Week 10

Binary Stars, Star Mass and Type IA Supernovae

November 21

Learning objectives:

- Describe the methods used to derive the mass of stars.
- Explain the difference between Type IA and Type II supernovae.
- Describe what causes a Type IA supernovae.
- Explain how astronomers use brightness to figure out distances to stars and star clusters.

So, we find that stars evolve over time according to how massive they are!

How do we figure out the mass of a star???

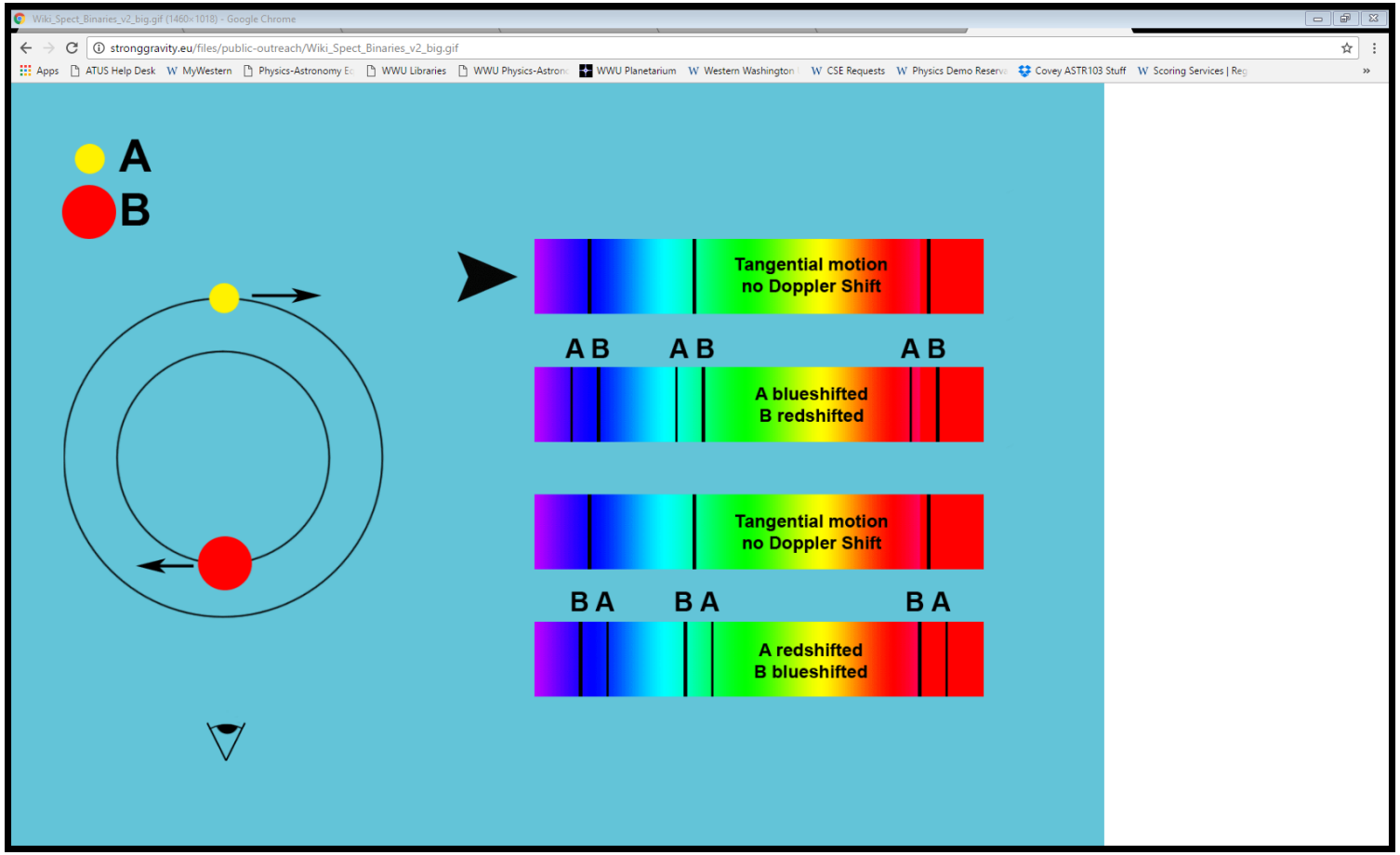
So, we find that stars evolve over time according to how massive they are!

How do we figure out the mass of a star???

