

Galaxies

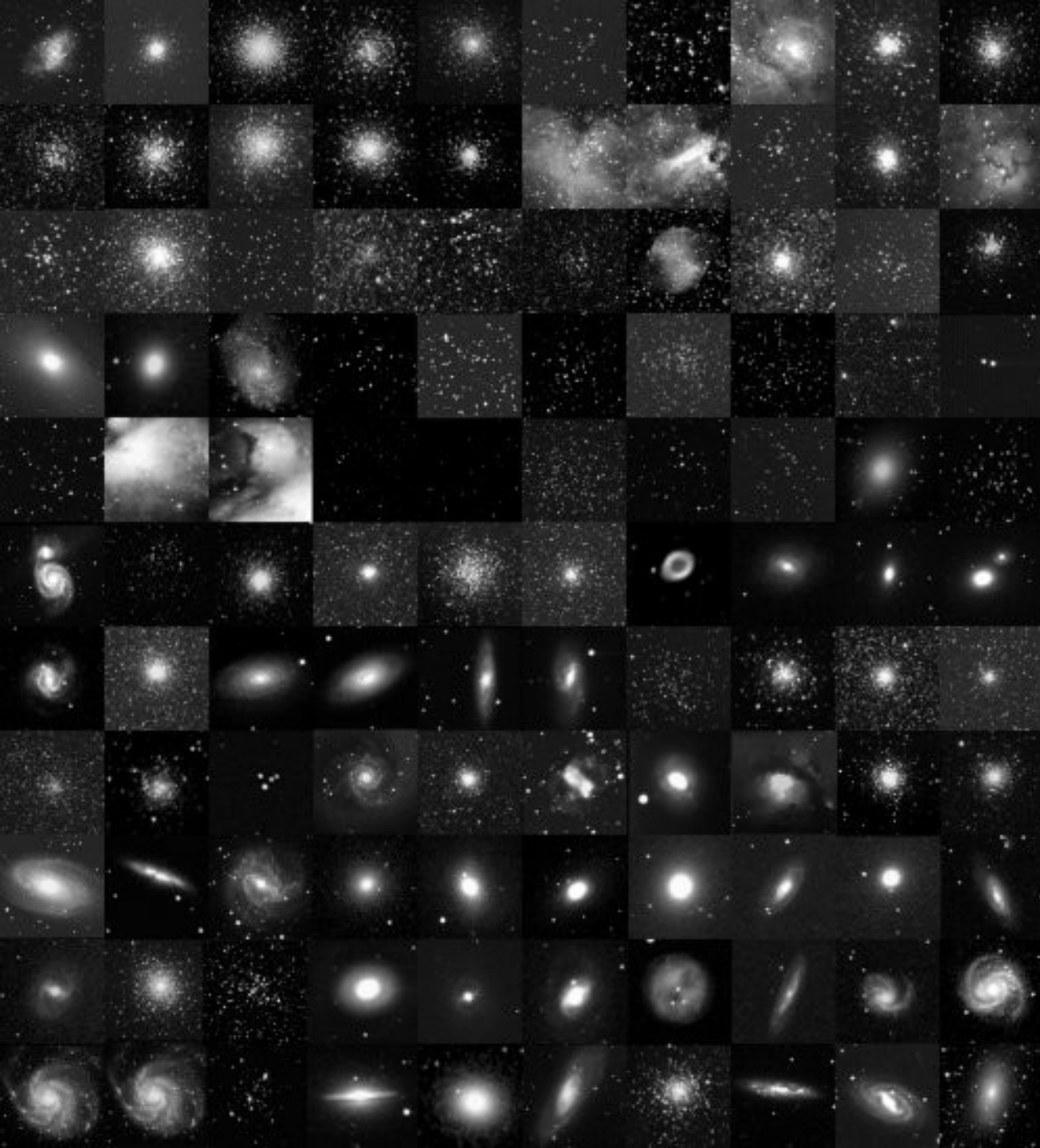
- How big is the Universe?
- Types of galaxies
 - Elliptical
 - Spiral
 - Irregular
- Groups of galaxies

Why are Cepheid variable stars useful in determining distances?

- A) They all have the same distance.
- B) Their luminosity can be determined from their pulsation period.
- C) They all have the same luminosity.
- D) They all have the same radius.

How big is the Universe?

- Spiral nebulae were identified not long after development of the telescope around 1600
- In the 1600's, it was suggested that spiral nebula are separate galaxies so far away that the stars blur together, but most people thought they were clouds of gas
- The question wasn't resolved until 1923.

