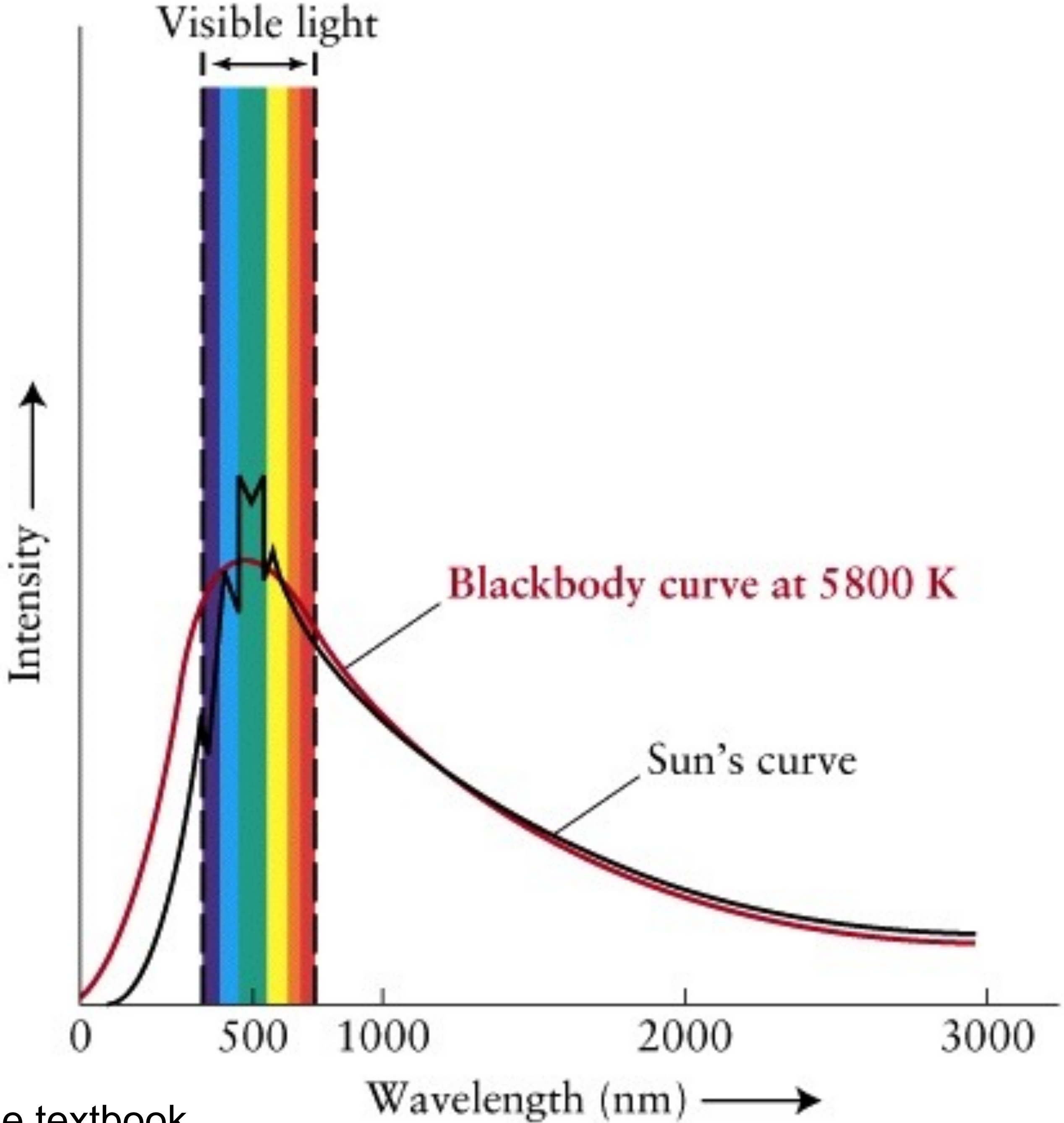
Blackbody Radiation

- Continuum spectrum
- Blackbody radiation
- Wien’s Displacement Law
- Luminosity
- Flux

The Sun's Continuum Spectrum

- The intensity of light from the Sun peaks at a wavelength λ=500nm
- Continuum spectrum is approximately that of a perfect blackbody with T=5800 K