- **By observing how their gravity affects other objects!**

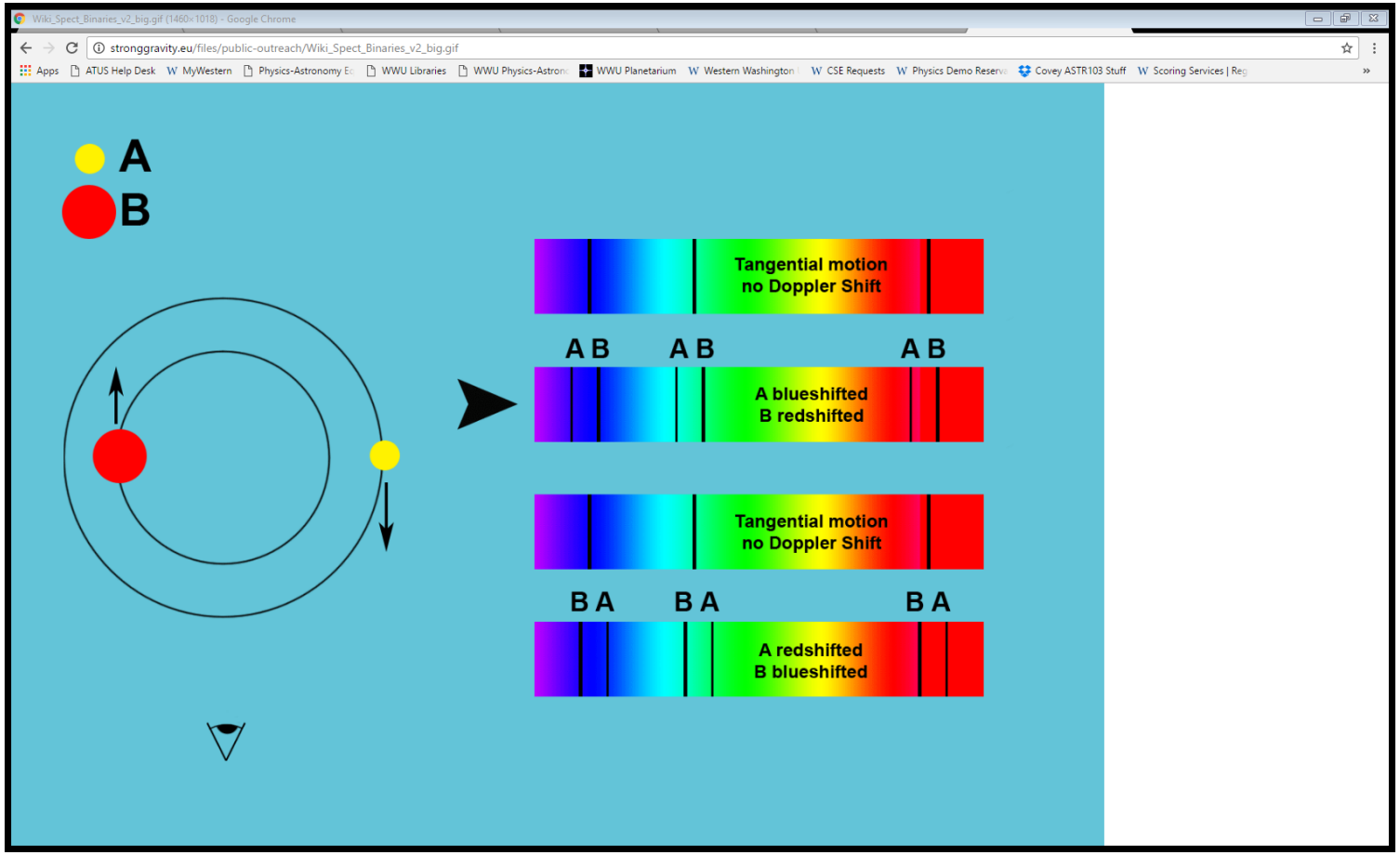
Binary stars

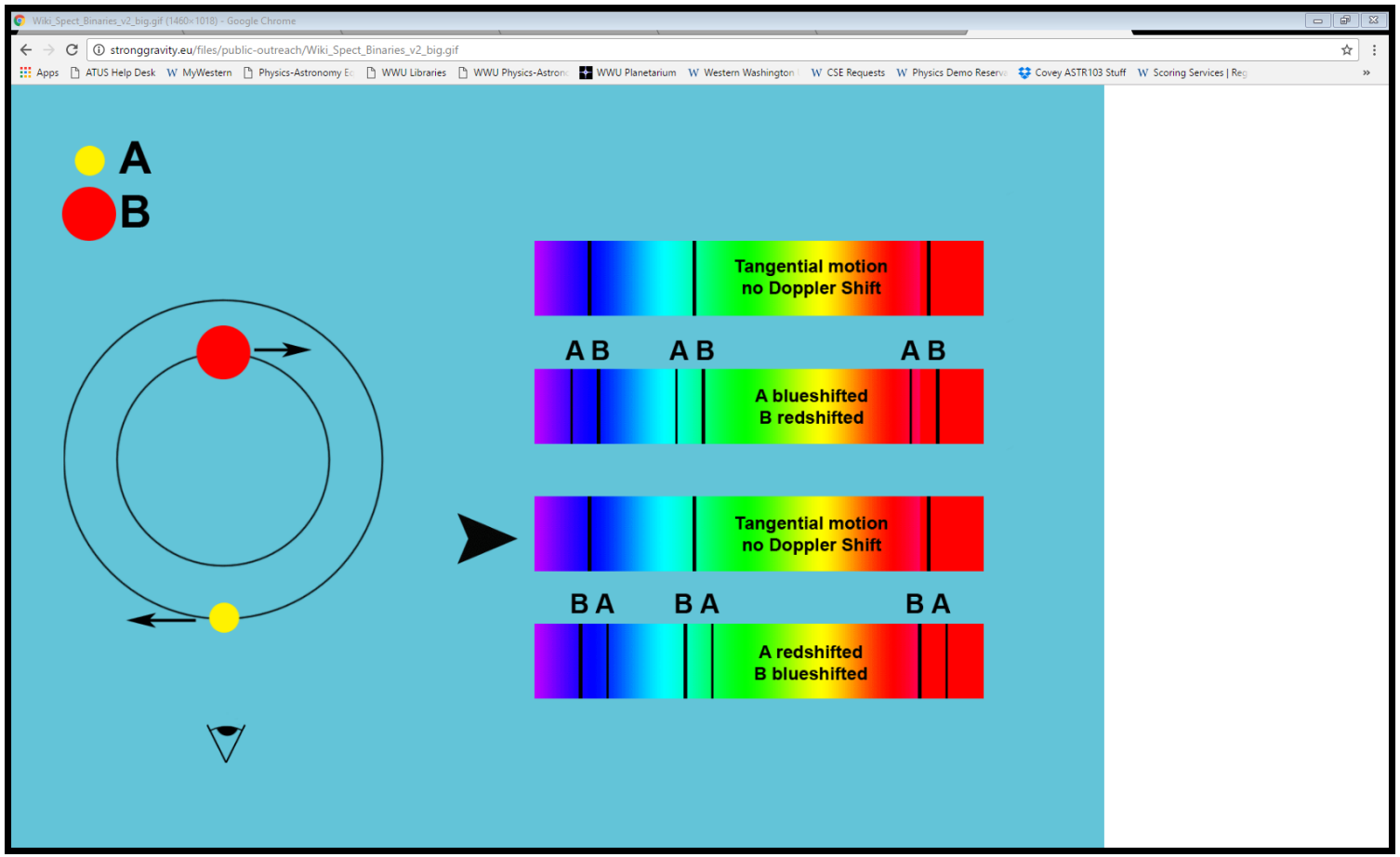
Use Doppler shift to determine how stars orbit each other

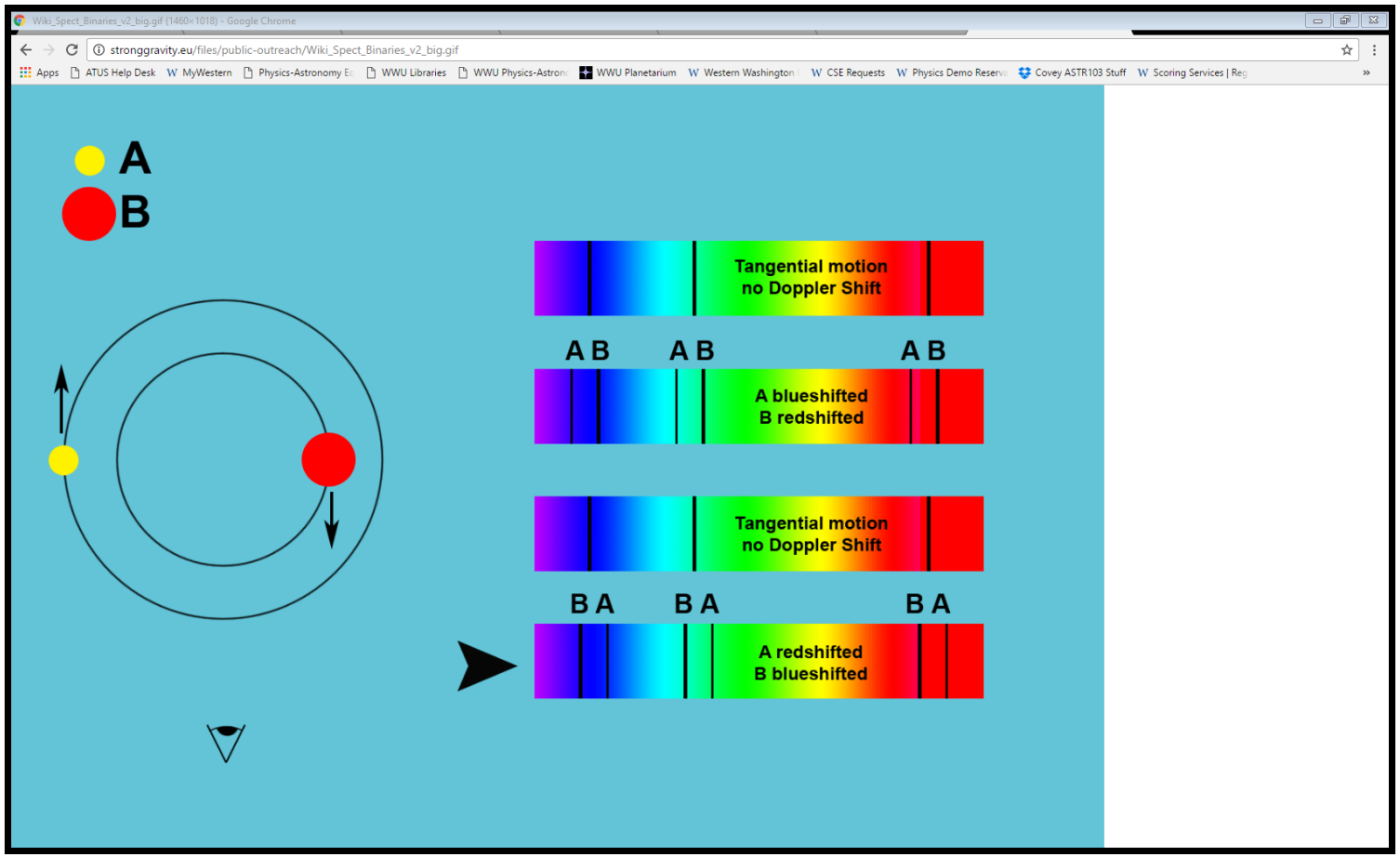


Checkout the animation:

