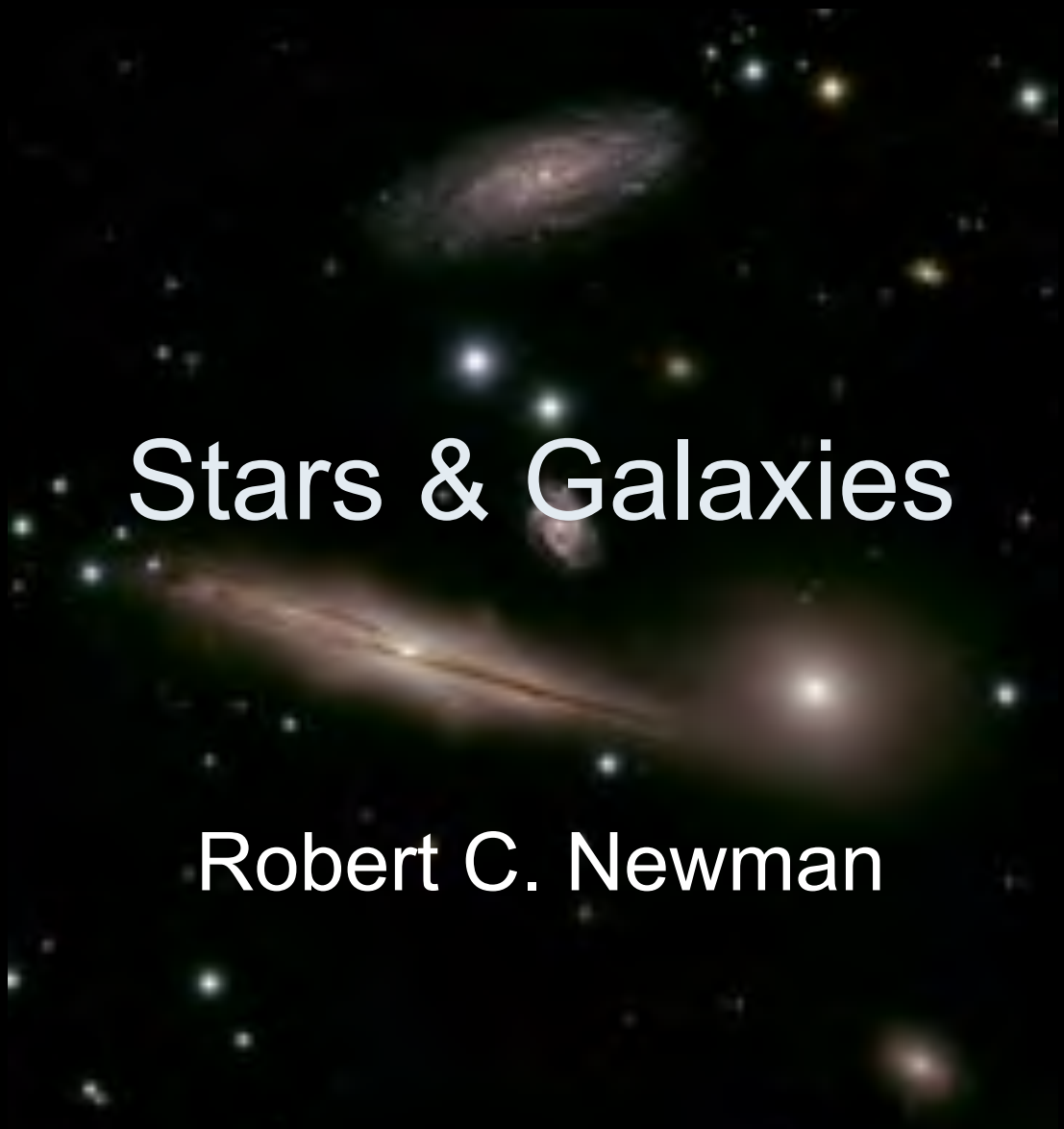


Stars & Galaxies

Robert C. Newman

Stars & Galaxies

- Here we want to start with stars, looked at from two different perspectives:
  - What they look like from earth
  - What we know about them from astronomy and astrophysics
- We will then look at clusters of stars
- And finally at the particular types of star clusters we call galaxies.


Stars

What are Stars?

- From earth, without telescopes, stars are just points of light in the sky.
- The ancients called any bright light in the sky a star, distinguishing various types:
  - Fixed stars
  - Wandering stars (planets, sun, moon)
  - Hairy stars (comets)
  - Shooting stars (meteors)

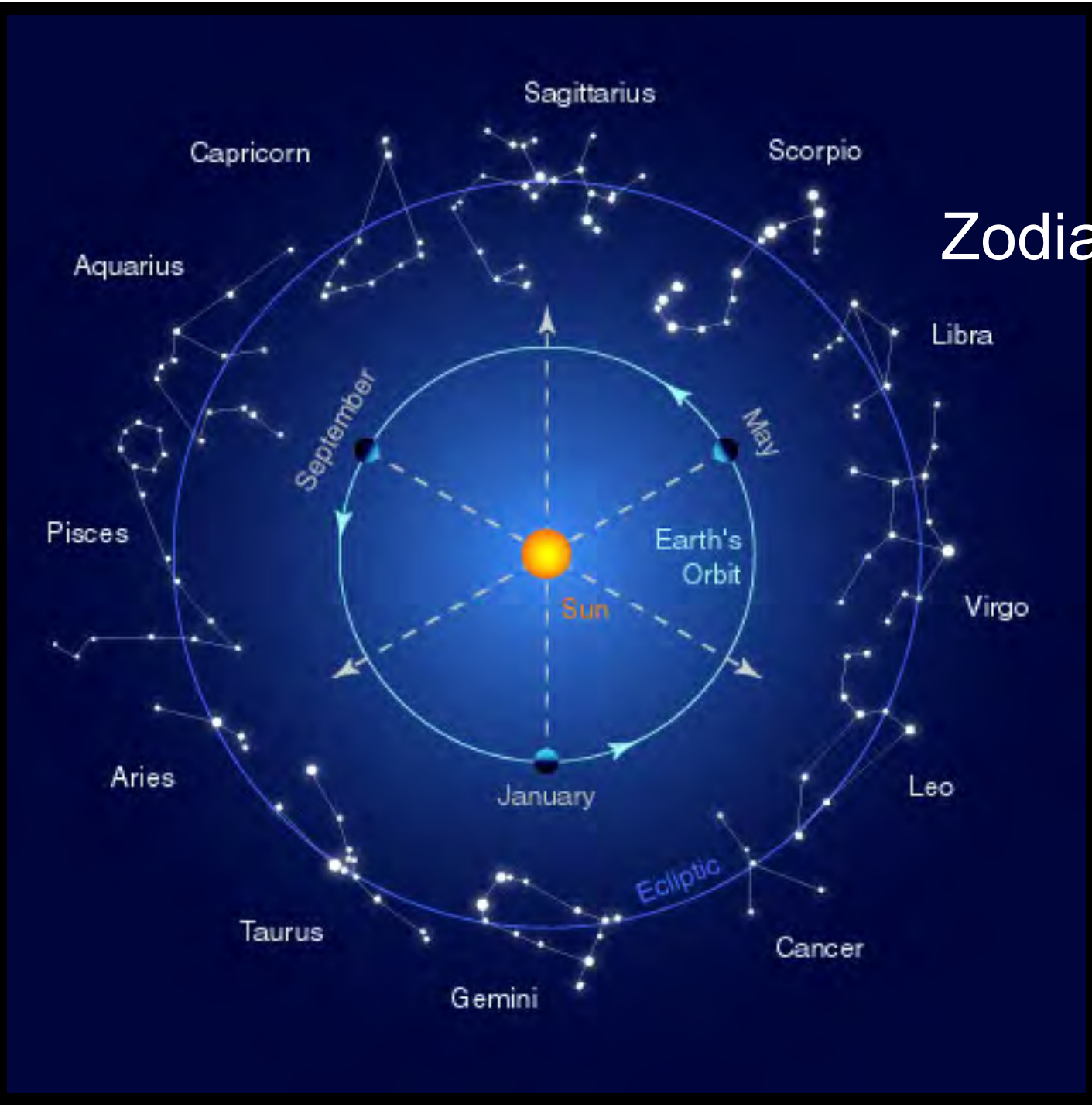
What are Stars?

