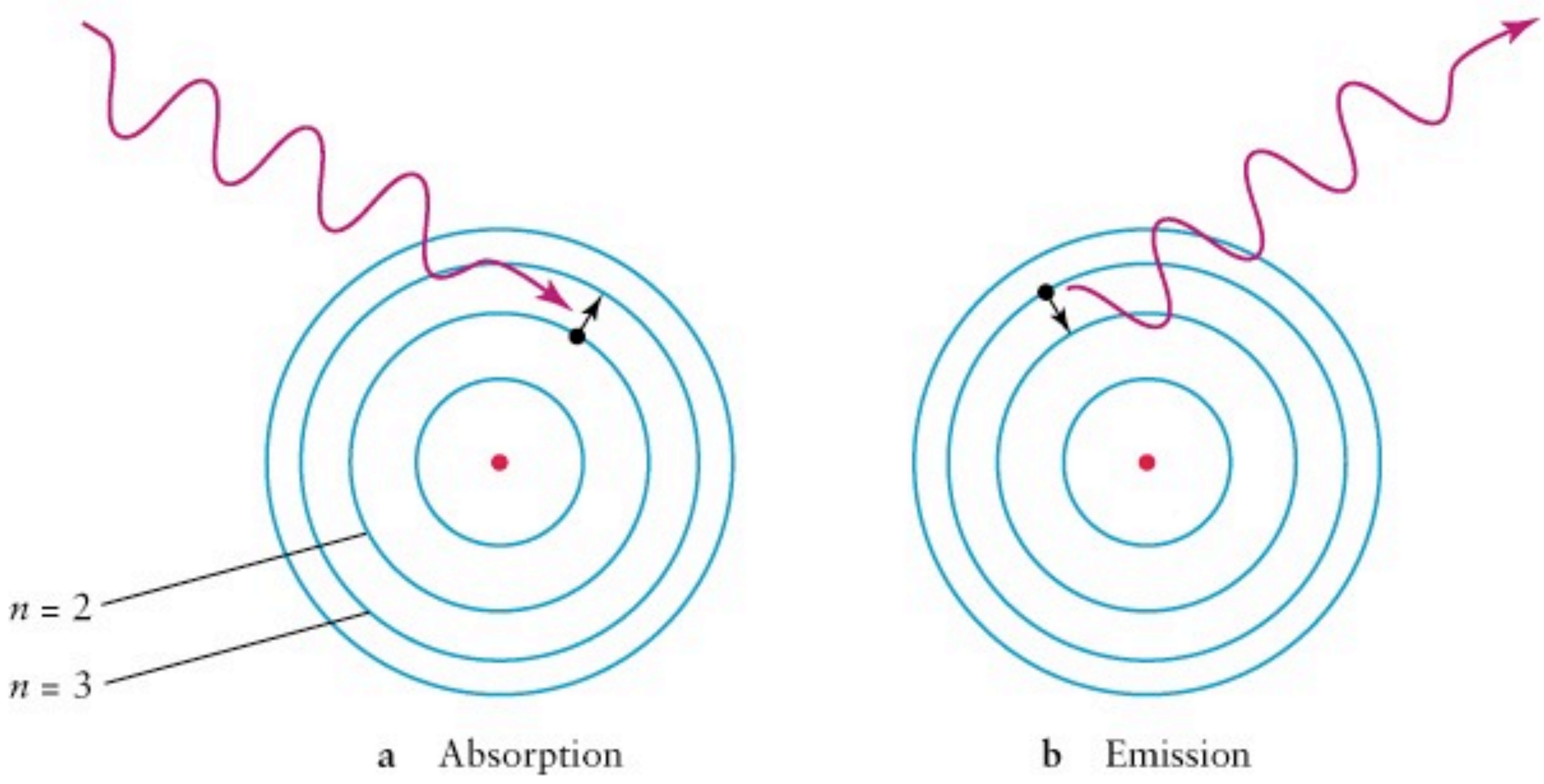
Energy Level Transitions

Properties of Matter: **Energy** *and* **Energy Levels**



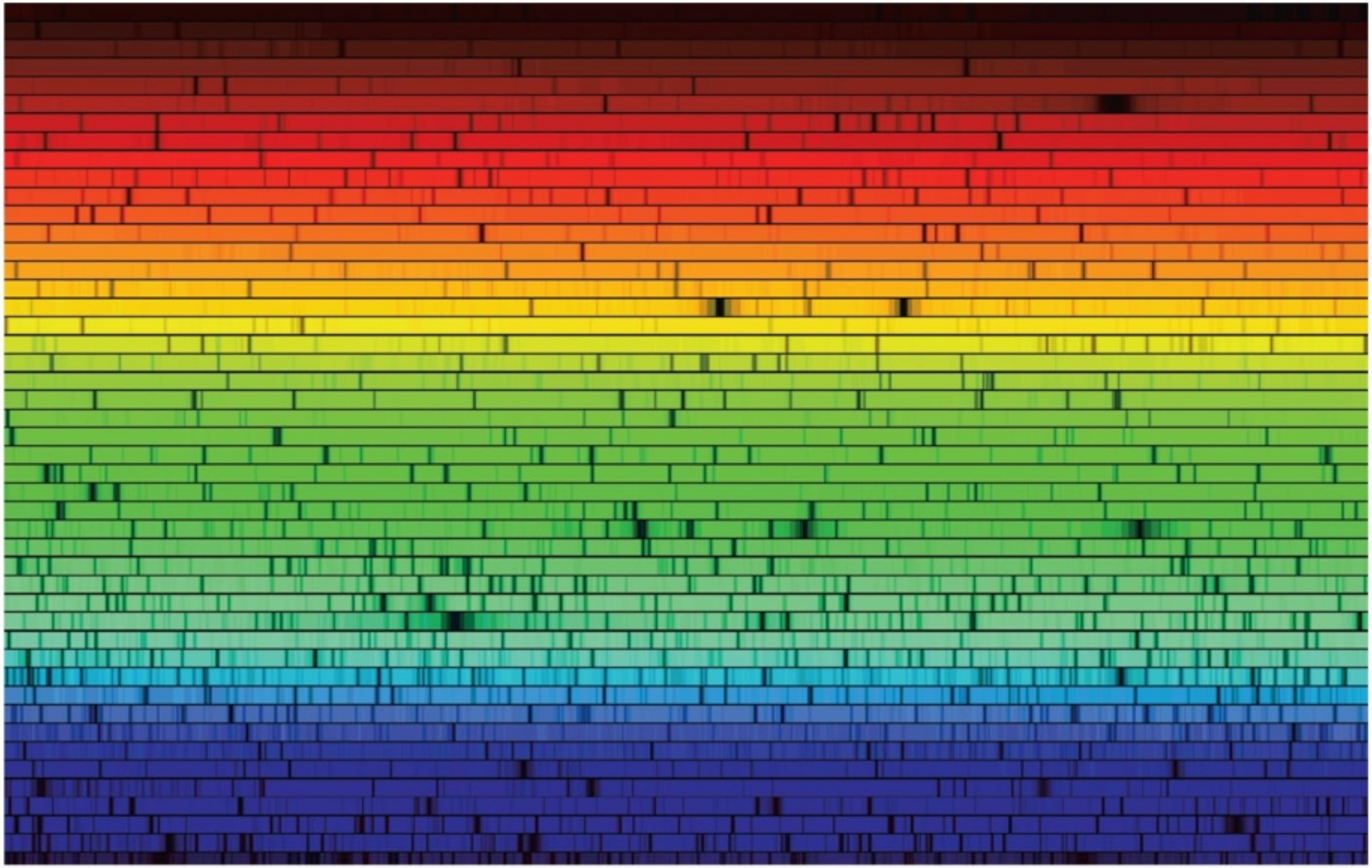
Photon/light emission

Properties of Matter: **Energy** *and* **Energy Levels**



Photon/light absorption and emission

Light as an Investigative Tool



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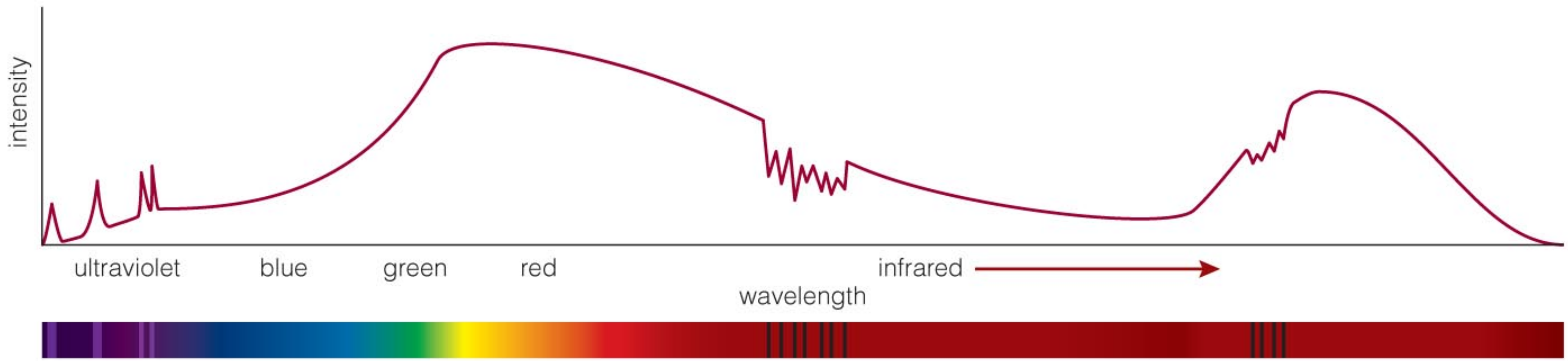