http://stronggravity.eu/files/public-outreach/Wiki_Spect_Binaries_v2_big.gif




Wiki_Spect_Binaries_v2_big.gif (1460×1018) - Google Chrome
stronggravity.eu/files/public-outreach/Wiki_Spect_Binaries_v2_big.gif
A
B
Tangential motion
no Doppler Shift
A B
A B
A B
A blueshifted
B redshifted
Tangential motion
no Doppler Shift
B A
B A
B A
A redshifted
B blueshifted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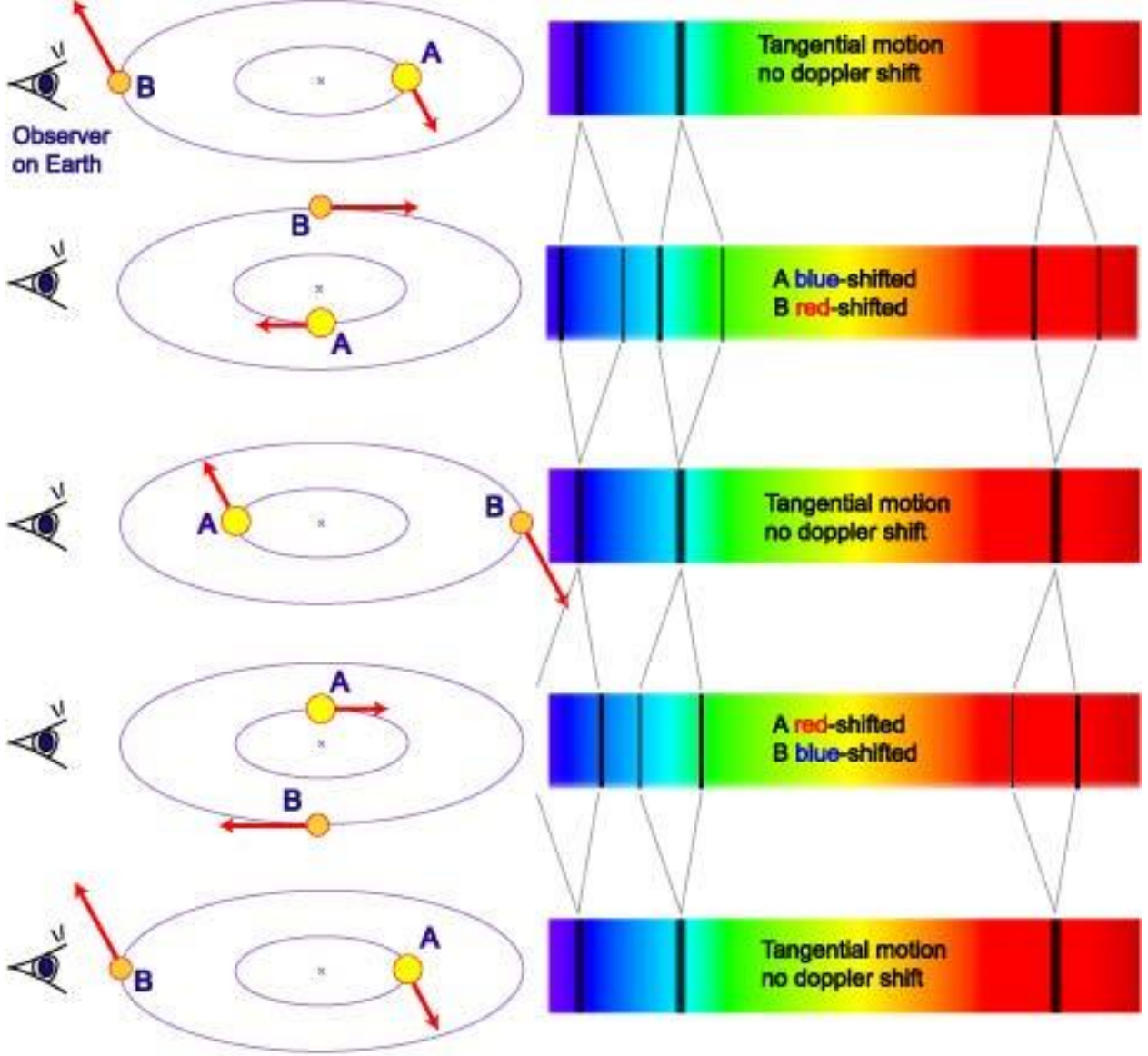
Tangential motion
no Doppler Shift
B A
B A
B A
A redshifted
B blueshifted

- Binary stars have a common center
- Mass seen in the behavior of stars moving around the center of mass