- With the 20th century, we have come to realize that stars are:
  - large balls of gas
  - held together by their own gravity
  - illuminated by heat produced within, usually by internal nuclear reactions.
- Our sun is the nearest star.
- Stars are distinguished from:
  - Planets – no nuclear reaction
  - Brown dwarfs – only deuterium or lithium fusion

Constellations

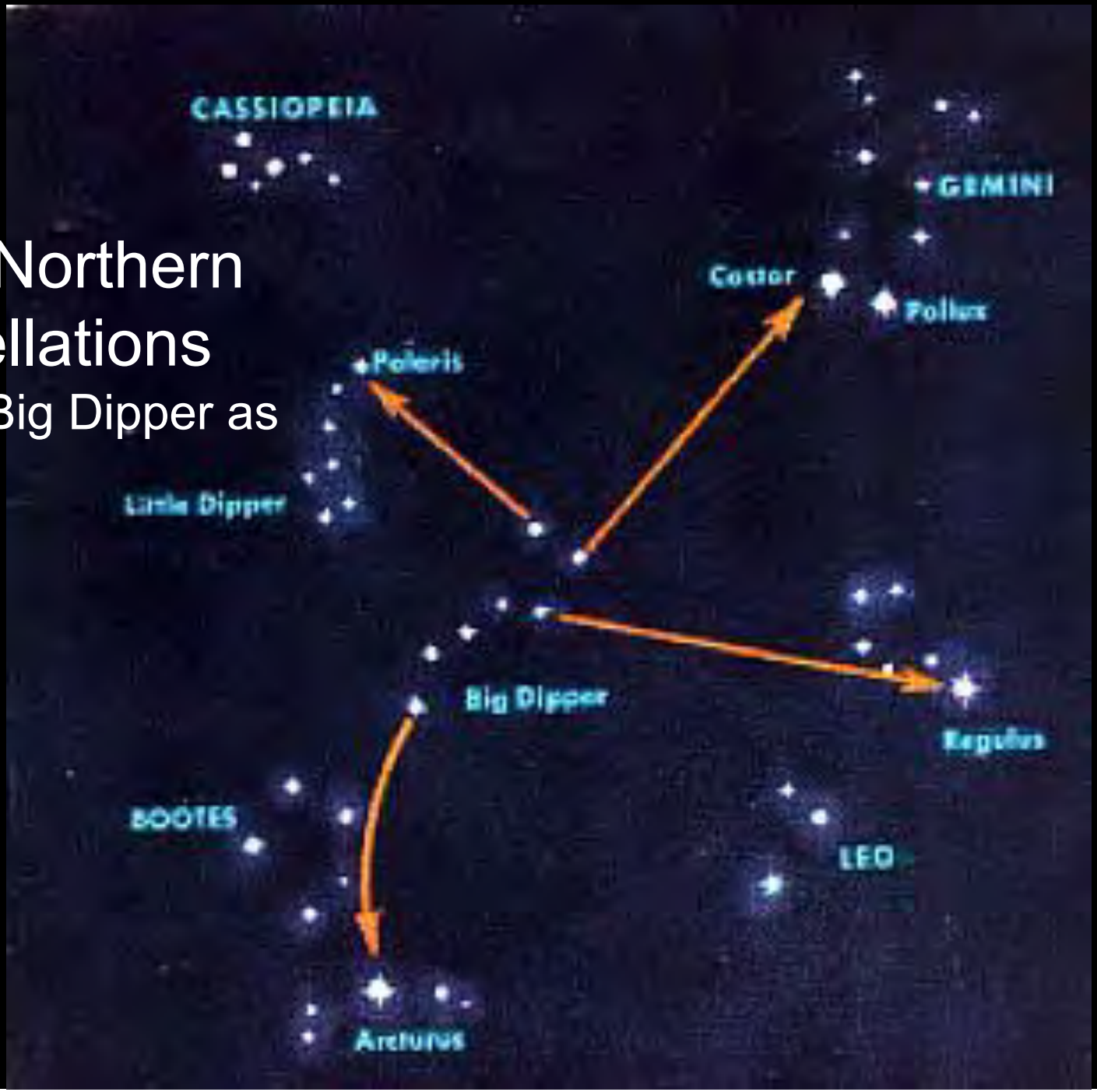
- 'Constellation' is the term we use for apparent star groups in the sky. Most of these are not actually gravitationally-bound groups.
- There is a standard set of 88 of these used in the West, 48/50 of which come down to us from the Greeks & even the Babylonians centuries before the time of Christ.
- 12 of these mark off the Zodiac, thru which the sun, moon, and planets pass.