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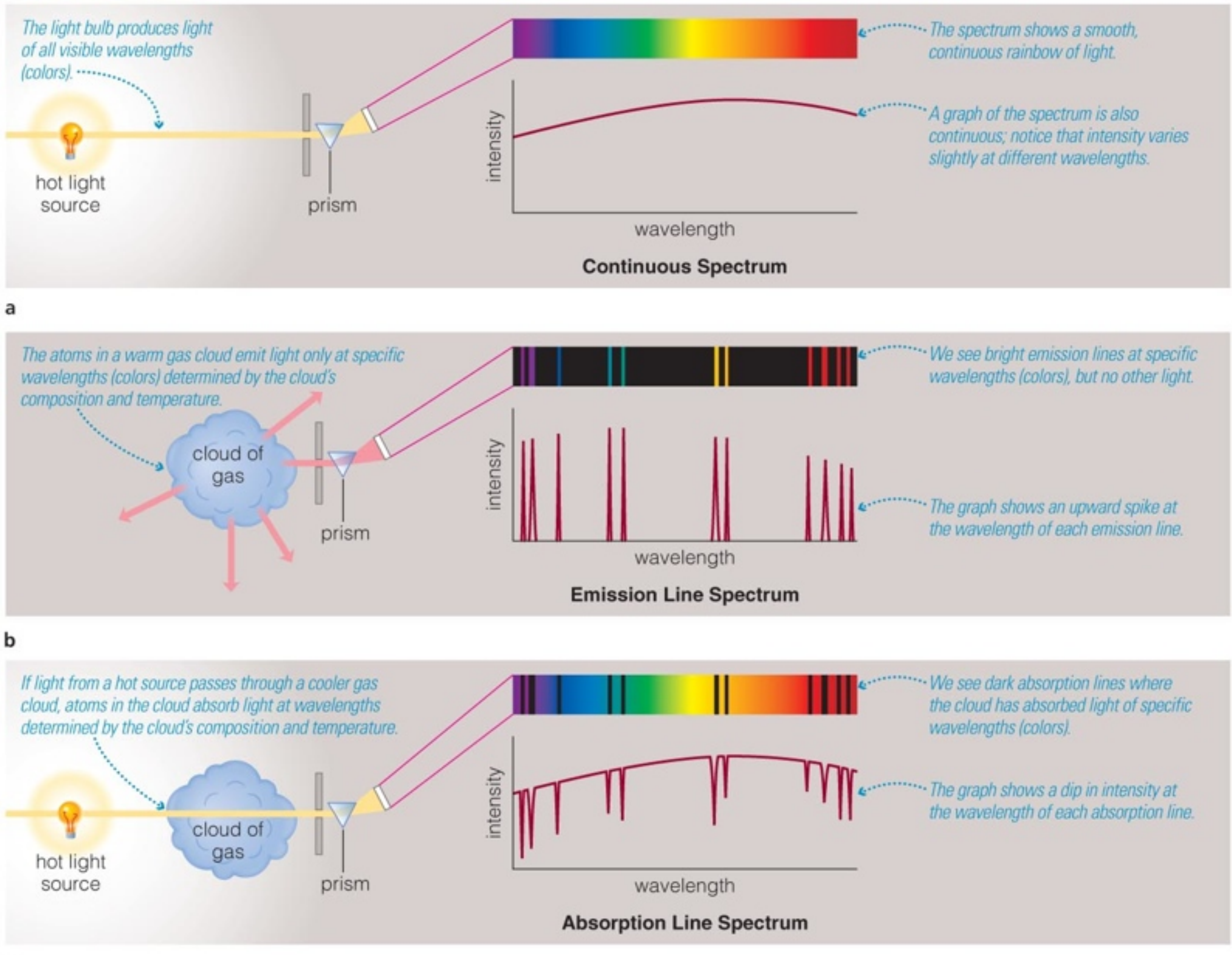

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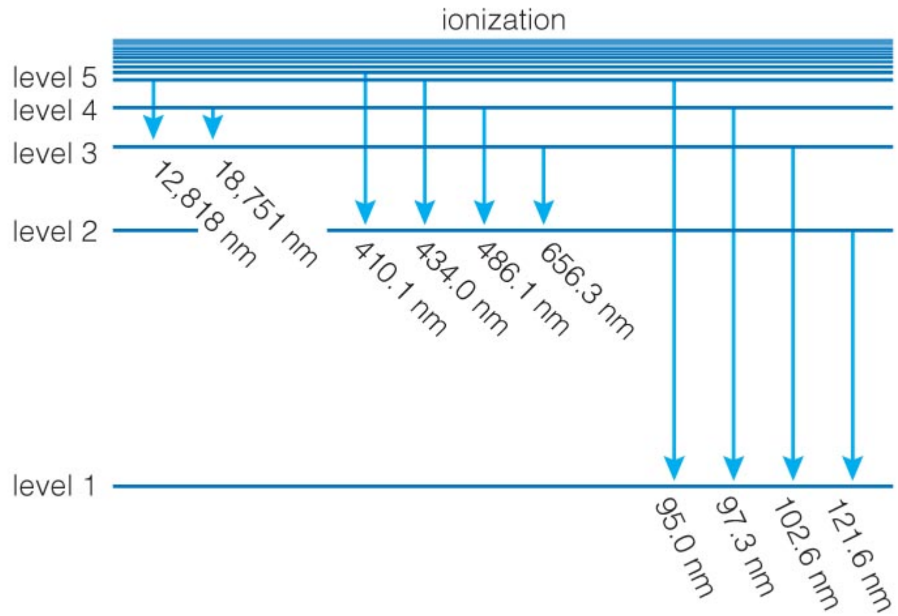


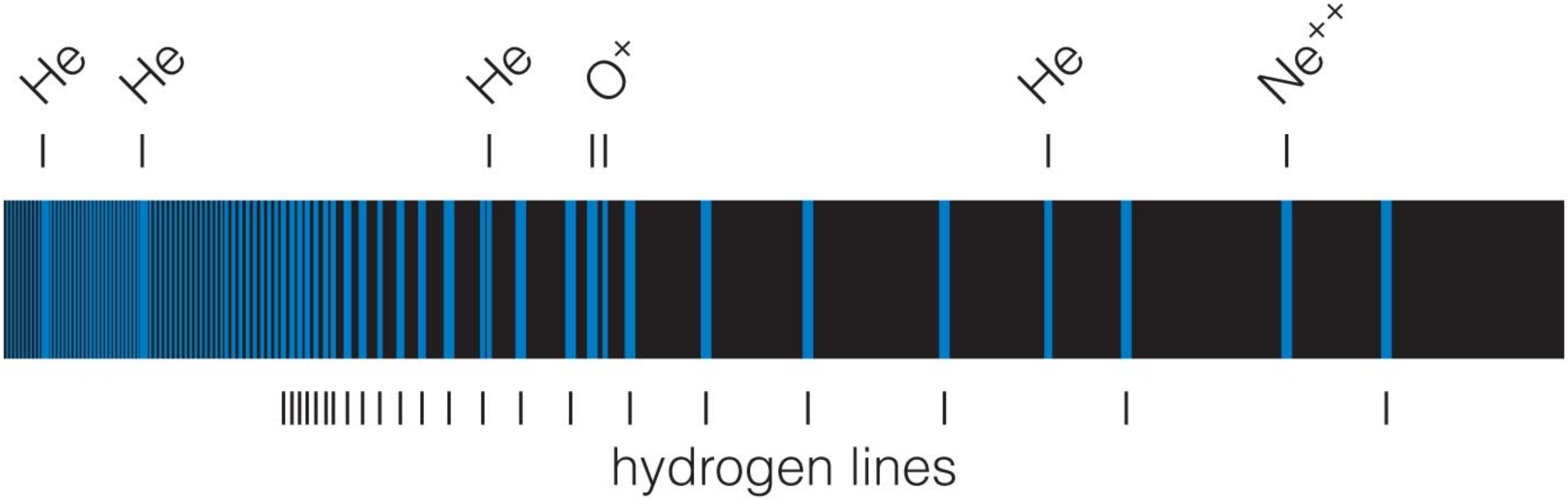
a Energy level transitions in hydrogen correspond to photons with specific wavelengths. Only a few of the many possible transitions are labeled.

b This spectrum shows emission lines produced by downward transitions between higher levels and level 2 in hydrogen.

c This spectrum shows absorption lines produced by upward transitions between level 2 and higher levels in hydrogen.