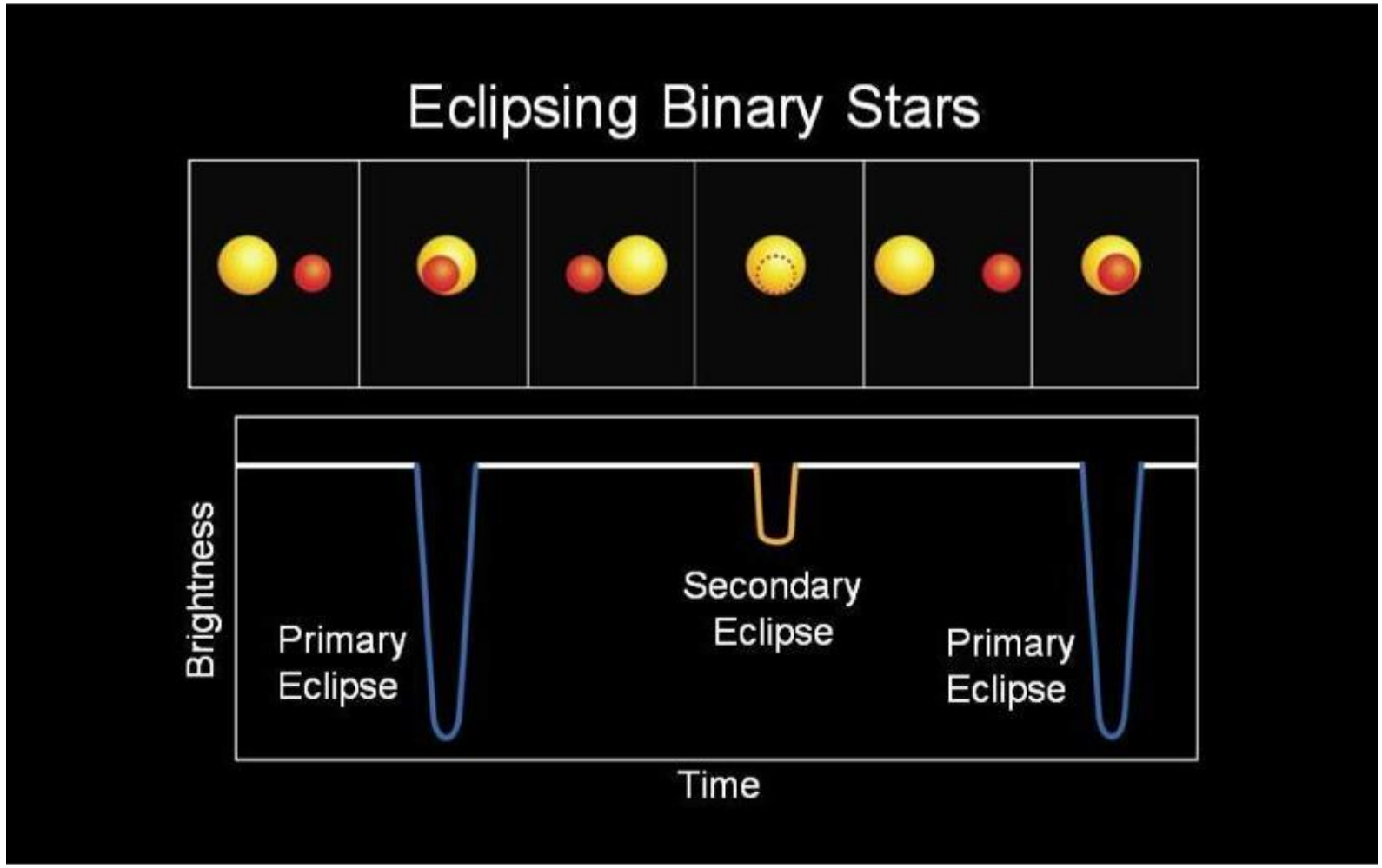


A Spectroscopic Binary System

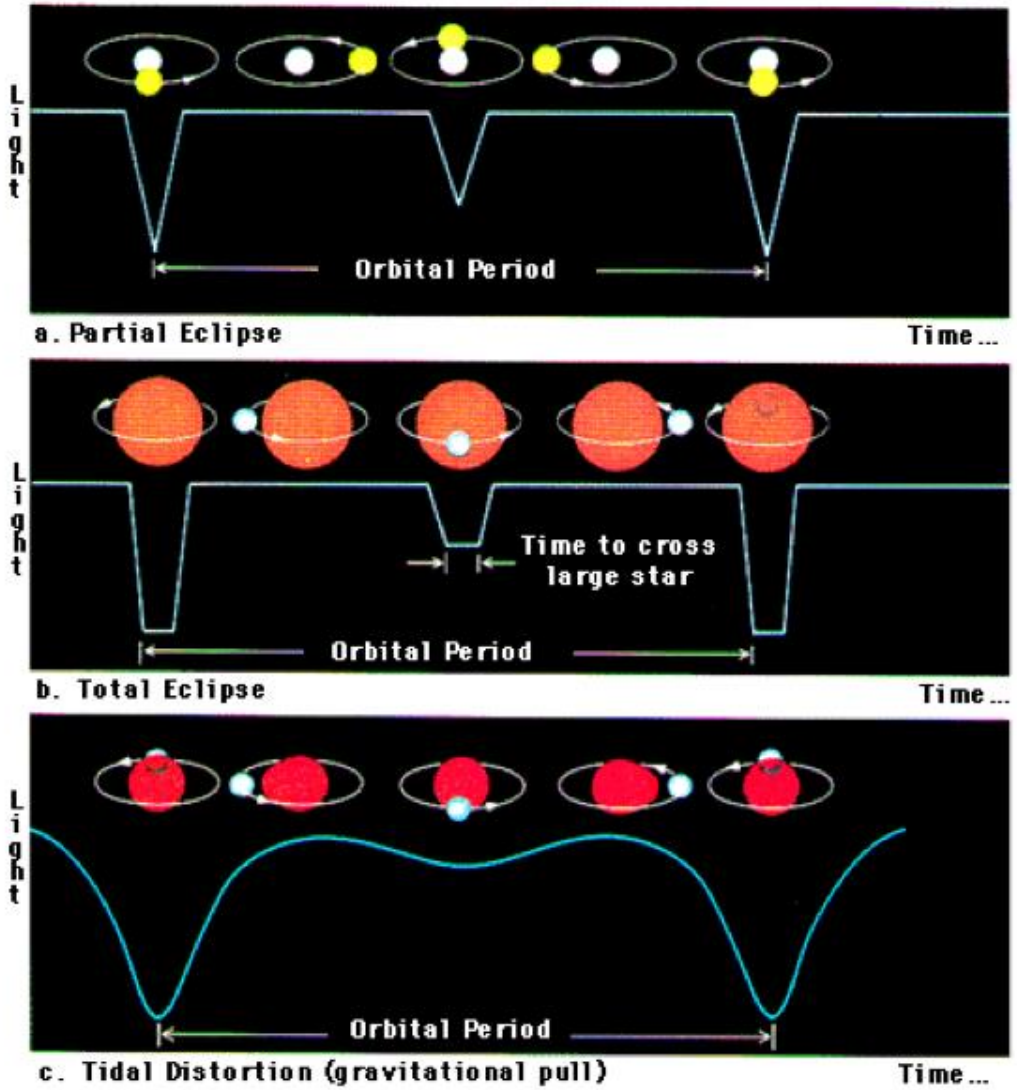
High-mass star A and lower-mass B orbit around a common centre of mass. The observed combined spectrum shows periodic splitting and shifting of spectral lines. The amount of shift is a function of the alignment of the system relative to us and the orbital speed of the stars.

Similar to transit method of exoplanet detection

Eclipsing binaries are oriented such that one star obscures the other during its orbit; the width and depth of the eclipse gives us information about the star's temperatures and radii.



The most important factors influencing the depth & shape of eclipses are the relative temperatures of the stars, and the orientation of the orbit (full eclipse vs. grazing).

