Stars

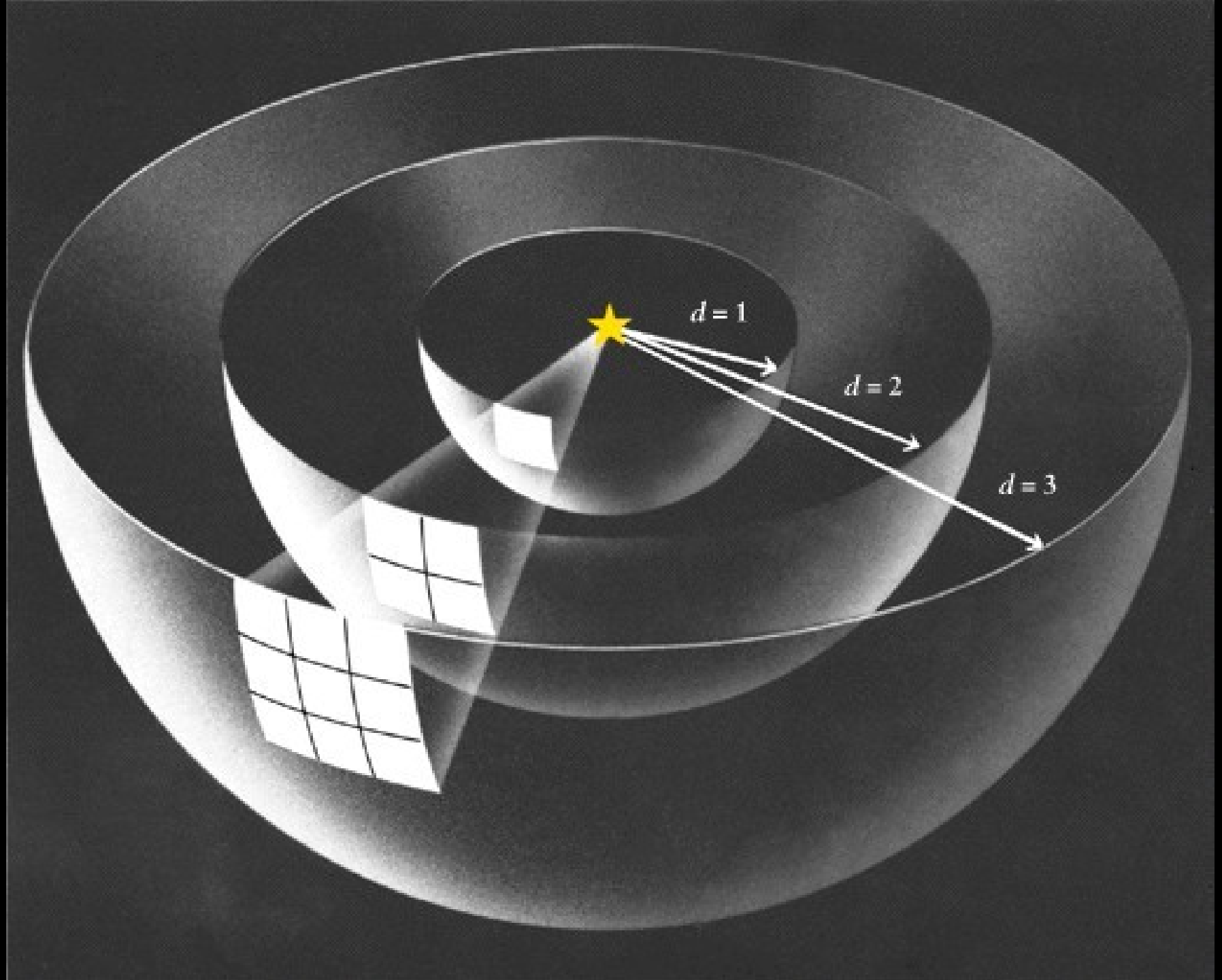
- Flux and luminosity
- Brightness of stars
- Spectrum of light
- Temperature and color/spectrum
- How the eye sees color

Which is of these part of the Sun is the coolest?

A) Core
B) Radiative zone
C) Convective zone
D) Photosphere
E) Chromosphere

Flux and luminosity

- **Luminosity** - A star produces light – the total amount of energy that a star puts out as light each second is called its Luminosity.
- **Flux** - If we have a light detector (eye, camera, telescope) we can measure the light produced by the star – the total amount of energy intercepted by the detector divided by the area of the detector is called the Flux.