Light as an Investigative Tool

Light as an Investigative Tool



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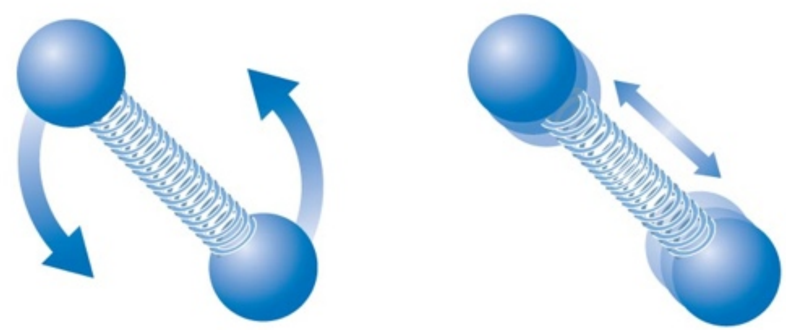
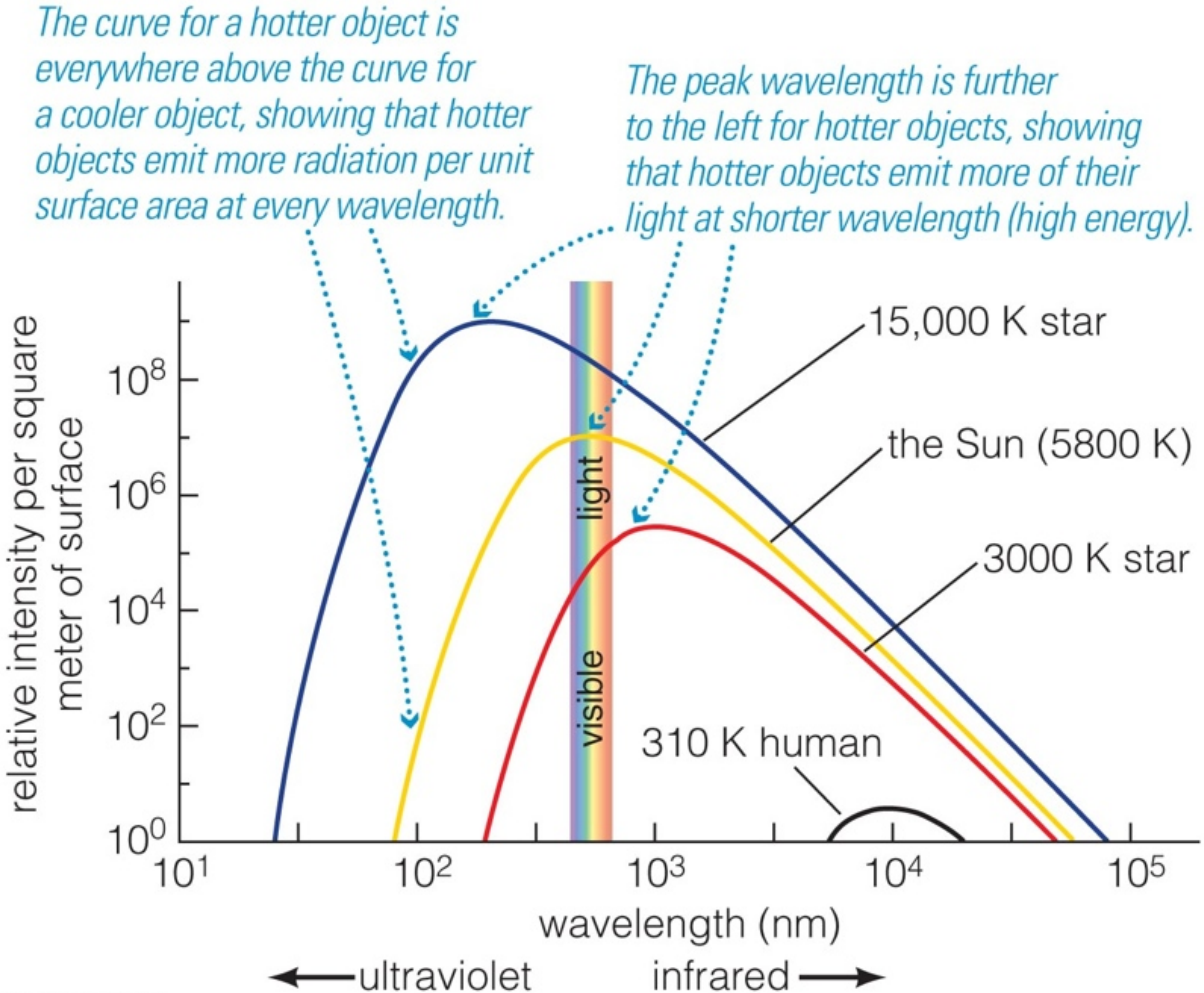


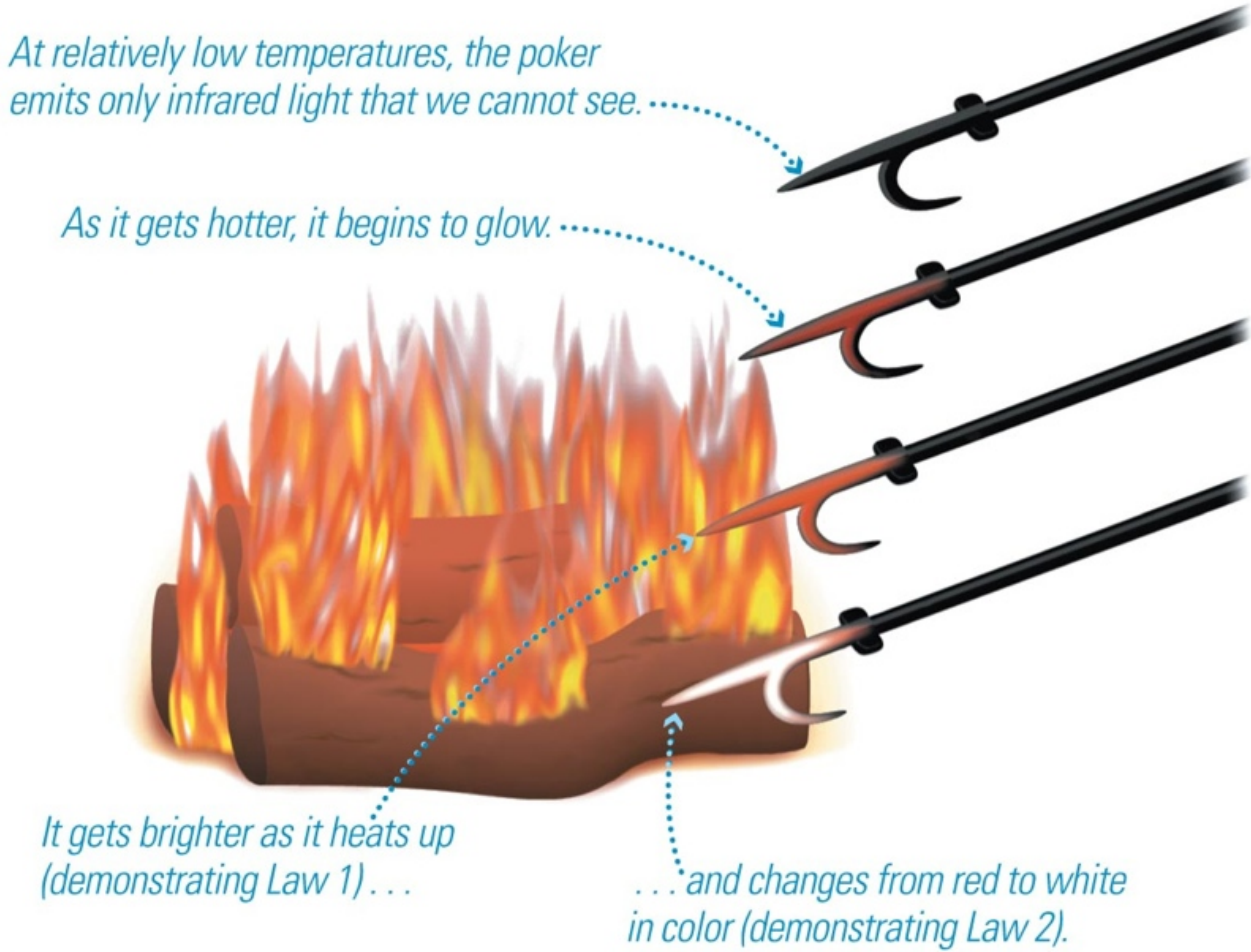
a We can think of a two-atom molecule as two balls connected by a spring. Although this model is simplistic, it illustrates how molecules can rotate and vibrate. The rotations and vibrations can have only particular amounts of energy and therefore produce unique spectral fingerprints.

b This spectrum of molecular hydrogen (H_2) consists of lines bunched into broad molecular bands.

Light as an Investigative Tool



Light as an Investigative Tool



Light as an Investigative Tool

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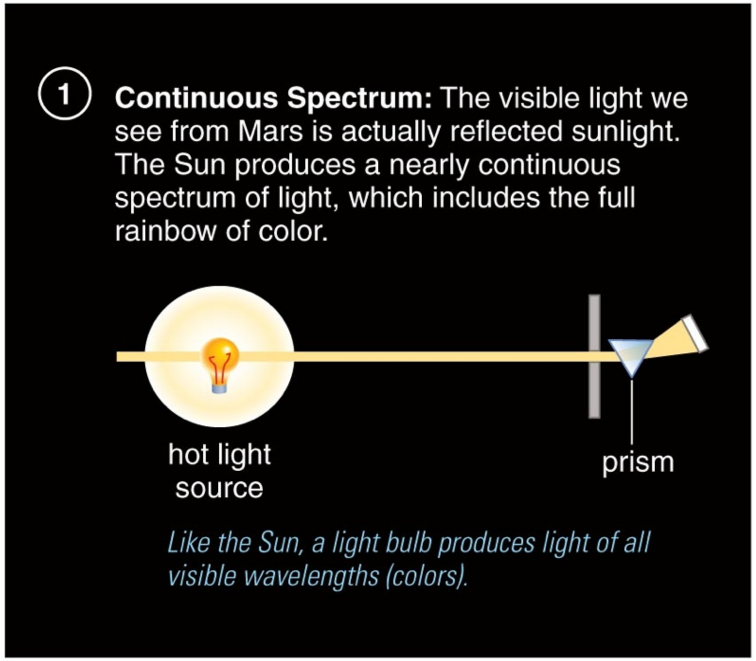

