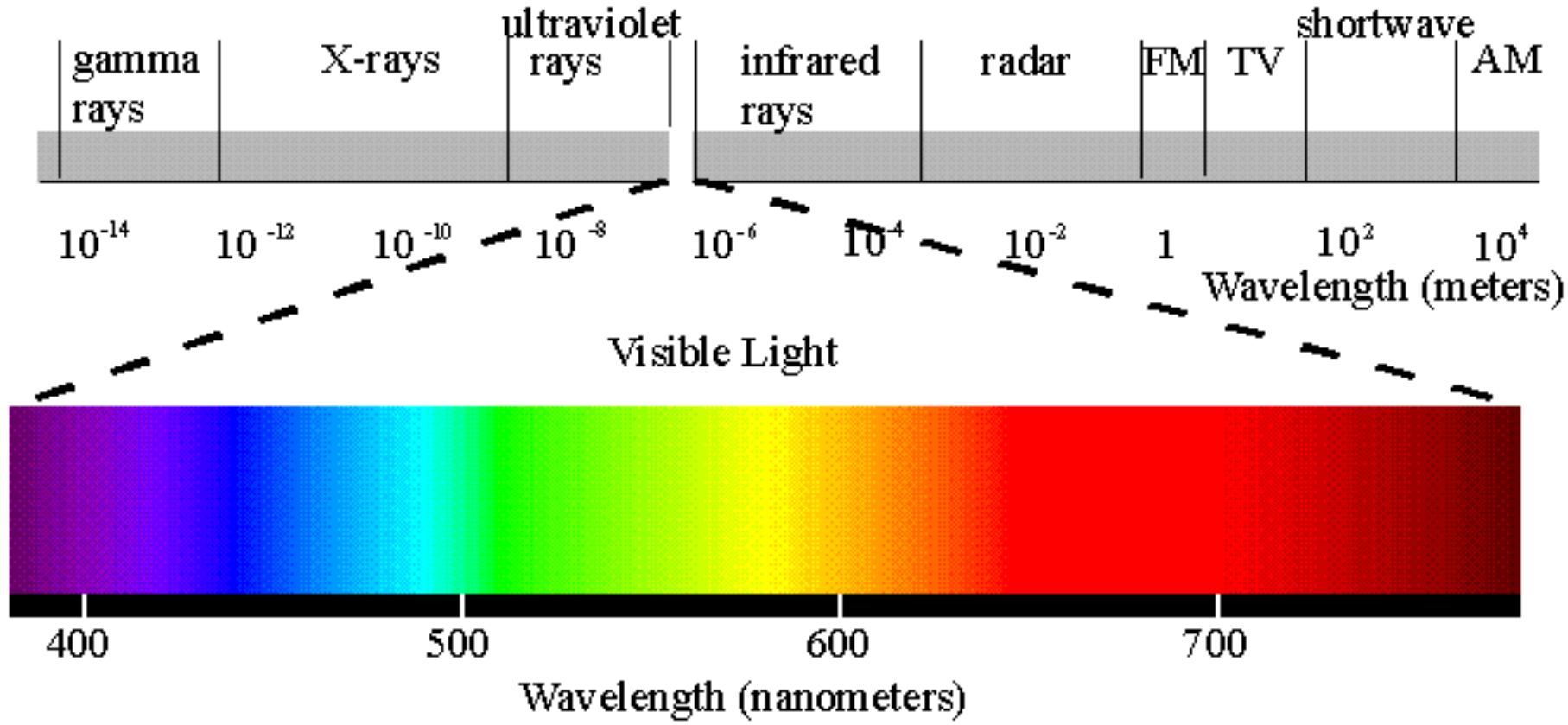
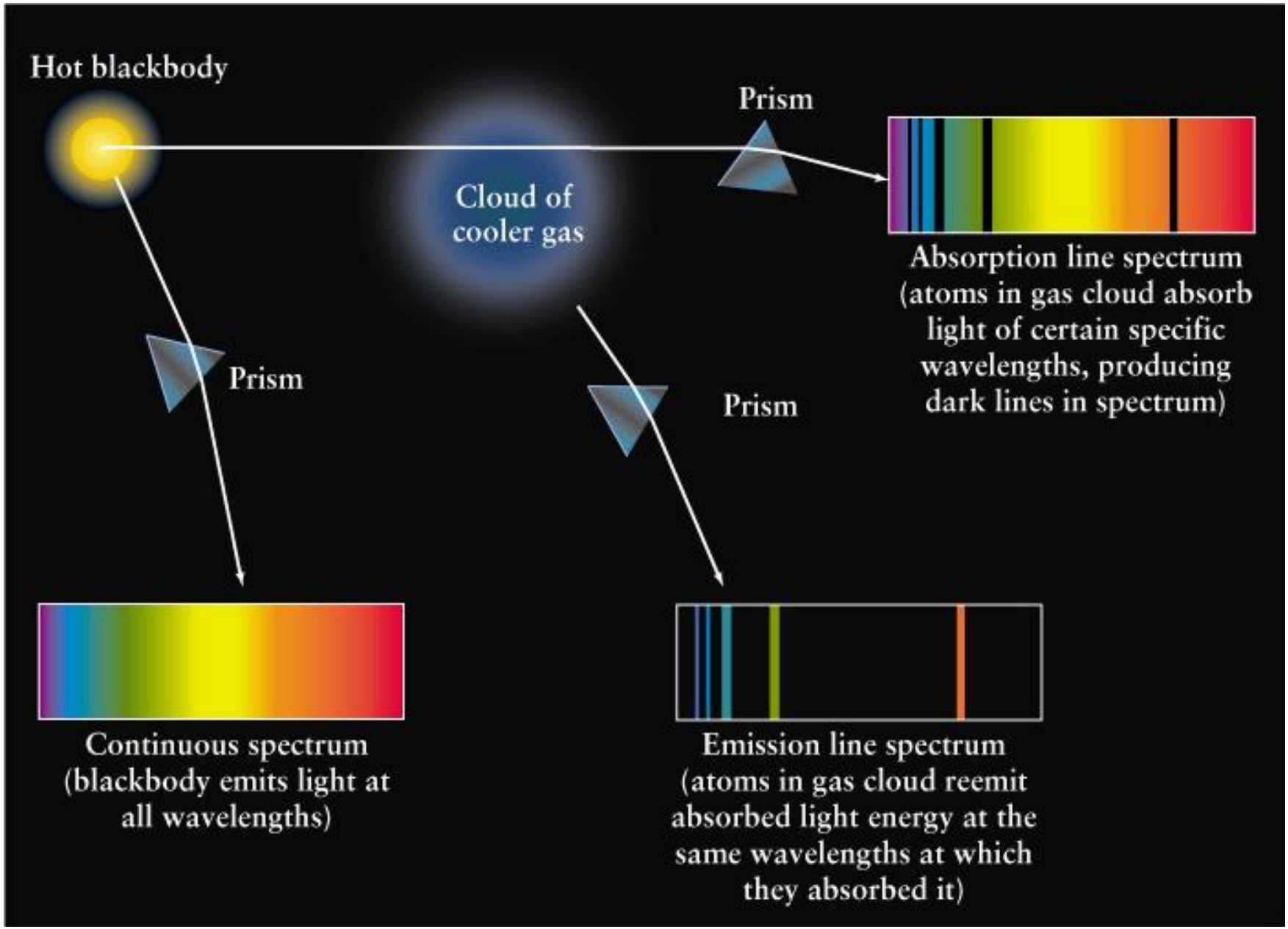
high energy