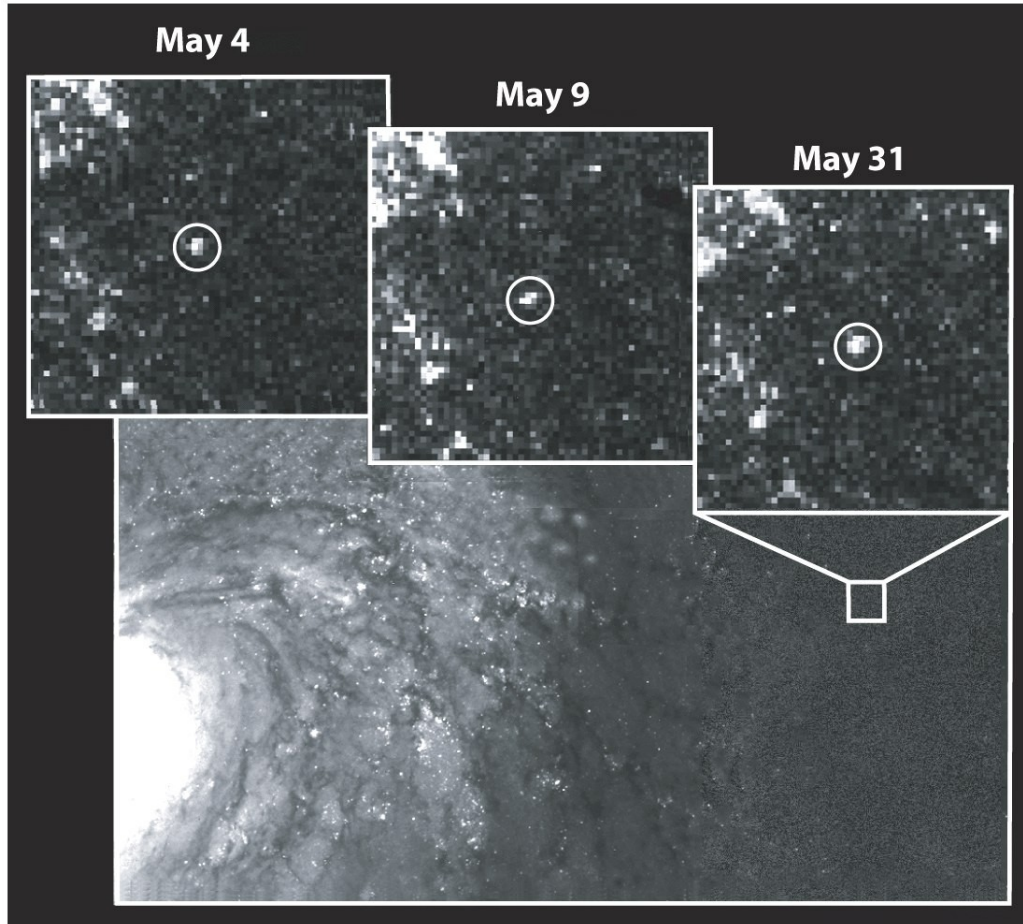


Are there
different
types of
objects
here?

Great debate

- Two astronomers held a great debate in 1920
- Harlow Shapley argued the Milky Way was the whole Universe
- Heber Curtis argued the Milky Way was just one of many galaxies – “island universes”
- Held in the Smithsonian's Museum of Natural History – the auditorium still looks the same

Distance to the Andromeda spiral nebula



- In 1923, Edwin Hubble found Cepheid variable in the Andromeda nebula and showed that the “nebula” was at a great distance, much larger than the size of the Milky Way.

How big is the Universe?

- Greeks (up about 100 B.C.)
 - Earth at Center
 - Universe extends to ‘sphere of Saturn’, largest measured distance is from Earth to Sun at several million miles
- Renaissance (1500-1650)
 - Sun at Center
 - Universe extends to ‘distant stars’ with inferred distance of about 100 billion miles, largest measured distance is from Sun to Saturn at about 1 billion miles

How big is the Universe?

- Parallax to stars
 - First parallax measured in 1838 to star 61 Cygni of 0.3 arcseconds for a distance of 11 ly = 7×10^{13} miles.
- Distance to center of Milky Way
 - from star counts 5000-10,000 ly (1785-1810)
 - from globular clusters 50,000 ly (1915)
- Distance to Andromeda nebula
 - from Cepheids 900,000 ly (1923)

What evidence do we have that there is hidden mass in the galaxy?

- A) cool clouds of hydrogen
- B) RR Lyrae variable stars in globular clusters
- C) flat rotation curve at large radii
- D) dusty regions in the plane

The mass of the Milky Way is best determined by

- A) measuring the total amount of hydrogen gas using the 21 cm line
- B) counting the stars it contains
- C) determining the gravitational force acting on stars
- D) measuring the distribution of globular clusters

