Black Body Radiation

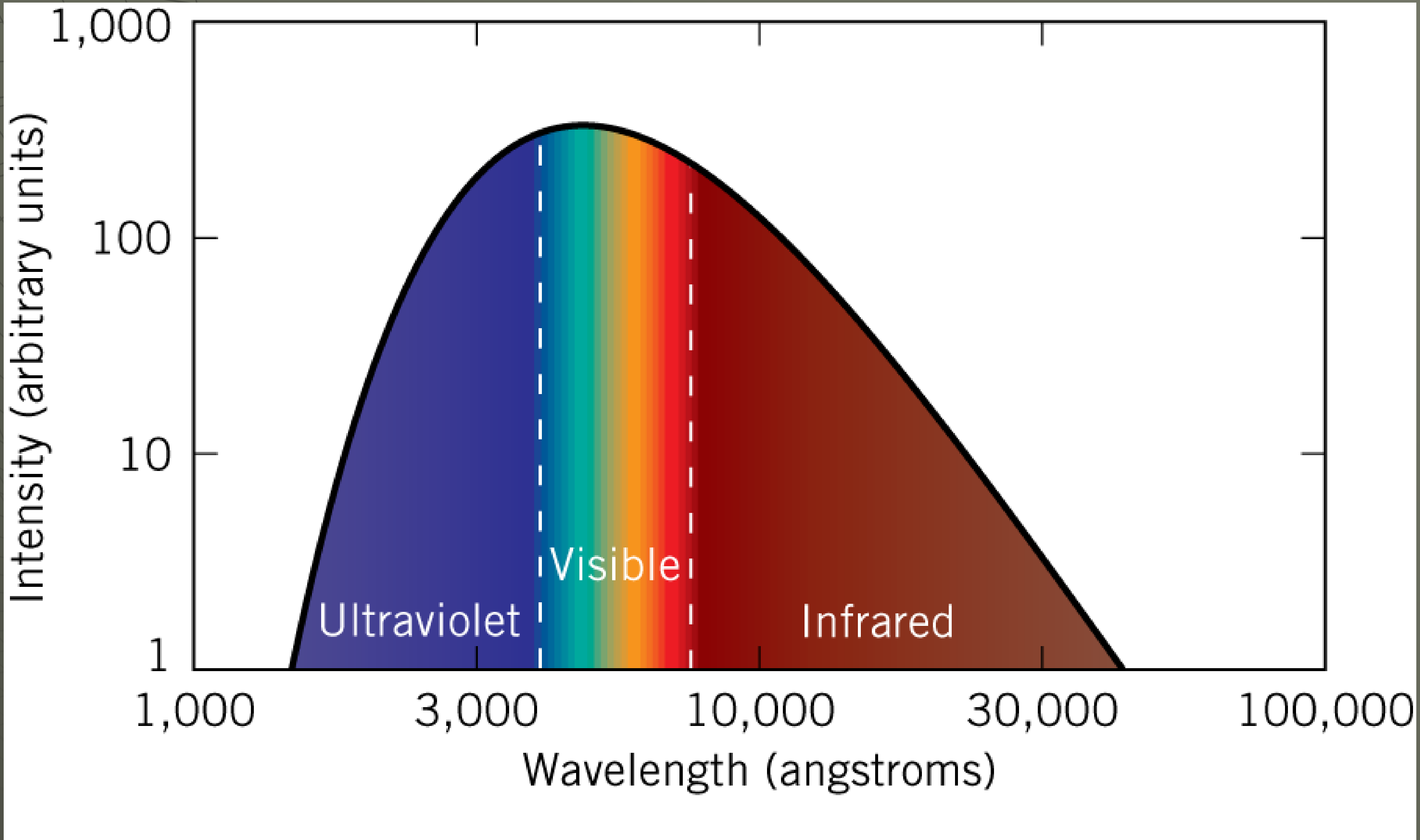
- Objectives
  - What emits a continuous spectrum
  - What are the properties of a blackbody
  - Are stars blackbodies….

Blackbodies

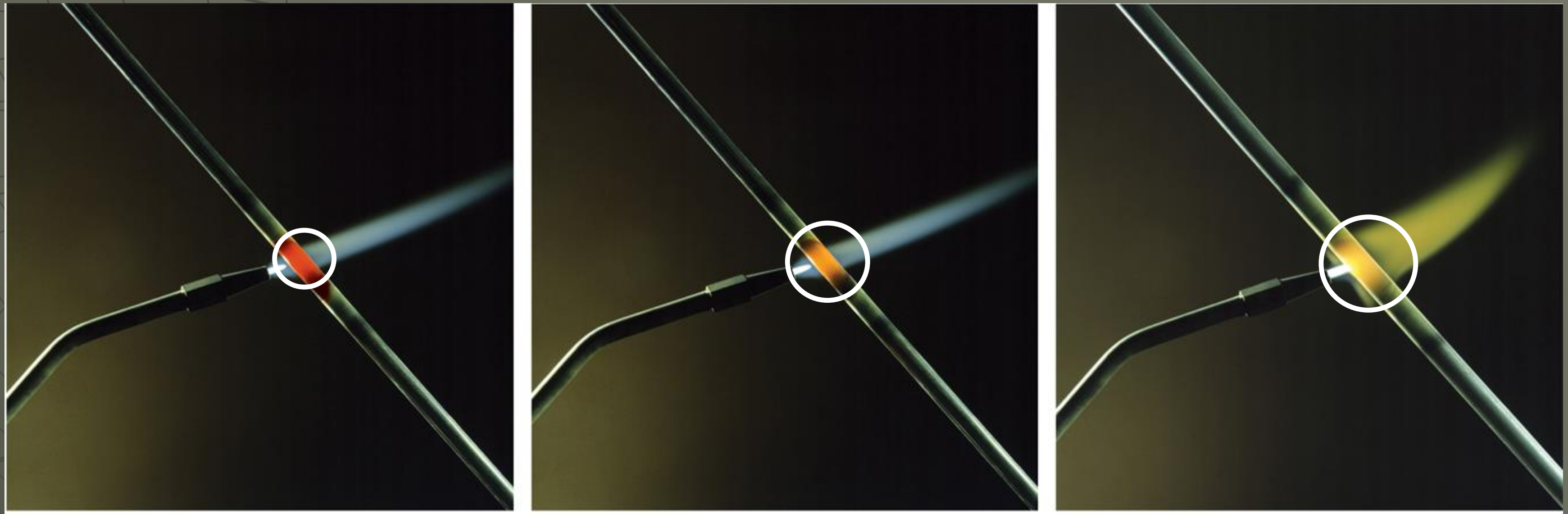
- Blackbodies: "perfect" radiators
  - Dense bodies (solids, liquids, etc.)
  - All atoms share energy very quickly
  - The whole blackbody has the same temperature
- Types of EM radiation emitted determined *only by temperature*, not chemical composition
- **continuous spectrum** of energy