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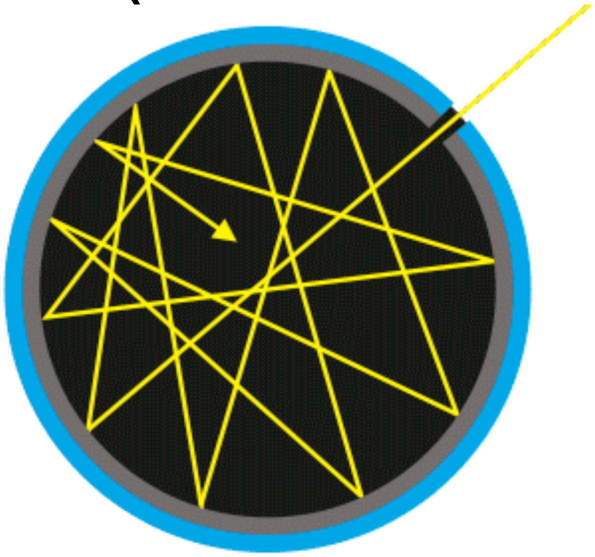
Blackbody Radiation

- A perfect absorber and emitter of radiation is called a blackbody
- Intensity of radiation is described by the Planck function (see handout)

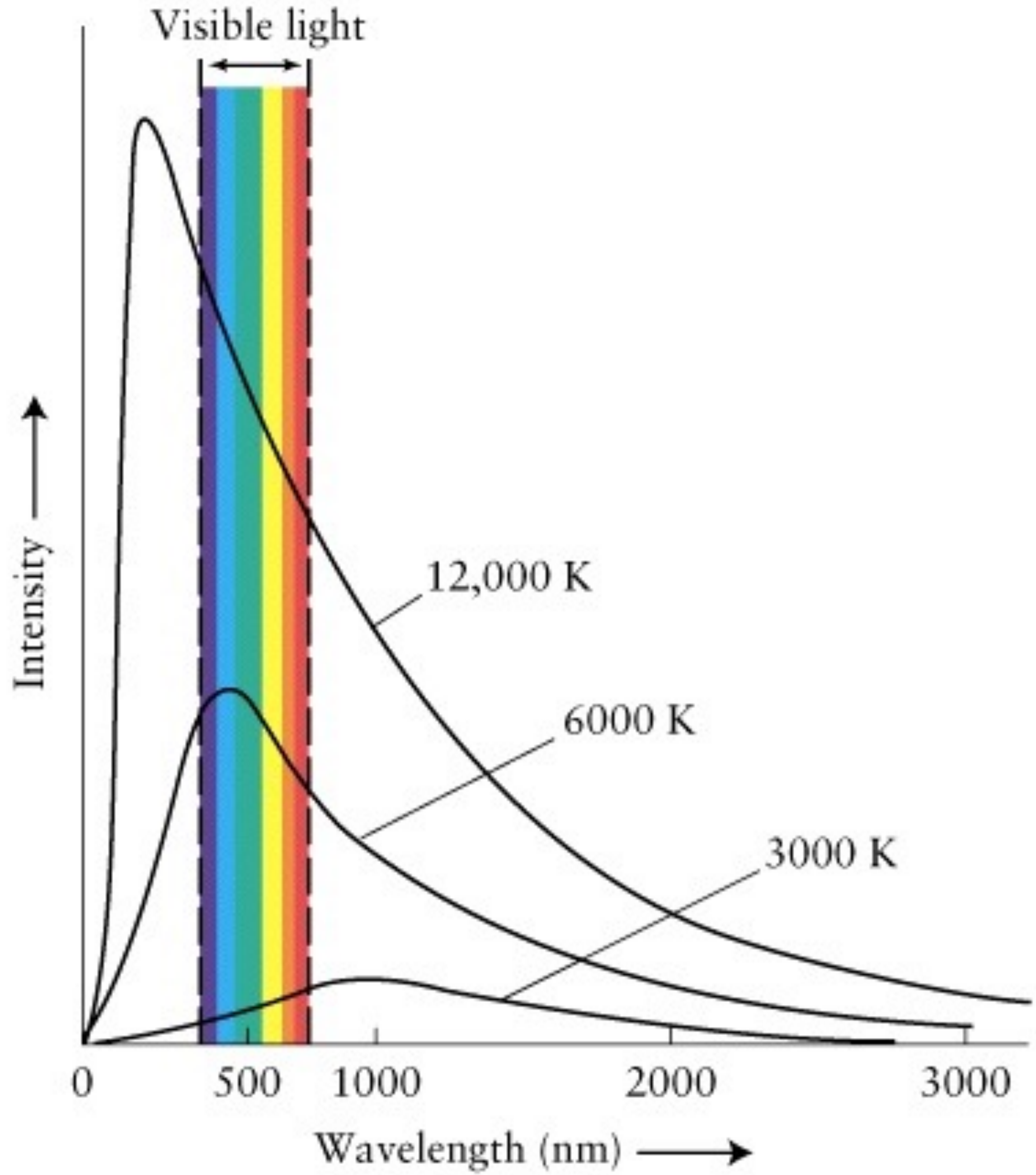


Conceptual Black Body

Wien Displacement Law

- The wavelength of the peak of the emission from a blackbody of temperature *T* is given by

$$\lambda_{max} = \frac{3\times10^{-3}}{T}$$



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Class Exercise

Calculate the wavelength of the peak of emission of the Sun with a surface temperature of 5 800 K.