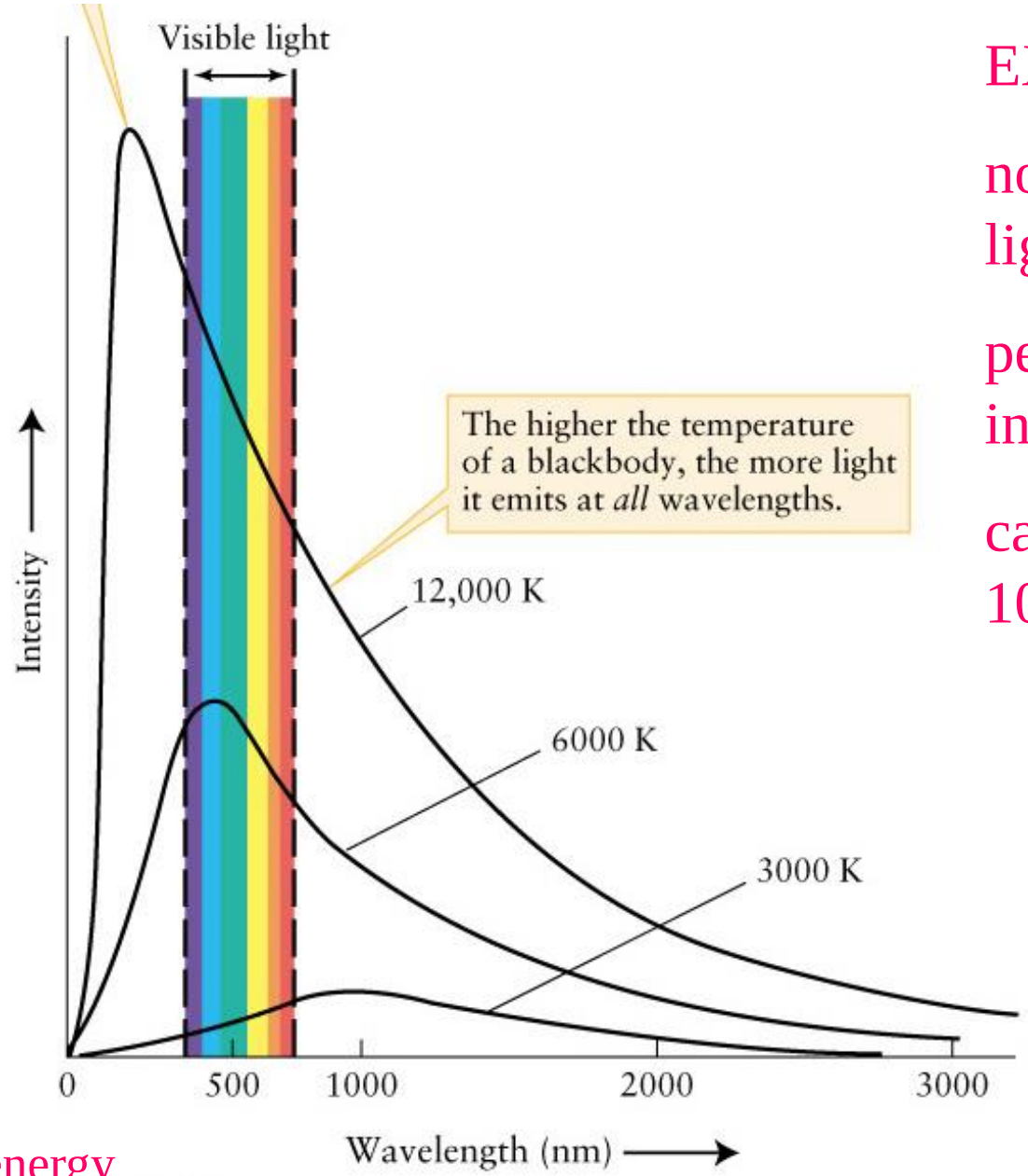
low energy

high frequency

low frequency




Hot blackbody
Prism
Cloud of cooler gas
Absorption line spectrum (atoms in gas cloud absorb light of certain specific wavelengths, producing dark lines in spectrum)
Prism
Prism
Continuous spectrum (blackbody emits light at all wavelengths)
Emission line spectrum (atoms in gas cloud reemit absorbed light energy at the same wavelengths at which they absorbed it)



high energy

EXAMPLES

normal, incandescent light bulbs T=5000K

people T=300K → infrared

campfires, stoves T=600-1000K, start to glow red

low energy photons

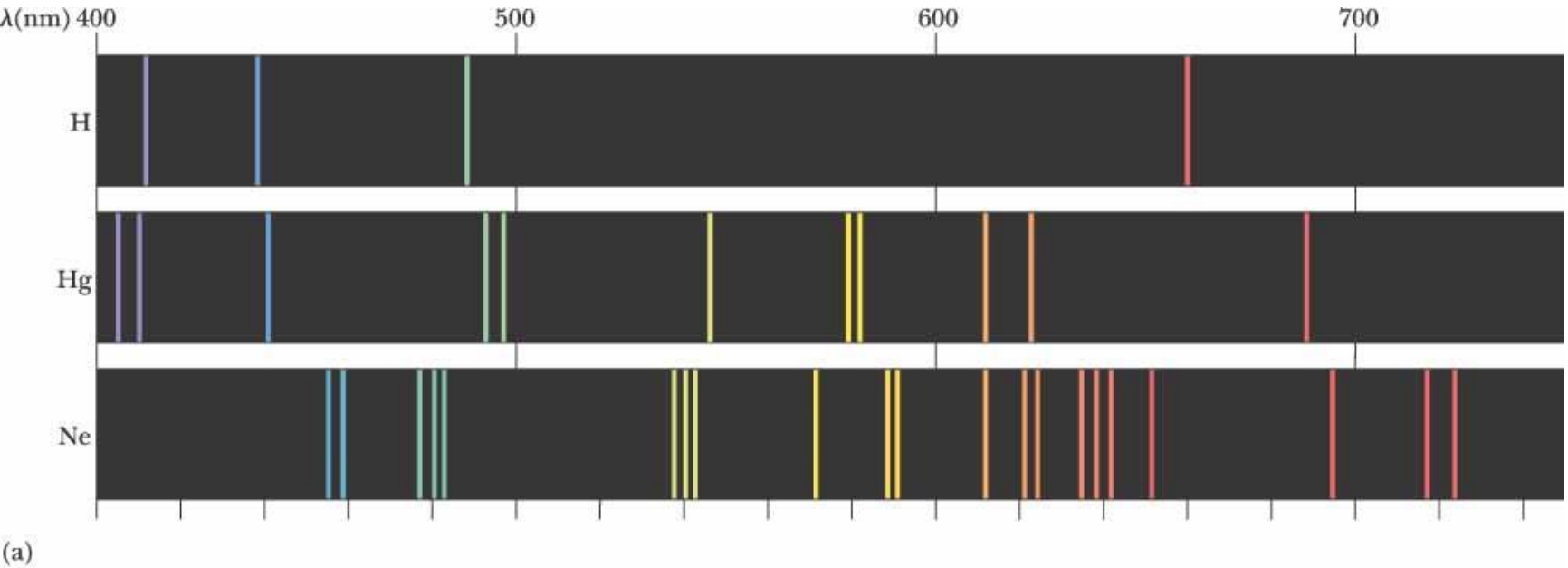
Atoms and Energy Levels

- Atom is a nucleus surrounded by electrons
- held together by electromagnetic force
- Electron can be in different energy states
- Changes in energy states (Quantum Leaps) produce discrete spectrum