A Continuous Spectrum

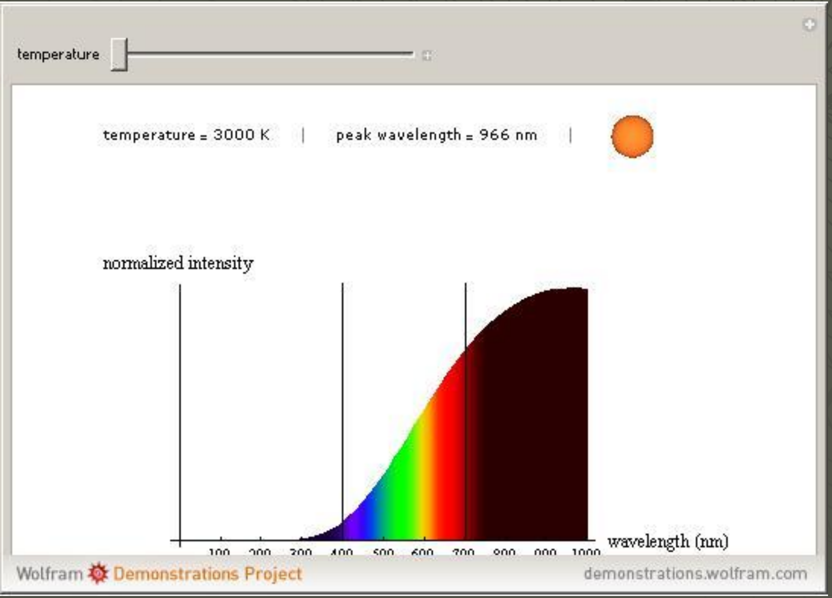
Brightness

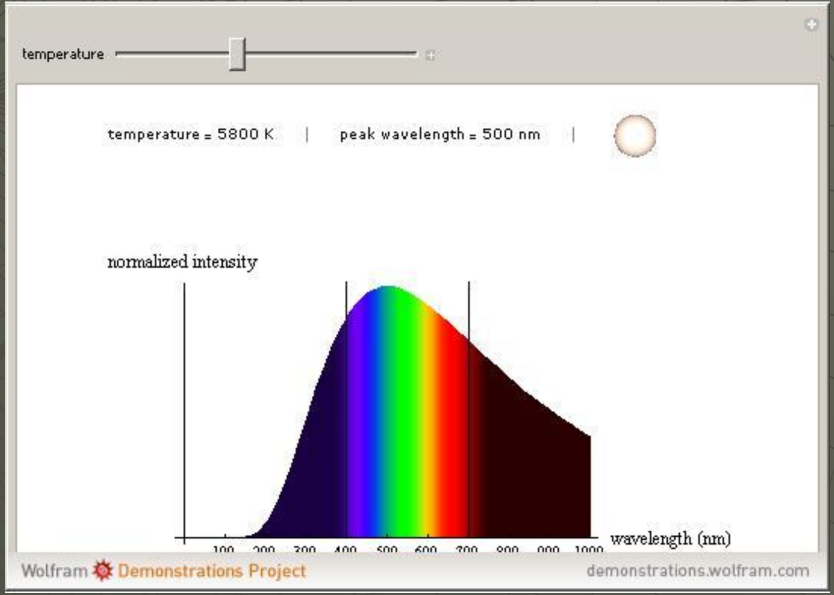


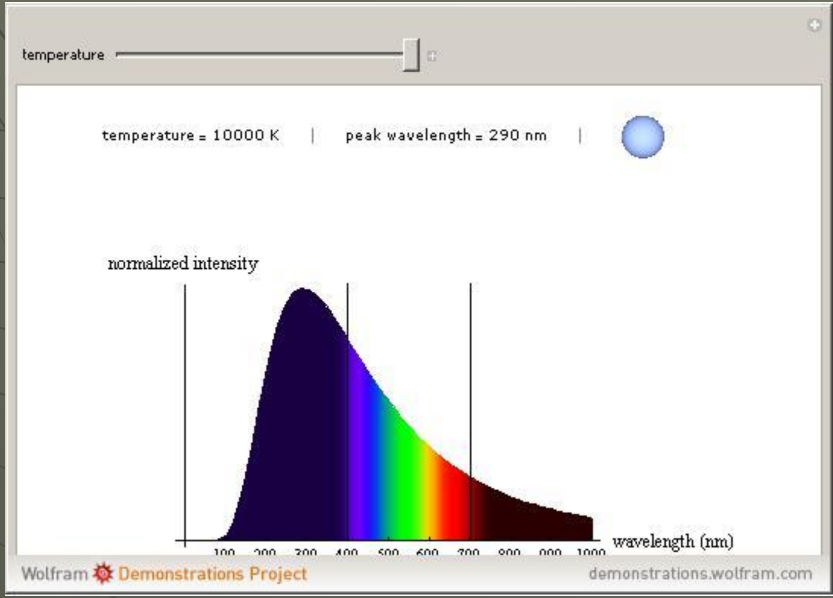
A Continuous Spectrum



(a) Hot: glows deep red (b) Hotter: glows orange (c) Even hotter: glows yellow







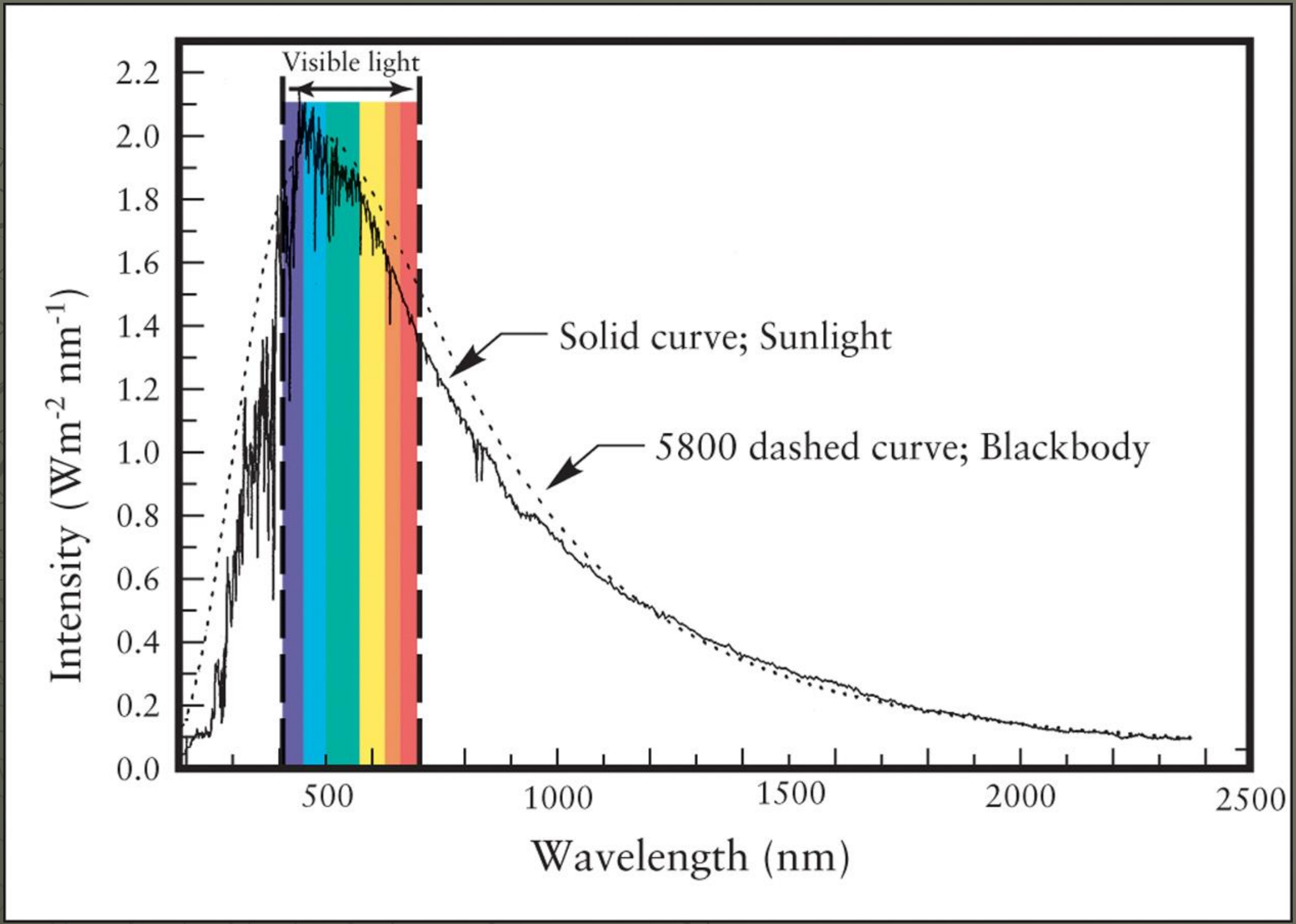
Wien's Law

- $\lambda_{max} = \frac{constant}{T}$
- λ_{max} = λ where peak brightness occurs
- T = temperature (measured in Kelvin)

- **λ_{max} → wavelength/color of the peak, NOT height**

Stars as Blackbodies

- Stars behave like blackbodies
- Peak wavelength **uniquely determined** by temperature