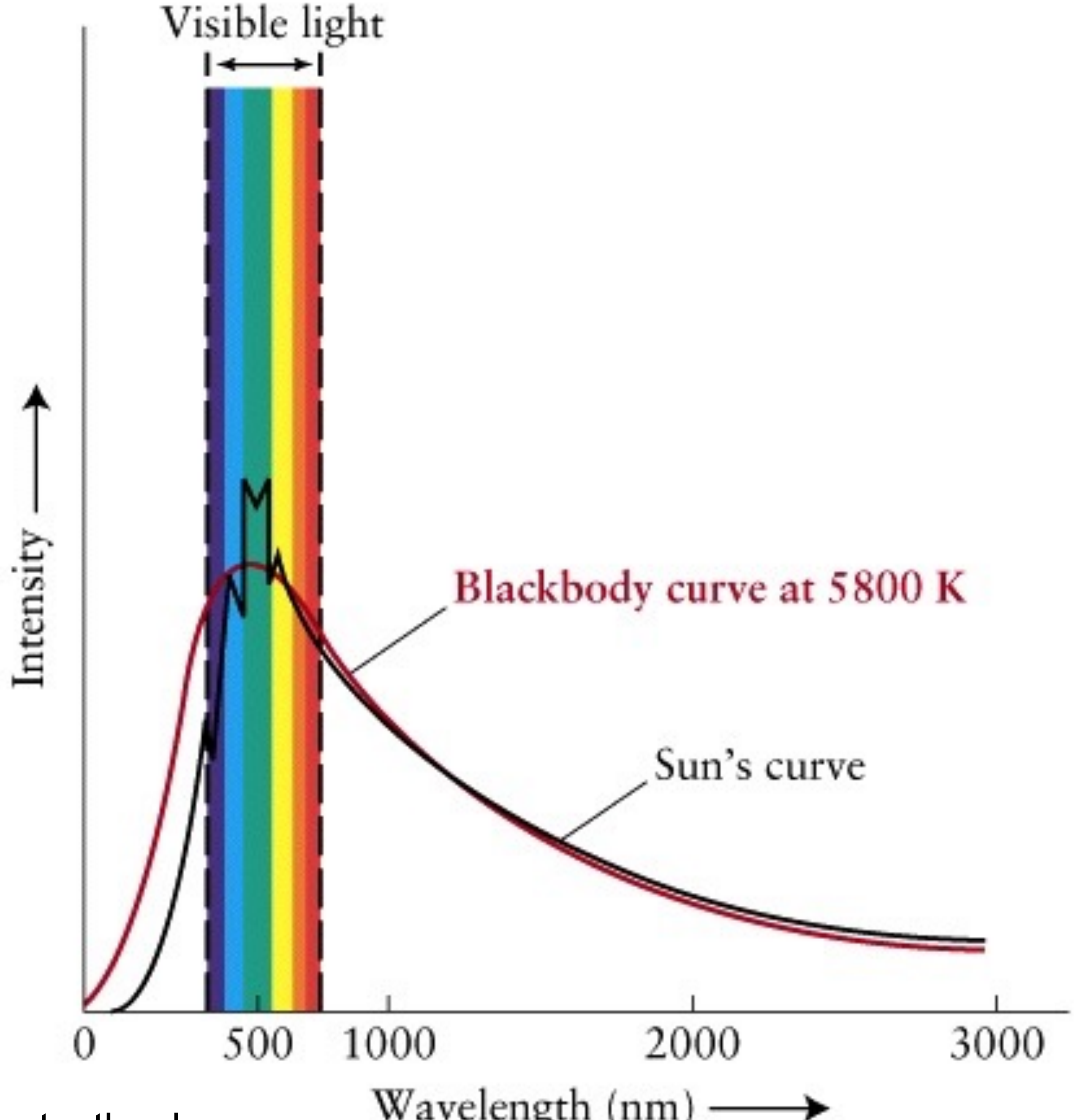
Class Exercise

$$\lambda_{max} = \frac{3\times10^{-3}}{T}$$

$$= \frac{3\times10^{-3}}{5800}$$

$$= 5.2\times10^{-7}\ \mathrm{m}$$

$$= 520\ \mathrm{nm}$$



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Luminosity of a Blackbody

- The total power in the radiation from a sphere of radius *R* emitting blackbody radiation with temperature *T* is

$$L = 4\pi R^2 \sigma T^4$$

  where σ is the Stefan-Boltzmann constant
- Used to define the effective temperature, T_{eff} of a star

Class Exercise

Calculate the effective temperature of the Sun given that it has a radius, $R=7 \times 10^8$ m and luminosity, $L=4 \times 10^{26}$ W

Class Exercise

$$L = 4\pi R^2 \sigma T_{eff}^4$$

$$T_{eff} = \left(\frac{L}{4\pi R^2 \sigma} \right)^{\frac{1}{4}}$$

$$= \left(\frac{4 \times 10^{26}}{4\pi (7 \times 10^8)^2 5.7 \times 10^{-8}} \right)$$