d = 1
d = 2
d = 3

Flux and luminosity

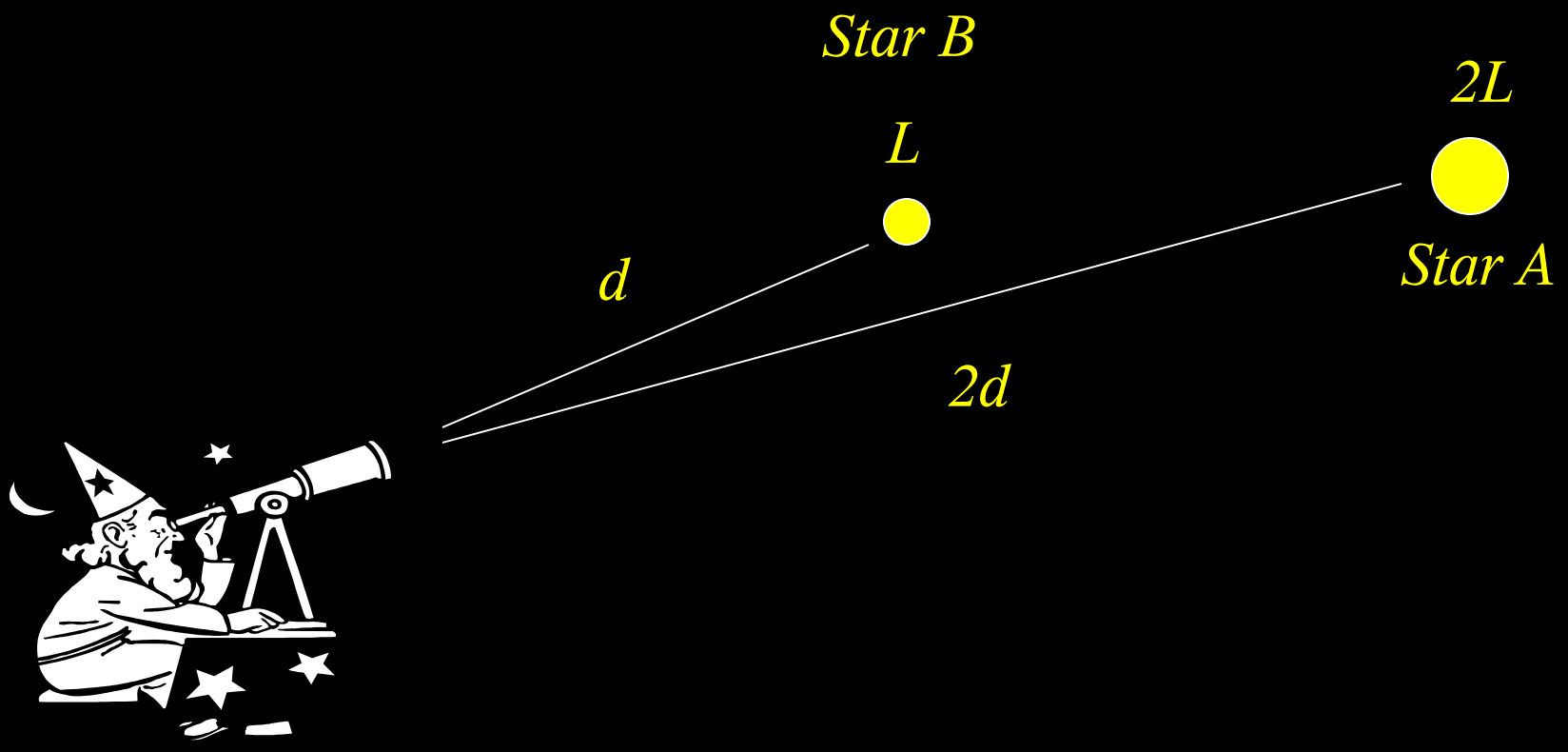
- To find the luminosity, we take a shell which completely encloses the star and measure all the light passing through the shell
- To find the flux, we take our detector at some particular distance from the star and measure the light passing only through the detector. How bright a star looks to us is determined by its flux, not its luminosity. Brightness = Flux.

Flux and luminosity

- Flux decreases as we get farther from the star – like 1/distance^2
- Mathematically, if we have two stars A and B