Discrete Spectrum

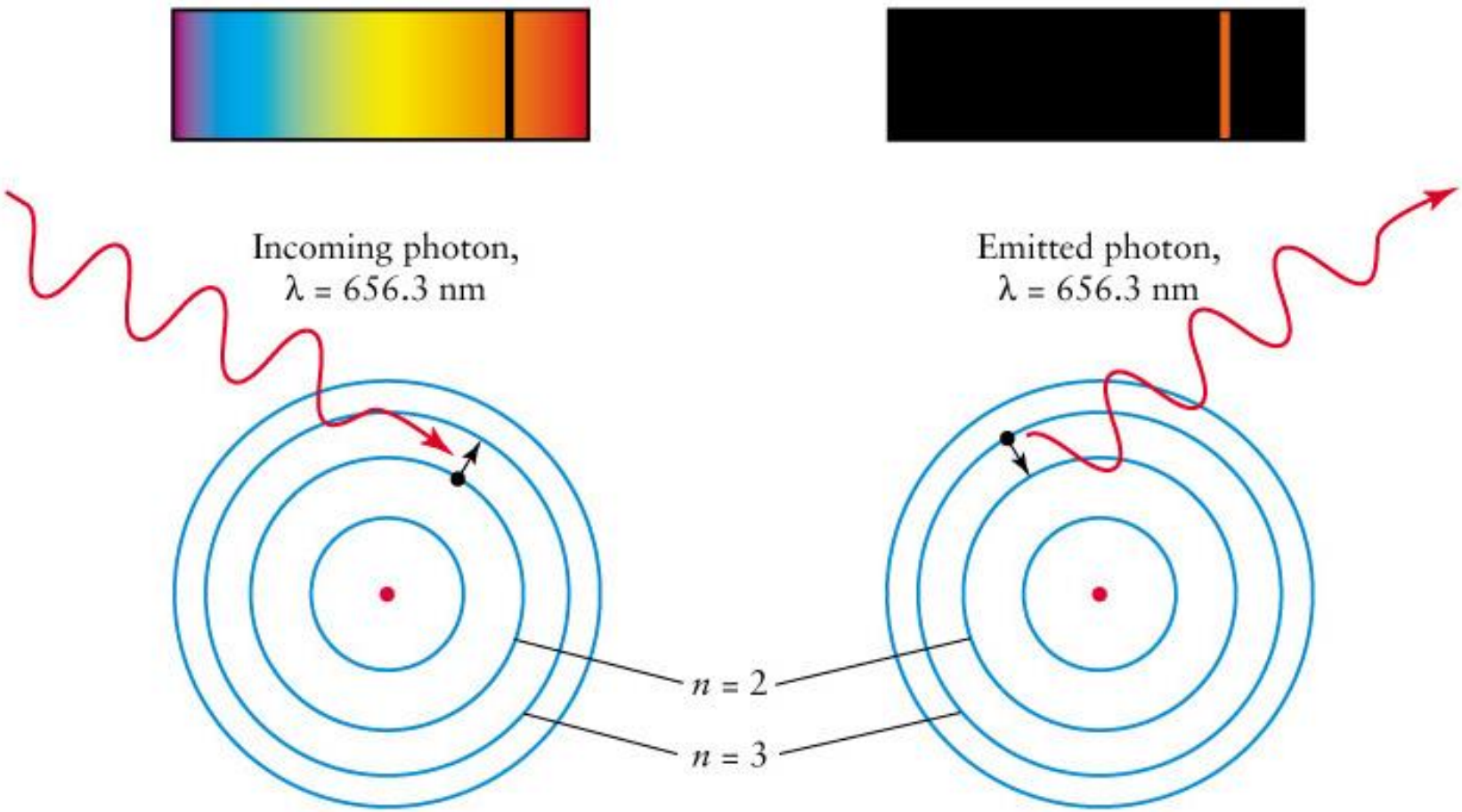
- “spikes” at specific frequencies
- Depends on which atoms are present
- Examples include fluorescent or Neon or Mercury lights
- Can identify chemical composition of objects (spectroscopy)

Atoms and Energy Levels

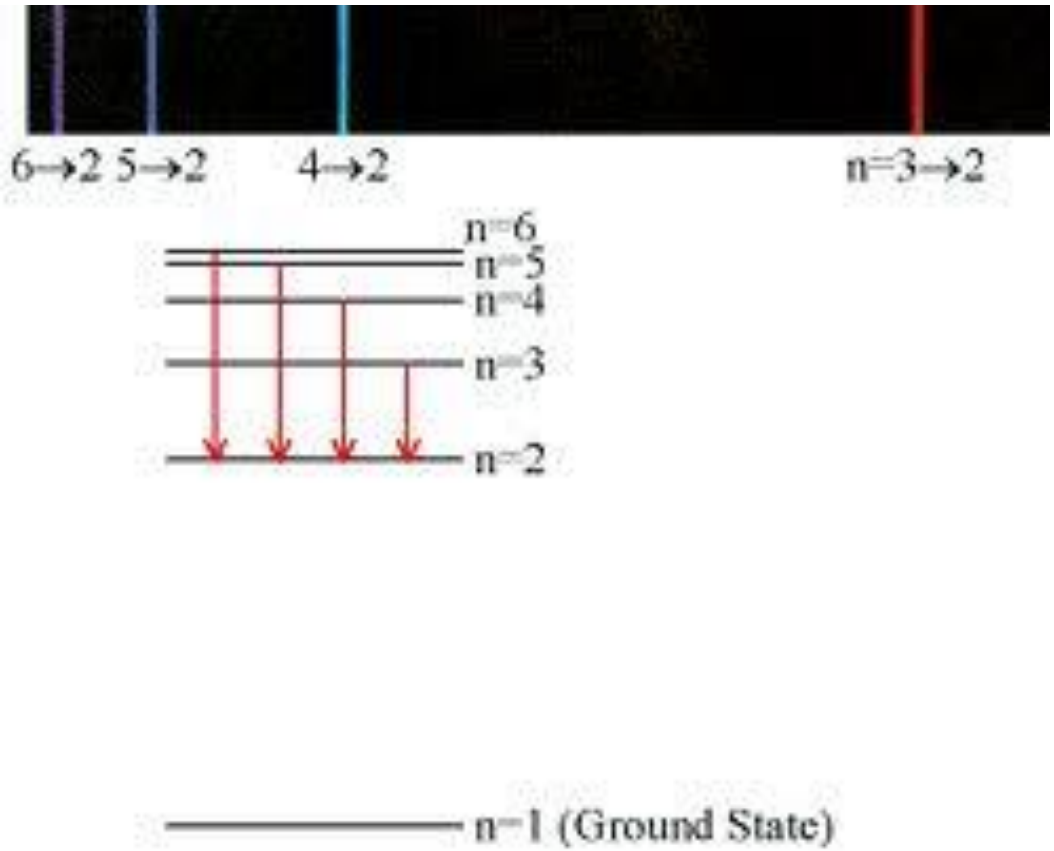


emission lines can tell one atom from another – in this case Hydrogen from Mercury from Neon