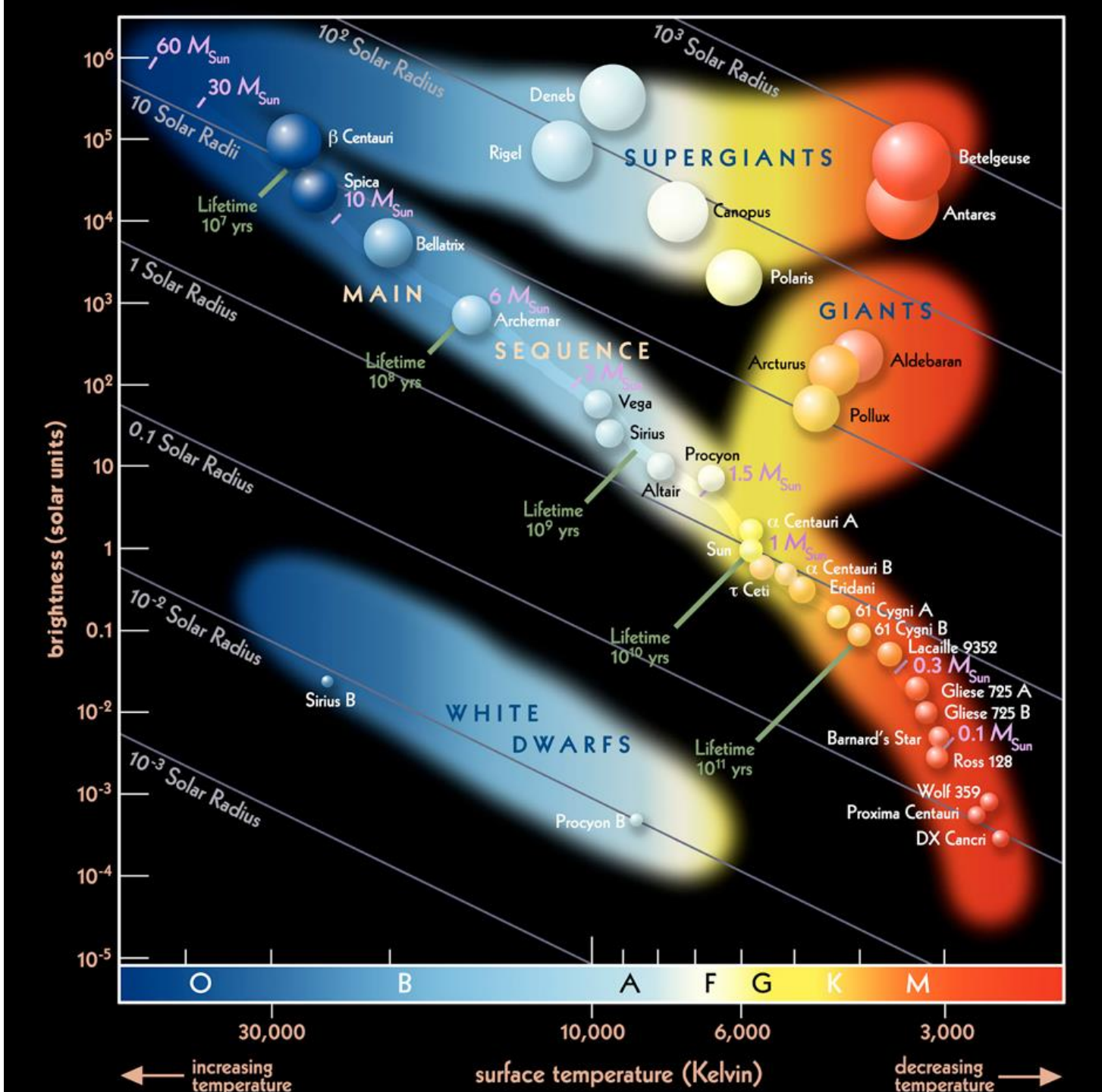


Binary Star Systems

1. Observe:
   - Star spectra
   - Gravitational interaction

2. Can derive:
   - Temperature & composition
   - Mass

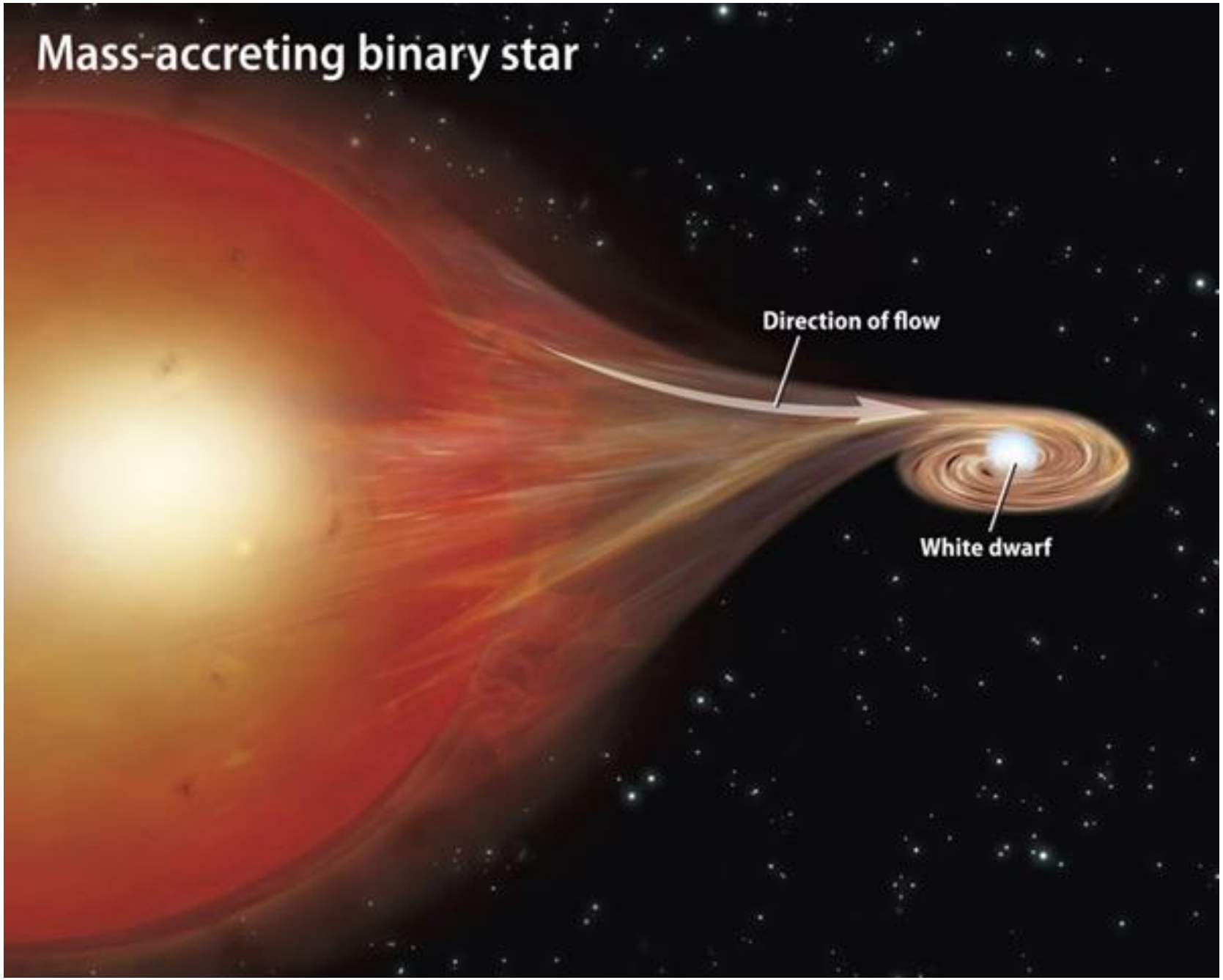
3. Can derive:
   - How temperature, composition and mass are all related



Binary Stars & Mass transfer

- Binaries interact
- High gravity around a white dwarf can pull mass from other star

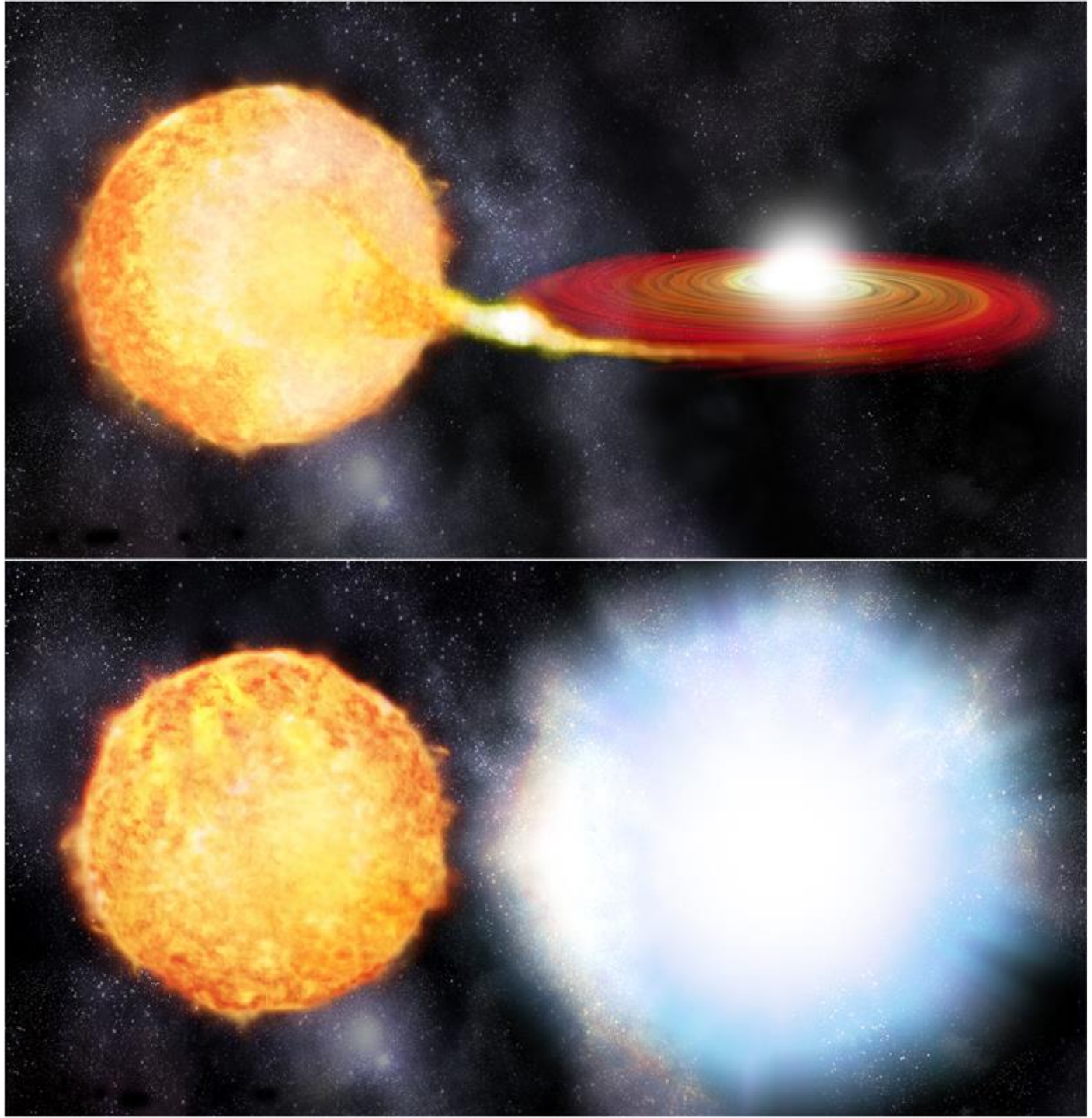
What is the consequence?