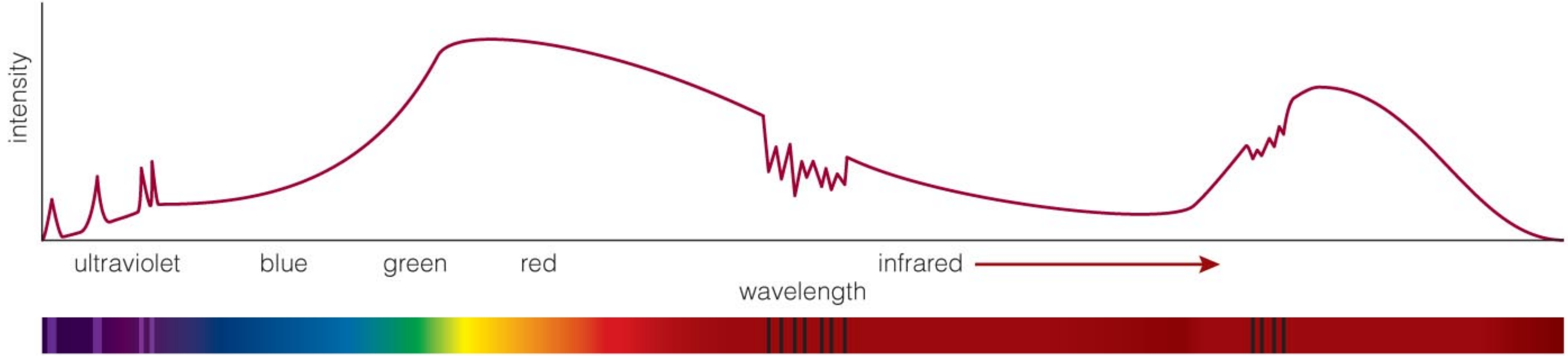

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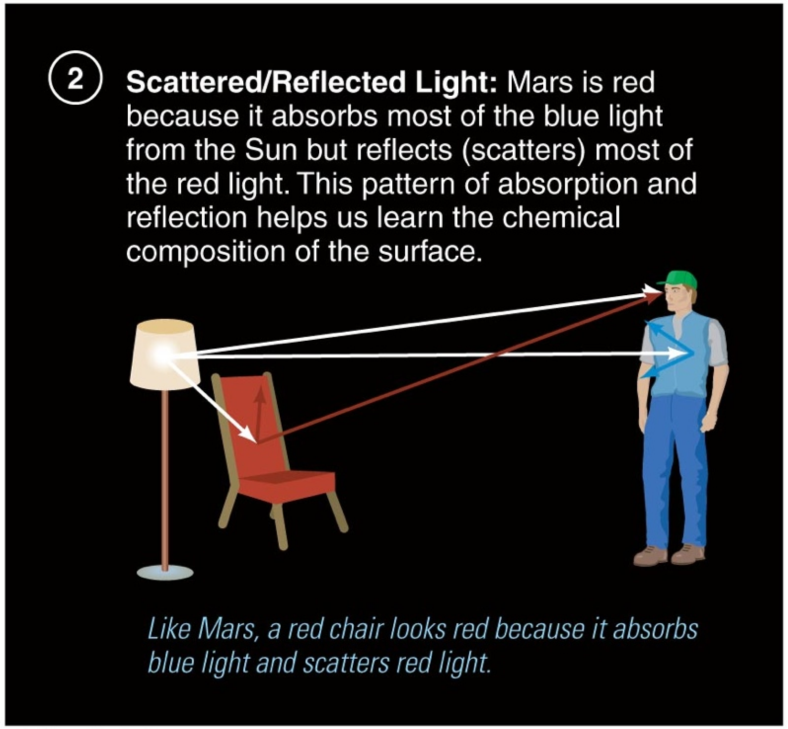

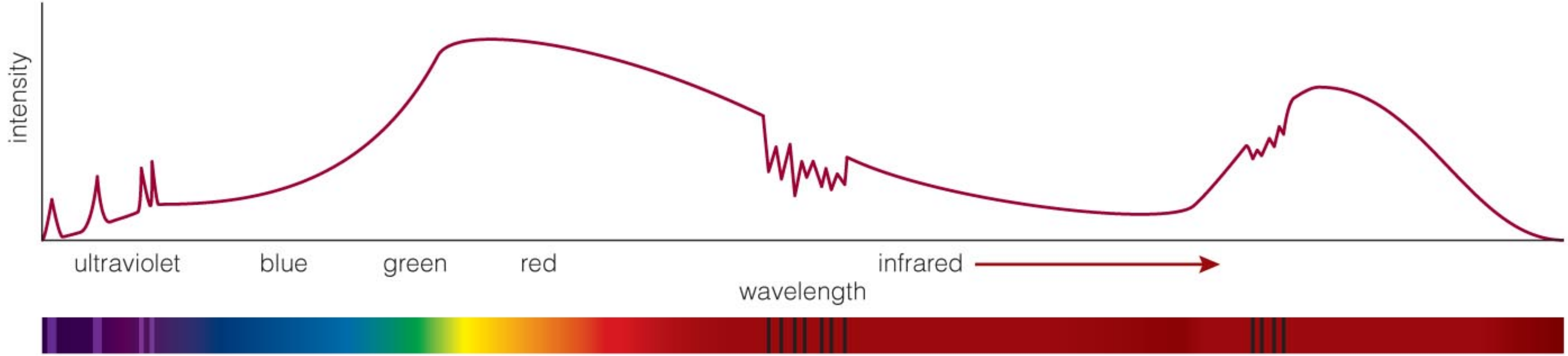

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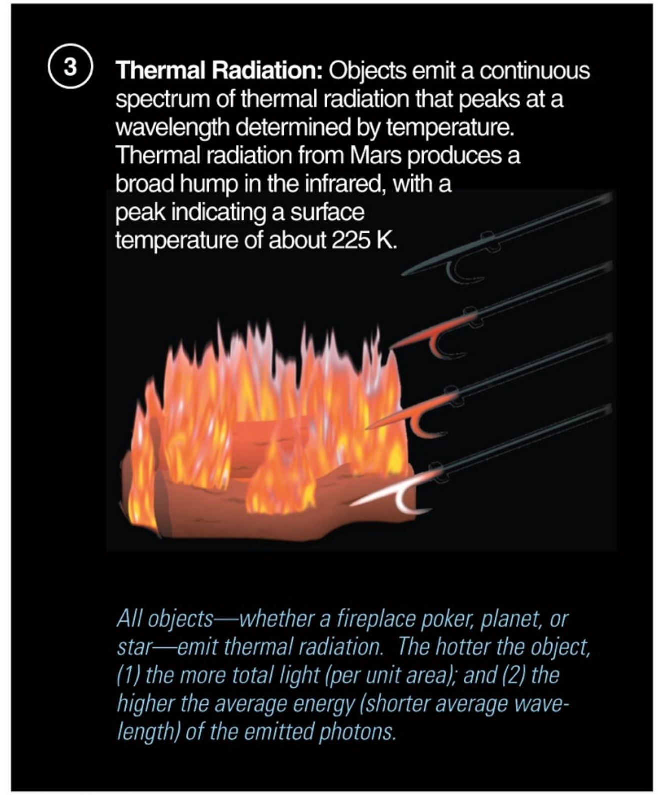

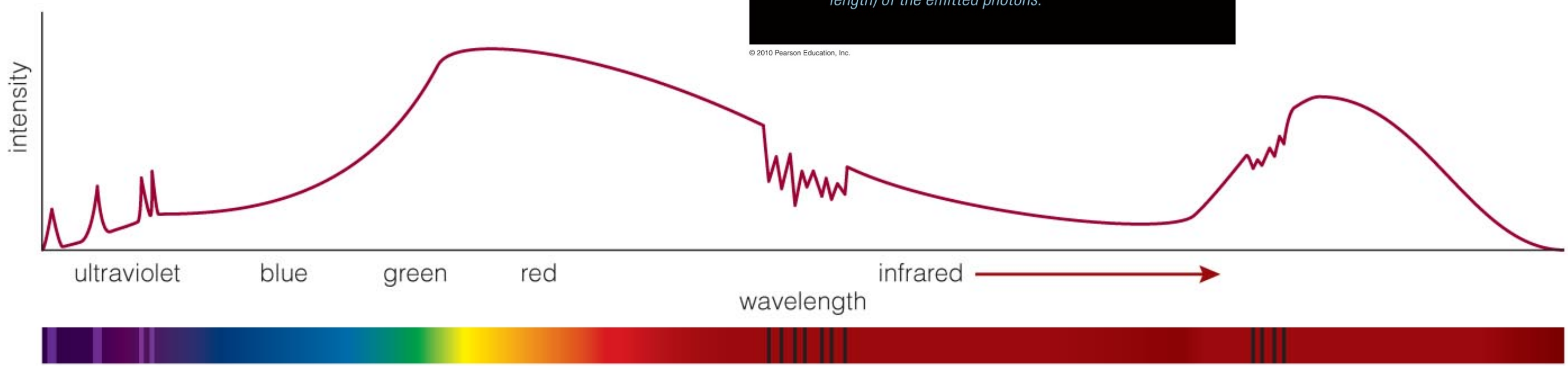

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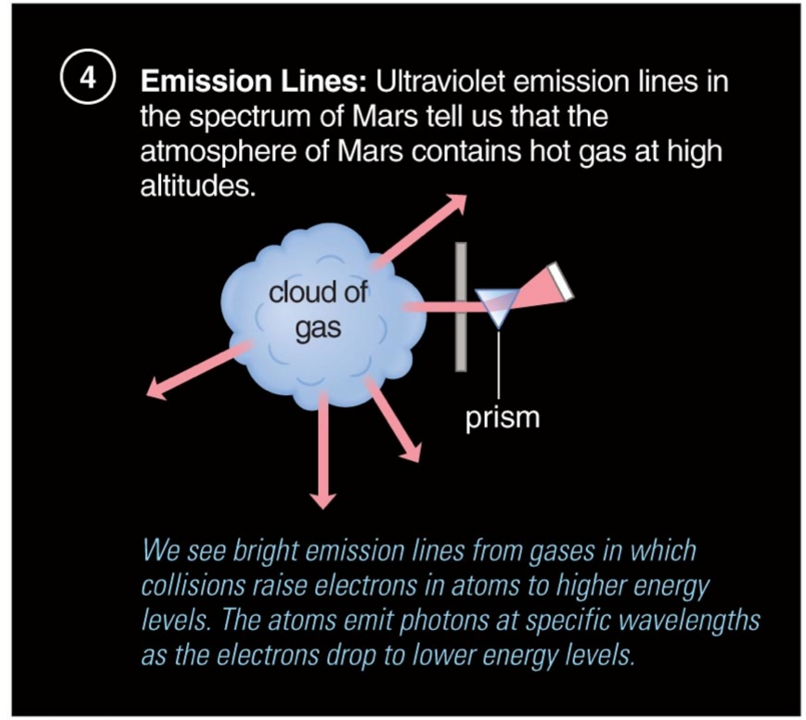