$$\frac{\text{Flux}_A}{\text{Flux}_B} = \frac{\text{Luminosity}_A}{\text{Luminosity}_B}\left(\frac{\text{Distance}_B}{\text{Distance}_A}\right)^2$$

Distance-Luminosity relation: Which star appears brighter to the observer?



Flux and luminosity

$$\frac{\text{Luminosity}_A}{\text{Luminosity}_B}=2 \qquad \frac{\text{Distance}_B}{\text{Distance}_A}=\frac{1}{2}$$

$$\frac{\text{Flux}_A}{\text{Flux}_B}=\frac{\text{Luminosity}_A}{\text{Luminosity}_B}\left(\frac{\text{Distance}_B}{\text{Distance}_A}\right)^2$$

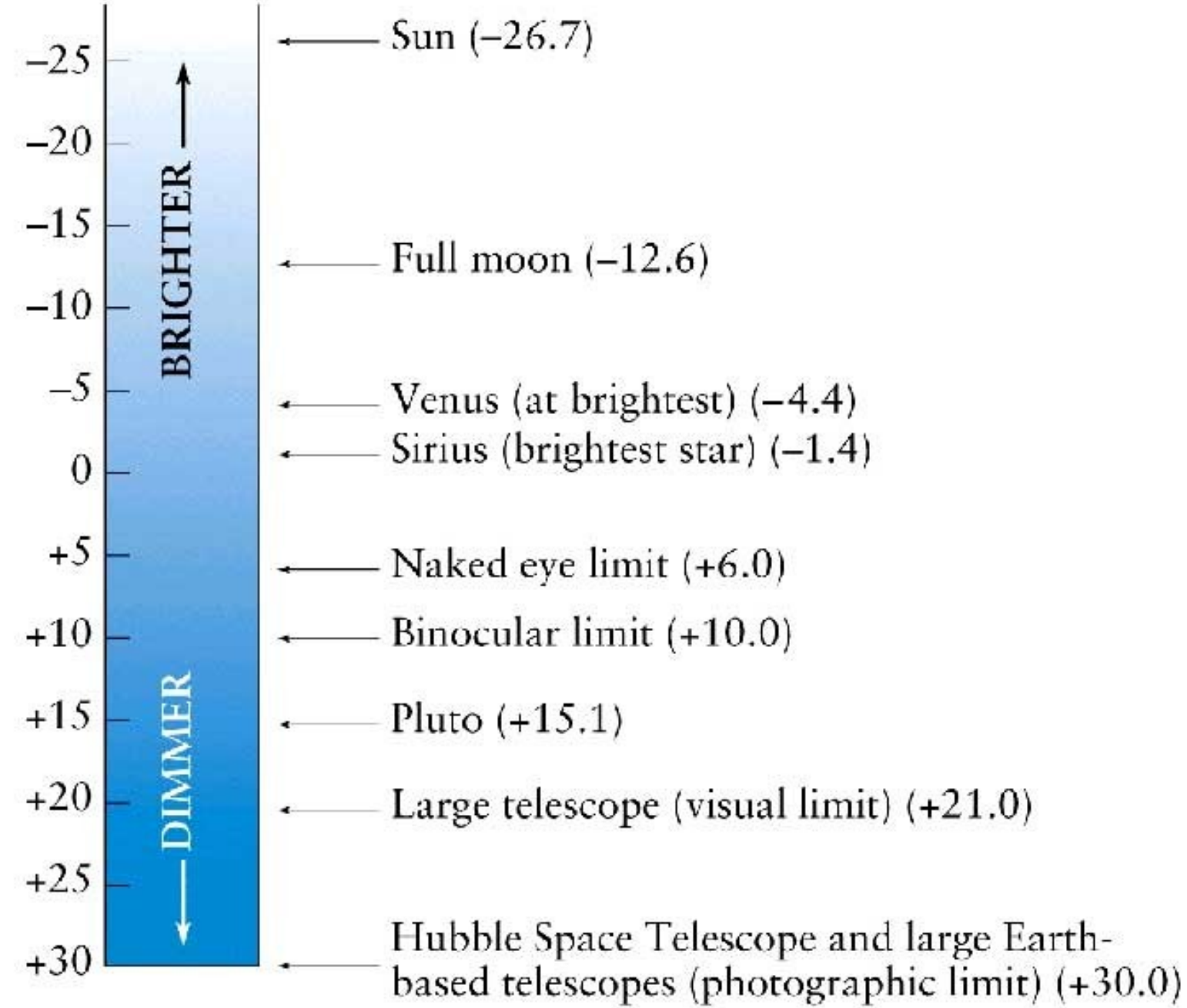
$$=2\left(\frac{1}{2}\right)^2=2\left(\frac{1}{4}\right)=\frac{1}{2} \qquad \text{Flux}_B=2\times\text{Flux}_A$$