- Thus, **color** of a star is a **direct indicator** of its temperature



1. Which of the two stars in the image is **hotter**?

A. The blue star (blue implies hotter)
B. The yellow star (yellow implies hotter)
C. The yellow star (because it is brighter)
D. Not enough information

Stellar Luminosity (Brightness)

- Stellar luminosity: light (energy/sec) given off by entire the star
- Entirely determined by 2 properties:

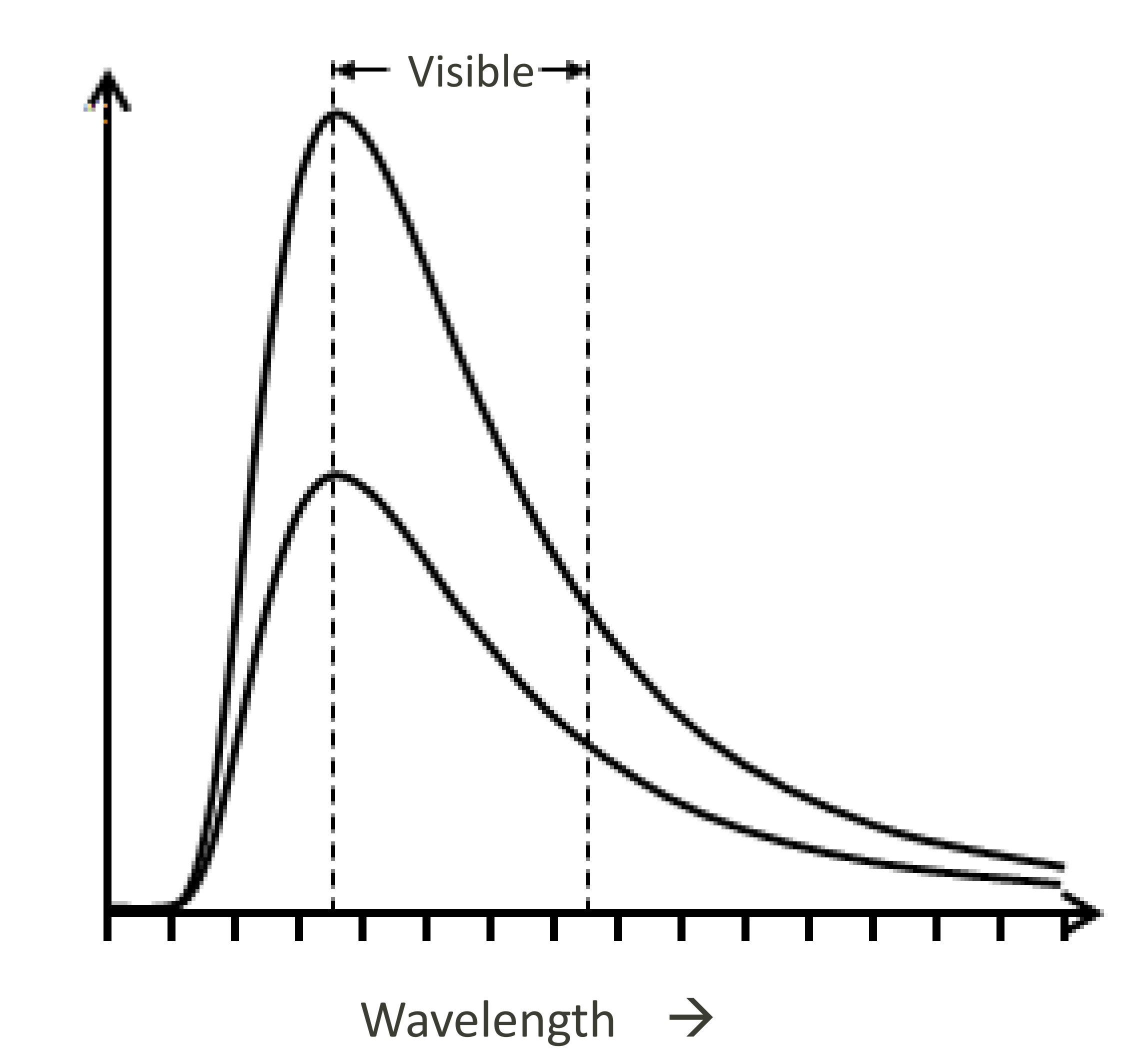
1. **Temperature:** a hotter star will be brighter
   - Given two stars of the same size
2. **Size/Radius:** a larger star will be brighter
   - Given two stars of the temperature