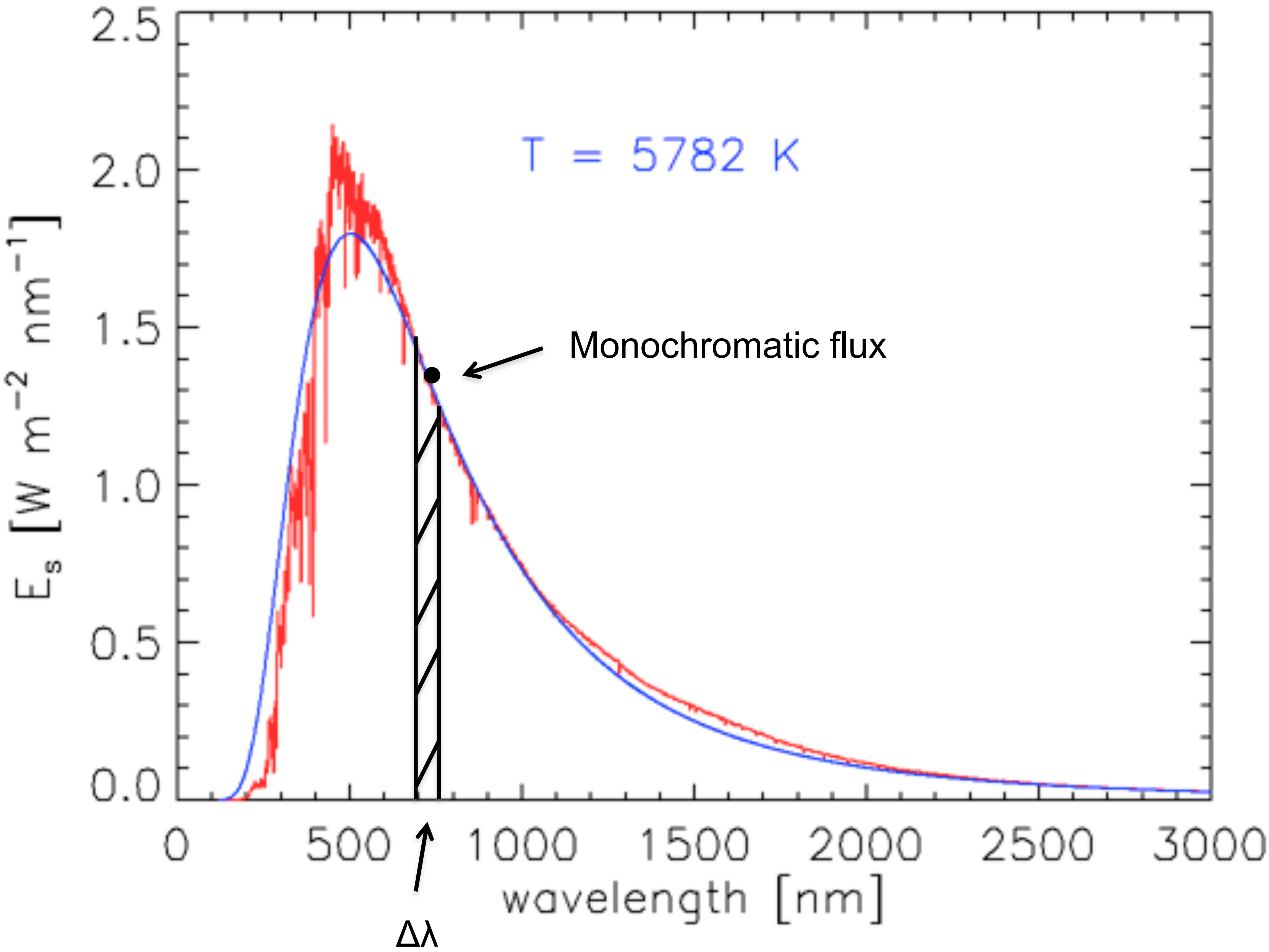
$$= 5\ 800\ \mathrm{K}$$

Luminosity and Flux

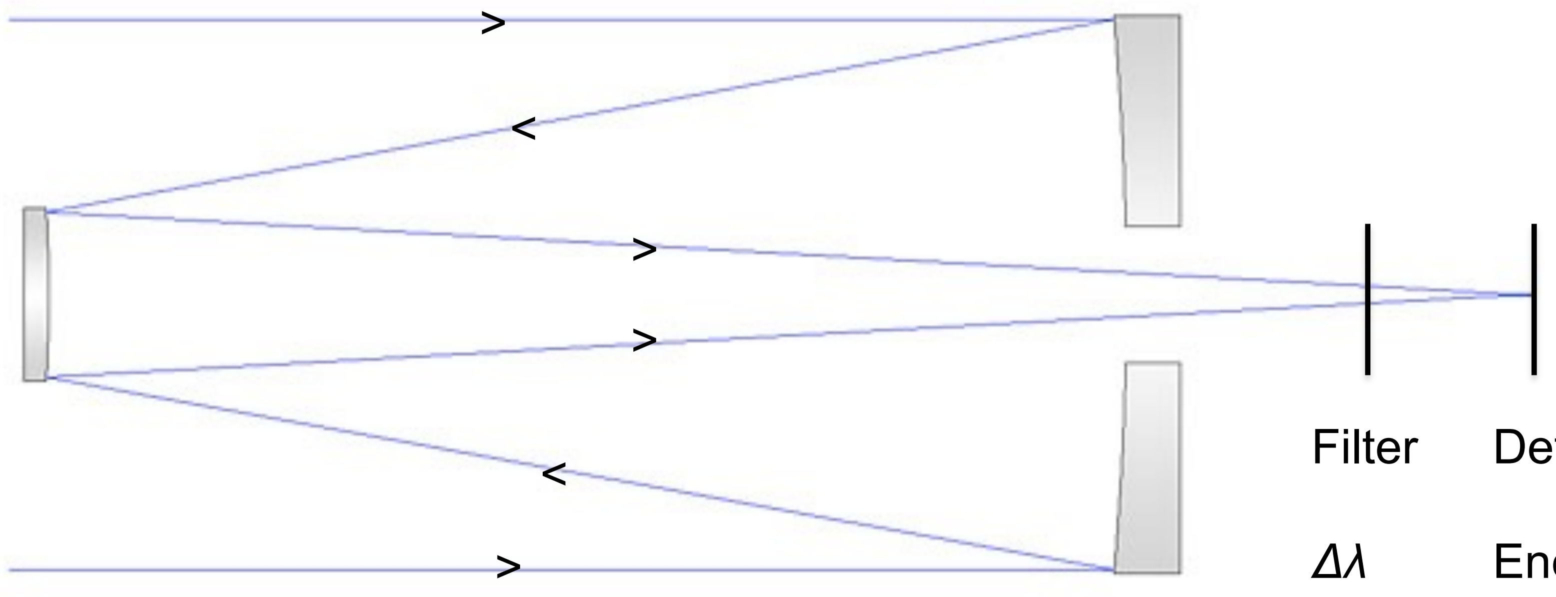
- We can also determine the luminosity of the Sun (or any star) by finding the total flux of radiation reaching Earth as long as we also know the distance
- When we observe the spectrum of a star we are measuring the flux of radiation as a function of wavelength