Nova & type IA Supernova

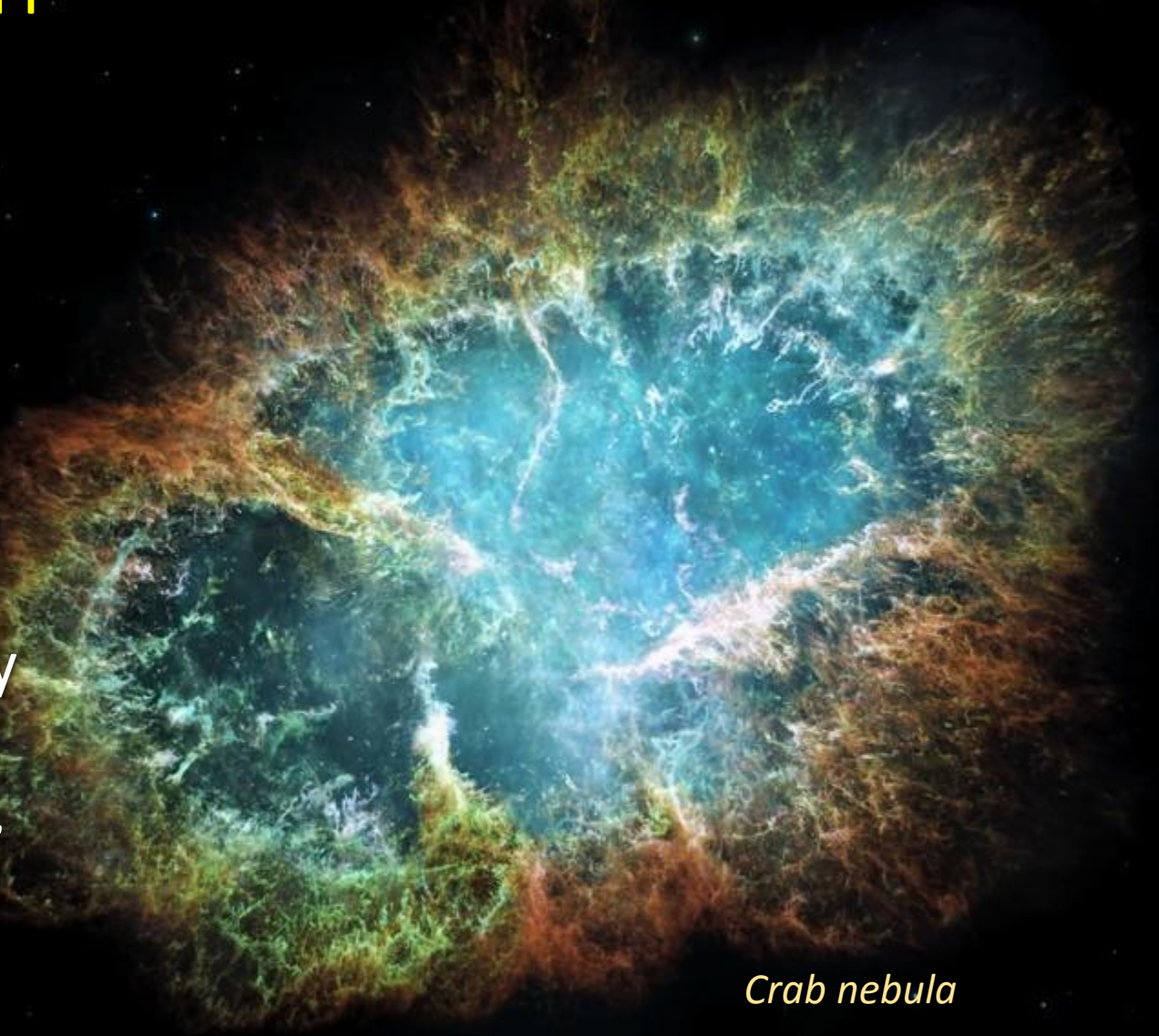
- Build up of mass leads to start of nuclear fusion

- Depending on rate & size of mass transfer…
  - *Nuclear detonation of the hydrogen outer layer*
  - ➢ **Nova**
  - *Rapid fusion in the white dwarf carbon core until star explodes*
  - ➢ **Type IA supernova**



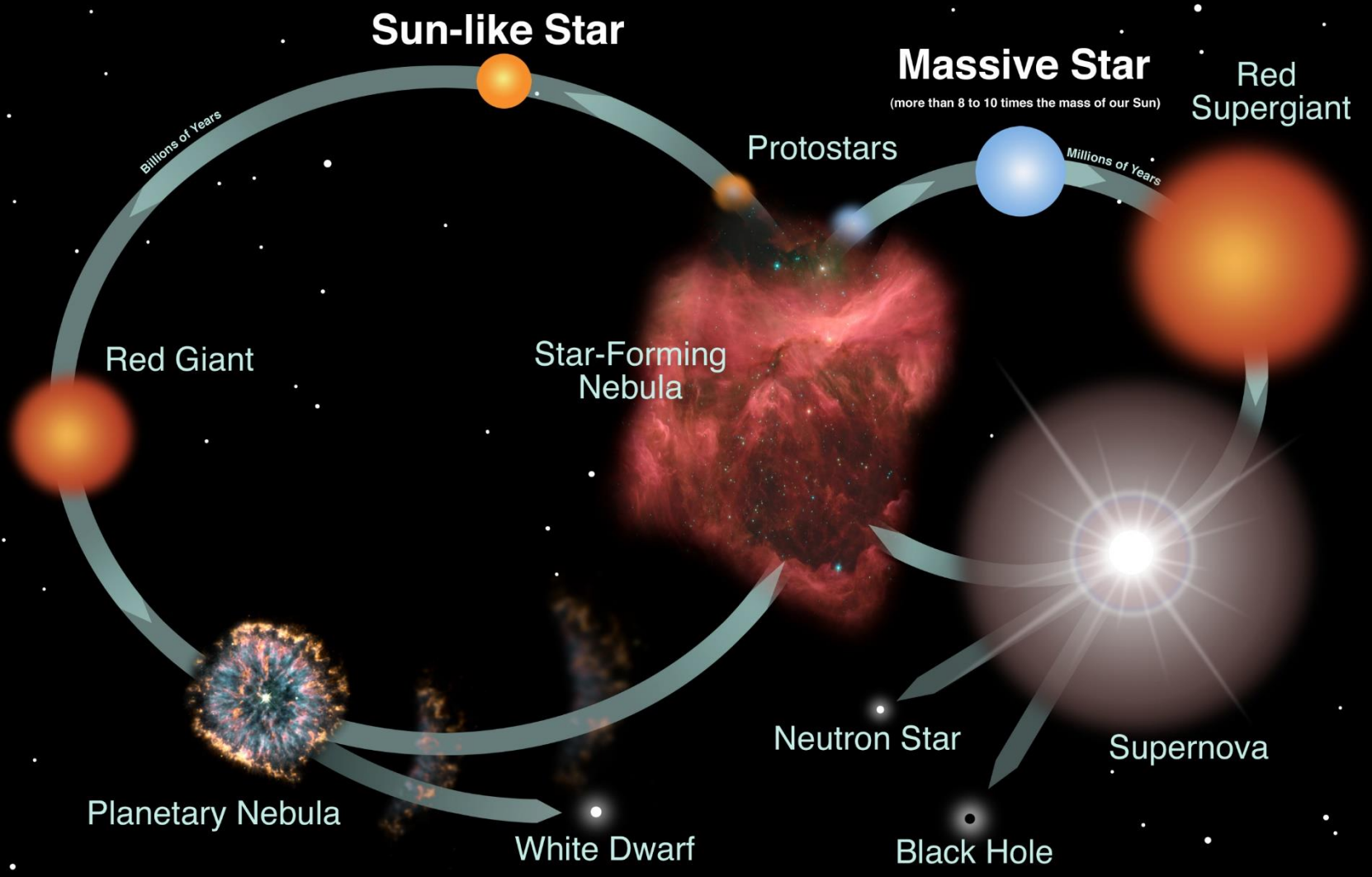
Rapid collapse of iron (Fe) core leads to supernova explosion