M100



NGC
1365



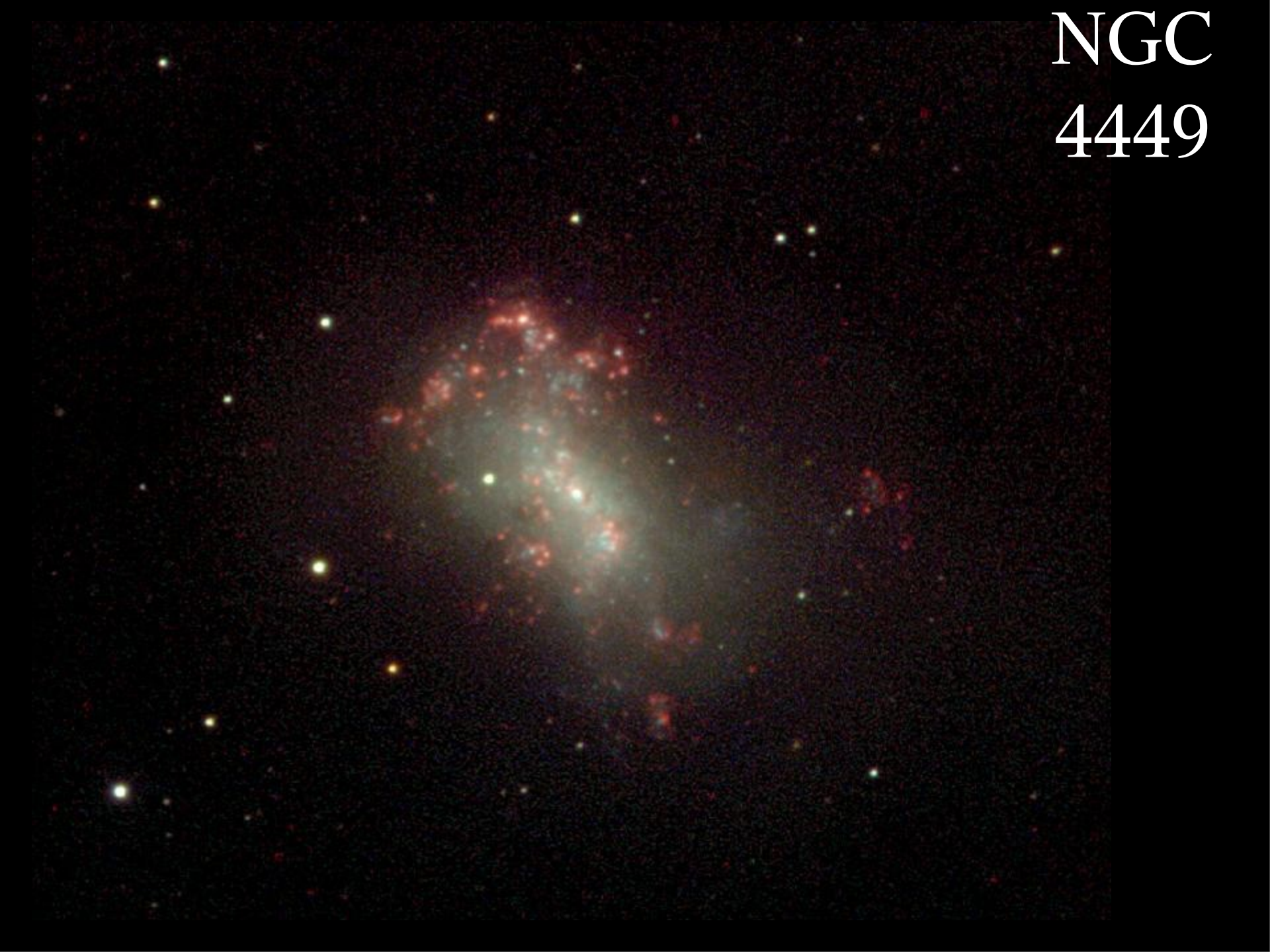
M87



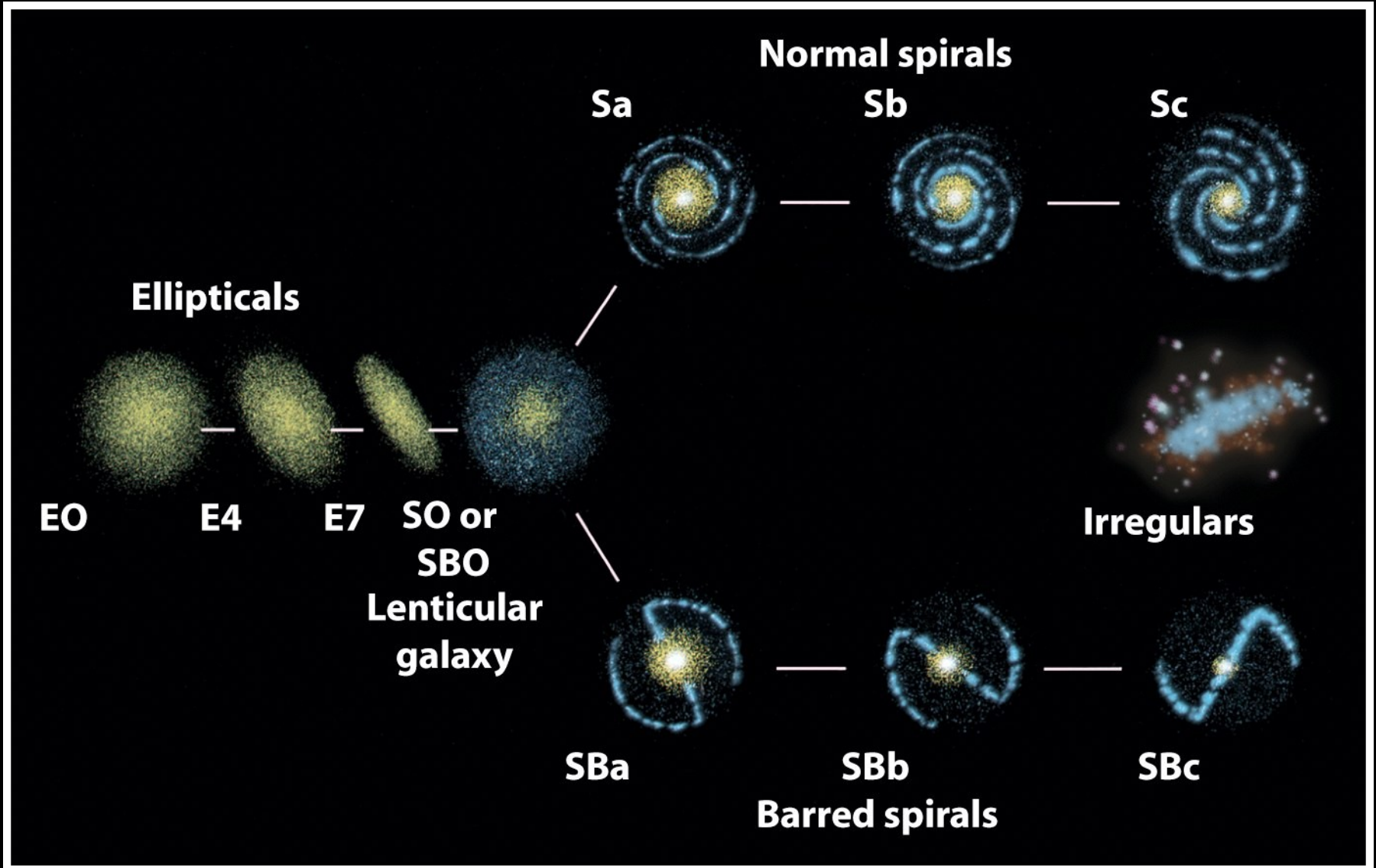
NGC
3377



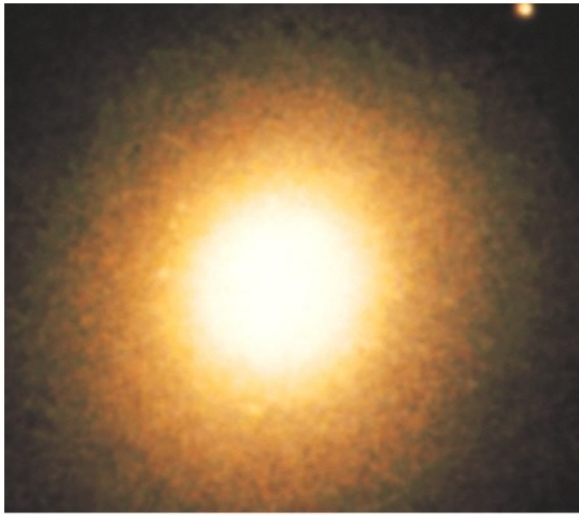