Brightness of stars

- Ptolemy (150 A.D.) grouped stars into 6 `magnitude' groups according to how bright they looked to his eye.
- Herschel (1800s) first measured the brightness of stars quantitatively and matched his measurements onto Ptolemy's magnitude groups and assigned a number for the magnitude of each star.

Brightness of stars

- In Herschel's system, if a star is 1/100 as bright as another then the dimmer star has a magnitude 5 higher than the brighter one.
- Note that dimmer objects have higher magnitudes


−25
−20
−15
−10
−5
0
+5
+10
+15
+20
+25
+30
BRIGHTER
DIMMER
Sun (−26.7)
Full moon (−12.6)
Venus (at brightest) (−4.4)
Sirius (brightest star) (−1.4)
Naked eye limit (+6.0)
Binocular limit (+10.0)
Pluto (+15.1)
Large telescope (visual limit) (+21.0)
Hubble Space Telescope and large Earth-based telescopes (photographic limit) (+30.0)

a

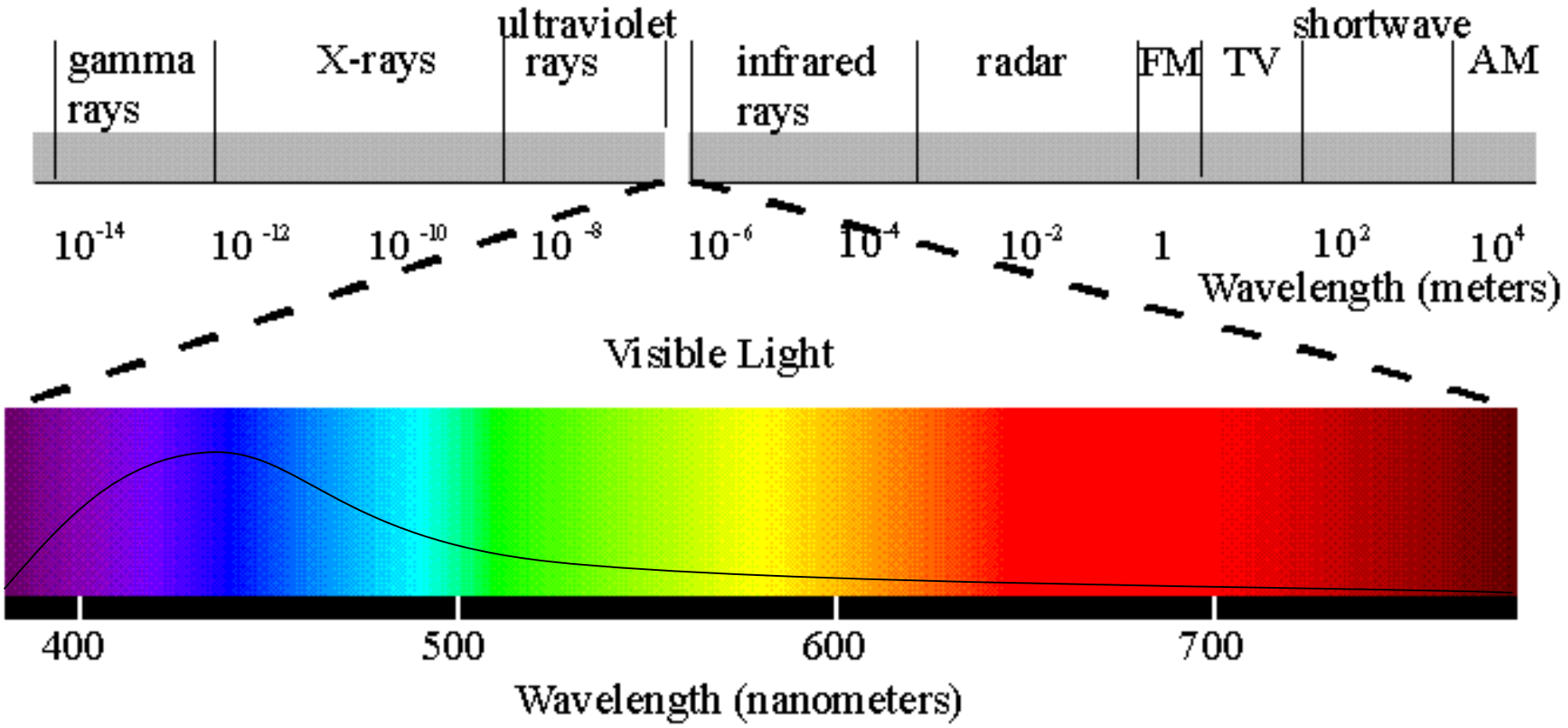
Absolute magnitude

- The magnitude of a star gives it brightness or flux when observed from Earth.
- To talk about the properties of star, independent of how far they happen to be from Earth, we use “absolute magnitude”.
- Absolute magnitude is the magnitude that a star would have viewed from a distance of 10 parsecs.
- Absolute magnitude is directly related to the luminosity of the star.

Which star would appear brightest?

A) Star A - 10 pc away, 1 solar luminosity
B) Star B - 30 pc away, 3 solar luminosities
C) Star C - 5 pc away, 0.5 solar luminosities
D) Charlize Theron

Electromagnetic spectrum



The "spectrum" of a particular star is how much light it produces at each wavelength.

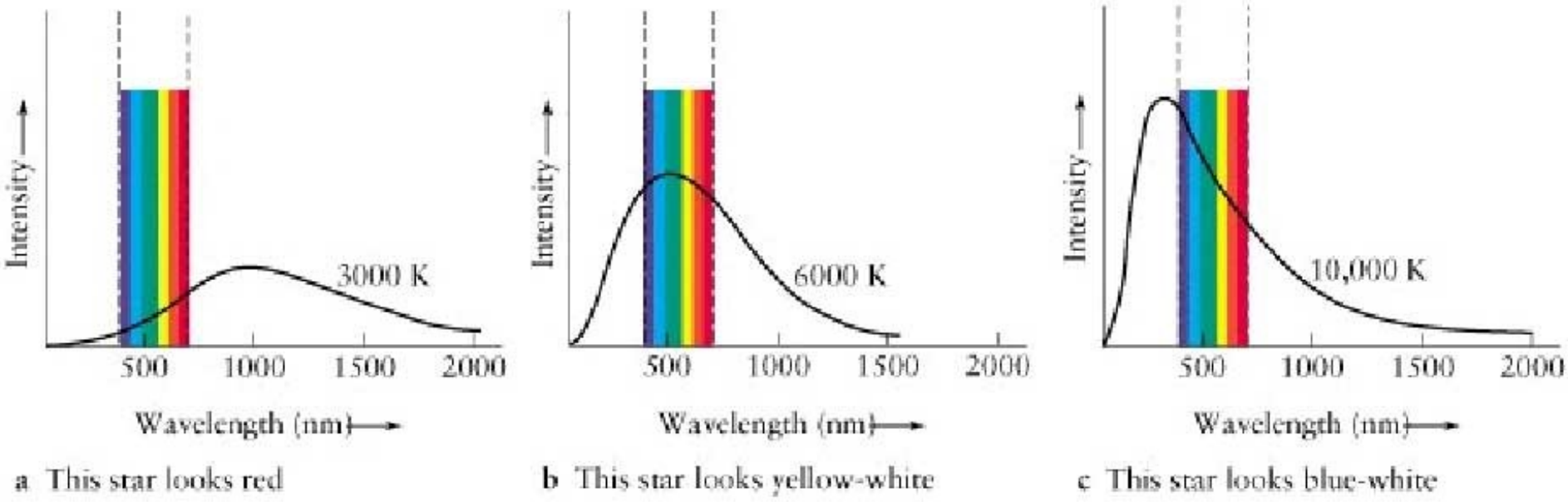
What can we learn from a star's color?

- The color indicates the temperature of the surface of the star.
- The same is true for the filament in a light bulb or any other hot object. In general, we call radiation from a hot body `black body' radiation (do demonstration 6B40.10).

Wien's law

- Cooler objects produce radiation which peaks at longer wavelengths (redder colors), hotter objects produce radiation which peaks at shorter wavelengths (bluer colors).

