




Jorge Ramirez
Instructor of Mathematics, Physics & Astronomy


Slide show is a collaboration of  and © 2017 Pearson Education, Inc. modified for educational purposes


ASTRONOMY

Chapter 26 GALAXIES
PowerPoint Image Slideshow



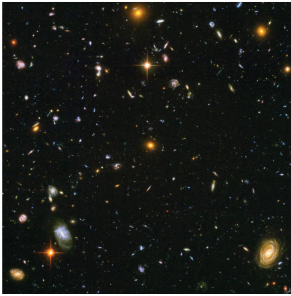
 openstax™

26.1 THE DISCOVERY OF GALAXIES 



▶ **Spiral Galaxy.** NGC 6946 is a spiral galaxy also known as the "Fireworks galaxy." It is at a distance of about 18 million light-years, in the direction of the constellations Cepheus and Cygnus. It was discovered by William Herschel in 1798. This galaxy is about one-third the size of the Milky Way. Note on the left how the colors of the galaxy change from the yellowish light of old stars in the center to the blue color of hot, young stars and the reddish glow of hydrogen clouds in the spiral arms. As the image shows, this galaxy is rich in dust and gas, and new stars are still being born here.


Galaxies and Cosmology




▶ A galaxy's age, its distance, and the age of the universe are all closely related.


▶ The study of galaxies is thus intimately connected with **cosmology**—the study of the structure and evolution of the universe.


© 2015 Pearson Education, Inc.

Figure 26.2 



▶ **Andromeda Galaxy.** Also known by its catalog number M31, the Andromeda galaxy is a large spiral galaxy very similar in appearance to, and slightly larger than, our own Galaxy. At a distance of about 2.5 million light-years, Andromeda is the spiral galaxy that is nearest to our own in space. Here, it is seen with two of its satellite galaxies, M32 (top) and M110 (bottom). (credit: Adam Evans)

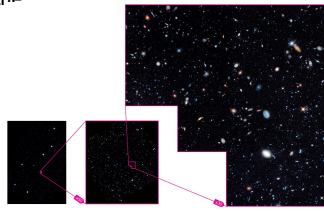
Figure 26.3 



▶ **Edwin Hubble (1889–1953).** Edwin Hubble established some of the most important ideas in the study of galaxies.

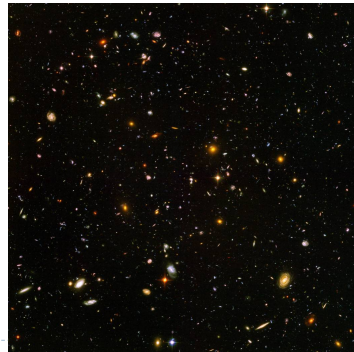
Hubble Deep Field

▶ Our deepest images of the universe show a great variety of galaxies, some them billions of light-years away.

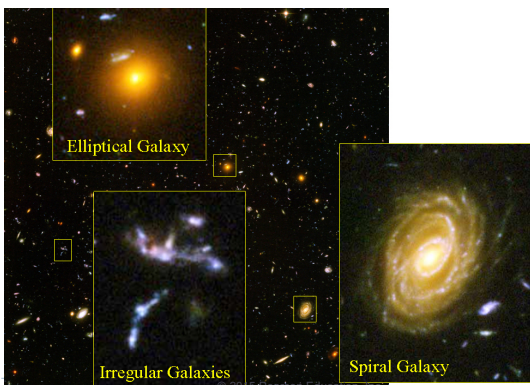
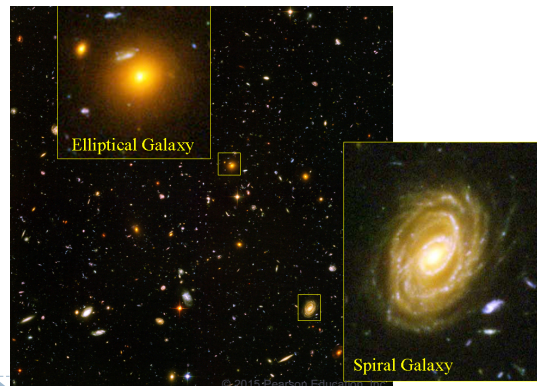
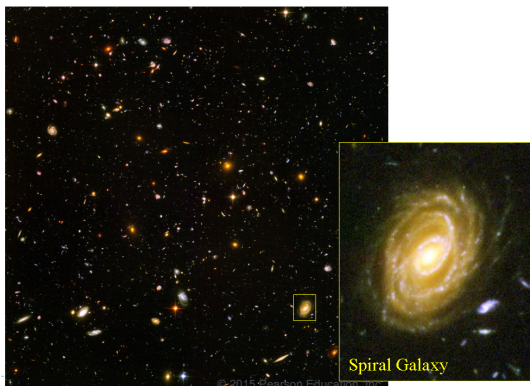


© 2015 Pearson Education, Inc.