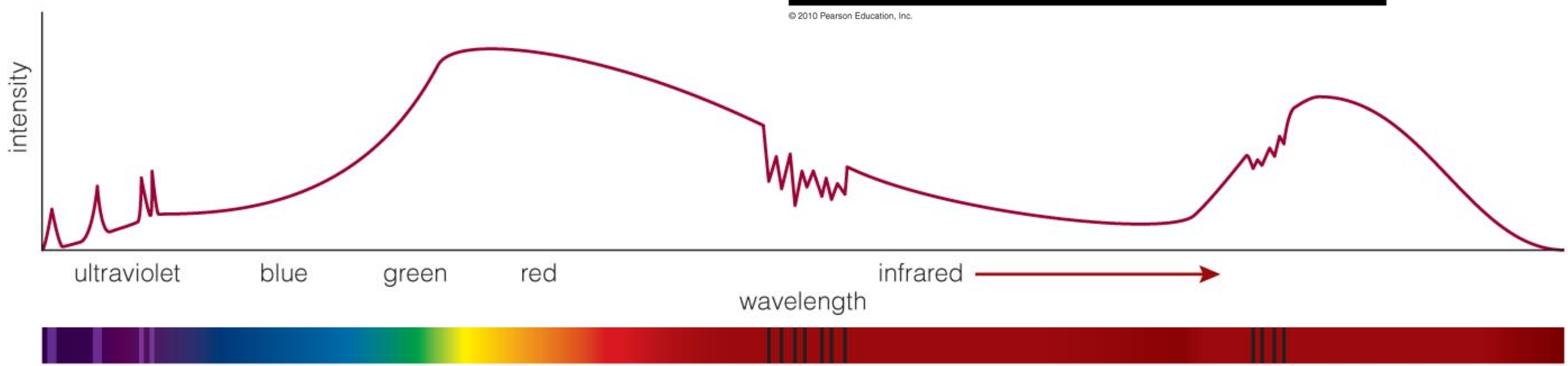

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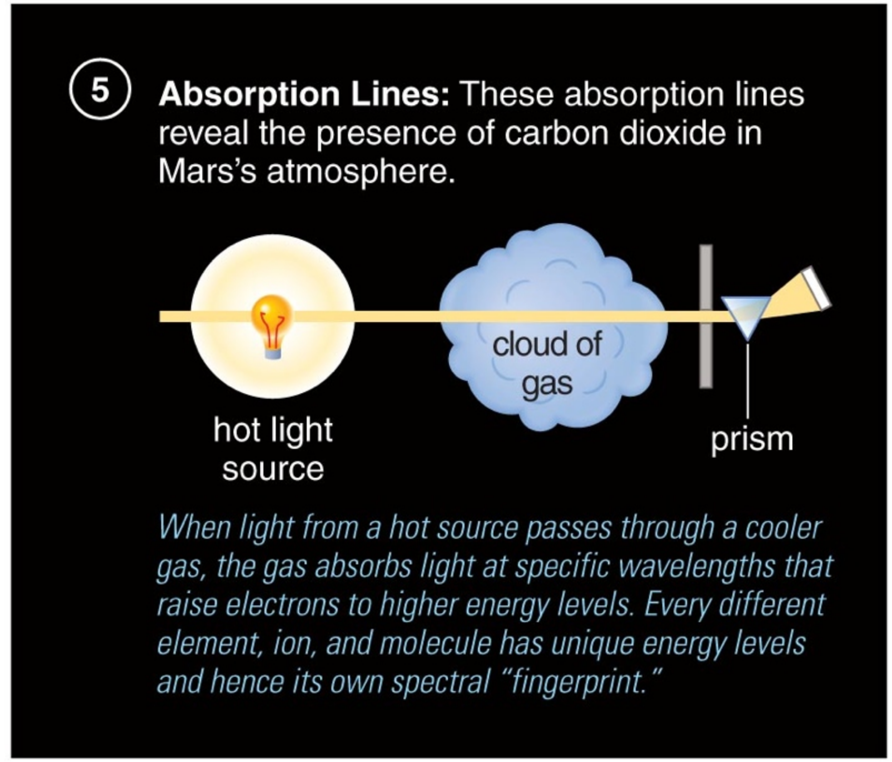

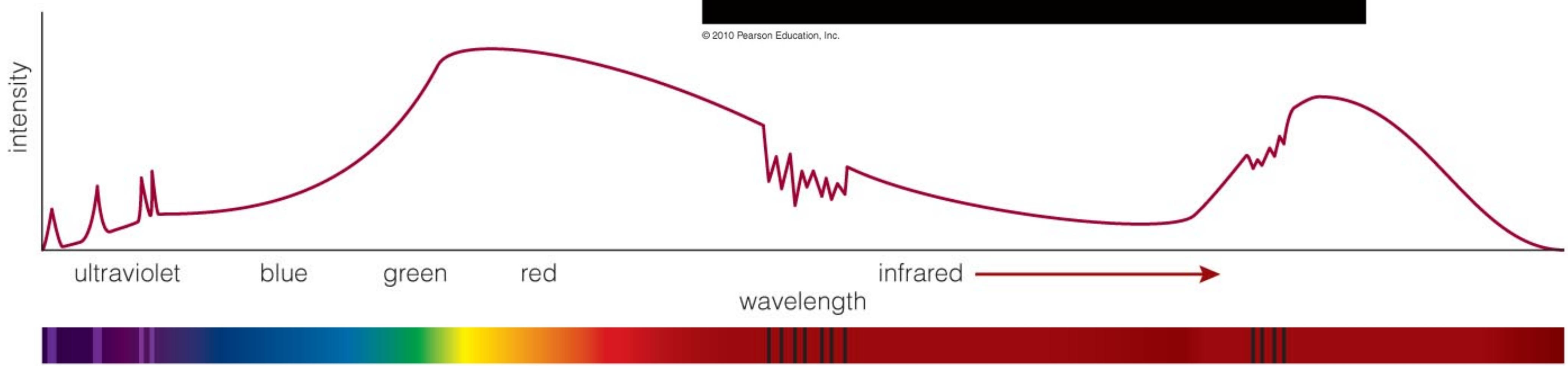

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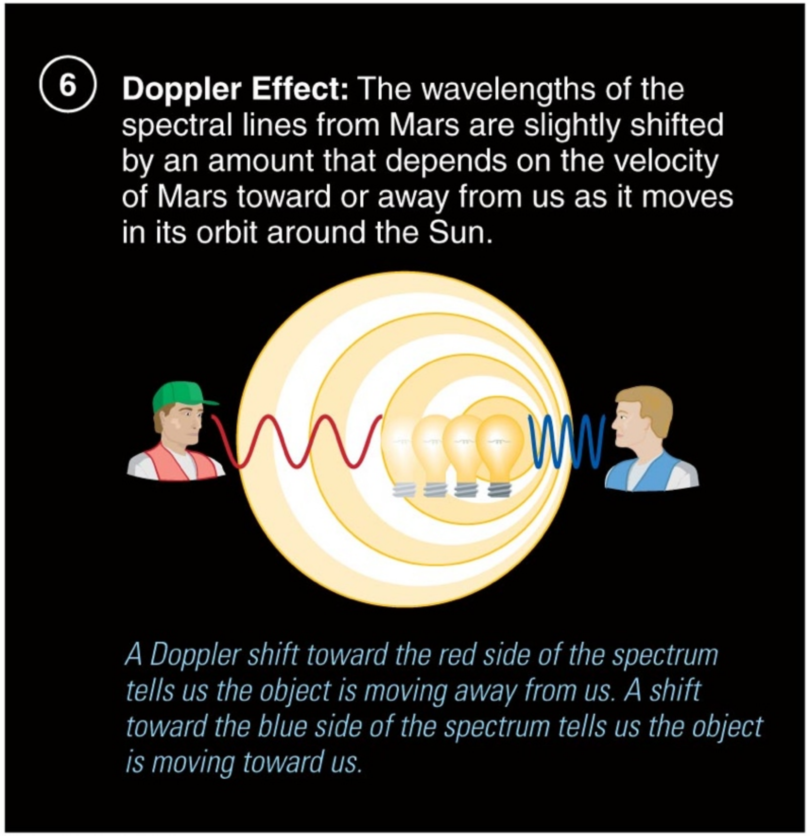
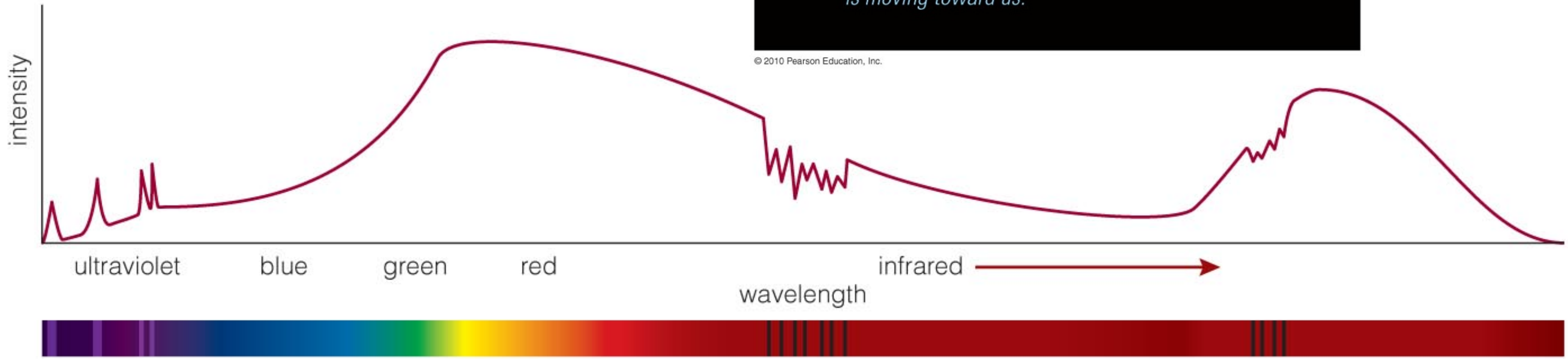
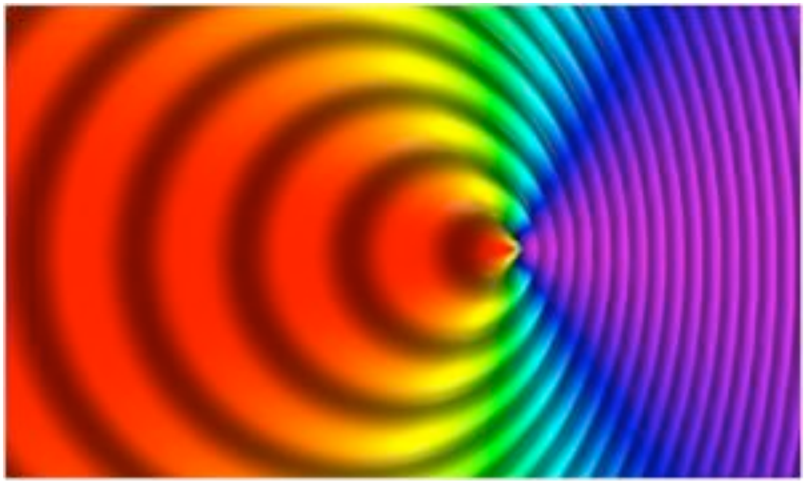