- Expands at 10000 km/s
- Releases all the elements into space
- Explosion has such high energy it can fuse heavy elements like Fe into even heavier elements, like Au, Pb all the way to U



Crab nebula

Comparing lives of low and high mass stars

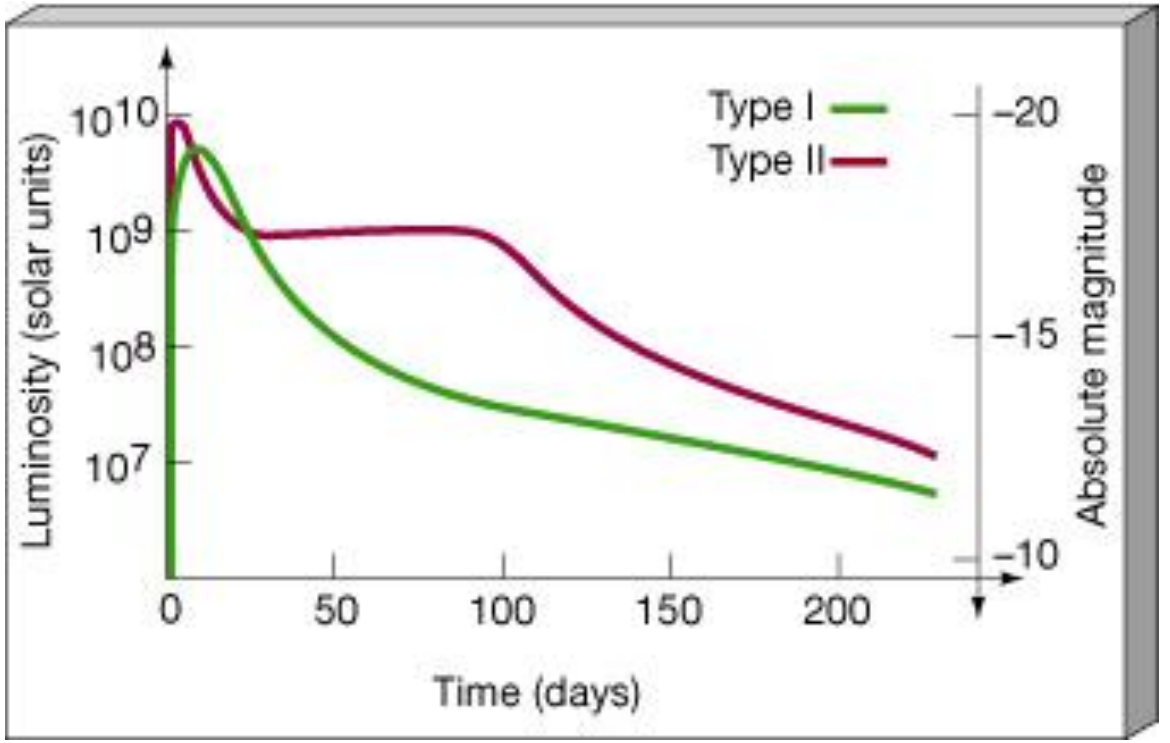


A marker for astronomical distances

- Type IA supernovae all have the same:
  - Light curve (brightness vs. time)
  - Luminosity
- Use Type 1A supernovae as “standard candles”
  - Compare apparent brightness to known luminosity

$$L = F_{detected} \cdot 4\pi d^2$$

  - Can calculate distance
    - Bright Type IA = nearby
    - Dim Type IA = far away



Light curve for Type IA and type II supernovae

Another way to find distance…

Analysis of star clusters

Pleiades

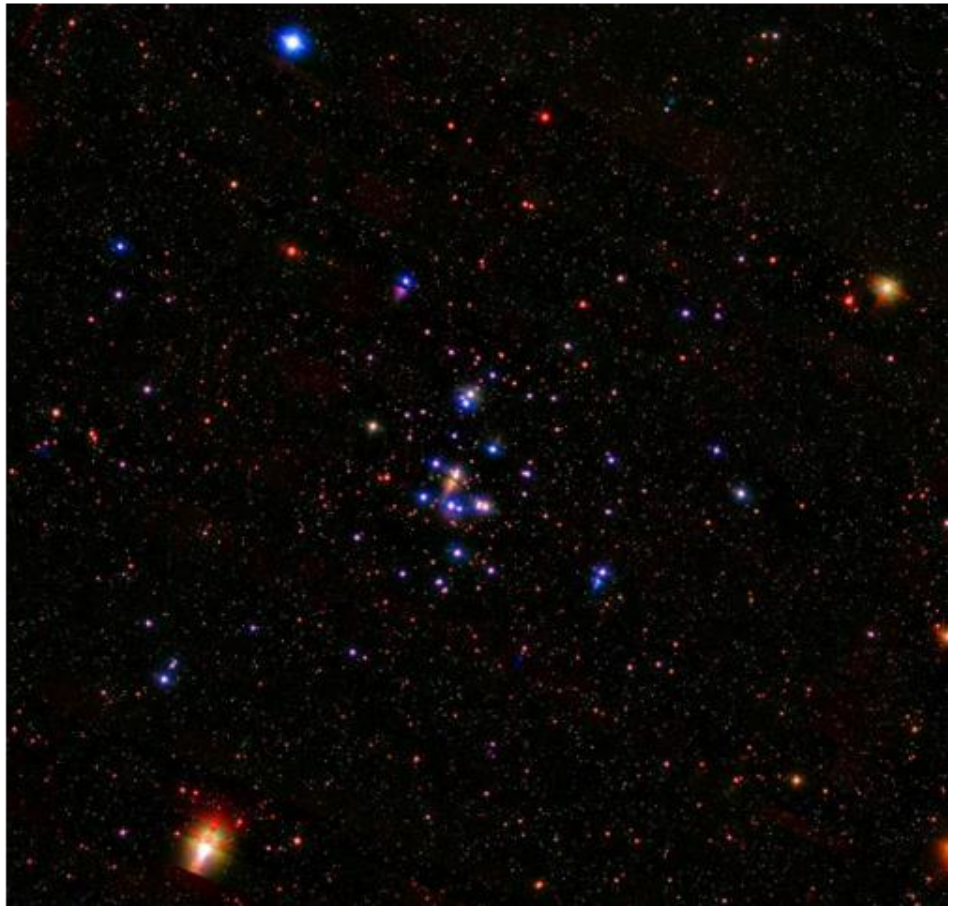
Star clusters come in two different flavors:

Globular Clusters

Rich (~10,000-100,000 stars)