Atoms and Energy Levels



Hydrogen lines



For Hydrogen, the lines in the visible spectrum are transitions to the n=2 (Balmer)

Those to the n=1 are in the UV (Lyman series)

- Transitions between different atomic energy states either emit or absorb light
- The energy of the light (the photon's frequency) is equal to the difference between the atomic energy states
- Pattern of photon frequencies tells what atom is emitting the light

$E(\text{photon}) = hf$

h = Planck's constant

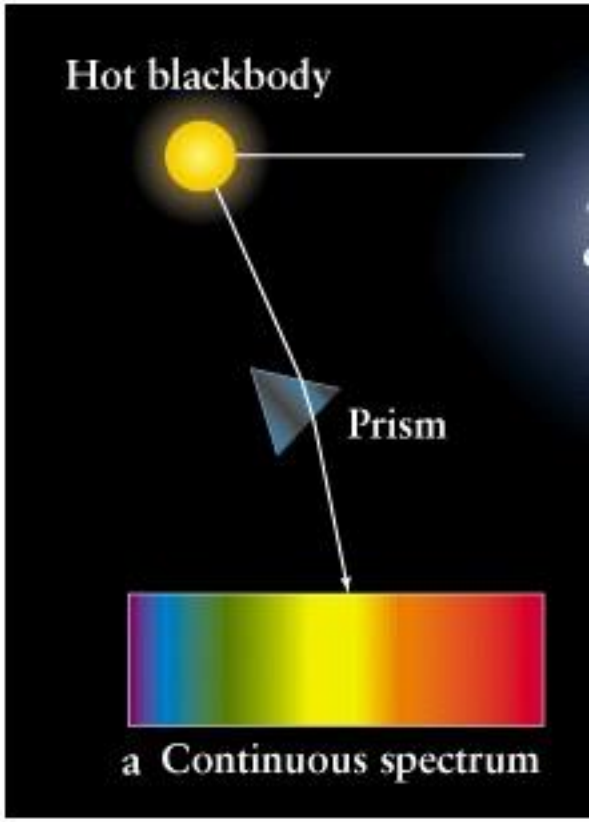
f = frequency

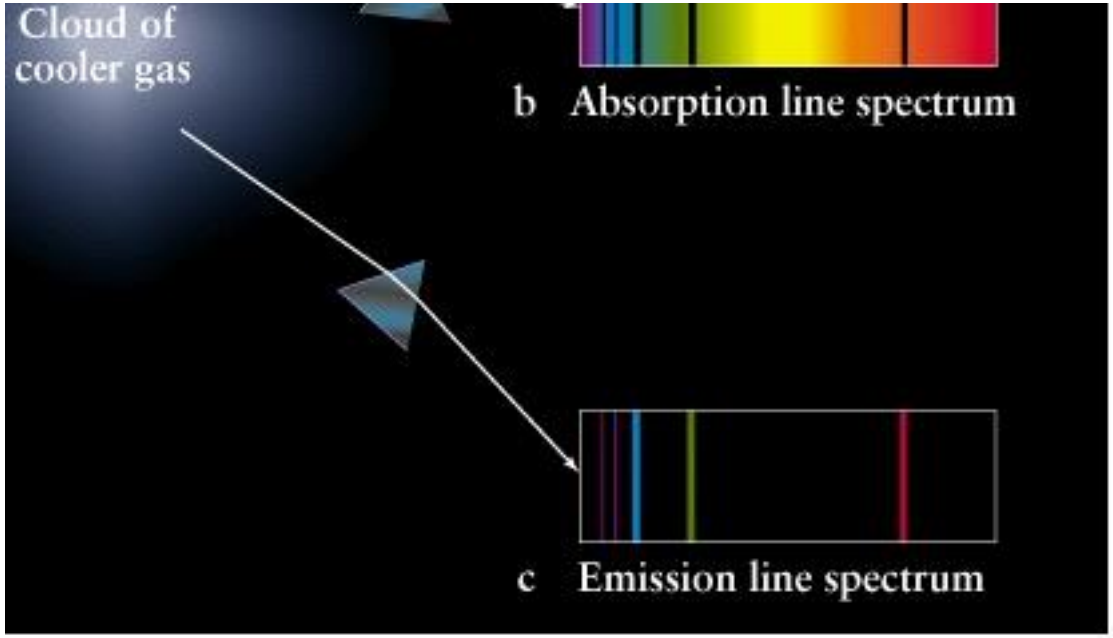
How fluorescent light works

- Tube filled with Mercury and Argon gas
- Initial HV heat up gas → Argon "plasma"
- moves electrons in Mercury to higher energy levels
- electrons "fall" to lower energy levels and emit UV light
- UV light absorbed by phosphor coating on walls and is reemitted at lower energy, with mix of colors that appears white