** Distance plays a role in how bright the star **appears** to us—but that's for later…

Stars of Same Temperature

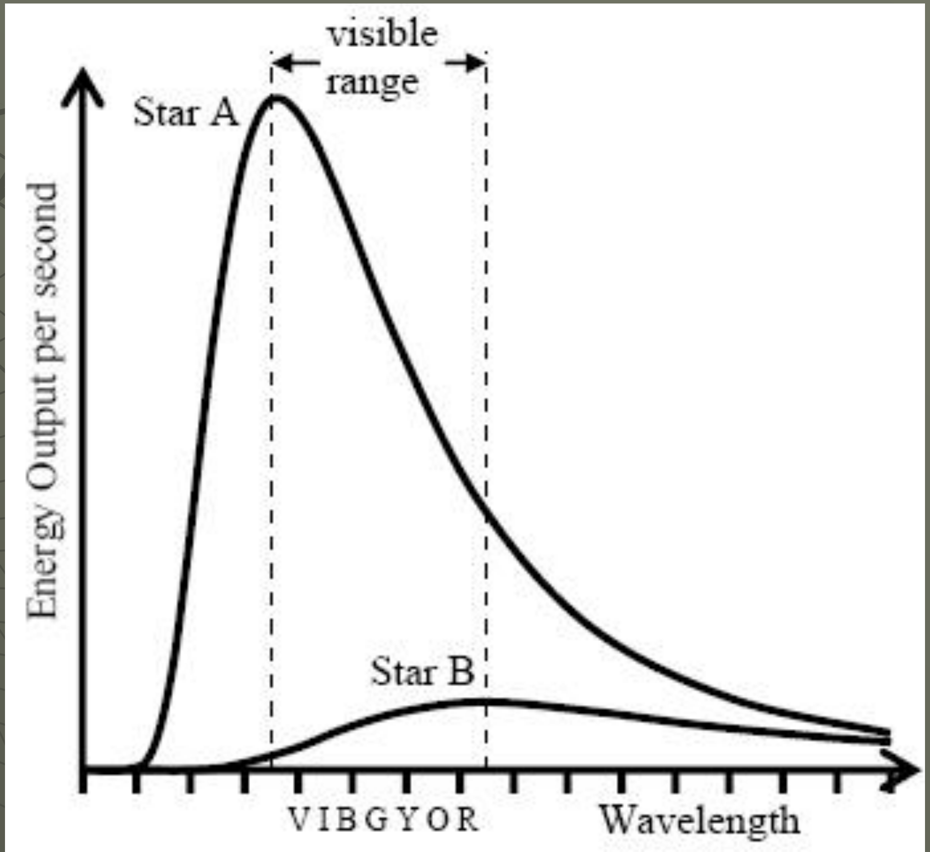
- Larger star more luminous
- For objects at equal temp, they both appear to be the same color