NGC
4449



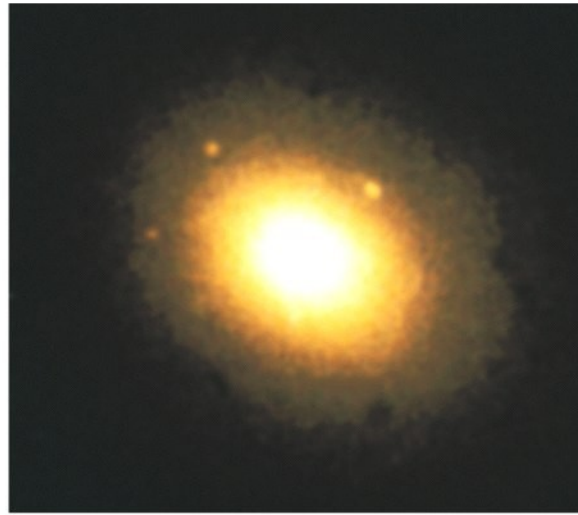
Classifying Galaxies



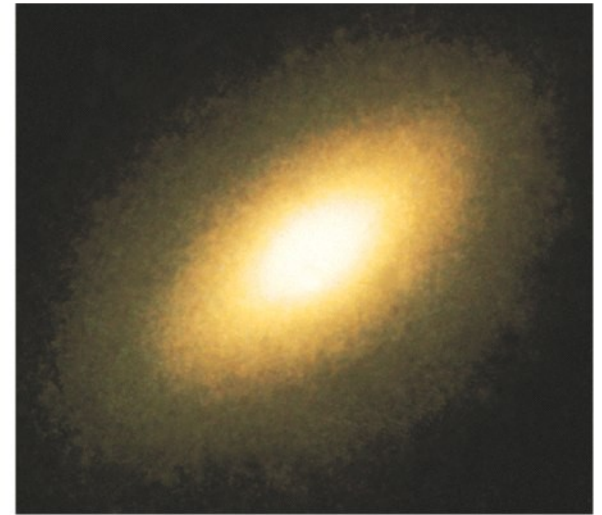
Elliptical galaxies



(a) E0 (M105)