LIGHT DEMONSTRATION

- use diffraction gratings instead of prisms

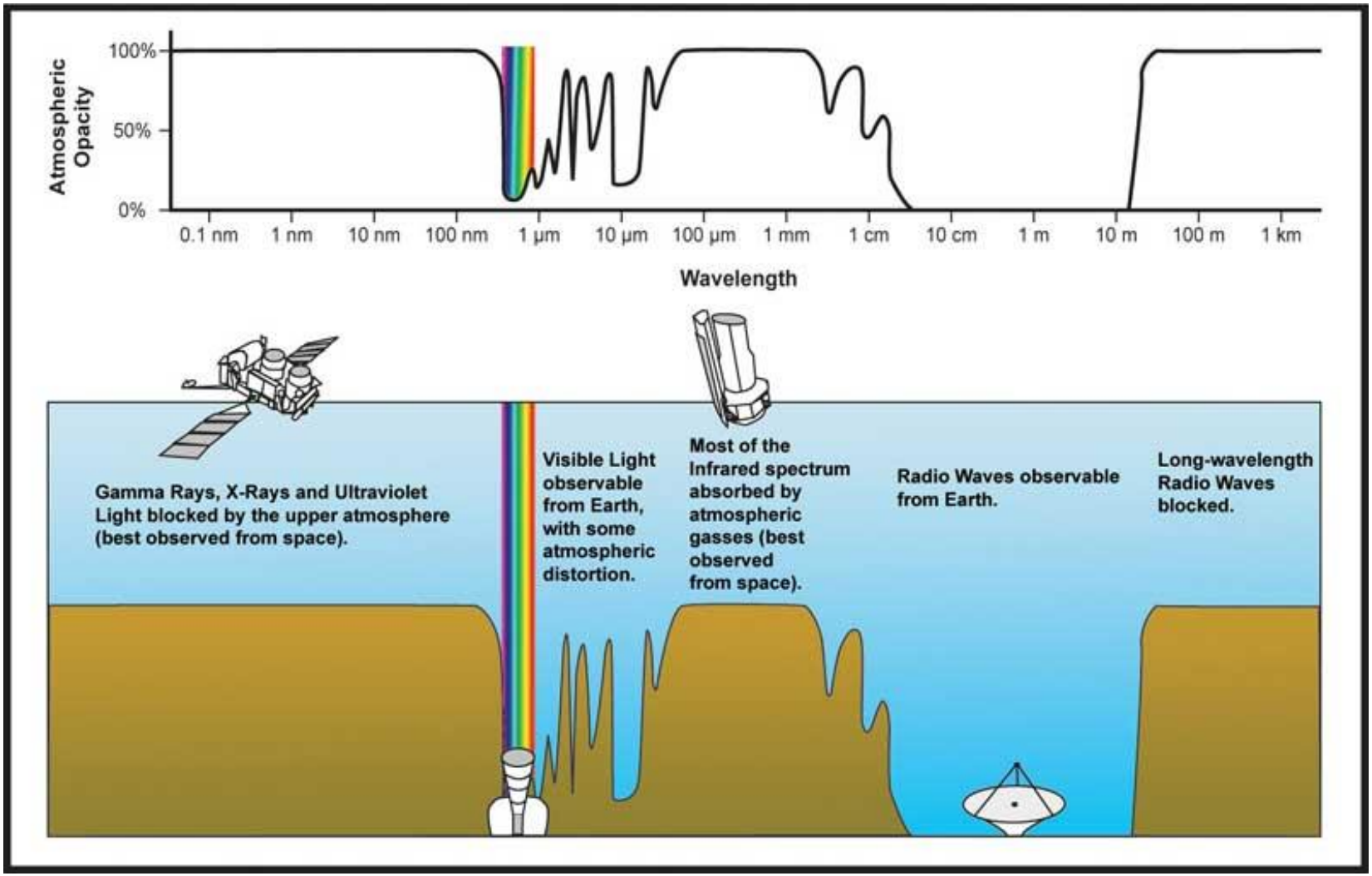




ABSORPTION OF LIGHT

- “clear” doesn’t absorb
- “opaque” absorbs
- depends on frequency. Glass is clear in the visible but opaque in the infrared. Can cause greenhouse effect
- Microwave ovens work by operating at a frequency near a water absorption line
- atmosphere only clear in visible, radio, and part of infrared