- Larger one gives off more light in every color/wavelength



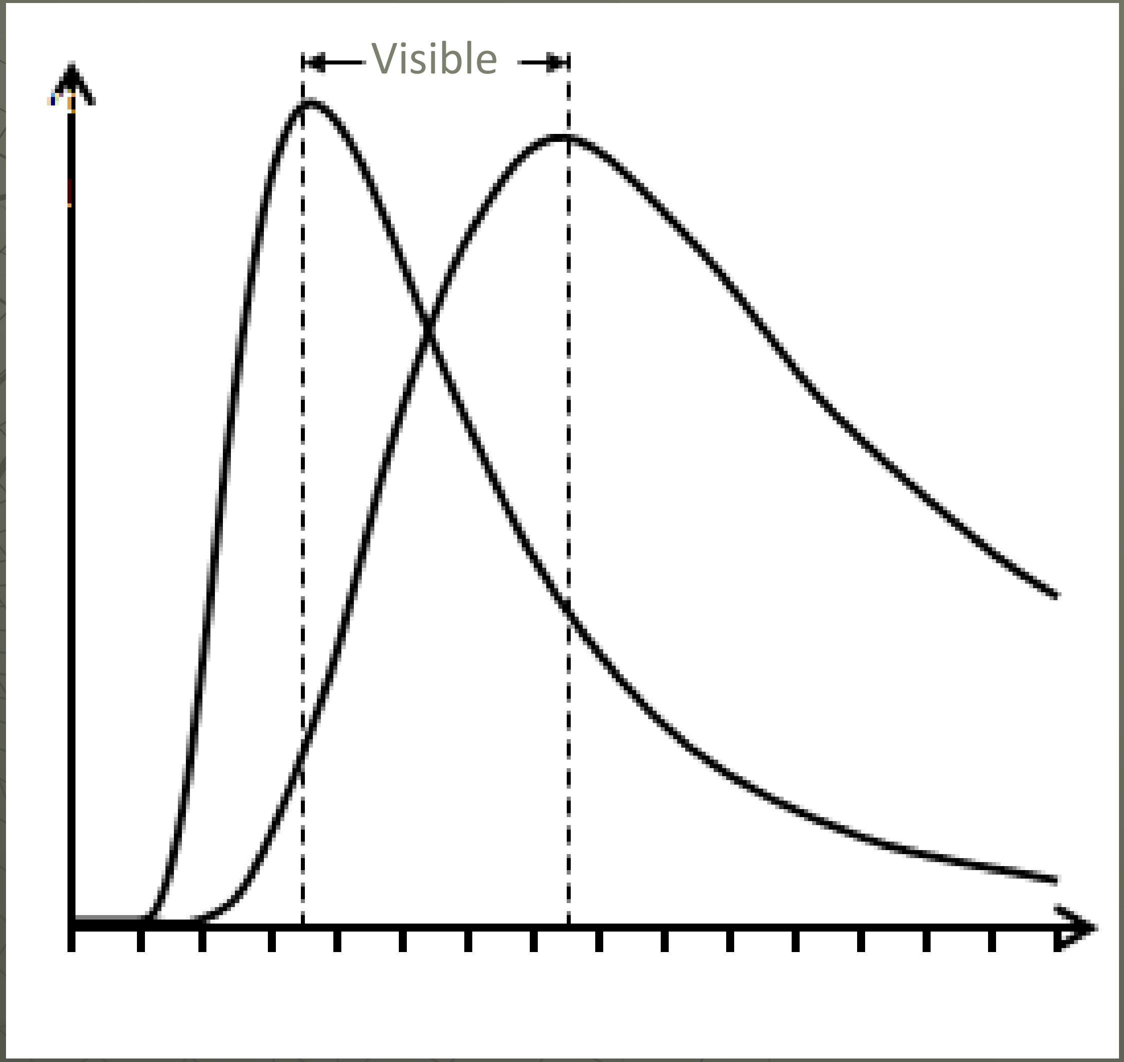
Stars of Different Temperature

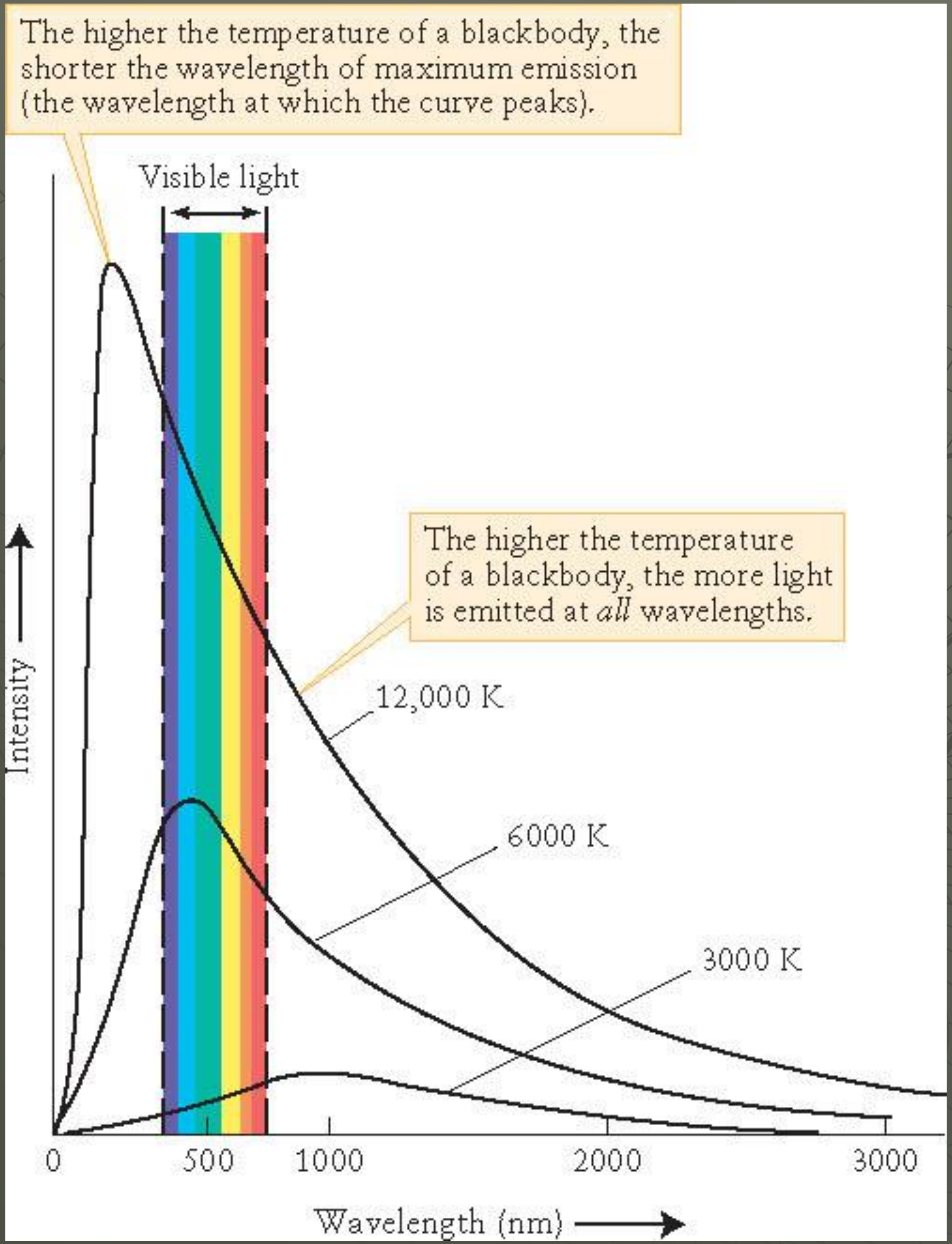
- If the stars have the same size, the bluer star is brighter



Special Case!

- **If a cooler star outshines a hotter star, it MUST BE LARGER!**
- This is the only way that a cooler star could outshine a hotter one at any color





Blackbody Radiation

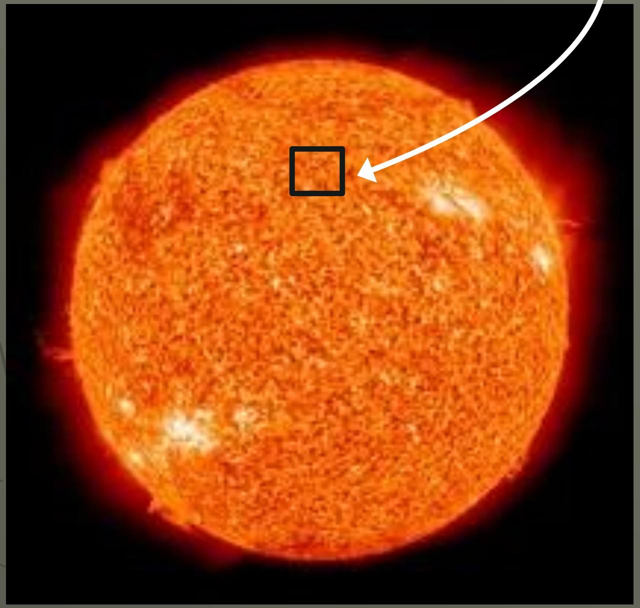
- *Get rid of size effect (energy per m^2)*