Monochromatic Flux

- monochromatic flux of radiation f_λ is defined as the amount of energy crossing a unit area per unit time per unit wavelength interval (Js^{-1}m^{-2}m^{-1} or e.g. Wm^{-2}nm^{-1})


T = 5782 K
Monochromatic flux
Δλ
E_s [W m^{-2} nm^{-1}]
wavelength [nm]
0
500
1000
1500
2000
2500
3000
0.0
0.5
1.0
1.5
2.0
2.5

Telescopes Measure Flux

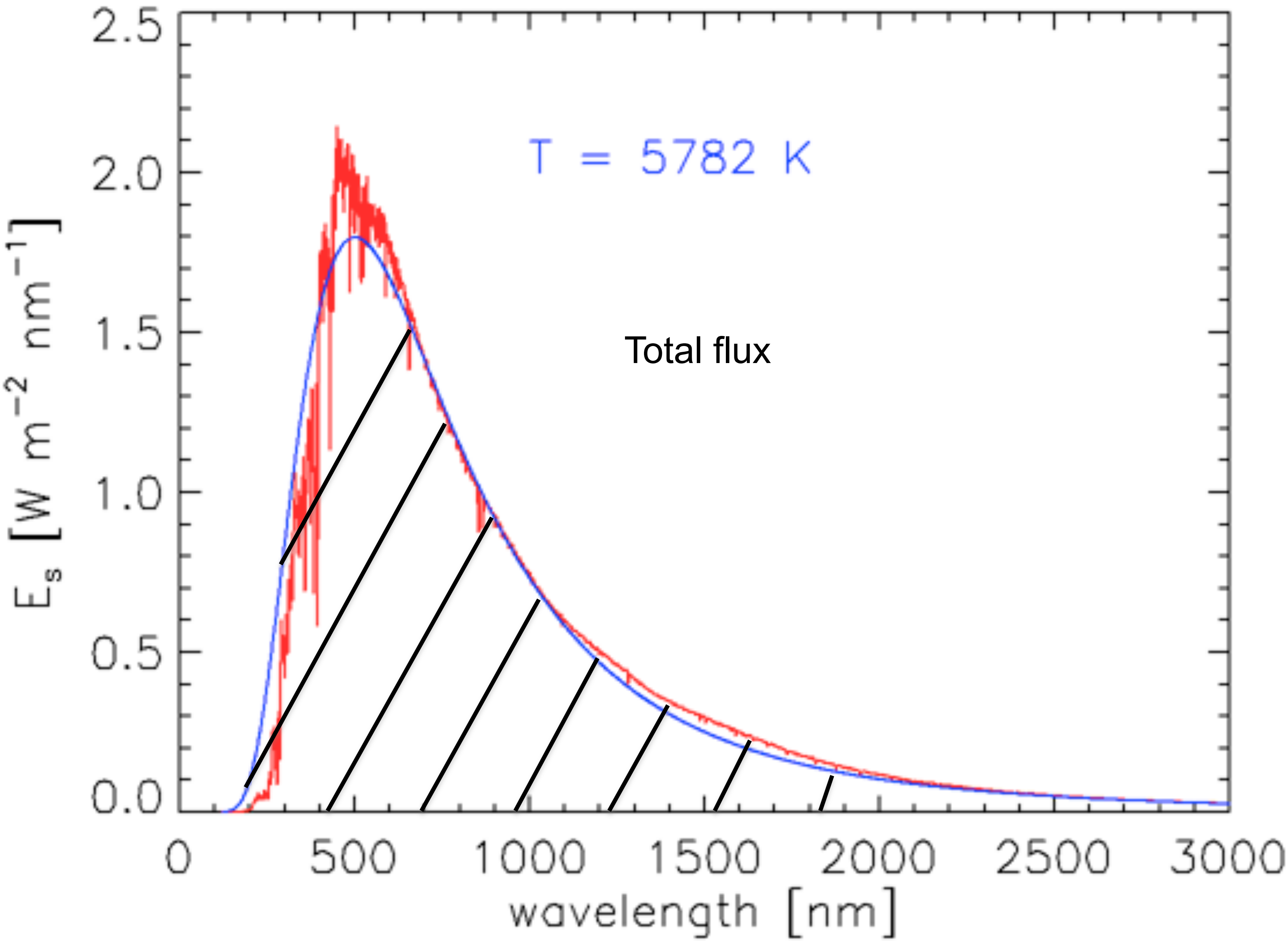


From starizona.com

Total Flux

- The flux of radiation, *f*, is defined as the amount of energy crossing a unit area per unit time ($Js^{-1}m^{-2}$ or Wm^{-2})
- It is the sum of the monochromatic fluxes over all wavelengths