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

Spectrum demonstration 6B40.55

Hotter objects produce radiation which is

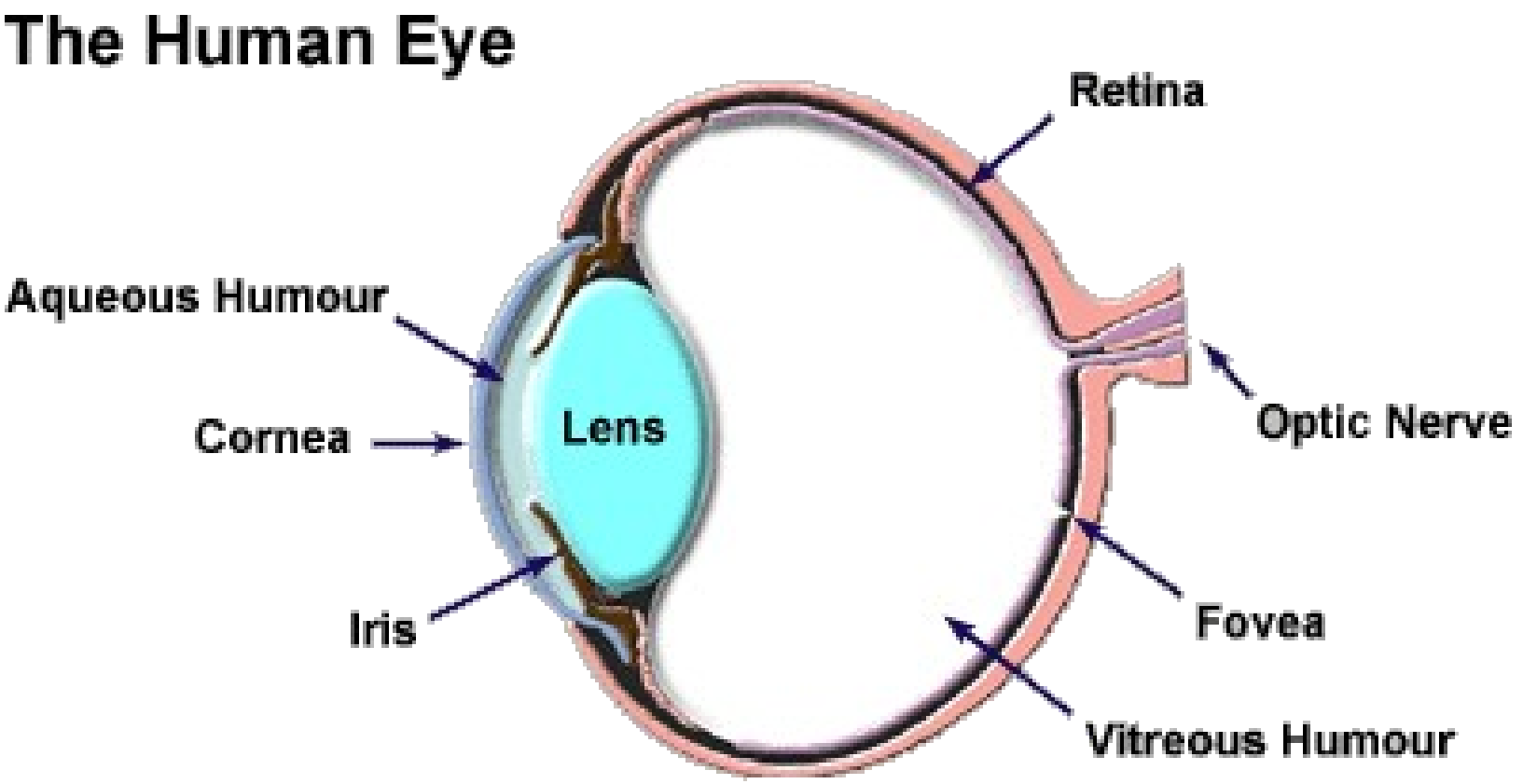
A) peaked at shorter wavelengths than cooler objects

B) brighter than cooler objects

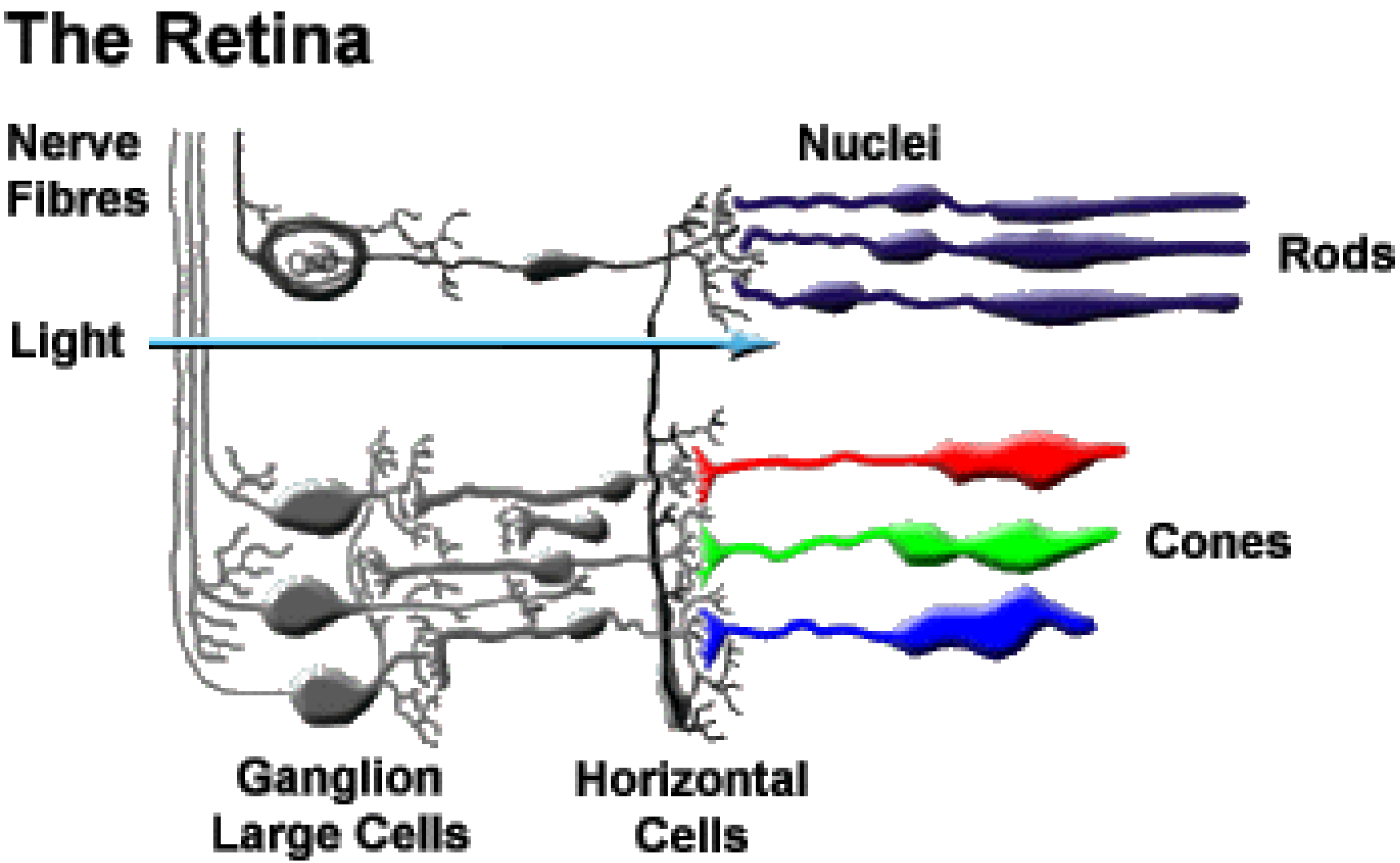
C) peaked at longer wavelengths than cooler objects