Stefan-Boltzmann Law:

$$F = \sigma T^4$$

F=*flux*, units of J/m^2 s

σ=constant=5.67×10^{-8} W/m^2 K^4



Luminosity and Flux

- Flux (F) brightness in an area
- *Luminosity (L)* brightness of the object as a whole

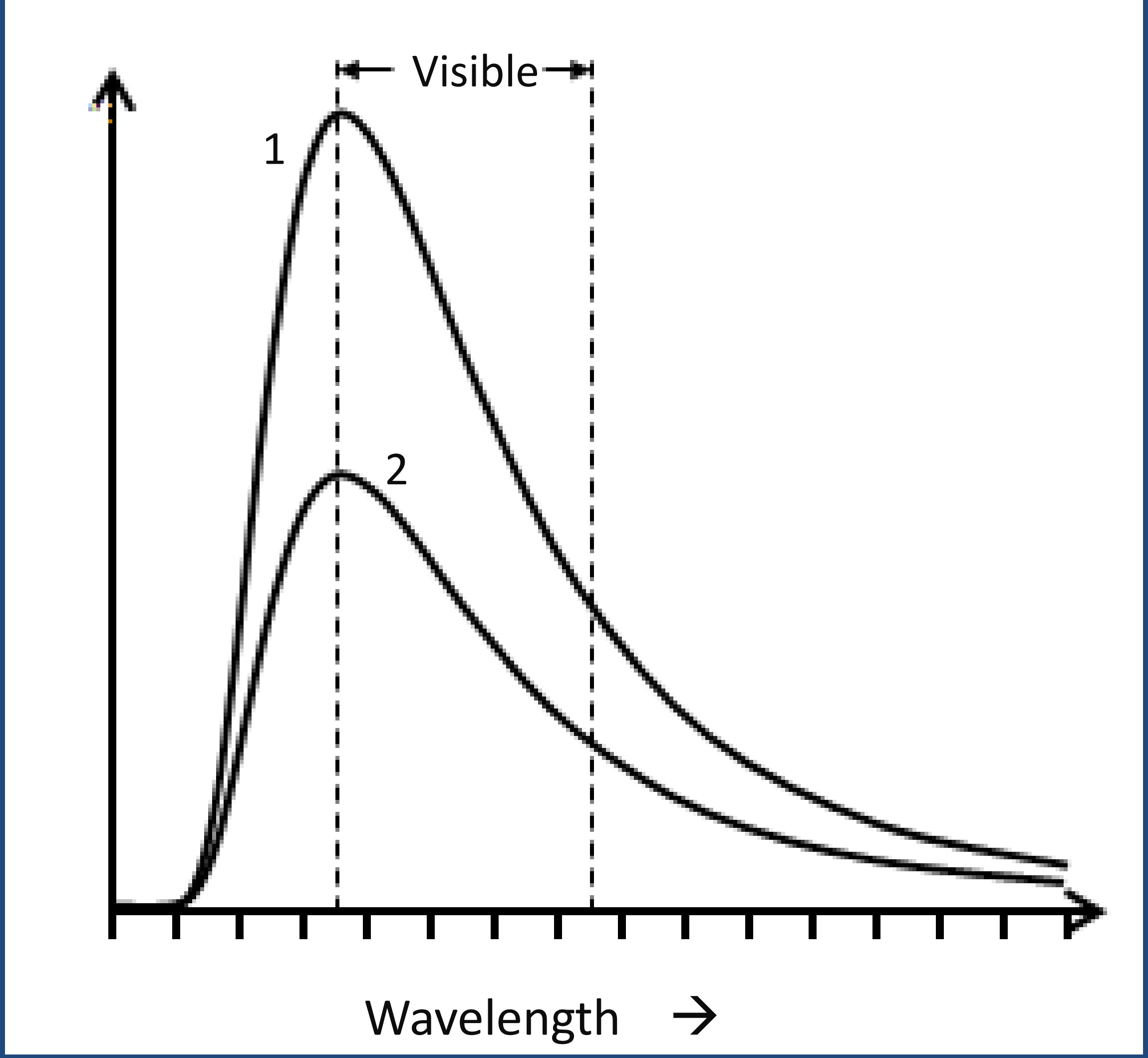
$$L = F \times (\text{Surface Area})$$

For a sphere (like a star):

$$L = F \times 4\pi R^2$$

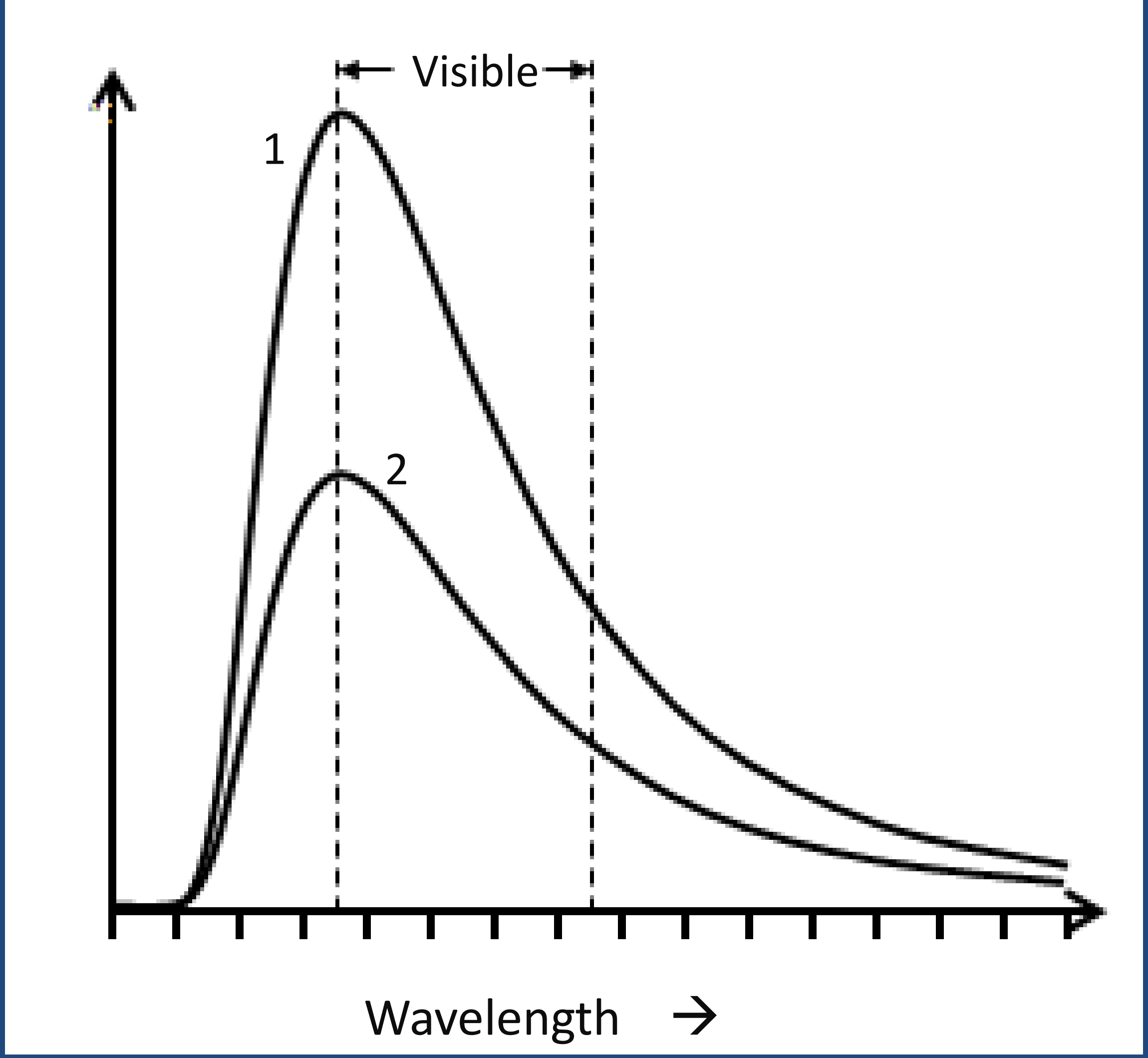
2. What is NOT true about these stars?