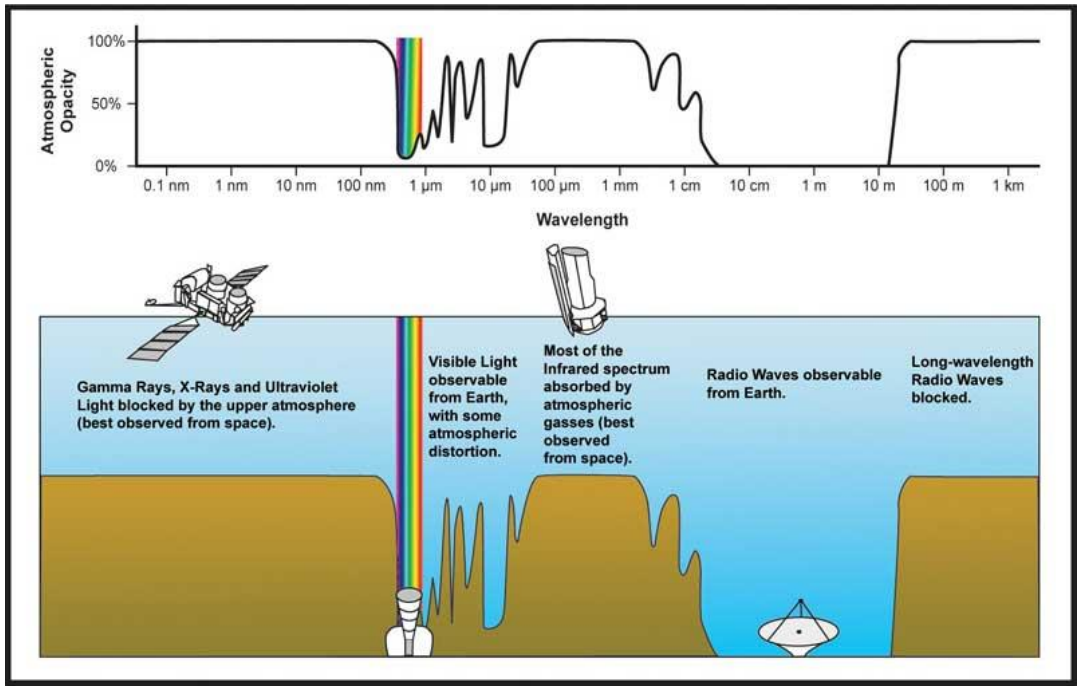
Absorption of Light in Atmosphere



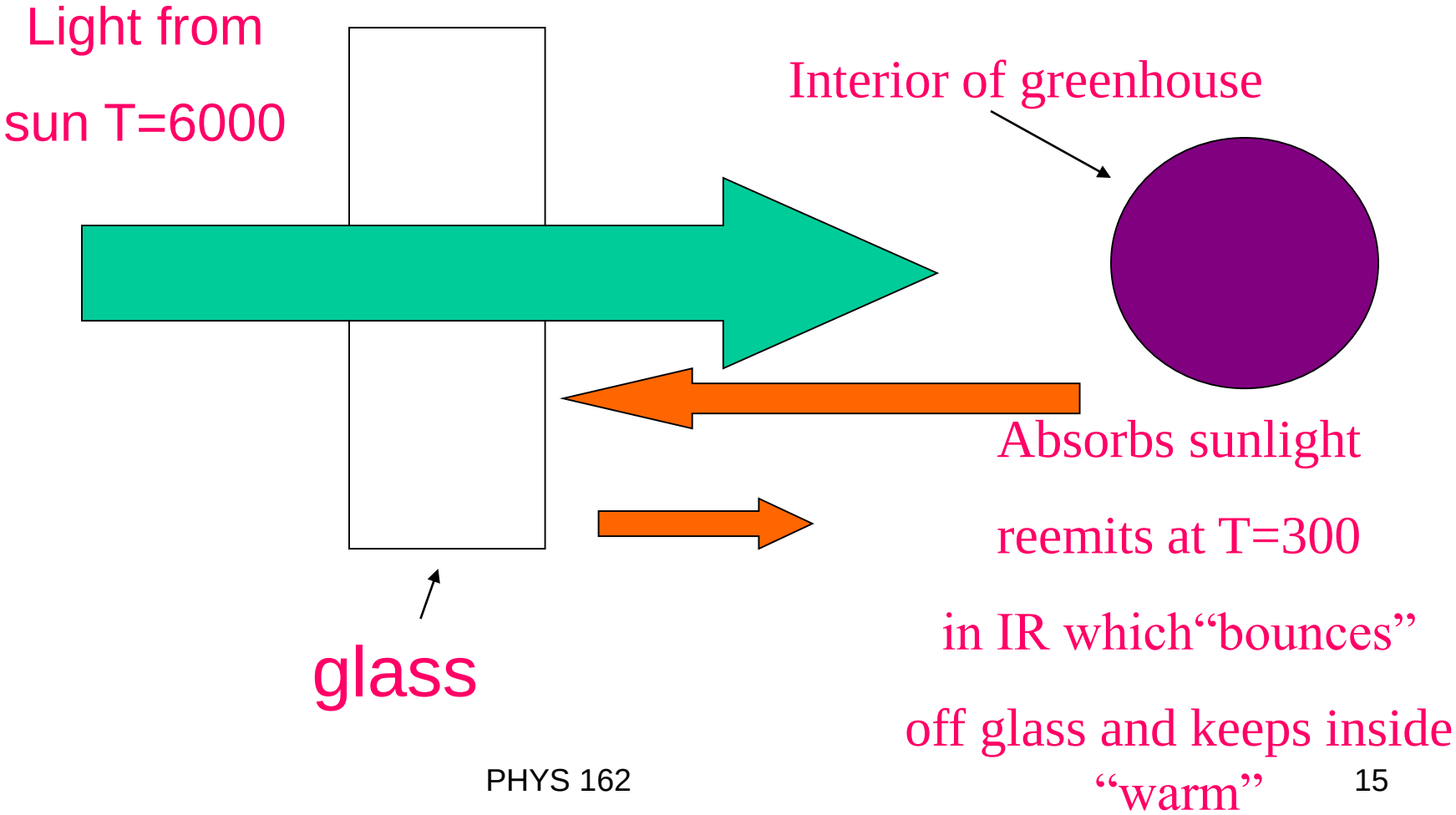
Absorption of Light in Atmosphere

Good transmission in visible, radio and parts of IR spectrum → Earth-based telescopes

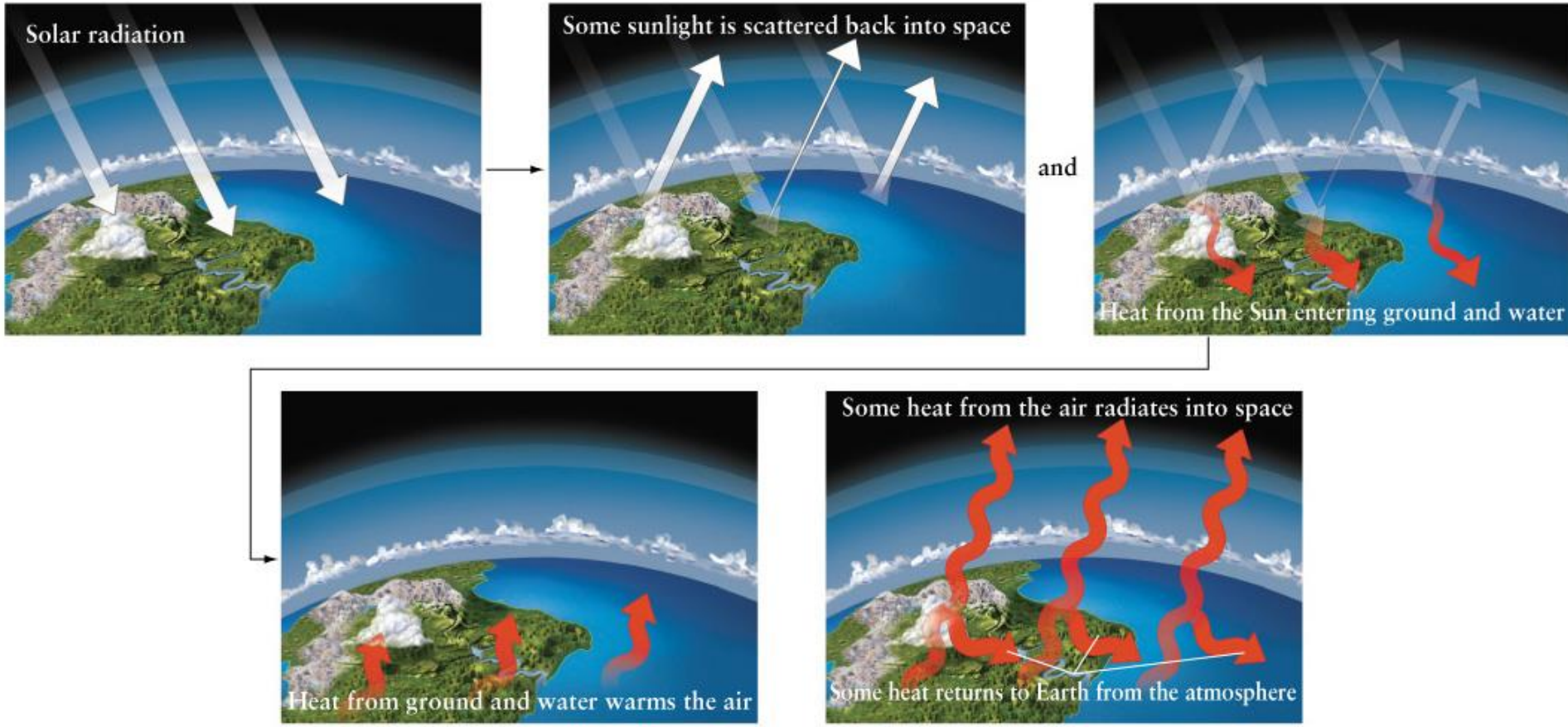
Poor transmission in X-ray, UV, and parts of IR → space-based telescopes