D) dimmer than cooler objects

How your eye sees light and color



Rods and cones on the retina sense light

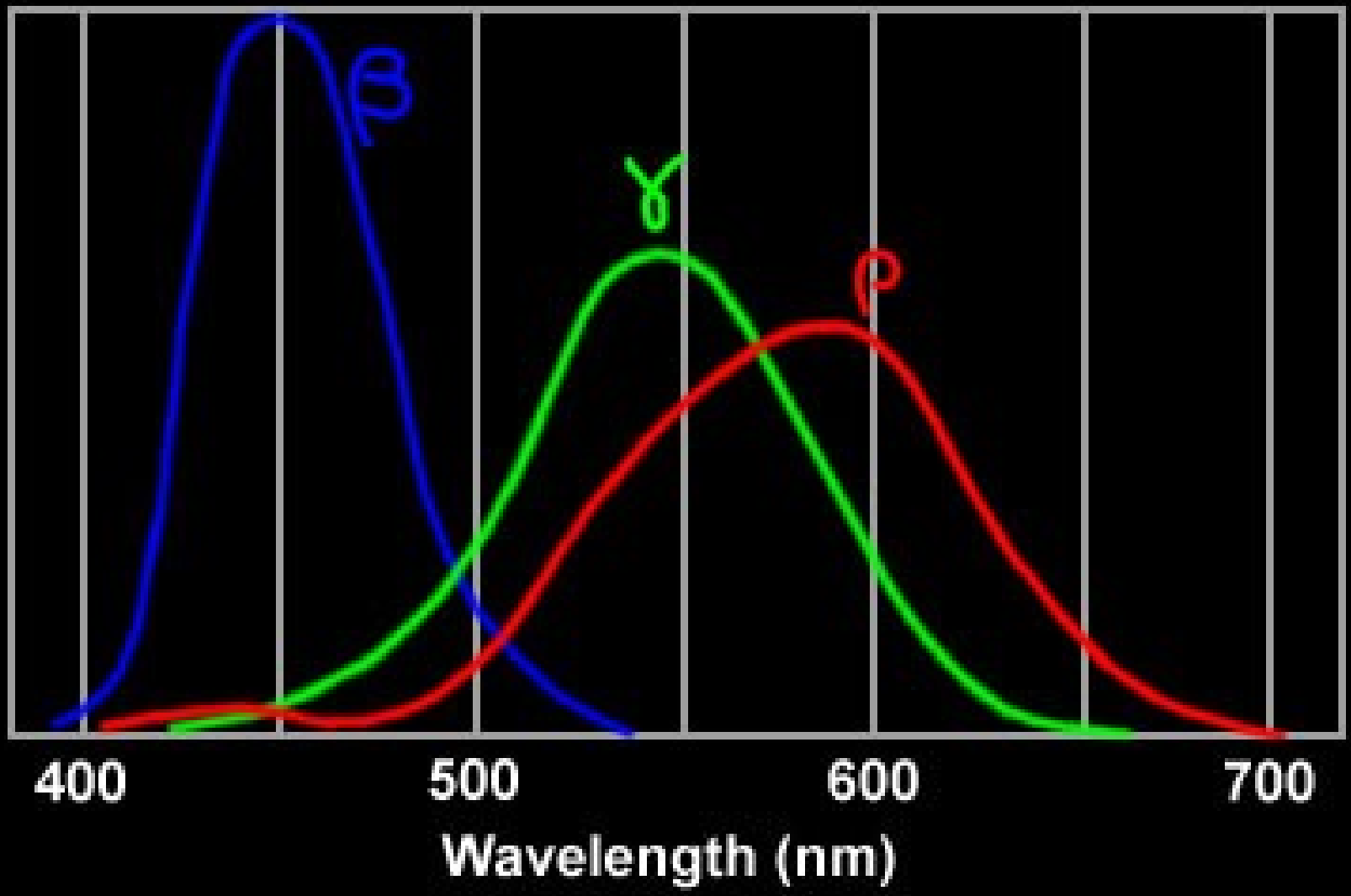


Rods and cones

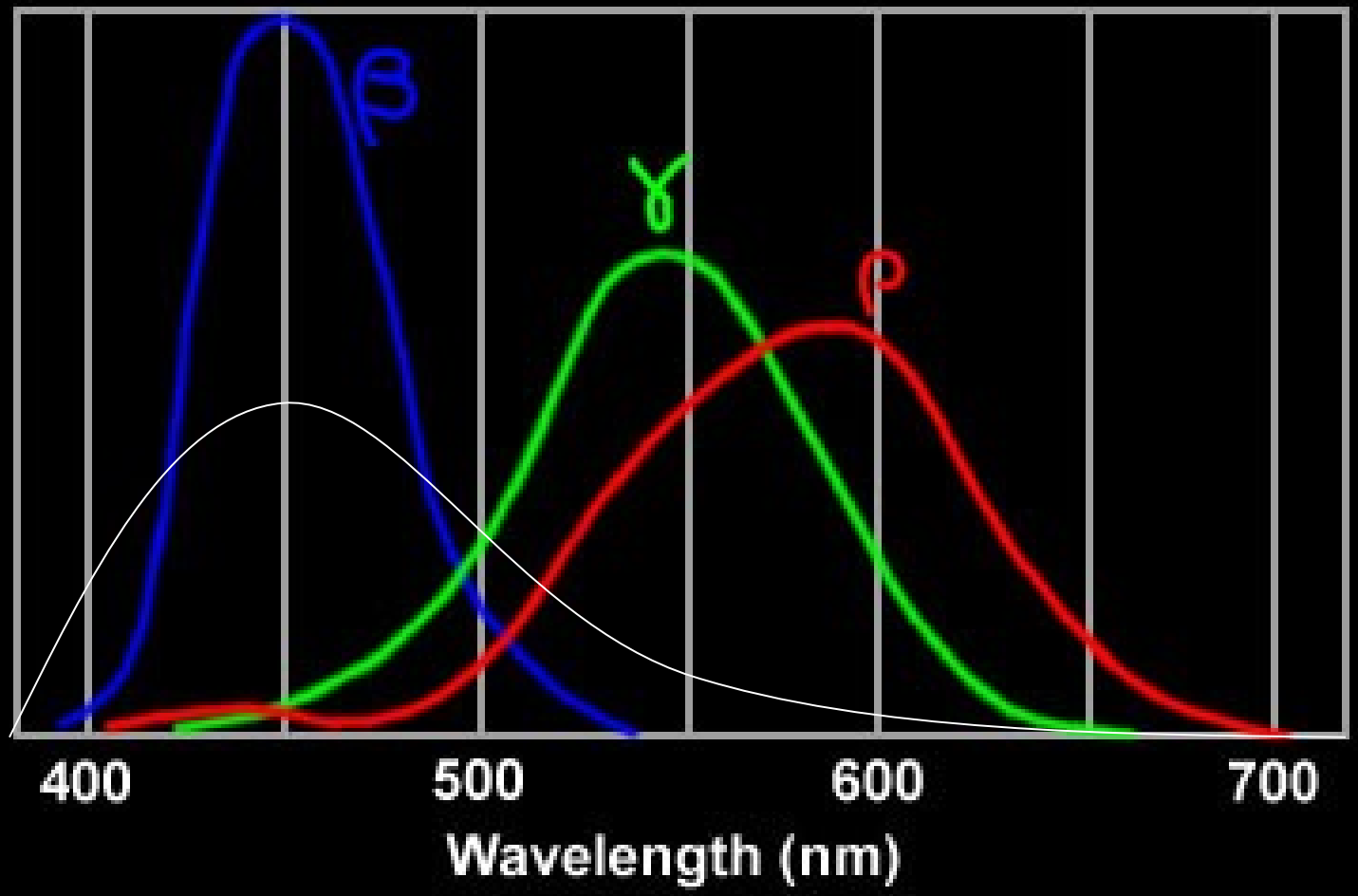
- Cones are color sensors
- There are cones for red, green, and blue
- The color ones perceives depends on the firing rates of the red vs. green vs. blue cones
- Cones need relatively bright light to work