Zodiac

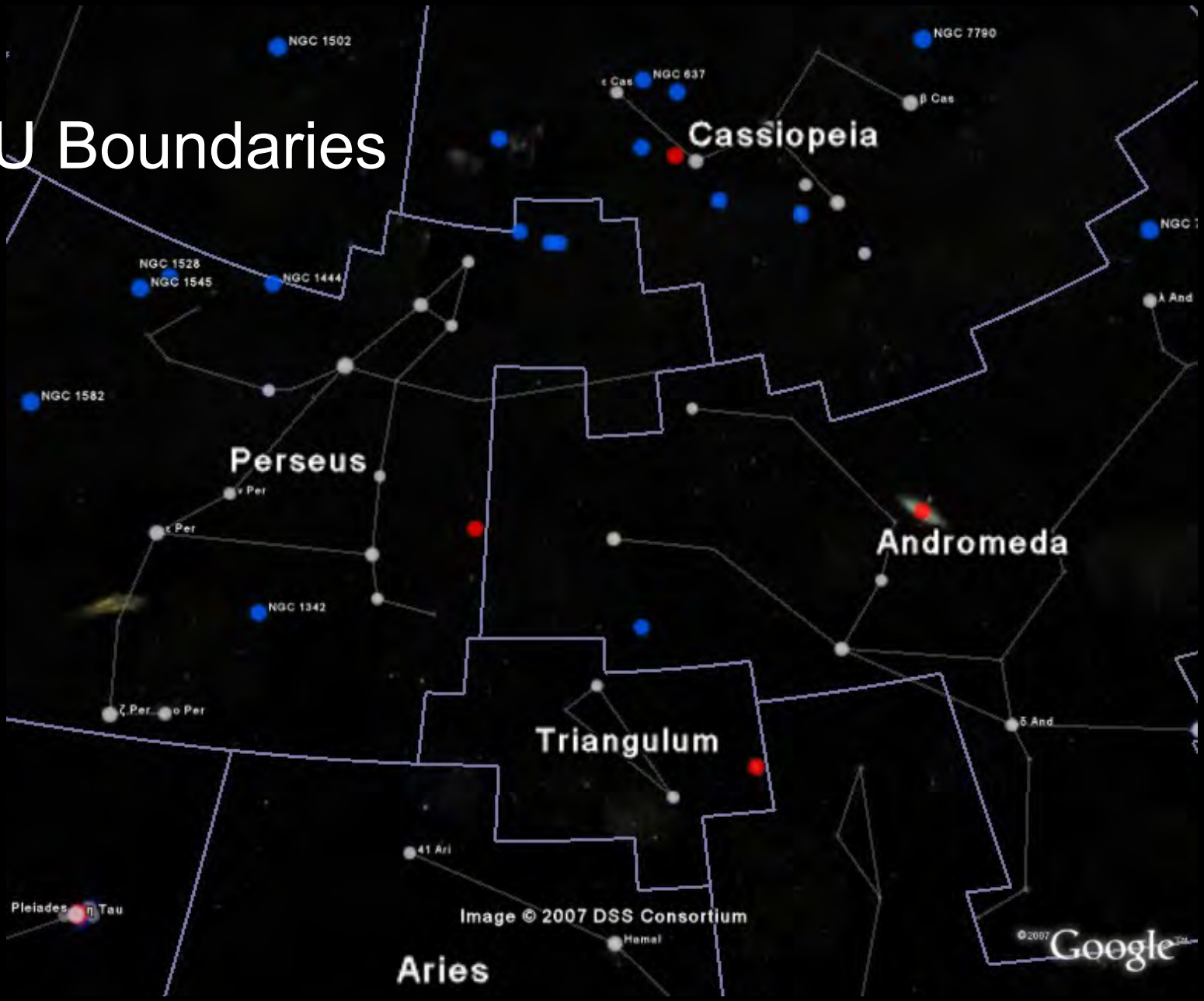


Some Northern Constellations

with the Big Dipper as pointer



IAU Boundaries



Use of the Constellations

- The constellations are used today in astronomy to help observers find their way around in the night sky.
- They have been used by travellers for direction and by farmers for when to plant crops.
- The constellations have been & are still being used by astrologers for fortune-telling.
- Some Christians believe they portray a 'Gospel in the Stars' that goes back to God or to the patriarchs.

Different Kinds of Stars

- Even a brief glance at the stars shows us that they differ in brightness.
- As one looks at the stars more carefully, it becomes apparent that they are not all the same color.
- Look at the constellation of Orion shown in the next panel.

Orion

Different Kinds of Stars

- Astronomers classify the apparent brightness of stars by magnitude.
  - The lower the number, the brighter the star
- They use a similar system for the actual brightness of the star, called absolute magnitude.
- They use a letter system to designate the star color: O, B, A, F, G, K, and M.

Brightness

- The ancients called the brightest stars 'first magnitude,' the next brightest 'second magnitude,' and so on thru 6th.
- Modern astronomy has regularized this, using zero and negative numbers for the very brightest objects, and higher numbers for objects invisible w/o optical help.
- For instance, see some examples in the next panel:

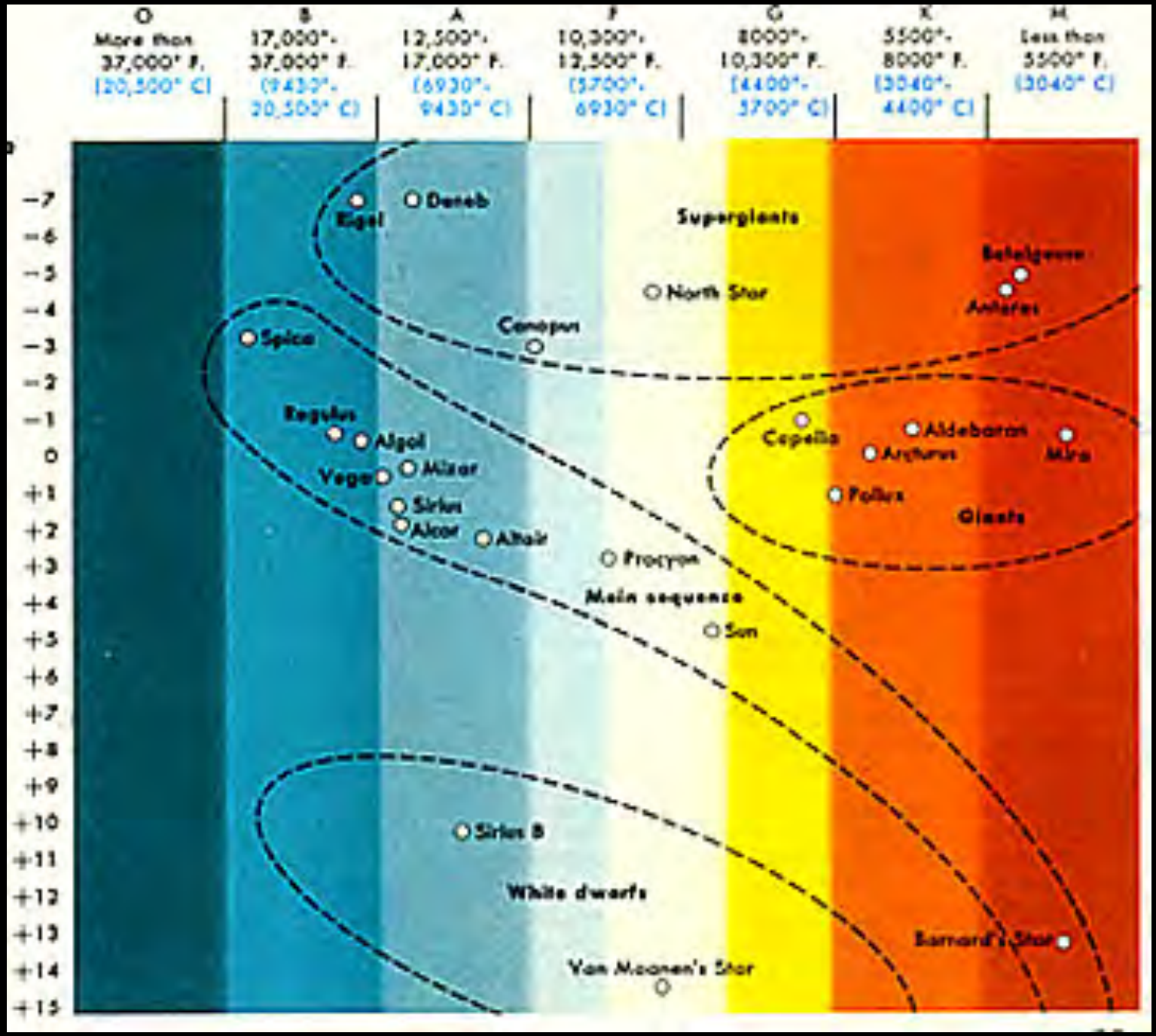
Apparent Magnitude

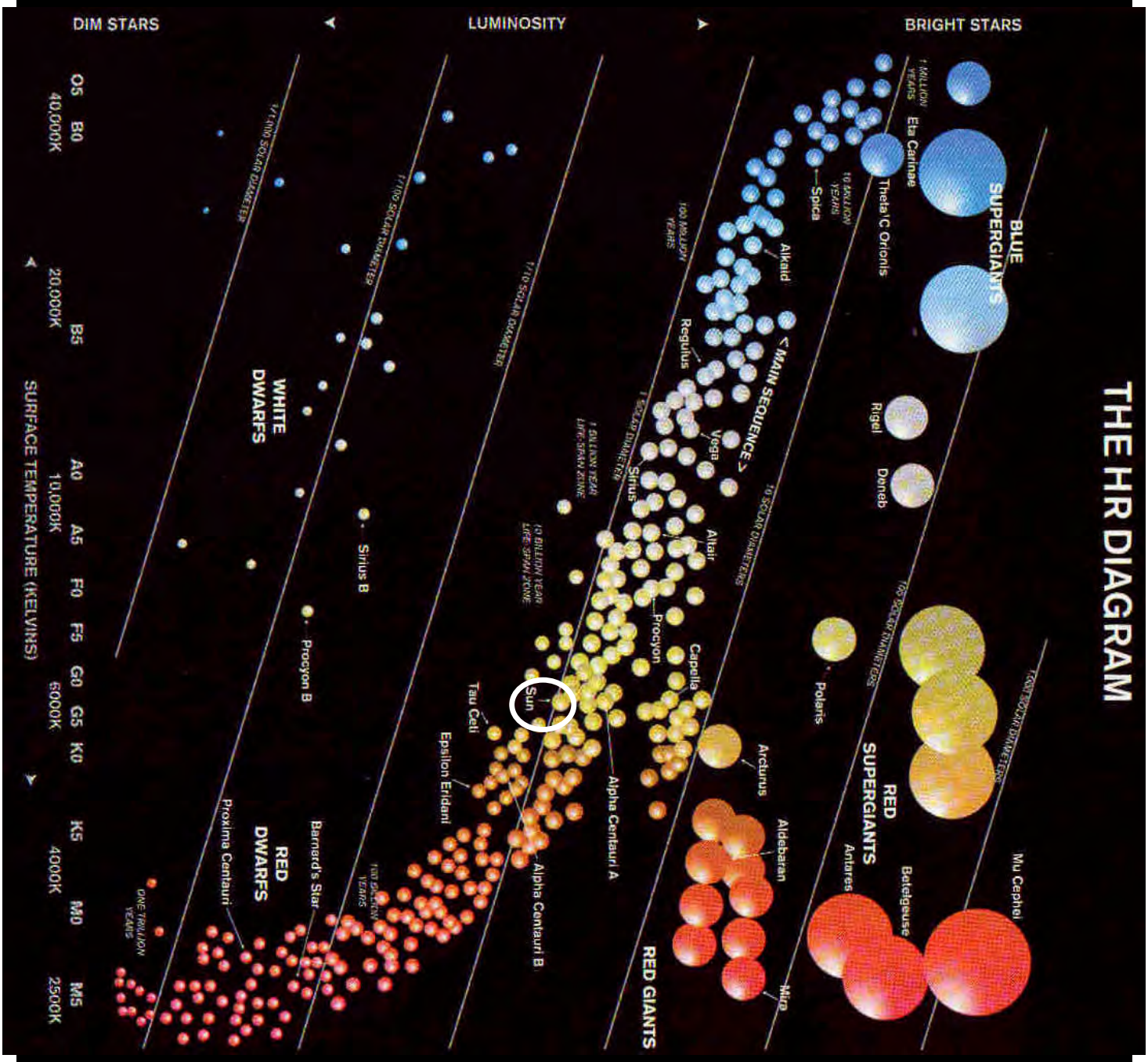
• Sun	• -26.7
• Venus	• -4.4
• Sirius	• -1.4
• Vega	• 0.0
• Betelguese	• 0.4
• Limit w/ naked eye	• 5

Absolute magnitude is what the apparent magnitude of a star would be if it were 10 parsecs (32.6 light years) away.

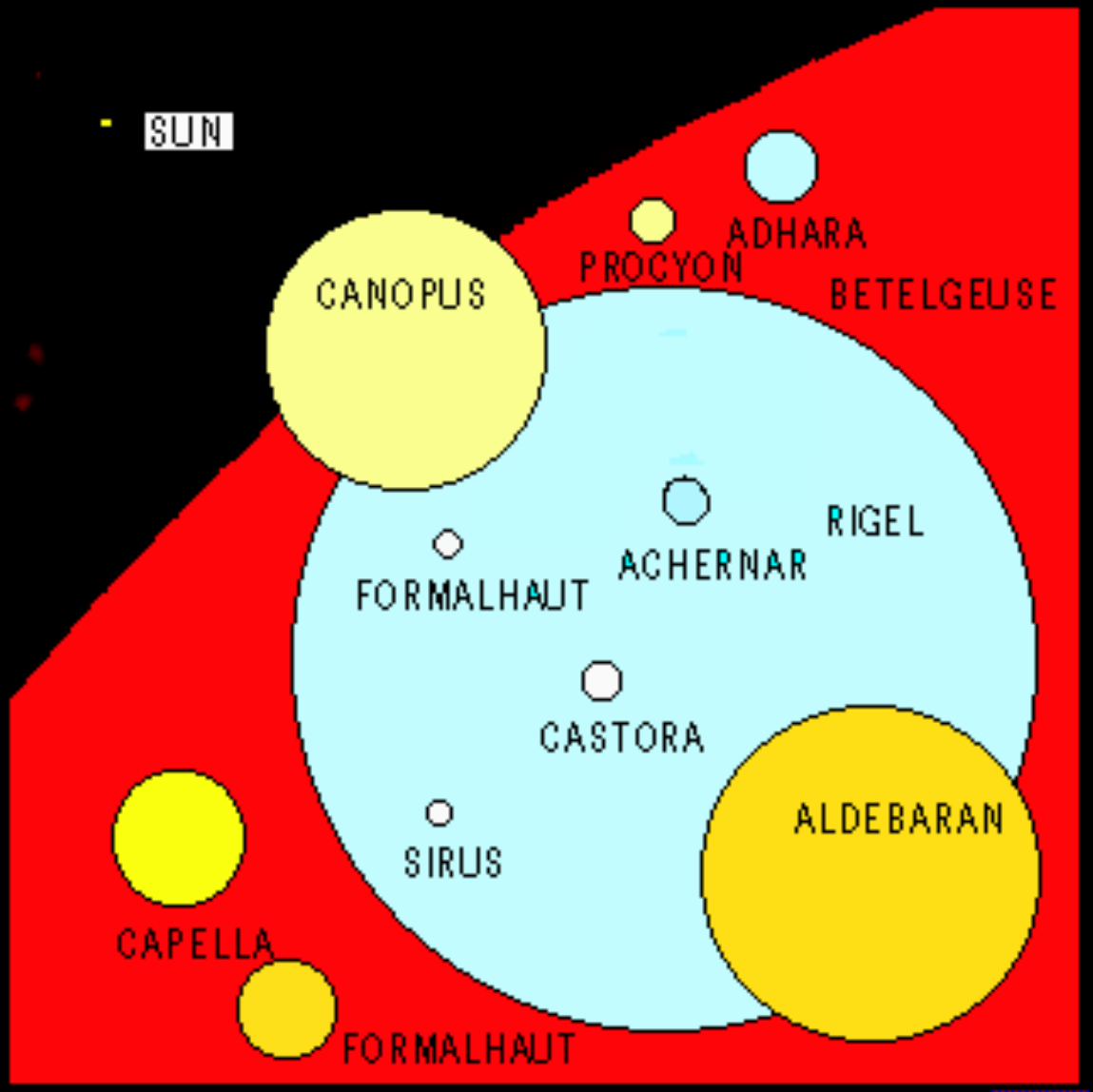
Star Color (Temperature)