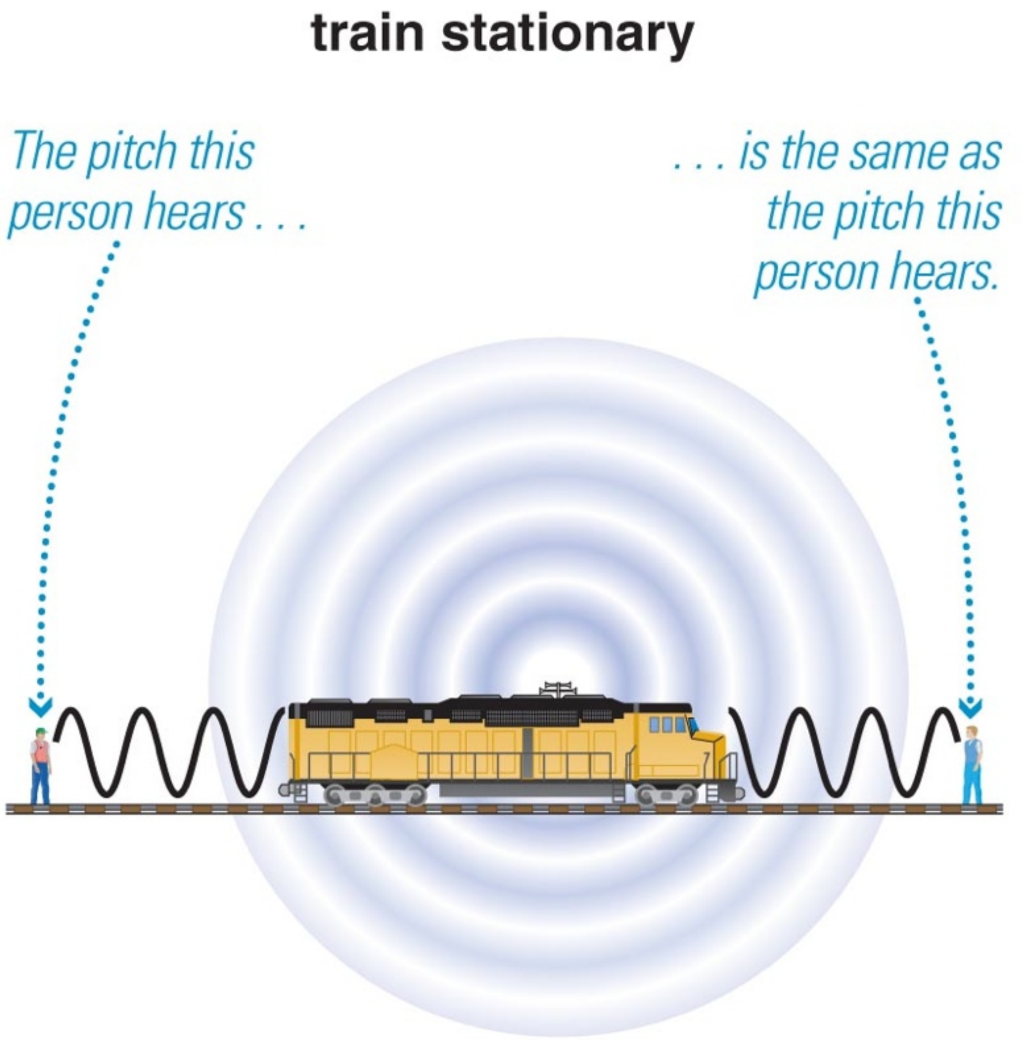


The Doppler Effect

A change in wavelength due to relative motion.
Applies to sound and light.