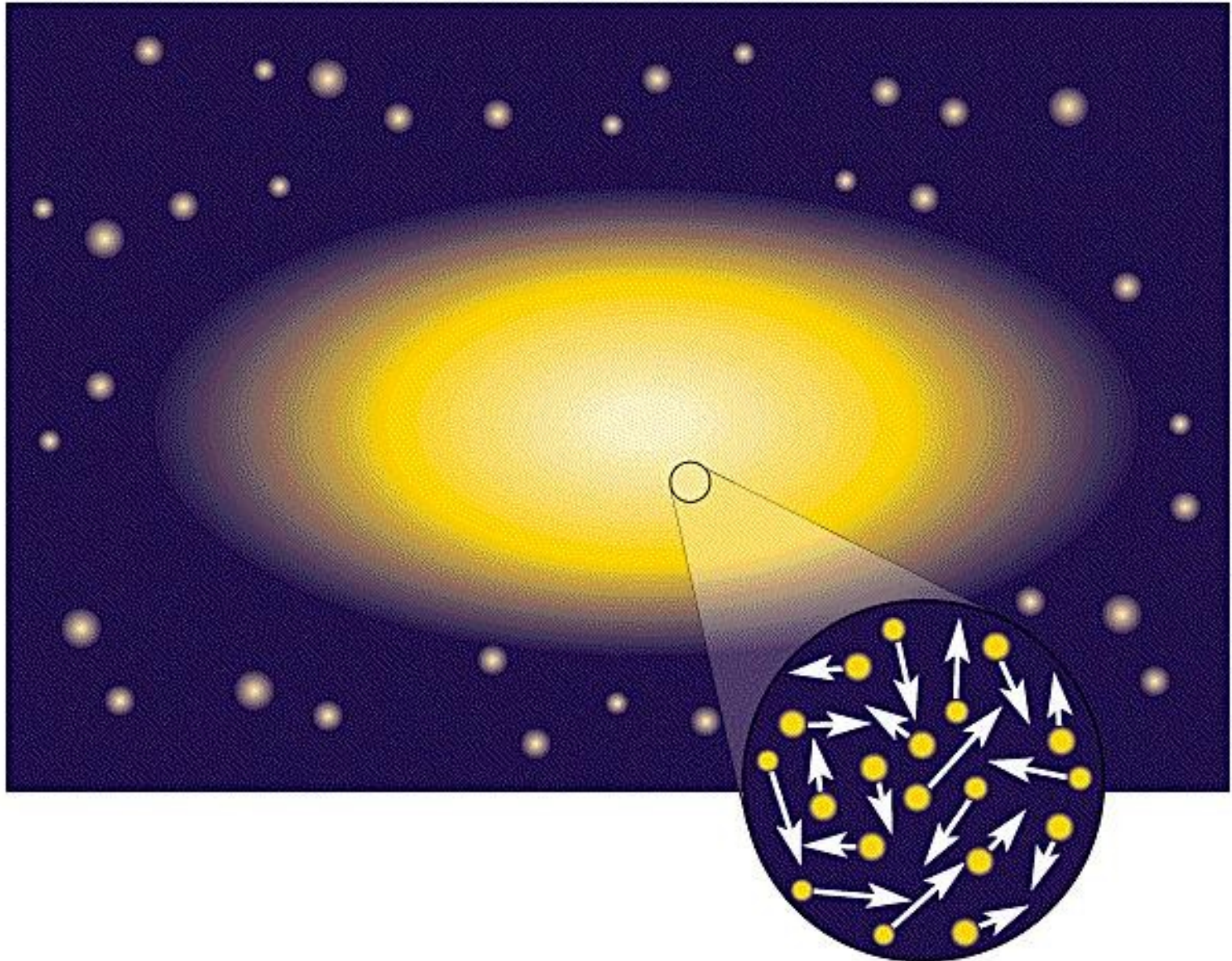
(b) E3 (NGC 4365)



(c) E6 (NGC 3377)

- little interstellar gas and dust
- very little star formation
- mainly old stars (billions of years old)
- few or no young stars (millions of years old)