• O	• ~ 35,000 K
• B	• ~20,000 K
• A	• ~10,000 K
• F	• ~7000 K
• G	• ~6000 K
• K	• ~4700 K
• M	• ~3500 K



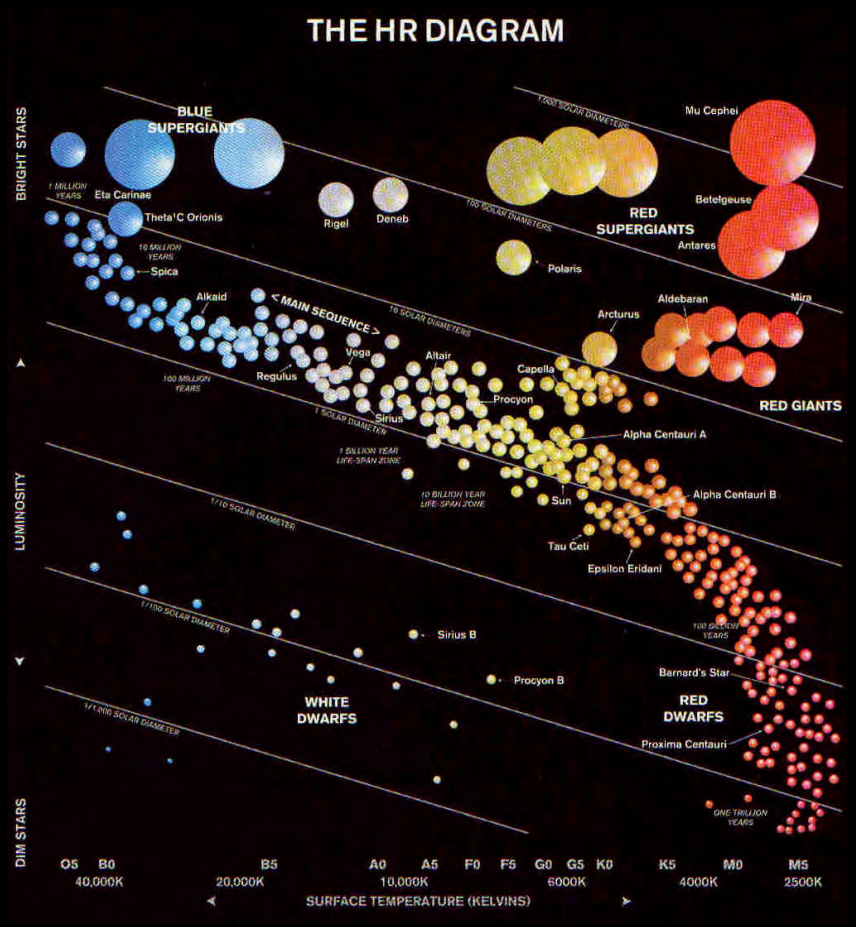

THE HR DIAGRAM
BRIGHT STARS
LUMINOSITY
DIM STARS
BLUE SUPERGIANTS
RED SUPERGIANTS
RED GIANTS
MAIN SEQUENCE
WHITE DWARFS
RED DWARFS
Eta Carinae
Theta 1 C Orionis
Spica
Alkaid
Regulus
Vega
Sirius
Rigel
Deneb
Altair
Procyon
Capella
Polaris
Arcturus
Aldebaran
Antares
Betelgeuse
Mu Cephei
Mira
Sun
Tau Ceti
Epsilon Eridani
Alpha Centauri A
Alpha Centauri B
Sirius B
Procyon B
Barnard's Star
Proxima Centauri
O5 B0 B5 A0 A5 F0 F5 G0 G5 K0 K5 M0 M5
40,000K 20,000K 10,000K 6000K 4000K 2500K
SURFACE TEMPERATURE (KELVINS)

Star Sizes



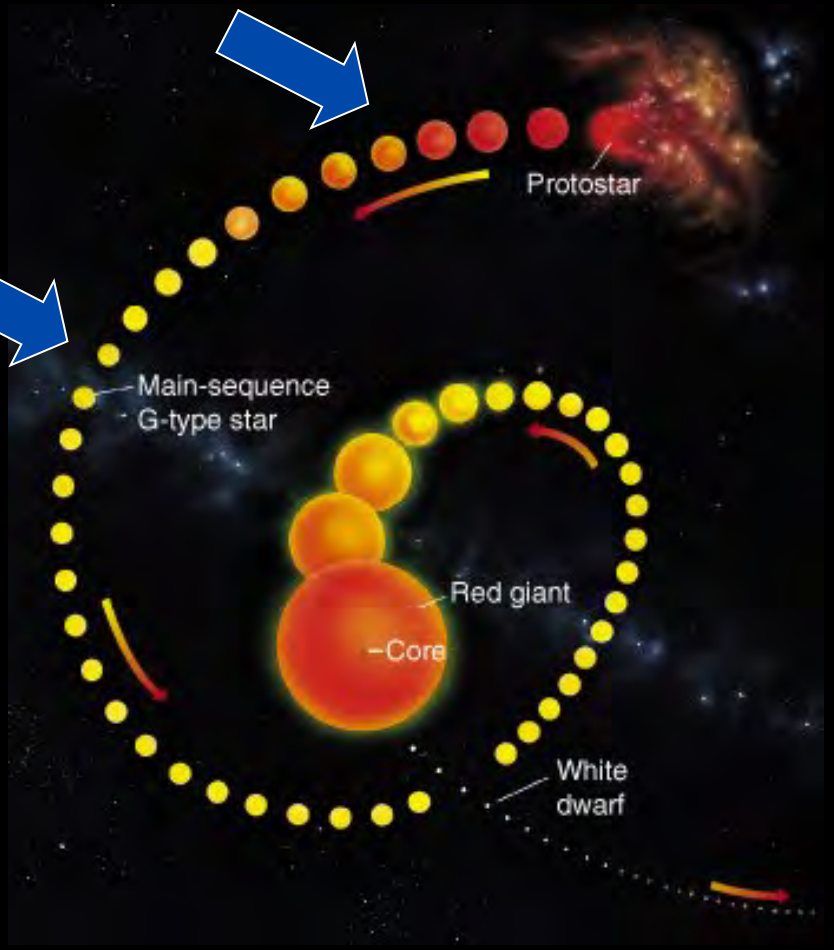
The Hertzsprung-Russell Diagram

- The curve thru the center is the Main Sequence, stars burning hydrogen in their cores.
- The stars at upper right are red giants.
- The stars at lower left are white dwarfs.