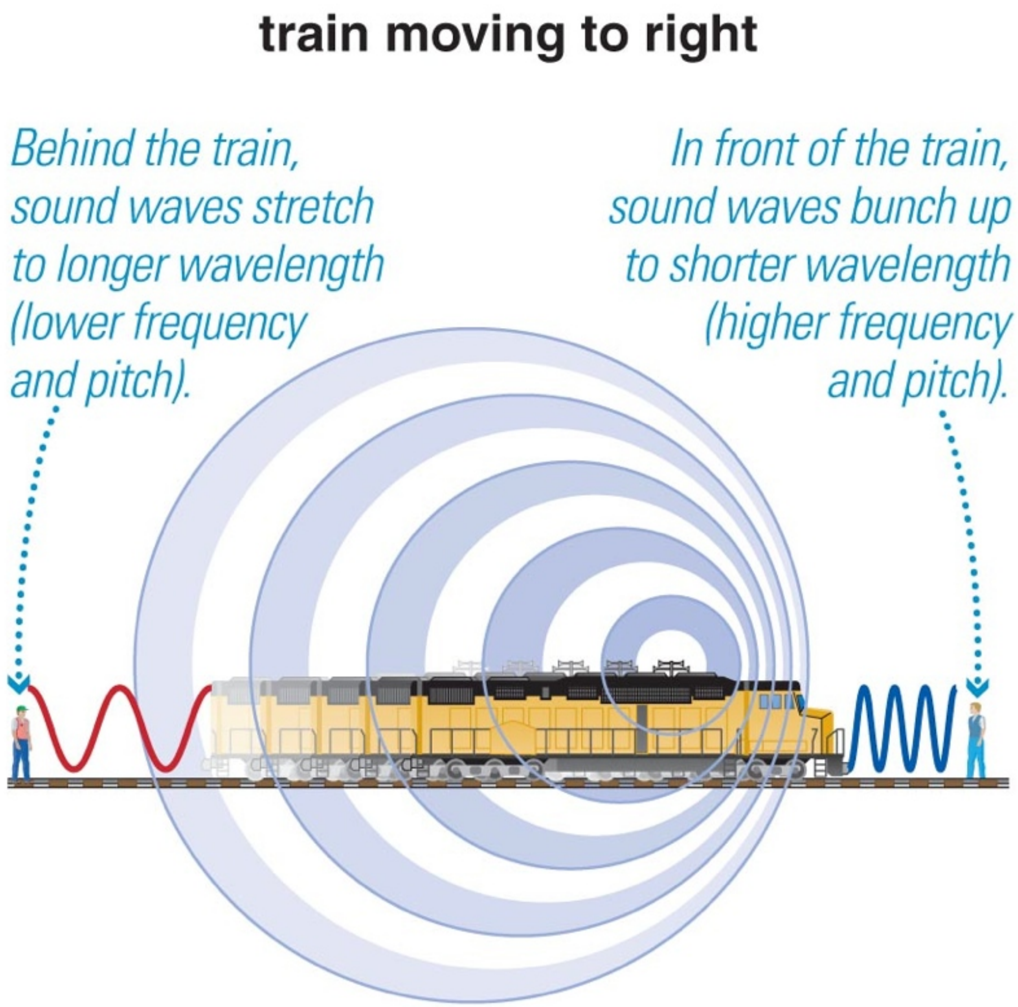


The Doppler Effect



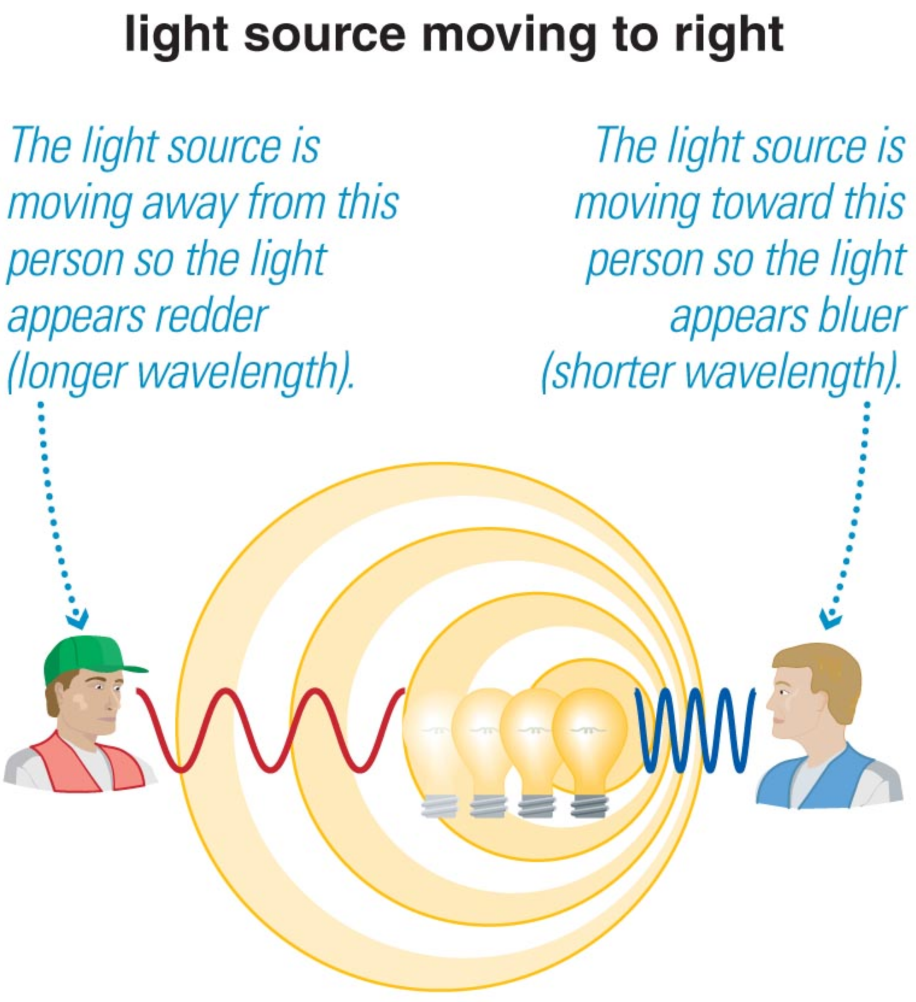
a The whistle sounds the same no matter where you stand near a stationary train.

The Doppler Effect



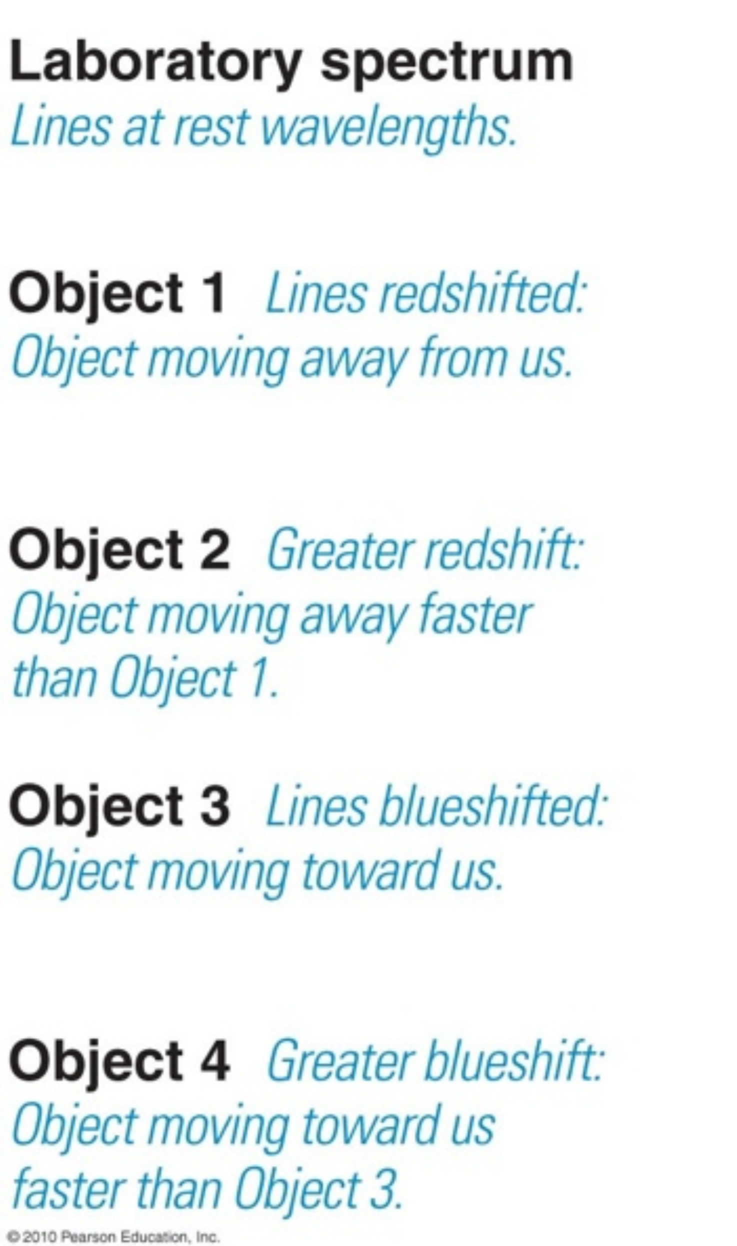
b For a moving train, the sound you hear depends on whether the train is moving toward you or away from you.

The Doppler Effect

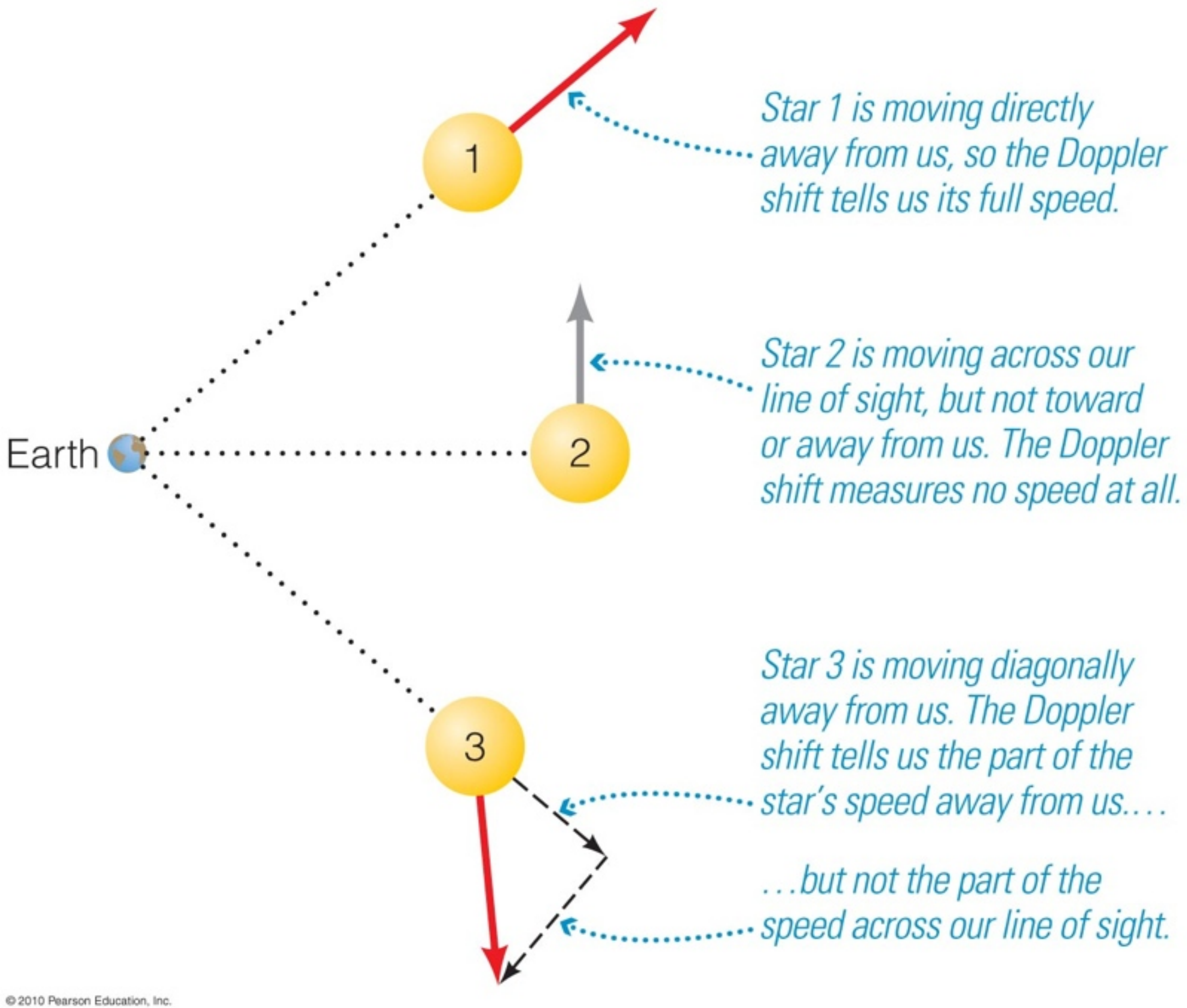


c We get the same basic effect from a moving light source (although the shifts are usually too small to notice with our eyes).