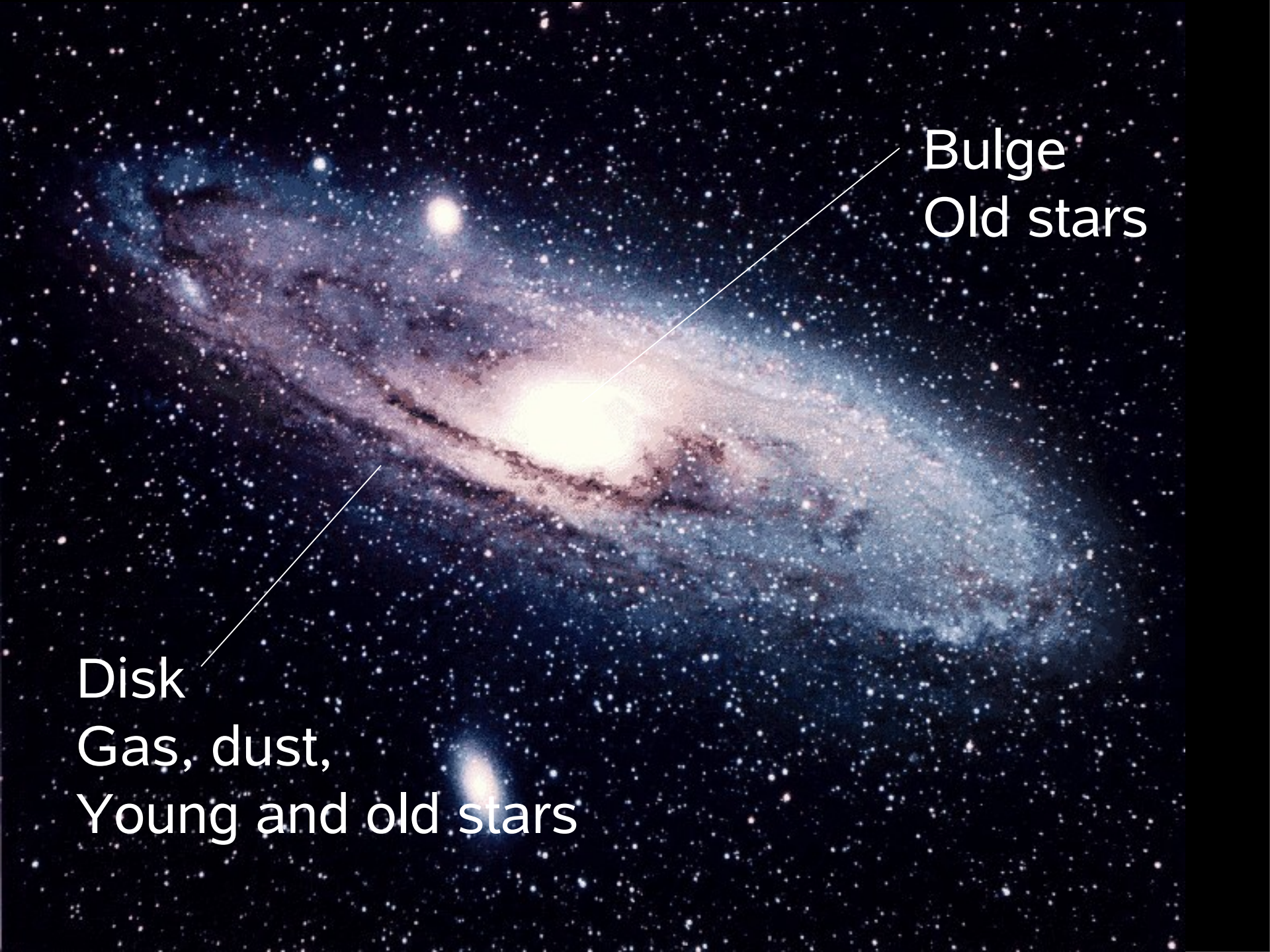
Elliptical galaxies



M86

M84





Bulge
Old stars

Disk
Gas, dust,
Young and old stars

Spirals vary in prominence of bulge, tightness of arms, presence of bar



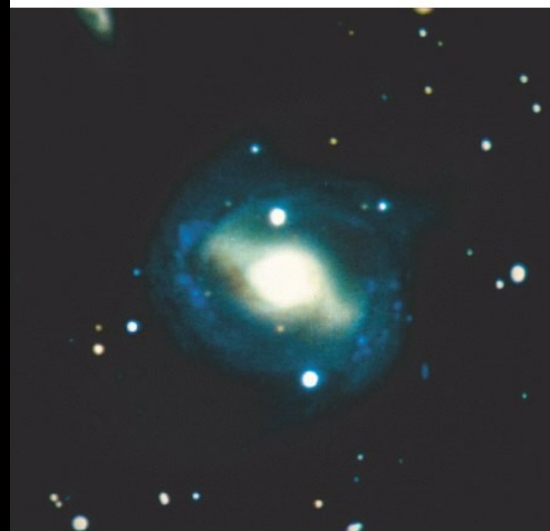
(a) Sa (NGC 1357)



(b) Sb (M81)



(c) Sc (NGC 4321)



(a) SBa (NGC 4650)