Greenhouse Effect

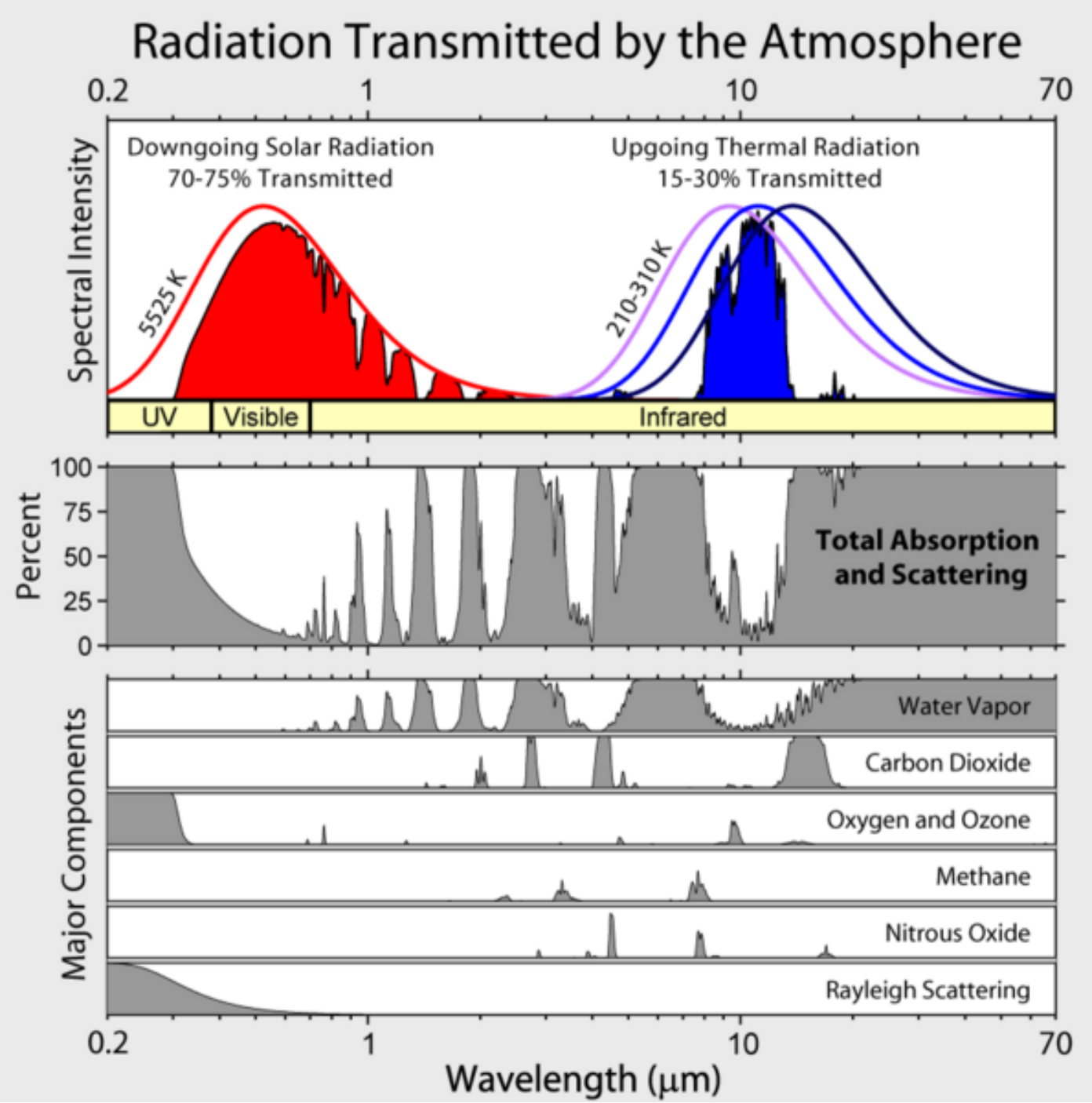


Greenhouse effect in Earth's Atmosphere

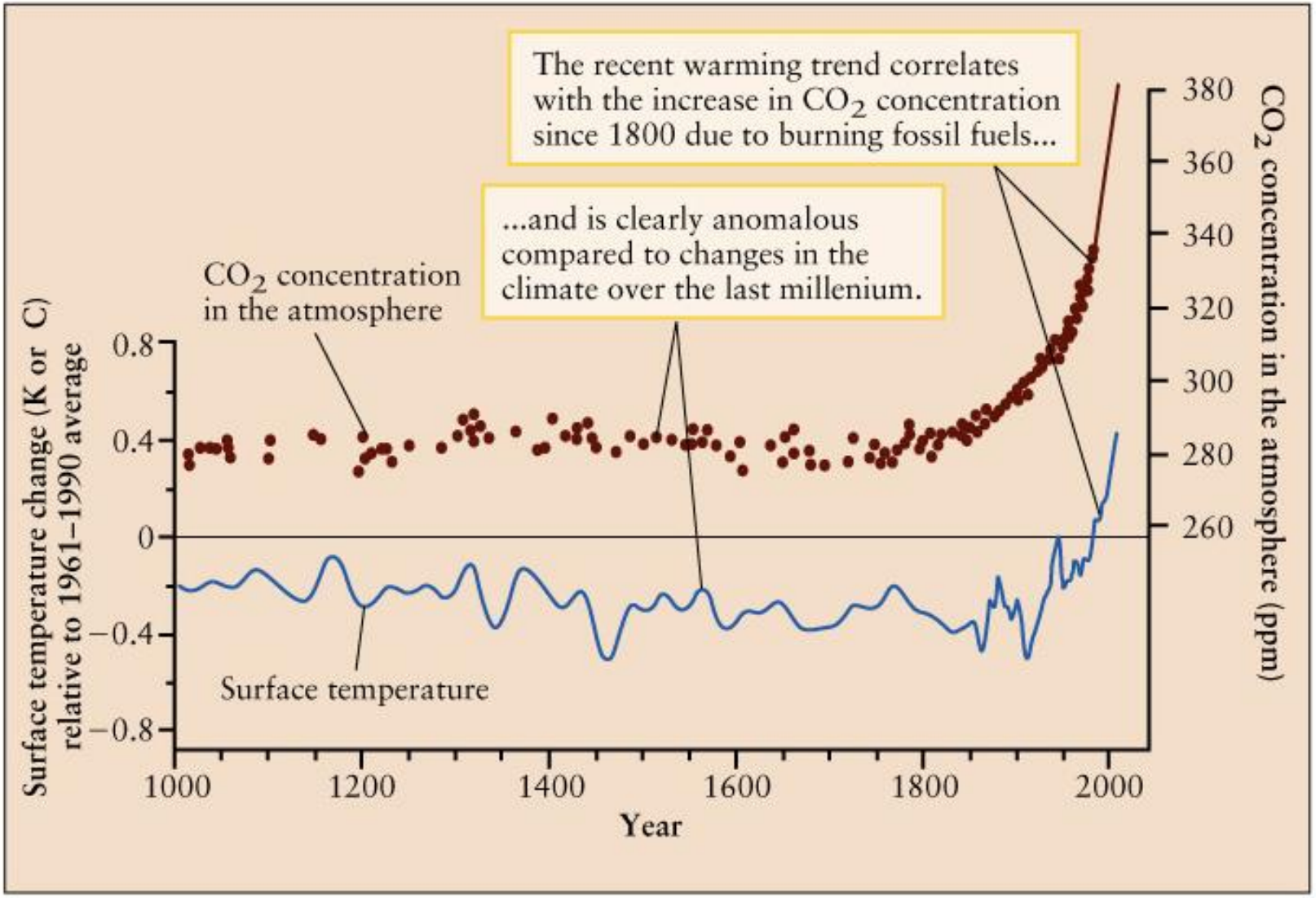


Greenhouse Effect in Earth's Atmosphere

- Primary "greenhouse gas" in atmosphere is water vapor
- It presence helps to keep Earth's average temperature above freezing
- Water's absorption frequencies depend mostly on the mass of Hydrogen
- Carbon Dioxide absorption frequencies depend on the masses of C and O → different then water and so "fill in" parts of the spectrum and so add to the absorption in the Infrared. Methane also absorbs in the IR.


