GALAXY SORTING
by Sally Stephens

Background Information on Galaxy Classification

In 1924, astronomer Edwin Hubble proved that galaxies are very distant "island universes" -- each one a collection of millions or billions of stars bound together by gravity. Within a few years, he had set up a system to classify them that is still used today, albeit with some modifications and additions.

Hubble's system divides galaxies into three basic categories: 1) elliptical galaxies, relatively featureless spherical or ellipsoidal (football-shaped) collections of stars; 2) spiral galaxies, with their distinctive arms of stars that spiral out from their centers; and 3) irregular galaxies, a catch-all category for galaxies that don't look like either traditional ellipticals or spirals.

Elliptical galaxies, marked by the letter E, are further subdivided depending on how well-rounded they appear. A number is added that ranges from 0 to 7, with completely round ellipticals denoted by 0, and flattened systems (which look like a squashed football) denoted by 7. An E5 galaxy, for example, is not very spherical, appearing twice as long as it is wide.

Spiral galaxies are divided into two main types: regular spirals, denoted by the letter S, in which the arms spiral outward from the galaxy center, and barred spirals, marked SB, in which the arms wind outward from the ends of a straight "bar" of stars that passes through the center. About two-thirds of all spiral galaxies have some kind of bar. Indeed, astronomers have recently seen evidence of a bar in our own Galaxy's center, making the Milky Way a barred spiral. Both regular and barred spiral galaxies are defined by a spherical bulge of stars at their center, which is surrounded by a thin, rotating disk of stars that contains the spiral arms. You can tell the direction in which the disk rotates by looking at the spiral arms; they trail behind the direction of rotation, much like the coattails of a runner or water thrown out by a twirling lawn sprinkler.

In addition, both regular and barred spirals are subdivided according to how tightly wound the spiral arms are and how prominent the central bulge of stars appears. In Sa galaxies, the spiral arms are tightly wound and the central bulge appears bright, whereas in Sc galaxies, the arms are more loosely wound and the central bulge is much less prominent. Sb galaxies fall in between the two. Similar criteria apply to barred spirals, which are denoted by SBa, SBb and SBc. Irregular galaxies have no subdivisions.

There is also a class Hubble called S0 galaxies, which have characteristics of both ellipticals and spirals, showing a large central bulge and a disk, but no obvious dust lanes or spiral structure.

Regardless of the type, galaxies come in all different sizes. It's impossible to say how large a galaxy is based solely on its photograph. A very large galaxy that is also very distant might look like it is the same size as a much smaller one that's nearby. You have to know its distance to know a galaxy's true size. Our own Milky Way Galaxy is roughly 100,000 light years

across; its disk is only 1000 light years thick, however. (A light year is the distance light travels in one year, that is, 9.5×10^{12} kilometers.)

The Milky Way is a large spiral galaxy, but there are galaxies that are ten times its size, and many that are thousands of times smaller. In fact, astronomers now think that tiny, faint galaxies, called dwarf galaxies, may be the most plentiful galaxies in the universe. Indeed, there are probably so many dwarf galaxies that their combined mass probably exceeds that of all the larger galaxies taken together. But their small size and dimness make them hard to detect and we have only been able to discover them when they are relatively nearby.

Hubble based his classification scheme solely on what galaxies look like. His scheme is still used today because it turns out there are significant physical differences between the different types of galaxies, differences that were not known when Hubble first classified them. Elliptical galaxies contain mostly old stars, with very little gas and dust found between stars. Since new stars form from clouds of interstellar gas and dust, elliptical galaxies lack the raw ingredients to make new stars. Spiral galaxies, on the other hand, have a mix of young and old stars. Interstellar gas and dust fill the disks of spiral galaxies, and new star formation continues to take place in their disks. Irregular galaxies appear chaotic, and often have many bright, young stars, the result of recent bursts of intense star formation.

For many years, astronomers thought the dissimilarities between galaxy types reflected different conditions present in each when they originally formed. Put another way, this view held that galaxies look like they do because they were "born that way." In this view, the stars in elliptical galaxies formed very quickly, using up all the interstellar gas and dust before the material had time to settle into a disk. Star formation in spiral galaxies, on the other hand, took place slowly over the galaxy's lifetime, continuing after the interstellar gas and dust had settled into a disk. One problem with this view has been trying to figure out why star formation would occur rapidly in ellipticals, but much slower in spirals.

Over the past few decades, however, astronomers have learned that galaxies can change their appearance over time, usually as a result of interactions, collisions, or mergers between galaxies. Interactions between galaxies are common because, relatively speaking, galaxies (especially those found in rich groups) are closer to each other than typical stars are. The distance between the Milky Way and its closest large neighbor (the Andromeda Galaxy) is only about 25 times the diameter of the Milky Way. (And our Galaxy has several smaller neighbor galaxies that are significantly closer than that.) By contrast, the distance between the Sun and its nearest neighboring star is about 30 million times greater than the Sun's diameter.

Galaxy interactions can turn one type of galaxy into another. Two or more spiral galaxies, for example, can collide and merge, turning into a giant elliptical galaxy. Mergers and collisions often stimulate intense bursts of star formation in the affected galaxies. As a result, many irregular galaxies are now also thought to be the result of galactic interactions or collisions.

Although collisions alter the overall appearance of galaxies, they rarely bother the stars themselves, other than changing their galactic orbits. There is so much empty space between the stars that the stars of two colliding galaxies can pass among each other, like ships on the dark

ocean at night. The galaxies as a whole can't miss hitting each other, but the individual stars within them rarely collide.

Astronomers now know that interactions and collisions can play a role in what galaxies look like. But they still don't know exactly how important that role is. It is now thought that both the initial conditions and interactions later in a galaxy's life combine to influence how galaxies appear.

Over the years, astronomers have added a few refinements to Hubble's classification scheme. For example, one modification considers whether arms spiral outward from a ring of stars or not. Another considers a spiral galaxy's total brightness, and assigns a “luminosity class” to each spiral. These changes have come about as astronomers learned more about galaxies and which properties are more (or less) important. No doubt future astronomers will make additional changes to Hubble's classification scheme as they try to understand why galaxies look the way they do.

Galaxy Names

Astronomers generally refer to galaxies by their catalog names, that is, by the number by which they are listed in a specific catalog. Eighteenth-century comet-hunter Charles Messier compiled a list of "fuzzy-looking" objects in the night sky, so he wouldn't mistake them for new comets (which were his real interest). Many of the brightest galaxies are included in the Messier catalog, and are denoted by the letter "M" followed by their number on the list, e.g., M32.

Another major source of galaxies is the New General Catalog, a list of non-stellar objects compiled initially by J.L.E. Dreyer in 1888. The list has since been expanded to include (in the catalog and its supplements) nearly 15,000 objects. Objects in the catalog are identified by the catalog's initials, "NGC", followed by their number in the catalog, e.g., NGC 4565. The later additions are called Index Catalogs, and so some galaxies have an IC number instead of an NGC number. The same galaxy may be referenced in more than one catalog. Thus, for example, the names M101 and NGC 5457 refer to the same galaxy.

Galaxies within the “Local Group” of several dozen galaxies (that includes the Milky Way) are often just denoted by the constellation in which they are found, such as Leo I or Andromeda II.