Highly symmetric

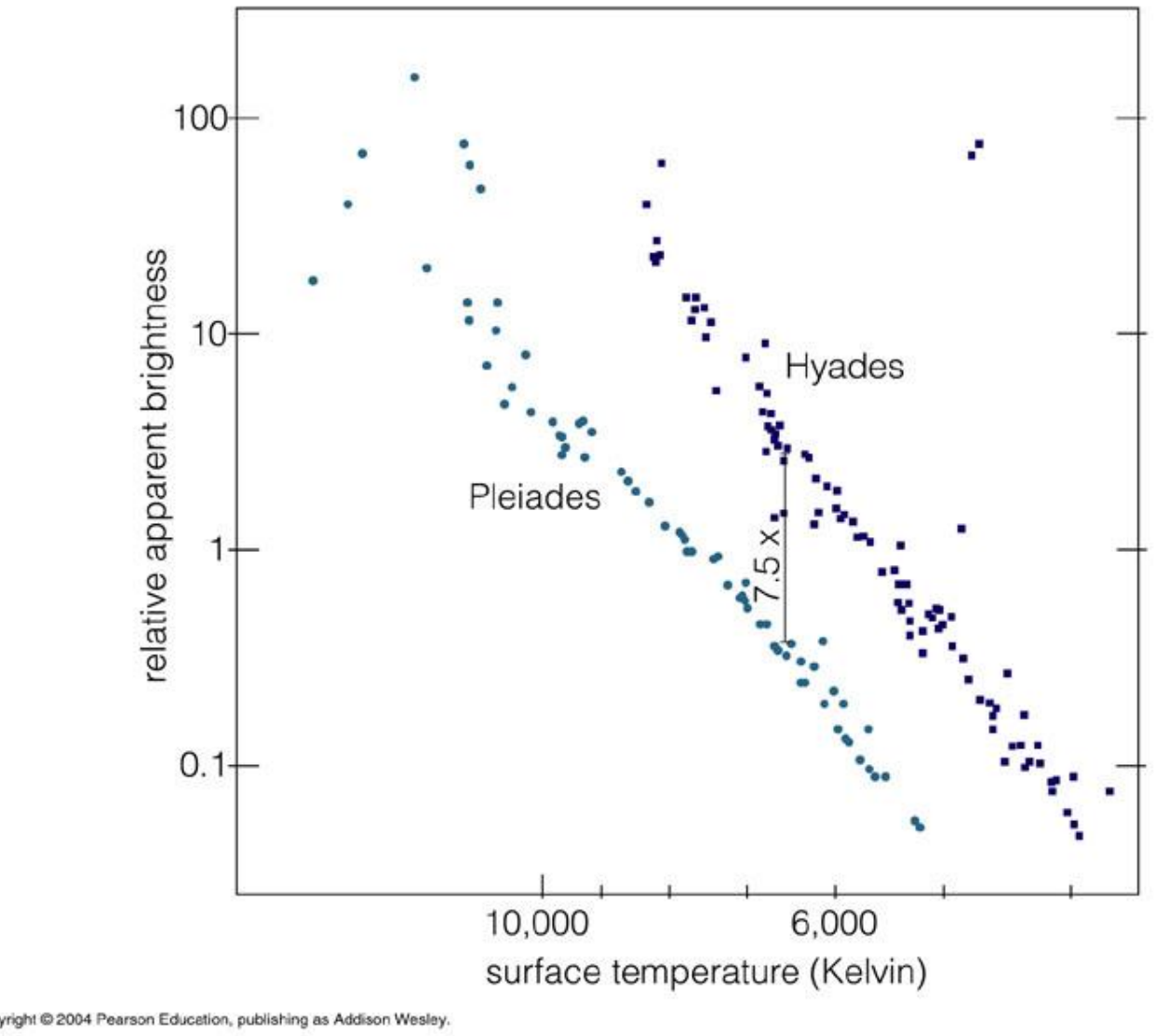
Open Clusters

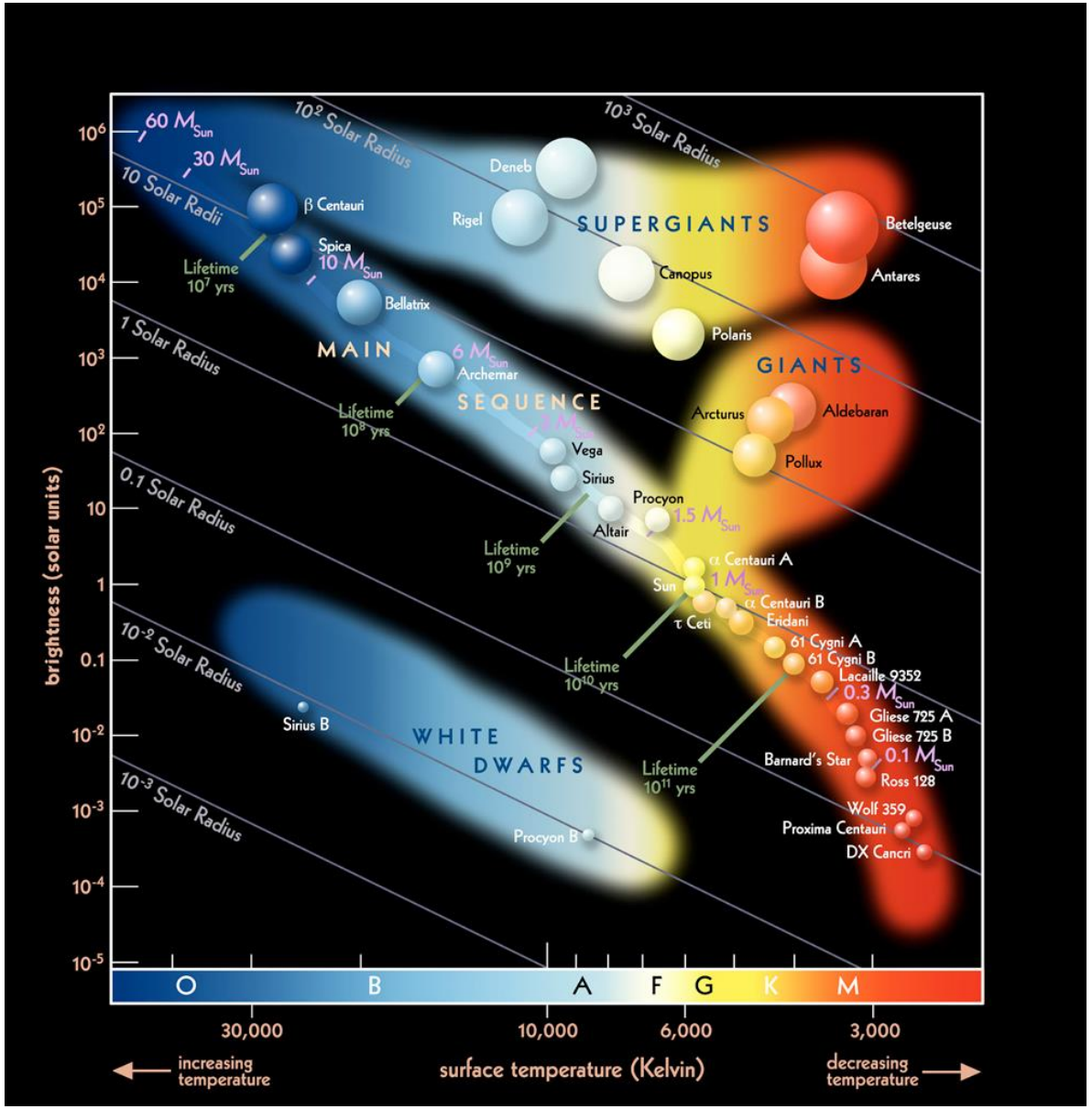


Sparse (~100-1,000 stars)

Asymmetric

Measuring the brightness of cluster stars enables us to determine the distance to that cluster





Also want to be able to measure the AGE of stars

We'll examine that tomorrow….

ACTIVITY 22