- Rods give finer, more detailed vision
- Rods can work with less light
- At night, color vision is less effective because only the rods function

Sensitivity of cones



A star will produce light overlapping the response of all three cones. The color of the star depends on how strong its spectrum is in the ranges covered by the different cones.



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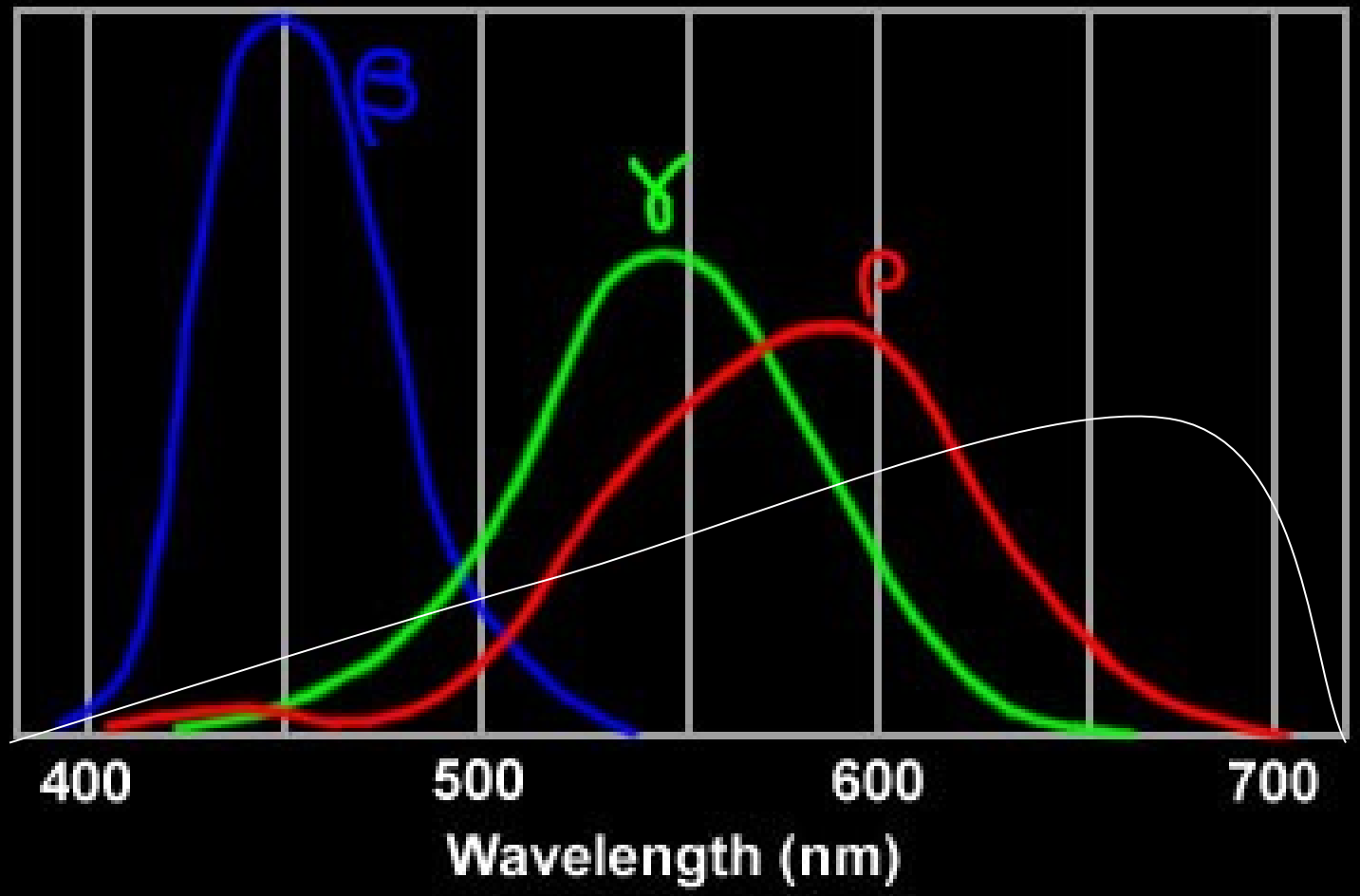