Radiation Transmitted by the Atmosphere
0.2
1
10
70
Spectral Intensity
Downgoing Solar Radiation
70-75% Transmitted
Upgoing Thermal Radiation
15-30% Transmitted
5525 K
210-310 K
UV
Visible
Infrared
Percent
100
75
50
25
0
Total Absorption
and Scattering
Major Components
Water Vapor
Carbon Dioxide
Oxygen and Ozone
Methane
Nitrous Oxide
Rayleigh Scattering
Wavelength (μm)

Greenhouse effect in Earth's Atmosphere



Climate Change vs Politics
DH :: "I Don't Get It"

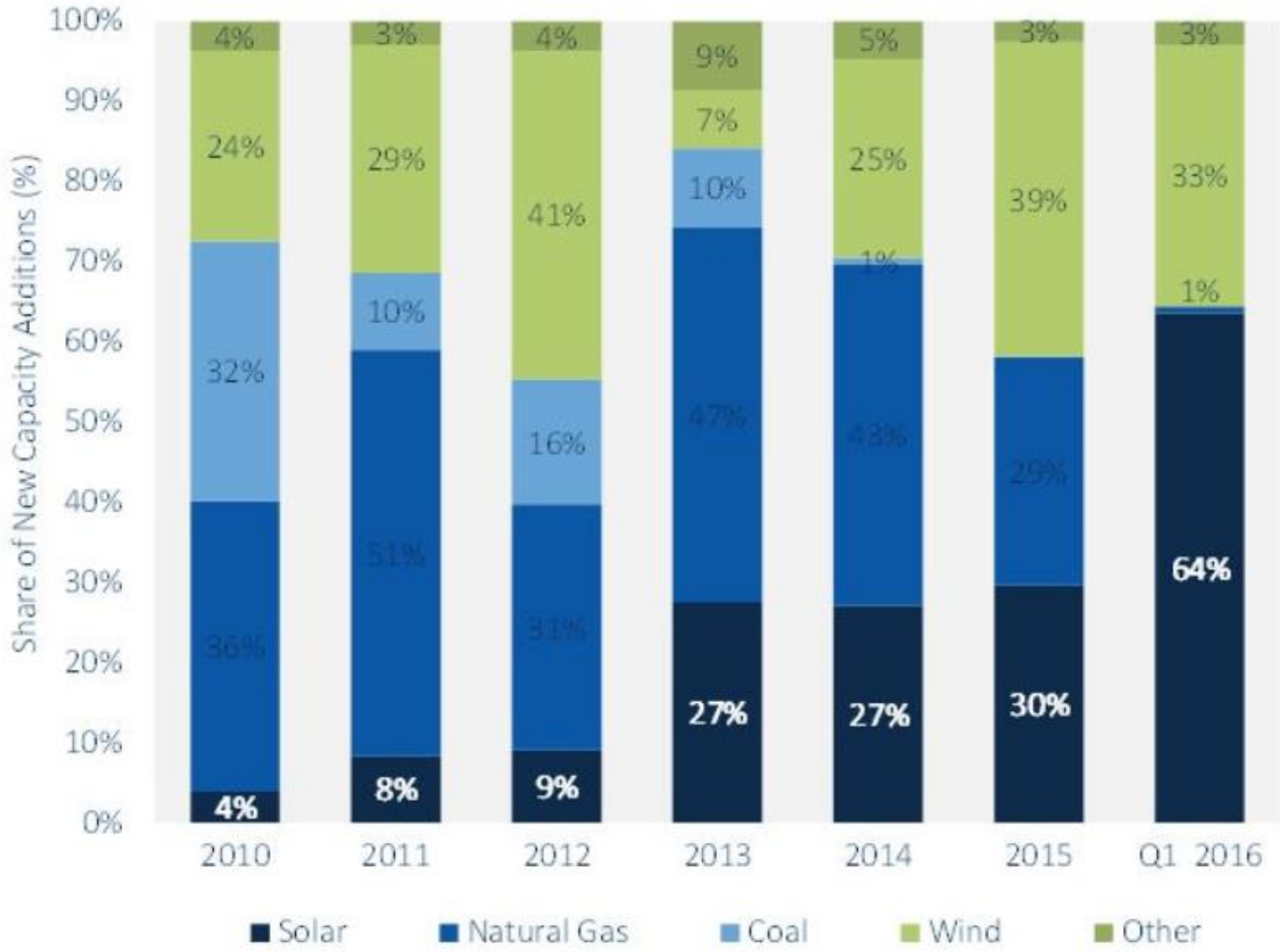
- In 1970s, two environmental problems understood
  - Freon → Ozone depletion, enhanced UV → "solved"
  - Carbon Dioxide → climate change → "not solved"
- Carter administration started R&D national lab on renewable energy, canceled during Reagan administration. If had proceeded could now have much larger fraction of US energy from renewables, cheaper energy costs for consumers, less reliance on coal/oil, reduced greenhouse effect, possibly fewer wars in Mideast(??)
- Not done "I didn't get it" then and still don't

Renewable Energy in 2017

- Large Scale electric: Quite cheap natural gas (from fracking) with wind turbine competitive (>25% of electricity in Iowa from wind, costs dropped by 40% since 2008 with generated amount 3X larger)
- Small scale: solar energy cheap (60% drop in costs since 2008) if install on homes ~12% return on investment include taxes. DH home 50% solar and 50% wind for electricity. But most homes in DeKalb get electricity from coal (!). Large current move to “community” solar
- Geothermal good source for heat/AC but larger initial investment in older homes

New US Electrical Energy 2010-2016 → driven by costs

FIGURE: Share of New U.S. Electric Generating Capacity Additions



Climate Change vs Politics
DH :: "I Don't Get It"

- Accounting firm Price Waterhouse Cooper "20 years from catastrophe"
- Accounting firm Ernst & Young helps businesses on "Global climate change and sustainability" issues
- For insurance companies, climate change is their #1 risk factor for property/casualty losses

→"easy" solution: eliminate coal-produced electricity

→ saves money for more than (probably) 98% of Americans while also good for health/climate. But not being done

- Natural gas, solar, wind, and geothermal all cheaper (and less dangerous). But in many states the coal and coal-driven power industry is able to impede changes, or even force communities to change to using coal-fired plants, while other states (Ca, Ha, NY) are moving towards 100% renewables for electricity,
- "I don't get it"

Article January 2017

The Long Island Power Authority voted today to formally approve the development of New York's first ever, and the nation's largest, offshore wind farm! Last week Governor Andrew Cuomo took an historic step towards expanding clean, renewable energy in the Empire State and accelerating the transition to 100% clean, renewable energy.

By Gov. Cuomo directing state agencies to study pathways to power New York with 100% renewable energy, New York becomes the first state in the Continental U.S., and the biggest state in the country, to commit to exploring a complete transition to 100% clean, renewable energy! #ReadyFor100 #BeyondCoal