$$f = \int_0^\infty f_\lambda d\lambda$$

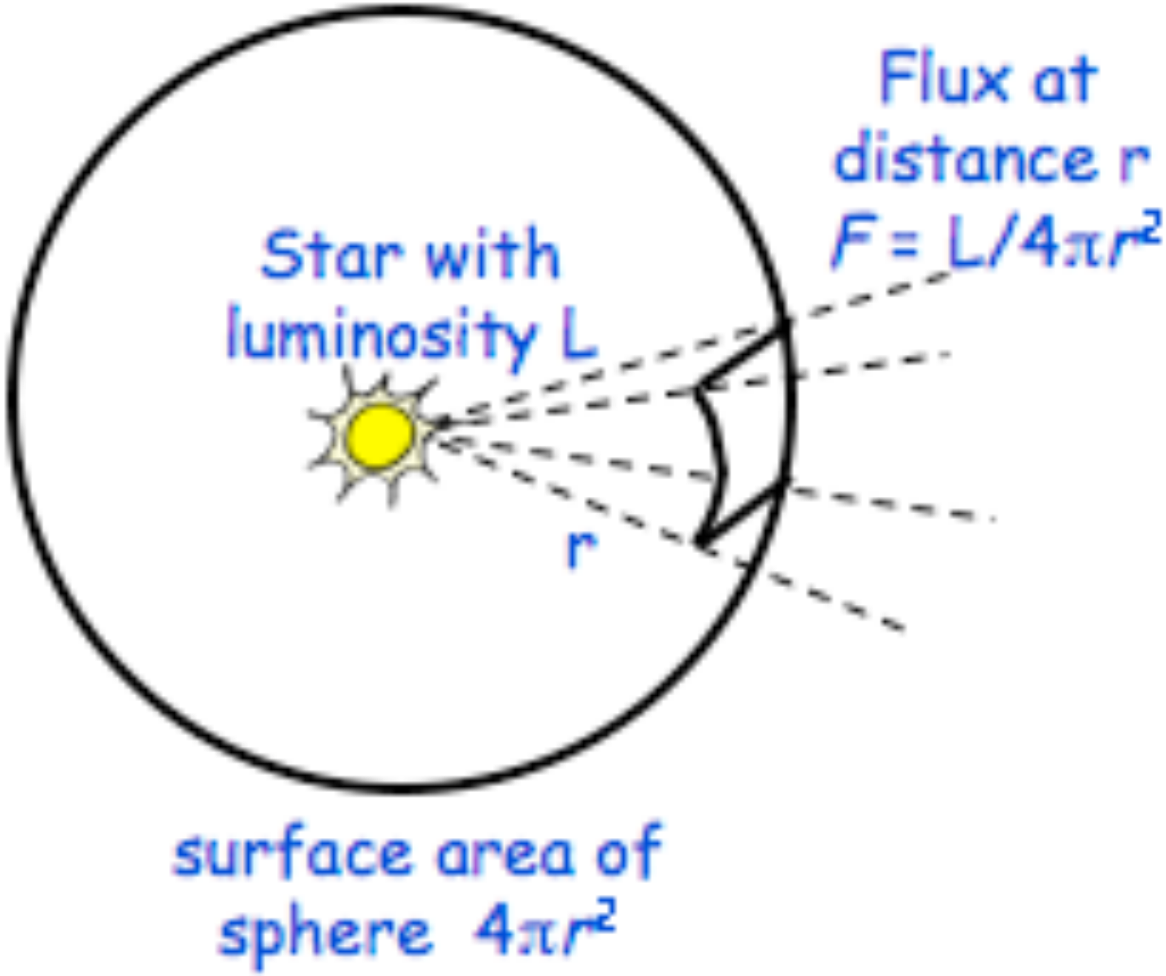

T = 5782 K
Total flux
E_s [W m^{-2} nm^{-1}]
2.5
2.0
1.5
1.0
0.5
0.0
0
500
1000
1500
2000
2500
3000
wavelength [nm]