A. Are the same color
B. Have the same temperature
C. They have the same size
D. All of the above



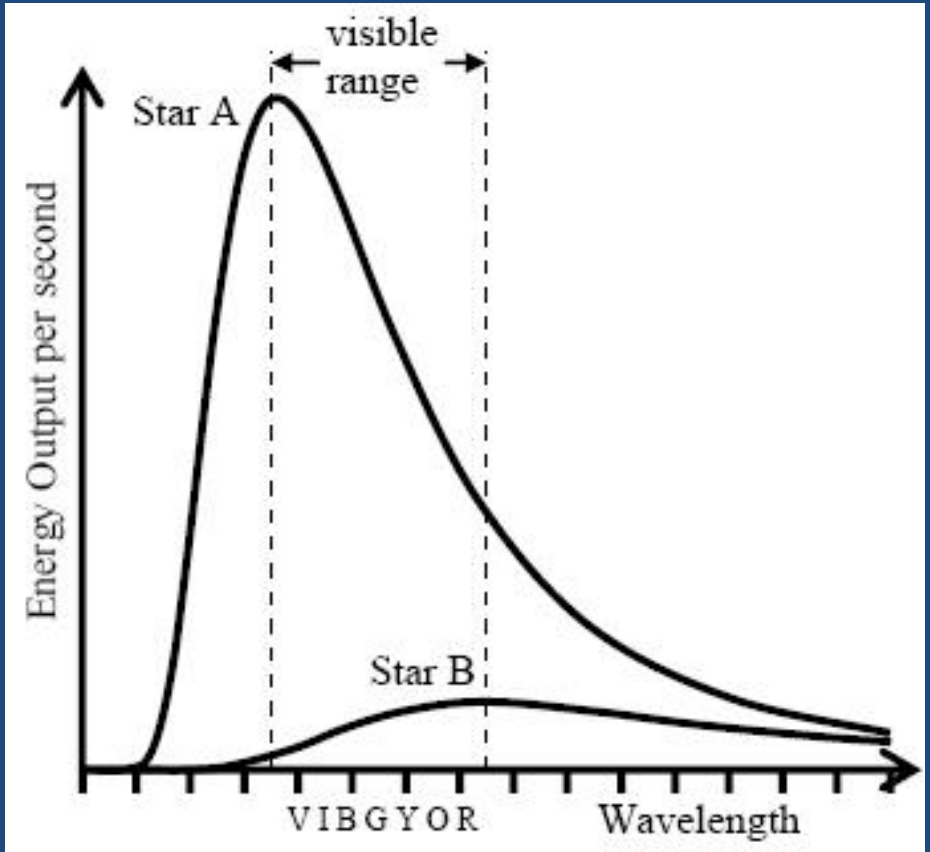
2. What can you say about the flux of these stars?

A. $F_1 < F_2$
B. $F_1 > F_2$
C. $F_1 = F_2$
D. Not enough information



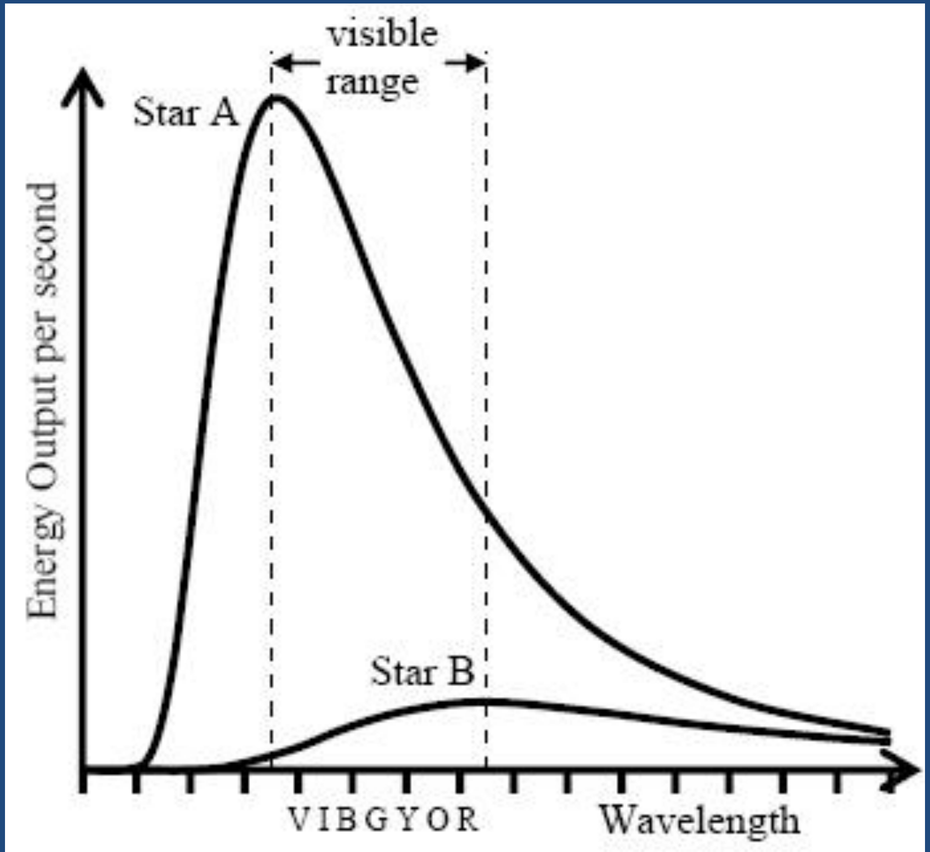
3. Which of the stars appears red to the eye?