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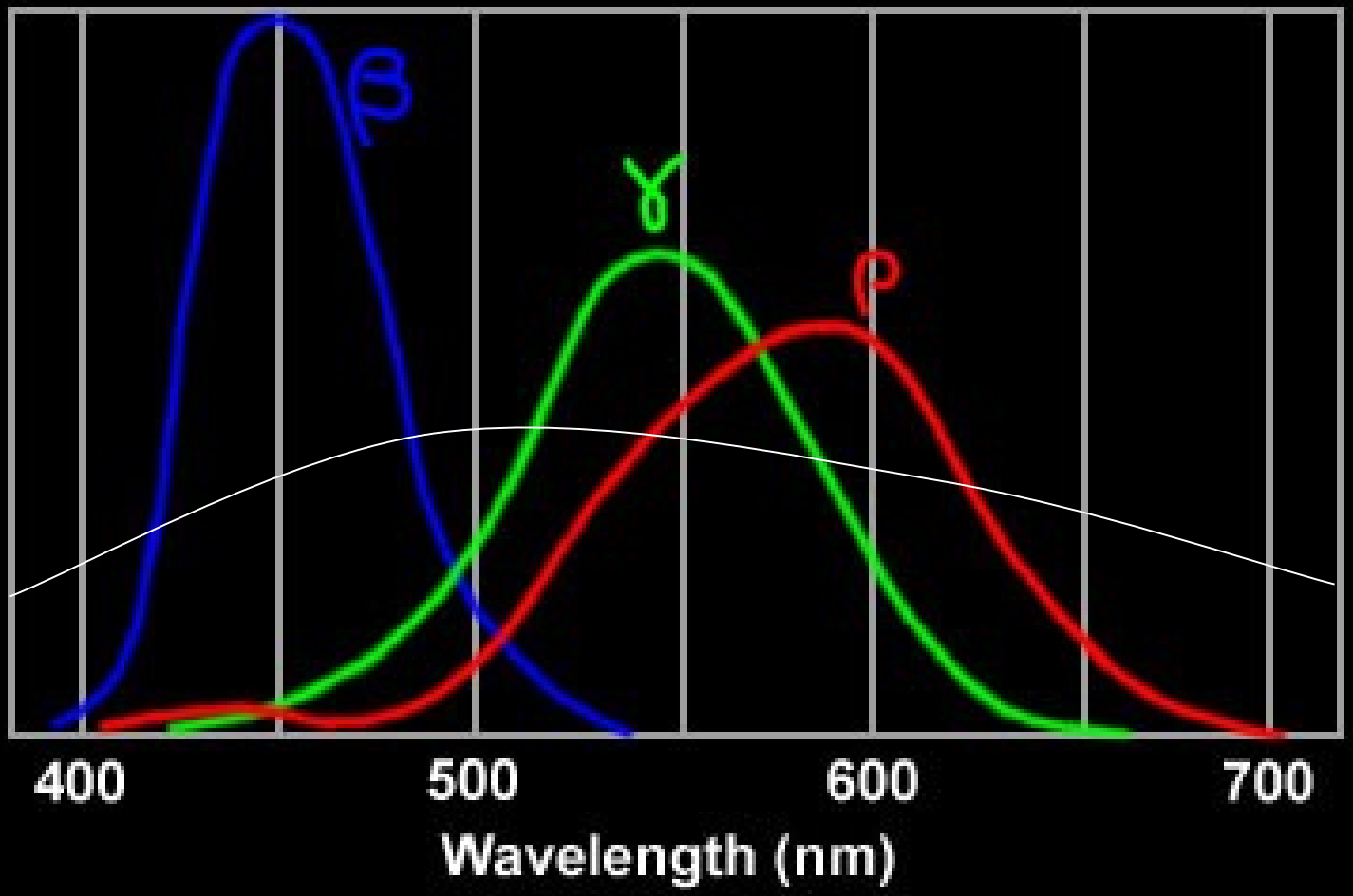

Review Questions

- What are flux, luminosity, and their relation?
- Is the magnitude of a star determined by its flux or luminosity? How about the absolute magnitude?
- How is the color of star related to its temperature?
- How does your eye see color?