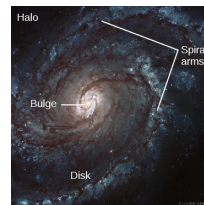
26.2 TYPES OF GALAXIES



© 2015 Pearson Education, Inc.



Spiral Galaxies



▶ **Spiral Galaxies.**

- (a) The spiral arms of M100, shown here, are bluer than the rest of the galaxy, indicating young, high-mass stars and star-forming regions.
- (b) We view this spiral galaxy, NGC 4565, almost exactly edge on, and from this angle, we can see the dust in the plane of the galaxy; it appears dark because it absorbs the light from the stars in the galaxy. (credit a: modification of work by Hubble Legacy Archive, NASA, ESA, and Judy Schmidt; credit b: modification of work by "Jschulman555"/Wikimedia)

Figure 26.5



▶ **Barred Spiral Galaxy.** NGC 1300, shown here, is a barred spiral galaxy. Note that the spiral arms begin at the ends of the bar. (credit: NASA, ESA, and the Hubble Heritage Team(STScI/AURA))

Disk Component:
stars of all ages, many gas clouds

Blue-white color indicates ongoing star formation.



Spheroidal Component:
bulge and halo, old stars, few gas clouds

Red-yellow color indicates older star population...

© 2015 Pearson Education, Inc.

Elliptical Galaxies



All spheroidal component, virtually no disk component

Red-yellow color indicates older star population.

© 2015 Pearson Education, Inc.

Figure 26.7



(a)



(b)

▶ **Elliptical Galaxies.**

- (a) ESO 325-G004 is a giant elliptical galaxy. Other elliptical galaxies can be seen around the edges of this image.
- (b) This elliptical galaxy probably originated from the collision of two spiral galaxies. (credit a: modification of work by NASA, ESA, and The Hubble Heritage Team (STScI/AURA); credit b: modification of work by ESA/Hubble, NASA)

Figure 26.8



▶ **Dwarf Elliptical Galaxy.** M32, a dwarf elliptical galaxy and one of the companions to the giant Andromeda galaxy M31. M32 is a dwarf by galactic standards, as it is only 2400 light-years across. (credit: NOAO/AURA/NSF)

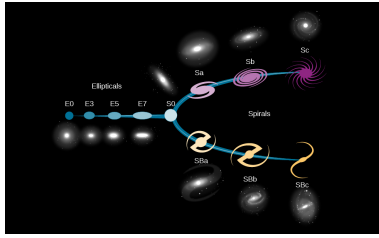


Lenticular Galaxy:

Has a disk like a spiral galaxy but much less dusty gas (intermediate between spiral and elliptical).

© 2015 Pearson Education, Inc.

Figure 26.6



► **Hubble Classification of Galaxies.** This figure shows Edwin Hubble's original classification of galaxies. Elliptical galaxies are on the left. On the right, you can see the basic spiral shapes illustrated, alongside images of actual barred and unbarred spirals. (credit: modification of work by NASA, ESA)

Irregular Galaxies



Neither spiral nor elliptical. Blue-white color indicates ongoing star formation.

© 2015 Pearson Education, Inc.

Evolution of Galaxies



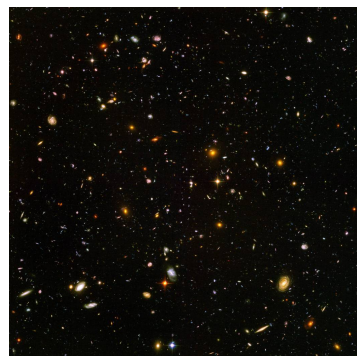
Spiral galaxies are often found in **groups** of galaxies (up to a few dozen galaxies per group).

© 2015 Pearson Education, Inc.