A. Star A
B. Star B
C. Both stars appear red
D. Neither star appears red



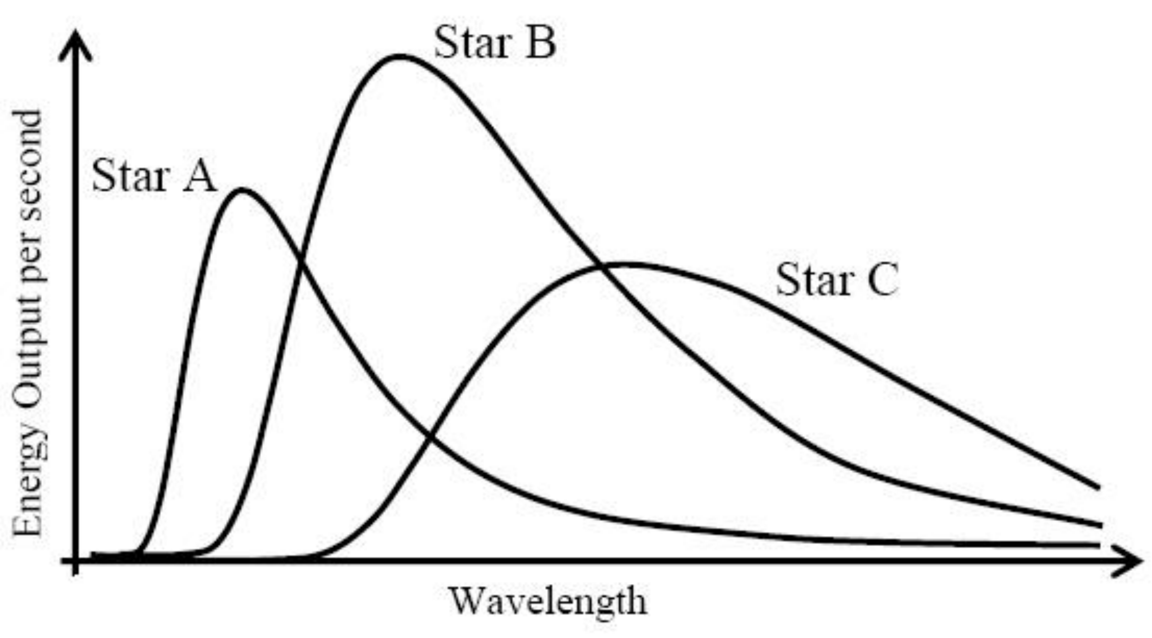
4. Which star gives off more (total) red light?

A. Star A
B. Star B.
C. The relative intensities cannot be determined from the information available.



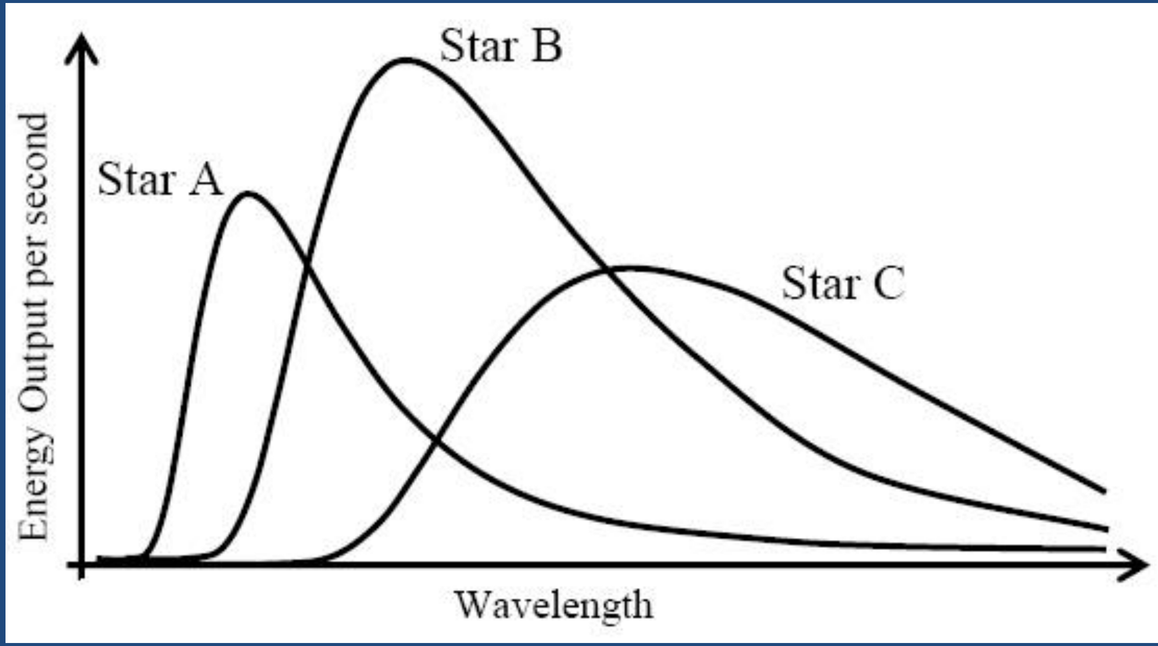
5. The graph at the right shows the blackbody spectra for three different stars. Which of the stars has the **highest temperature**?

A. Star A
B. Star B
C. Star C



6. The graph at the right shows the blackbody spectra for three different stars. Which of the stars has the **largest size**?

A. Star A
B. Star B
C. Star C



LT

- Luminosity, Temp, and Size
  - Skip part II
- Blackbody Radiation
  - p. 57 – 60