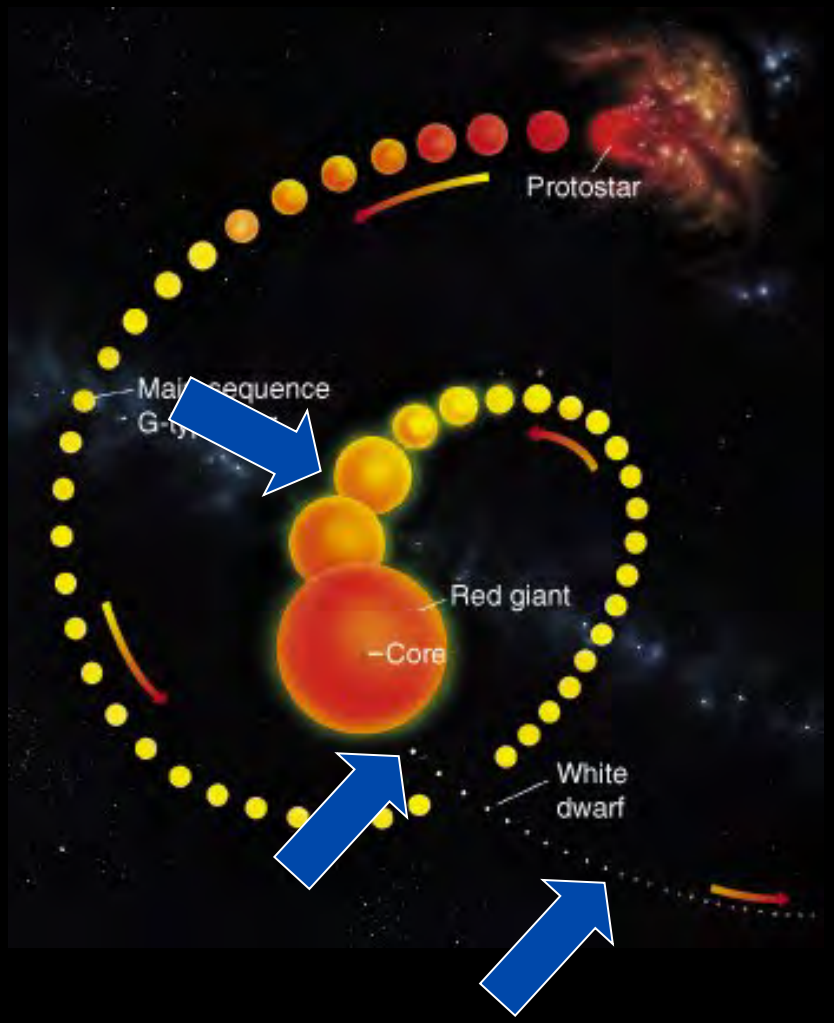
Lifespan of a G Star

- This spiral shows (schematically) the life of a G-type star (like our sun).
- It begins in the upper right as a gas cloud collapsing into a proto-star.
- It spends most of its active life on the Main Sequence.



Lifespan of a G Star

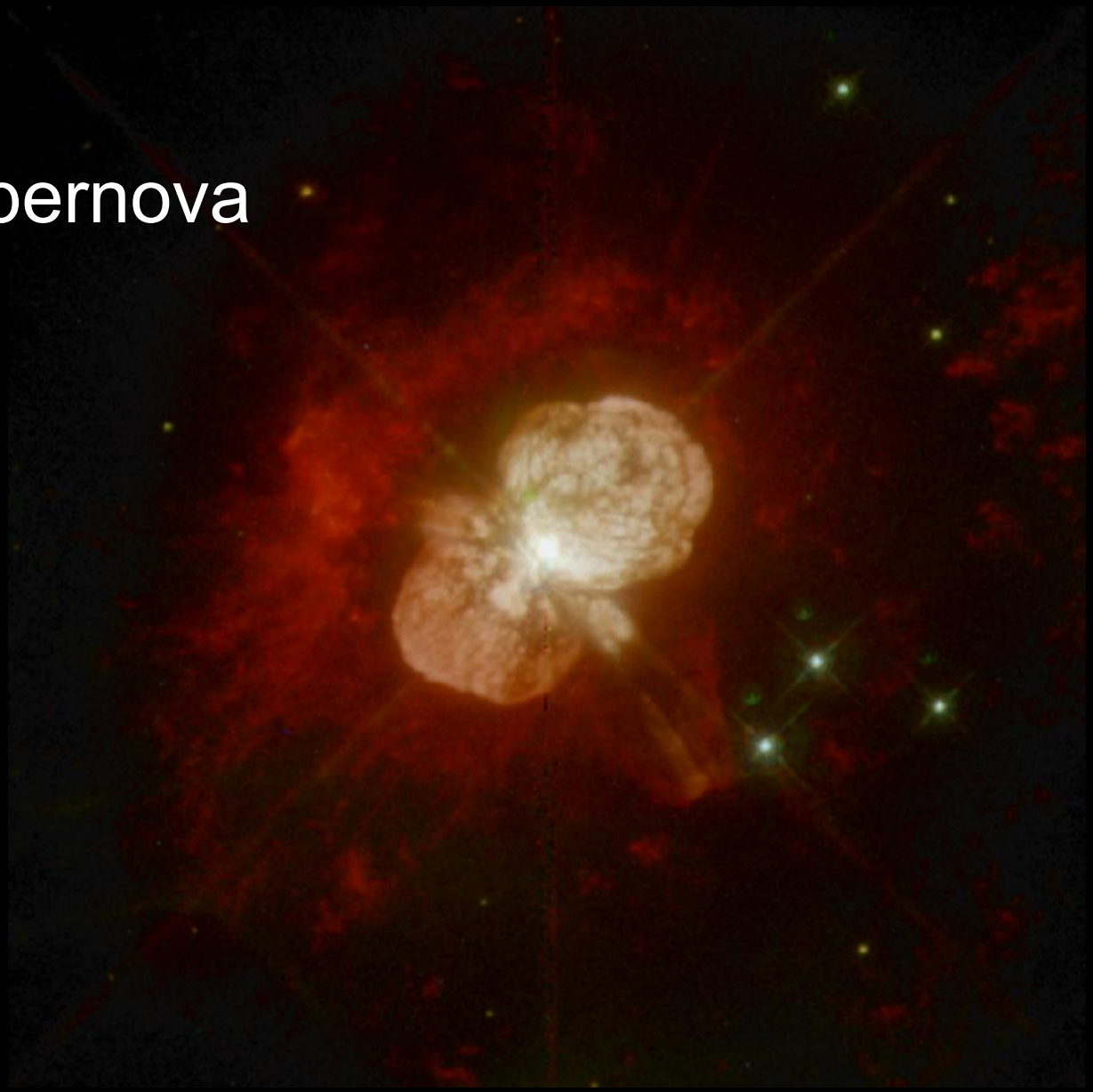
- When it uses up the H in its core, it expands to form a red giant, burning H in an outer shell & He in the core.
- When the He is gone, the star collapses to form a white dwarf.
- The dwarf gradually cools till it ceases to shine, becoming a black dwarf.