The Doppler Effect

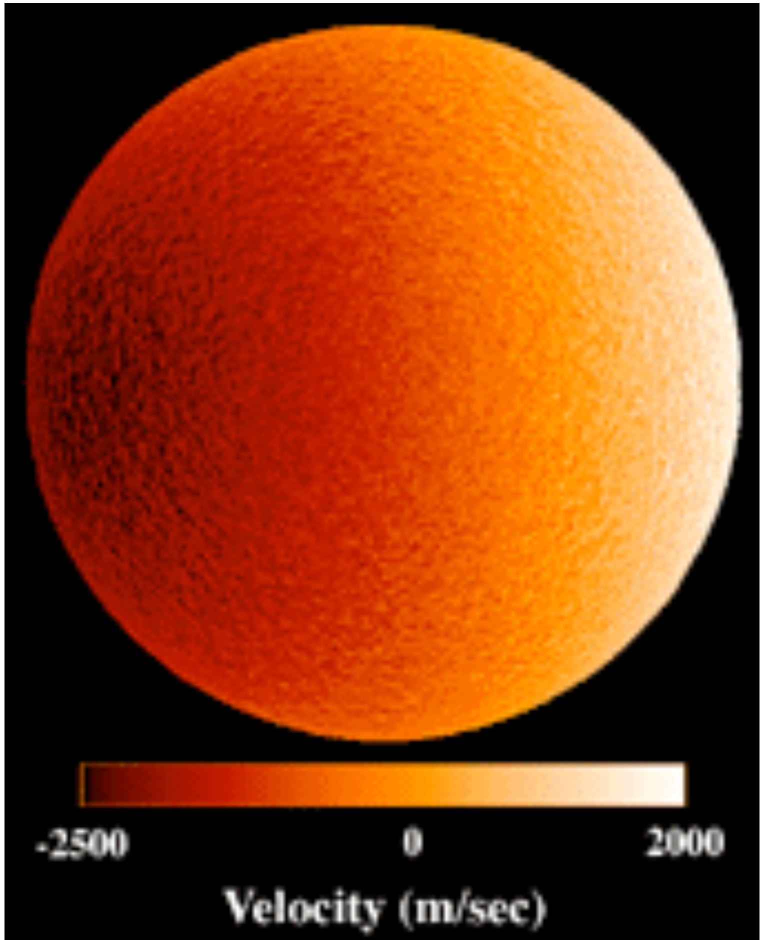


The Doppler Effect: Example



The Doppler Effect: Example

Star *Rotation*

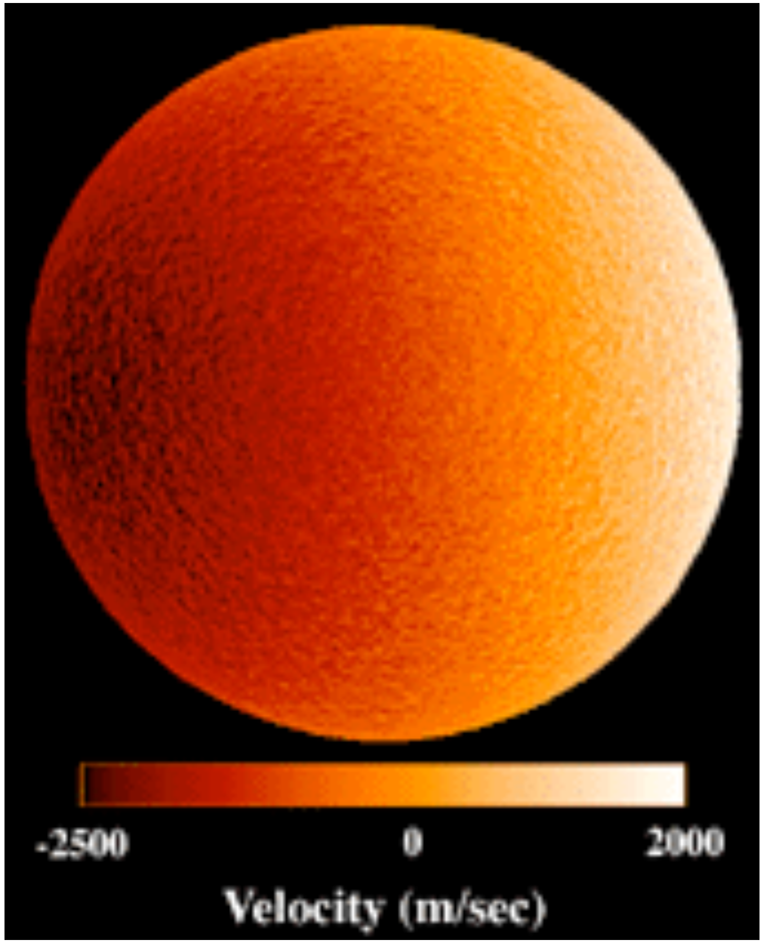


The Disk of the Sun

The Doppler Effect: Example

Star *Rotation*

Red

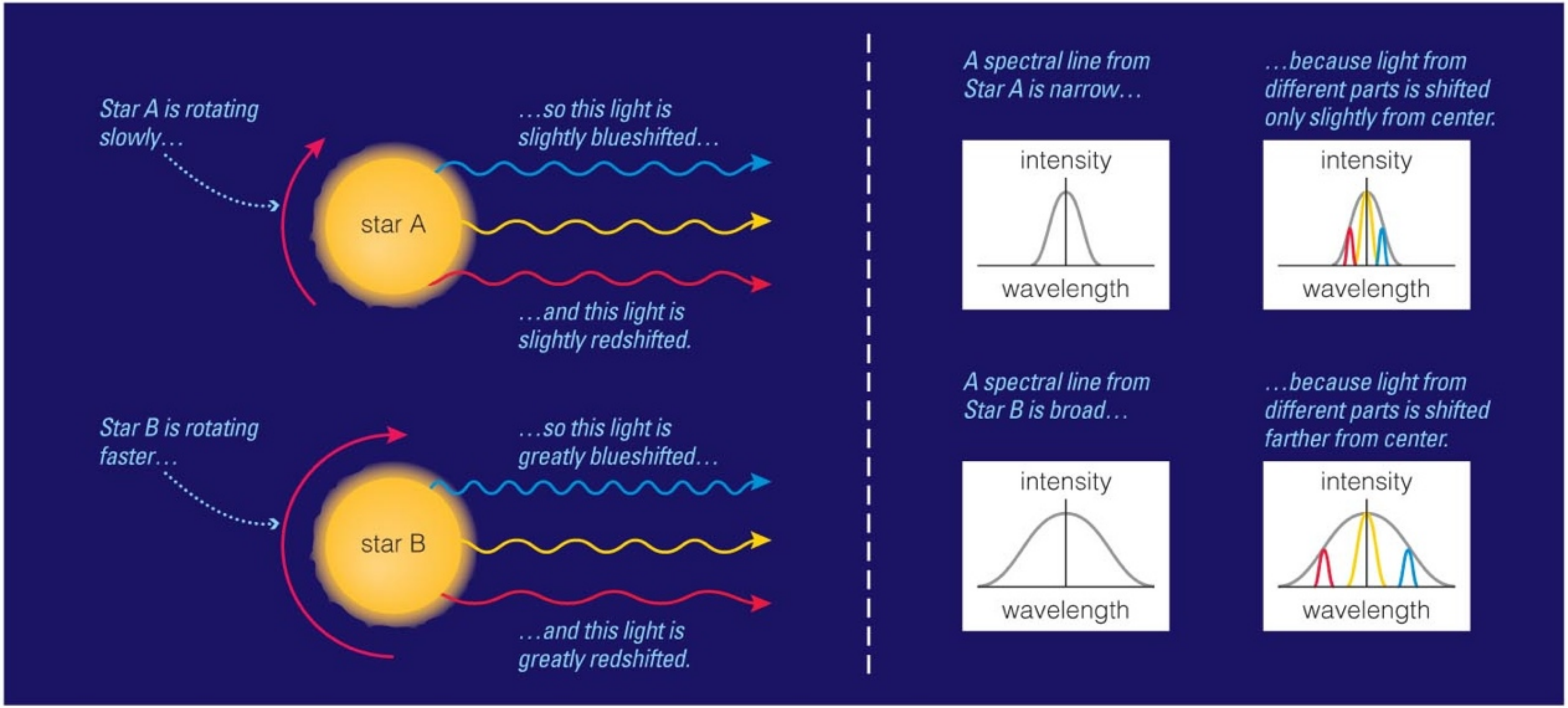


Blue

The Disk of the Sun

The Doppler Effect: Example

Star *Rotation*



HW and Extra Credit Opportunities

1. Mirror Lab Tours: Tu, Fr, 1pm or 3pm, ~60 - 90 minutes
Call Cathi Duncan, 520-626-8792 for reservation

2. Flandrau: *Observatory*:
16 inch Reflector:
W, Th, Fr, Sa: 7pm - 10pm

3. Flandrau: *Planetarium Show* -
Every day. More details online:

http://www.flandrau.org/programs/planetarium-shows/

Here are the planetarium show times:

Monday-Thursday
2:30 p.m.: Tucson Sky Tonight or Legends of the Night Sky

Thursdays (Family Night)
7 p.m.: Legends of the Night Sky

Fridays
2:30 p.m.: Tucson Sky Tonight
4:30 p.m.: Legends of the Night Sky
7 p.m.: Legends of the Night Sky

Saturdays
11 a.m.: Legends of the Night Sky
1 p.m.: Touring the Planets
3 p.m.: Tucson Sky Tonight
4:30 p.m.: Legends of the Night Sky
7 p.m.: Legends of the Night Sky

Sundays
1 p.m.: Touring the Planets
3 p.m.: Tucson Sky Tonight

Assignment (due: M, 9/20):
1.) Read Ch. 14
2.) Ch. 4 problems 1 - 12; Ch. 5 problems 29 - 38.