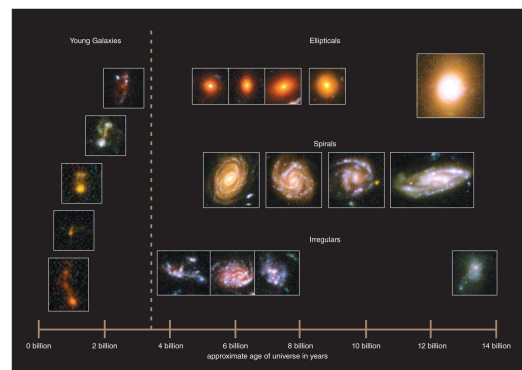
Elliptical galaxies are much more common in huge **clusters** of galaxies (hundreds to thousands of galaxies).

© 2015 Pearson Education, Inc.



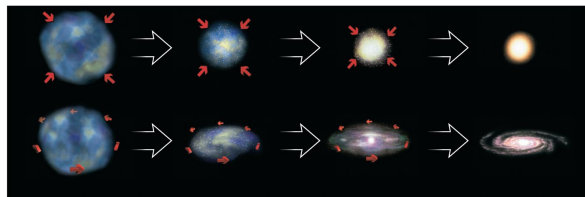
Deep observations show us very distant galaxies as they were much earlier in time (old light from young galaxies).

© 2015 Pearson Education, Inc.



© 2015 Pearson Education, Inc.

Conditions in Protogalactic Cloud?



MA INTERACTIVE FIGURE

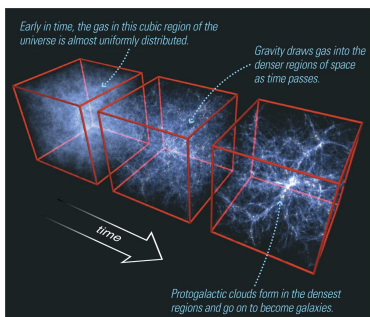
Spin: Initial angular momentum of protogalactic cloud could determine the size of the resulting disk.

© 2015 Pearson Education, Inc.



We must also consider the effects of collisions.

© 2015 Pearson Education, Inc.



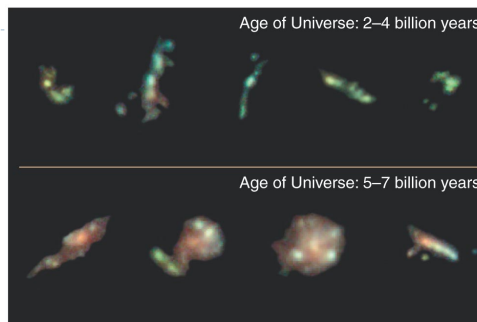
Early in time, the gas in this cubic region of the universe is almost uniformly distributed.

Gravity draws gas into the denser regions of space as time passes.

Protogalactic clouds form in the densest regions and go on to become galaxies.

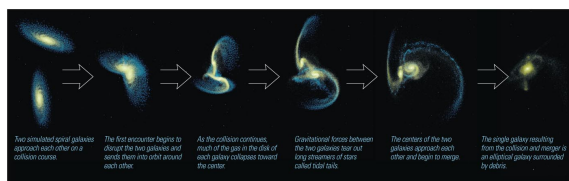
Collisions were much more likely early in time, because galaxies were closer together.

© 2015 Pearson Education, Inc.



Many of the galaxies we see at great distances (and early times) do indeed look violently disturbed.

© 2015 Pearson Education, Inc.



Two simulated spiral galaxies approach each other on a collision course.

The first encounter begins to disrupt the two galaxies and sends them into orbit around each other.

As the collision continues, much of the gas in the disk of each galaxy collapses toward the center.

Gravitational forces between the two galaxies tear out long streams of gas called tidal tails.

The centers of the two galaxies approach each other and begin to merge.

The single galaxy resulting from the collision and merger is an elliptical galaxy surrounded by debris.

MA INTERACTIVE FIGURE

Modeling such collisions on a computer shows that two spiral galaxies can merge to make an elliptical.

© 2015 Pearson Education, Inc.



Collisions may explain why elliptical galaxies tend to be found where galaxies are closer together.

© 2015 Pearson Education, Inc.



Giant elliptical galaxies at the centers of clusters seem to have consumed a number of smaller galaxies.

© 2015 Pearson Education, Inc.