How Larger Stars End

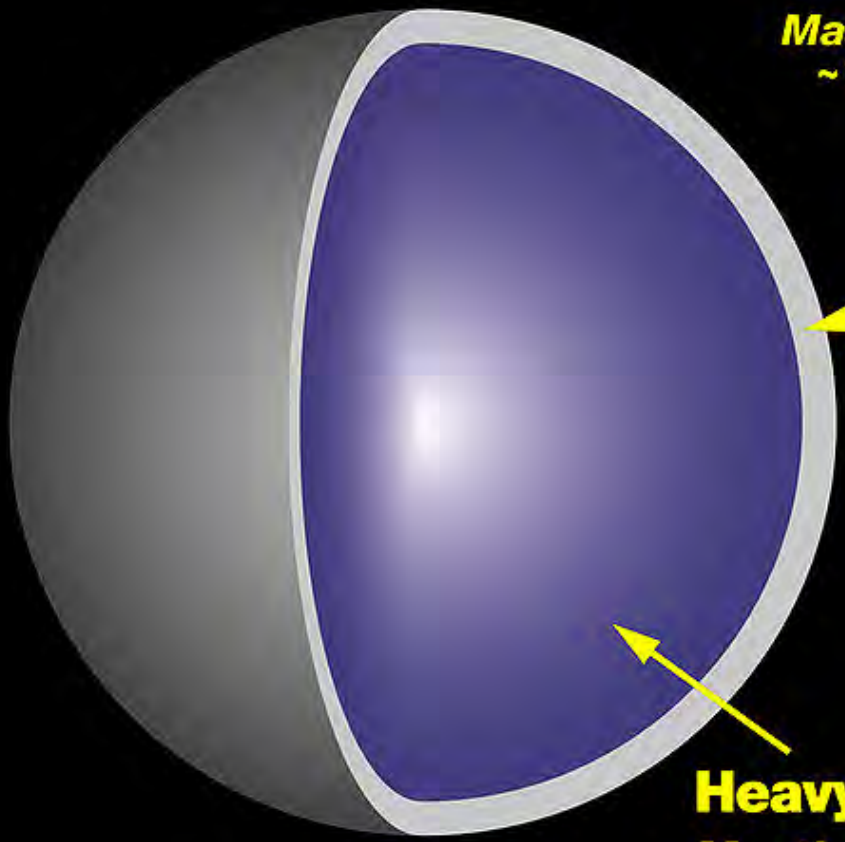
- Stars that are large enough explode rather than becoming white dwarfs.
- We call these exploding stars supernovas.
- The smaller exploding stars collapse to become neutron stars afterward.
- The larger exploding stars collapse to become black holes.

Supernova



Neutron Star

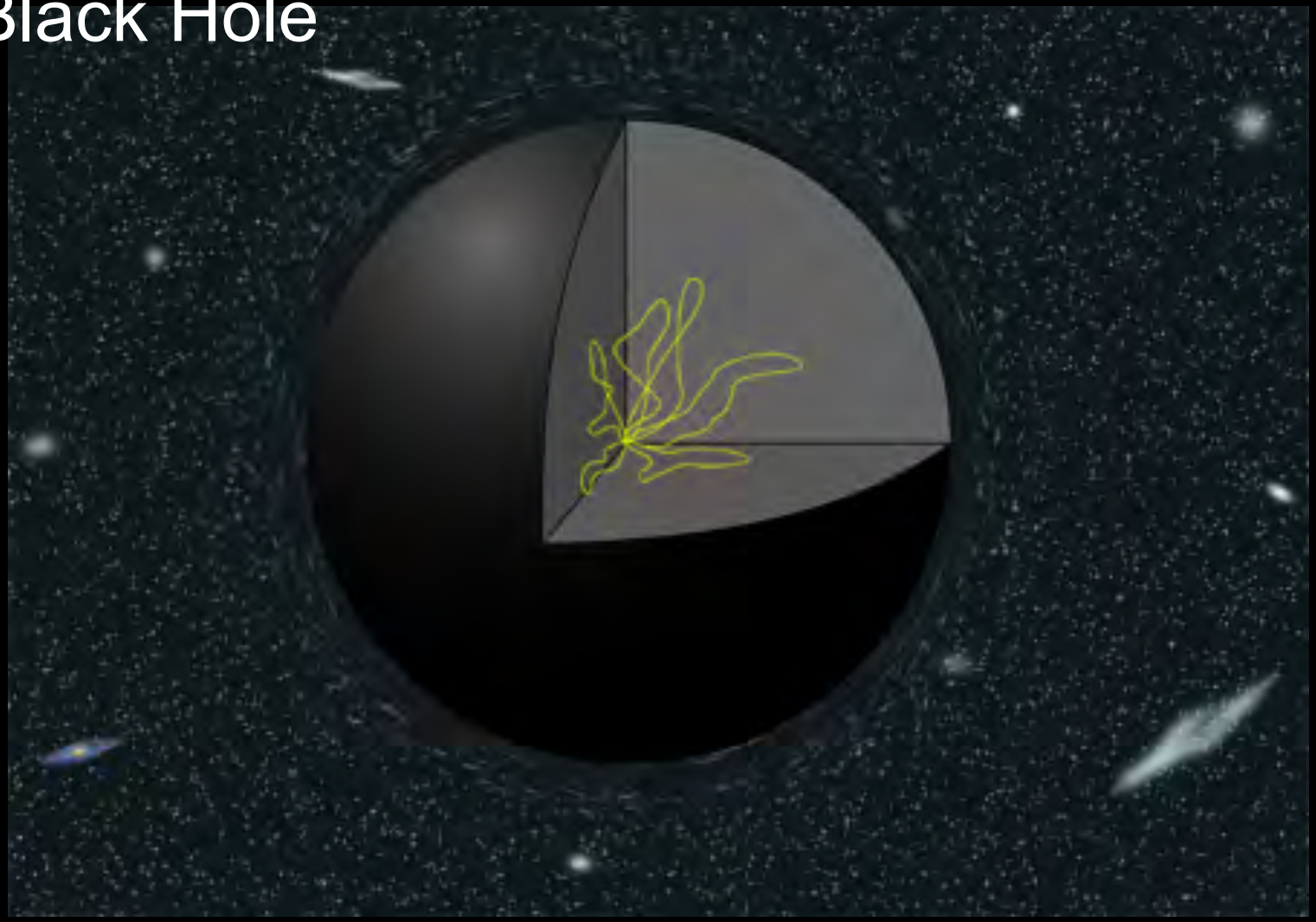
Mass ~ 1.5 times the Sun
~12 miles in diameter



Solid crust
~1 mile thick

Heavy liquid interior
Mostly neutrons,
with other particles

Black Hole



Star Clusters

- Star clusters are groups of stars that are really associated, rather than just being in the same direction from us, as many constellations are.
- Star clusters are of two kinds:
  - Galactic, or open, clusters
  - Globular clusters.

Galactic Clusters

- These are called galactic because they lie near the plane of our galaxy.
- They are called open because they are not as tightly packed as globular clusters.
- There are about 500 of these in our part of the galaxy.
- They have typically 20-300 stars.

Pleiades Cluster in Taurus

Globular Clusters

- Globular clusters are so named because they tend to have a rather spherical shape.
- They are much larger and more tightly packed than galactic clusters,typically having tens of thousands of stars.
- They move in a halo around the galaxy rather than in the galactic plane.

M80 – Globular Cluster in Scorpio

Galaxies

Galaxies

- 'Galaxies' are what we call the huge star clusters that inhabit our universe.
- These clusters range in size from ten million stars to about a trillion.
- The galaxy in which we live is popularly called the 'Milky Way,' because that is what it looked like to the ancients.