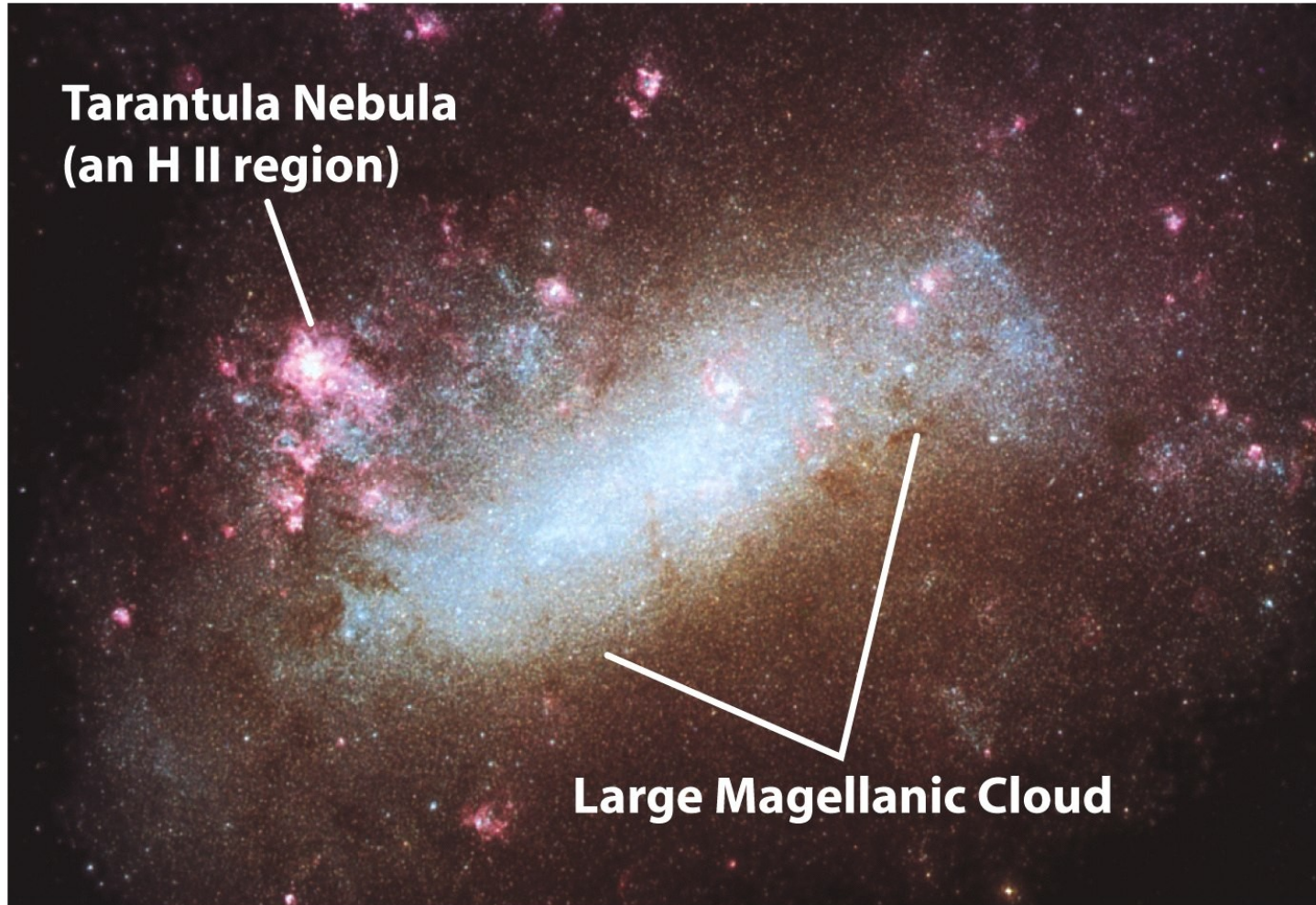


(b) SBb (M83)



(c) SBc (NGC 1365)