- At a distance, *d*, from the Sun it is given by

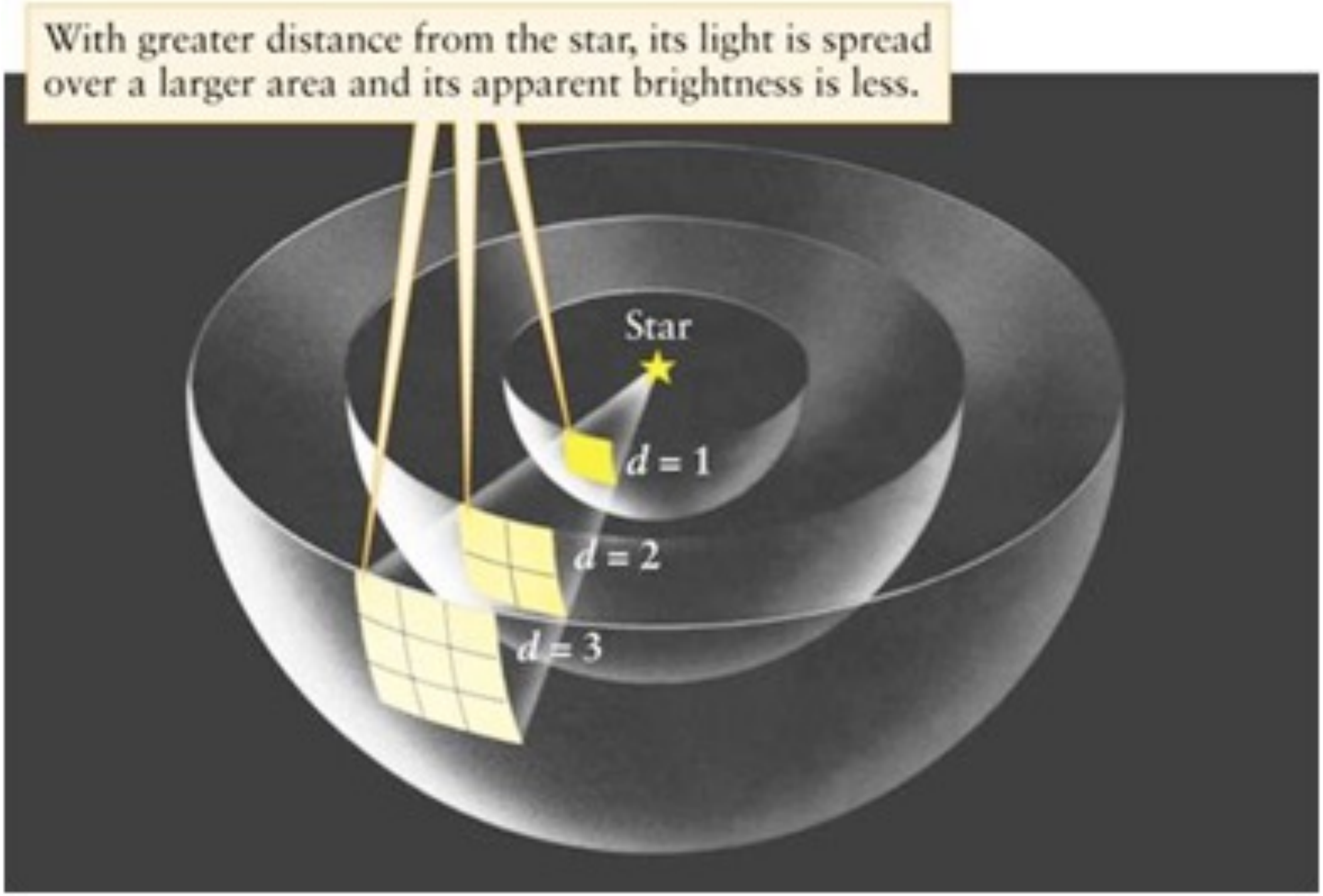
$$f = \frac{L}{4\pi d^2}$$

- Note that flux falls with the inverse square of the distance
- Hence, the luminosity can be found from

$$L = 4\pi d^2 f$$



From astronomy.swin.edu.au



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Which of these are examples of inverse square laws in physics?

Force due to electrostatic point charge

0%

Force due to tension in a spring

0%

Force due to gravity

0%

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Which of these are examples of inverse square laws in physics?

Force due to electrostatic point charge

##.##%

Force due to tension in a spring

##.##%

Force due to gravity

##.##%

Summary

- The Sun and stars radiate from their surfaces very much like a blackbody
- The effective temperature of a star can be found using Wien’s law
- The luminosity of a star can be found by measuring its flux and using the inverse square law