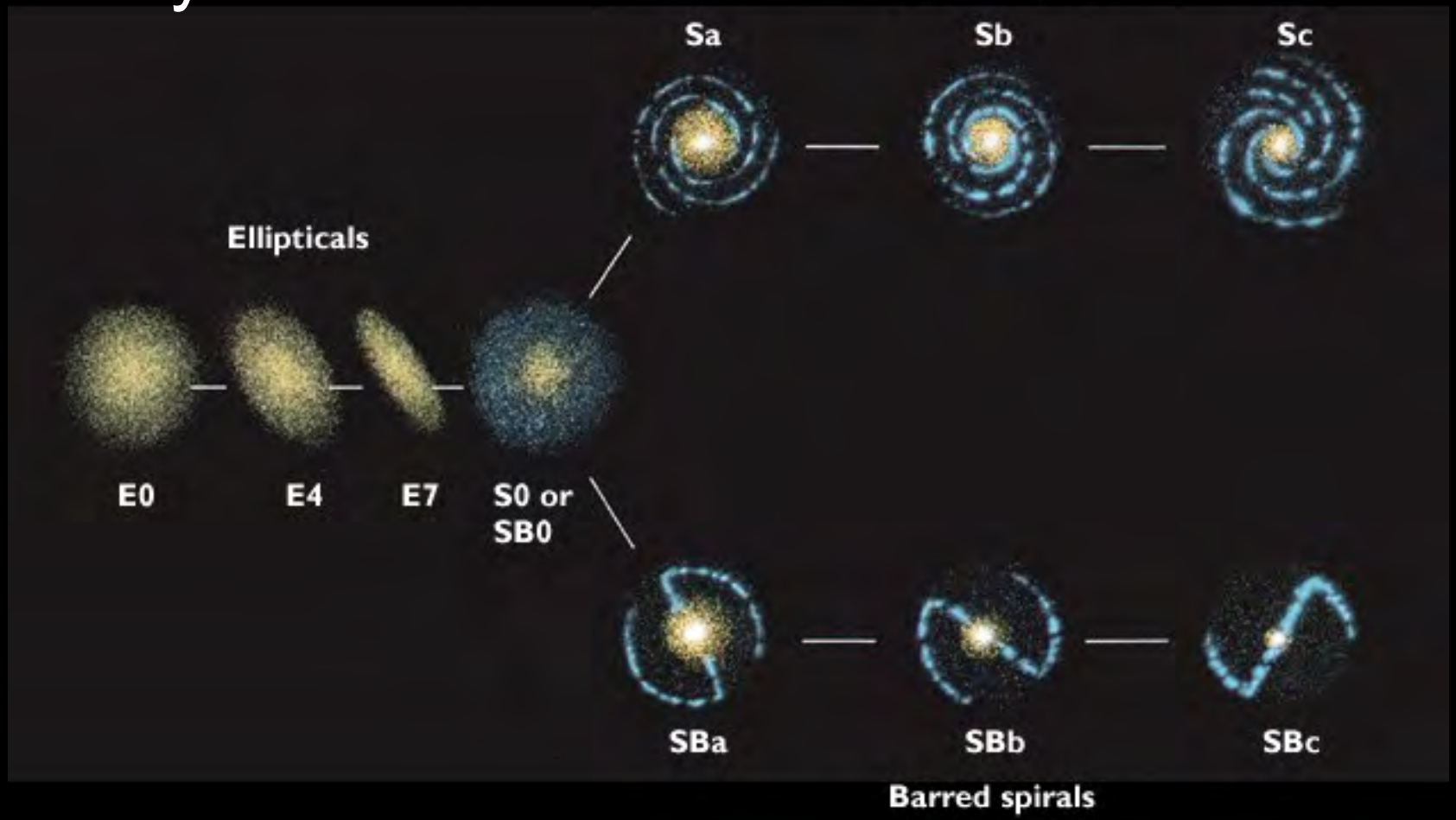
The Milky Way

Milky Way as imagined from outside

Galaxy Types

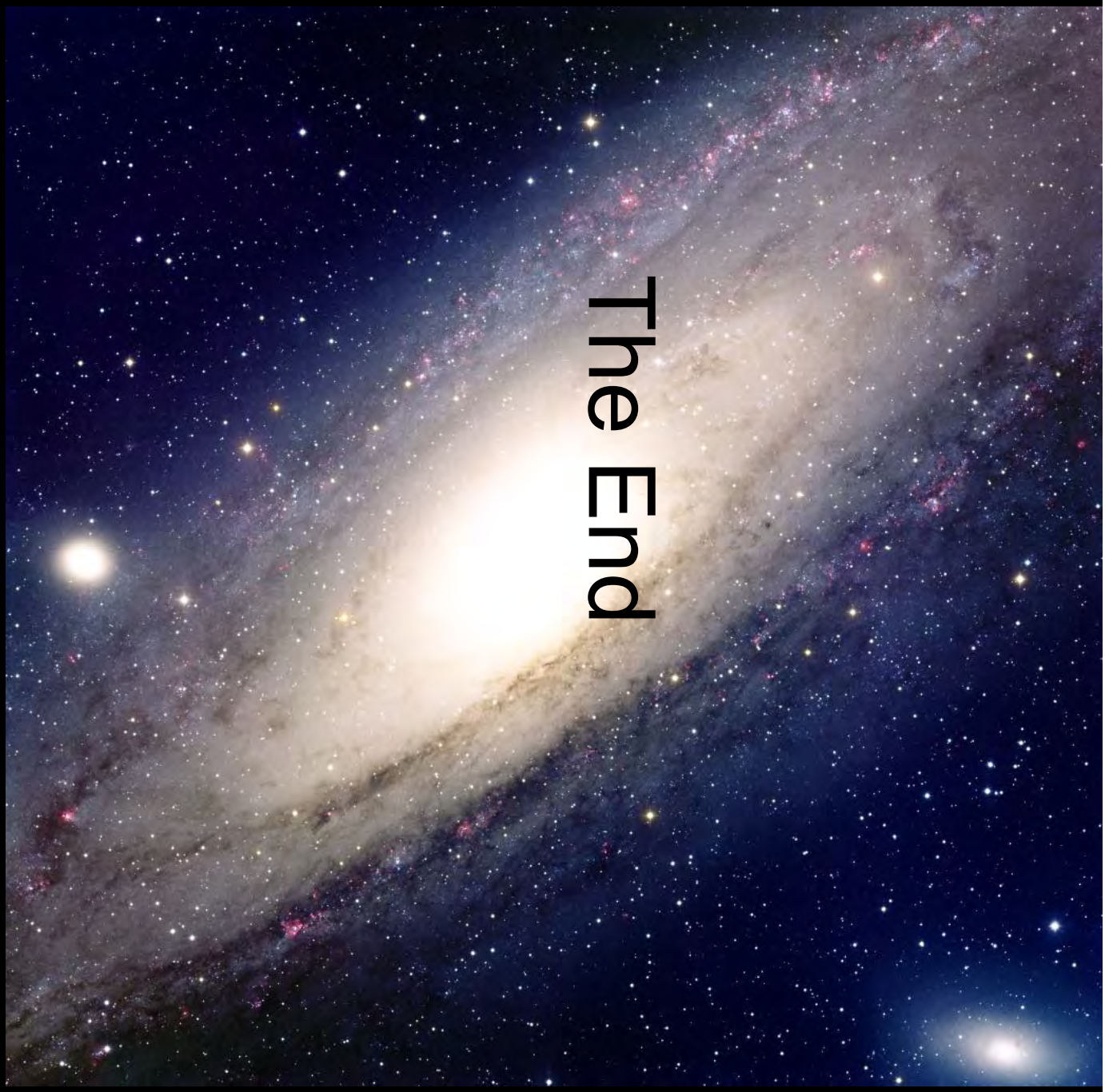
- Galaxies are usually categorized by shape into three types:
  - Elliptical
  - Spiral
  - Irregular
- They are usually categorized by size into:
  - Dwarf
  - Regular
  - Giant

Galaxy Classes



Our Milky Way

- Our galaxy is now known to be a barred spiral, something like SBa.
- Our galaxy contains about 200-400 billion stars, so is a rather large spiral.
- Its mass has recently been estimated to be about 3 trillion solar masses, but most of this is dark matter.
- Its size is about 100 thousand light years across and about 10 thousand ly thick.


The End