Irregular galaxies have asymmetric shapes and usually lots of young stars

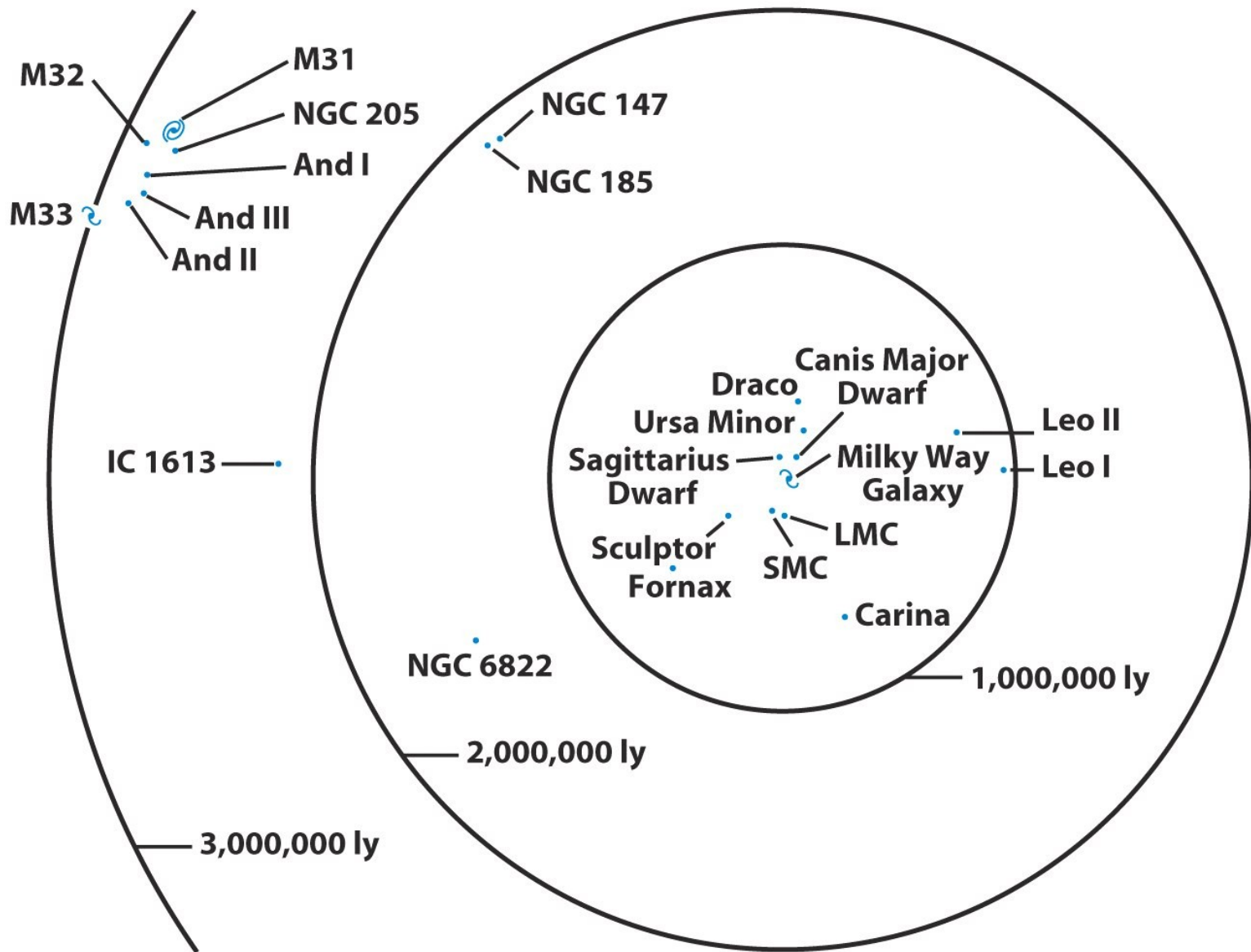


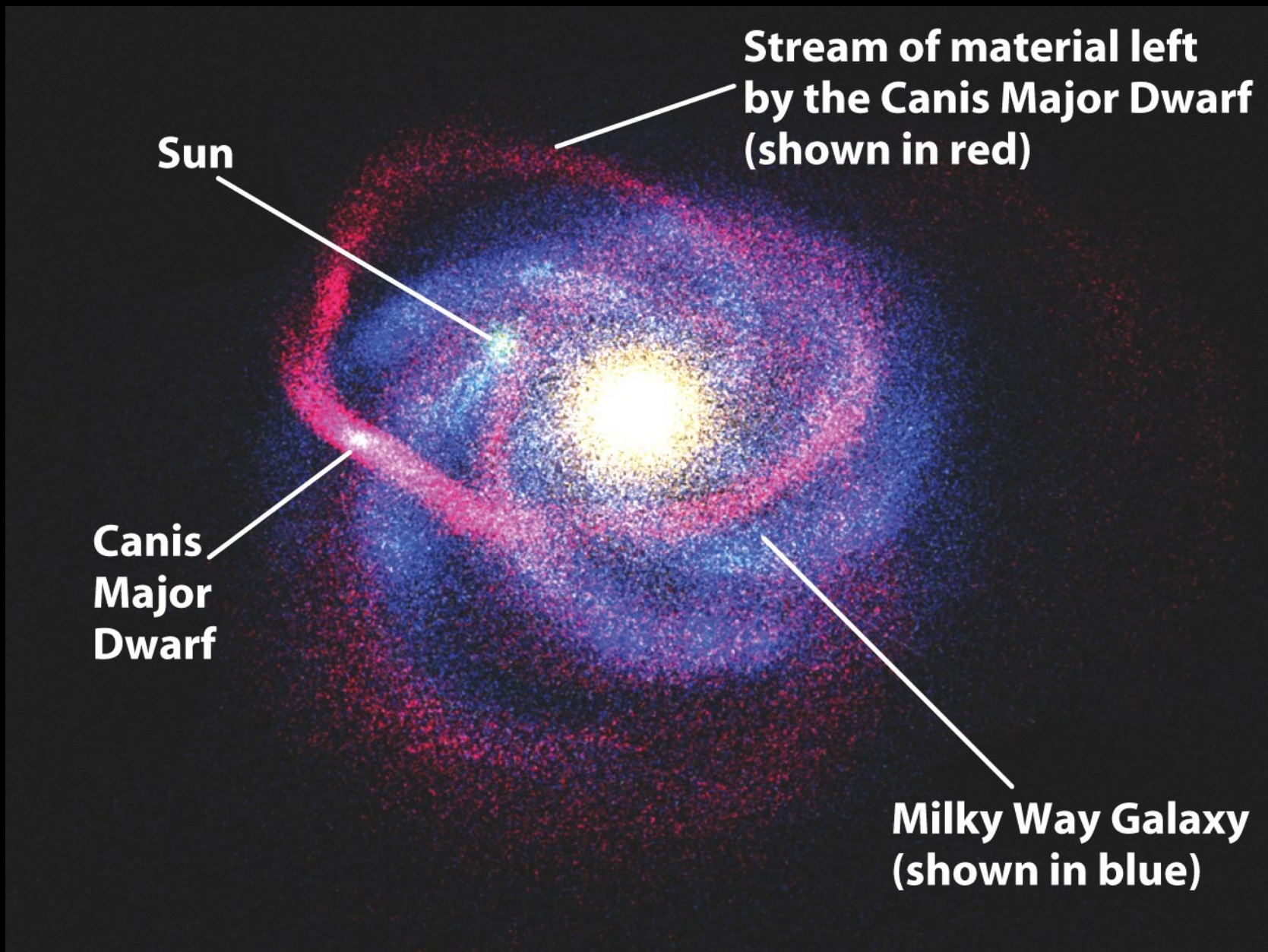
They are often found near other galaxies

The Milky Way galaxy is

- A) irregular
- B) elliptical
- C) spiral
- D) chocolate

Our Galaxy is a member of a small cluster called the Local Group





**Stream of material left
by the Canis Major Dwarf
(shown in red)**

Sun

**Canis
Major
Dwarf**

**Milky Way Galaxy
(shown in blue)**

Review Questions

- What was the definitive evidence showing that “spiral nebulae” are actually entire galaxies outside of the the Milky Way?
- What are the types of galaxies?
- How do the rotation patterns of stars differ in elliptical versus spiral galaxies?
- What is the Local Group?