

GALAXY SORTING by Sally Stephens

Captions for the Galaxy Images (for Teacher Reference)

NOTE: These captions are for the information of the activity leader. It is best to hold off giving out any of this information until AFTER the students have had a chance to develop and critique their own classification schemes.

1) **M32** -- This is an E2 elliptical galaxy. Note that it is a little more flattened or squashed than an E0 galaxy would be (compare with image 11). M32 is a companion galaxy to the Milky Way Galaxy's nearest large-galaxy neighbor, the Andromeda Galaxy (also known as M31). M32 is known as a dwarf elliptical galaxy because it is so small, only 2400 light years across (compared to the Milky Way's 100,000 light year diameter). It is located about 2.5 million light years away in the direction of the constellation Andromeda. *Image courtesy William C. Keel, of the University of Alabama, Tuscaloosa, and the Kitt Peak National Observatory.*

2) **M101** -- This is a Sc spiral galaxy. Notice how loosely wound the spiral arms appear, and how weak the central bulge looks relative to the brightness of the spiral arms. Both characteristics are typical of Sc galaxies. Compare the spiral arm winding and the central bulge strength with images 3, 6, 10, and 18. M101 is among the largest disk galaxies, with a diameter of 170,000 light years. It is located about 22 million light years away in the constellation Ursa Major. *Image courtesy William C. Keel, of the University of Alabama, Tuscaloosa, and the Kitt Peak National Observatory.*

3) **M65** -- This Sa spiral galaxy is seen at a highly tilted angle. Because of the tilt, the dust in one of its spiral arms (the one closest to us) appears to block the light behind it. This can help give us a sense of how thick the dust-filled disk is relative to its width (compare to spiral galaxies seen edge-on in images 9 and 12). Although M65 is viewed at an angle, its spiral arms appear to be fairly tightly wound, with little space between them. In addition, its central bulge is very bright, especially when compared to how bright the spiral arms appear (compare the arm winding and central bulge brightness to those in other spiral galaxies in images 2, 6, 10 and 18). M65 is roughly half the size of the Milky Way, and is located about 35 million light years away in the direction of the constellation Leo. *Image courtesy William C. Keel, of the University of Alabama, Tuscaloosa, and the Kitt Peak National Observatory.*

4) **M109** -- This SBc barred spiral galaxy has a prominent bar passing through its center. In addition, a ring of stars surrounds the center, and the outer arms seem to spiral outward from the end of the bar and the ring. The central bulge is bright but fairly small. Compare this to the other barred spirals in images 14 and 20. It is located about 55 million light years away in the direction of the constellation Ursa Major. *Image courtesy William C. Keel, of the University of Alabama, Tuscaloosa, and the Lowell Observatory.*

5) **M82** -- This chaotic-looking Irregular galaxy is known as a "starburst" galaxy because it shows evidence of a recent intense burst of star formation. The burst was caused by its interaction with another galaxy (M81, image 10). M82 is actually a rather small galaxy, about 1/4 the size of the

Milky Way. It contains about 1/5 the mass of its interacting companion M81. It is located about 12 million light years away in the direction of the constellation Ursa Major. *Image courtesy William C. Keel, of the University of Alabama, Tuscaloosa.*

6) **M51** -- Also known as the "Whirlpool Galaxy," this Sc spiral galaxy is clearly interacting with a much smaller Irregular companion galaxy. Notice how its spiral arms (especially the outer ones) appear distorted by the gravitational effects of the companion. In three dimensions, the companion is actually located well behind the arm that appears to connect the two galaxies. Indeed, some lanes of dust in the spiral arm block light from the companion. The central bulge of M51 is relatively small and not much brighter than the spiral arms (compare to other spiral galaxies in images 2, 3, 10, and 18). M51 is very similar in size to the Milky Way, and is located about 22 million light years away in the direction of the constellation Canes Venatici (the Hunting Dogs). *Image courtesy William C. Keel, University of Alabama, Tuscaloosa, and the Lowell Observatory.*

7) **The Large Magellanic Cloud** -- This Irregular galaxy is one of the Milky Way Galaxy's closest companions, located only 160,000 light years away. It has a diameter of about 20,000 light years. It is part of the Local Group, a small grouping of several dozen galaxies, including the Milky Way, that are gravitationally bound together. The Large Magellanic Cloud (also known as the LMC) is so close, it is interacting with the Milky Way Galaxy. In fact, astronomers now think interaction with the LMC may have helped form the bar in the Milky Way's center. In about a few billion years, the Milky Way will "swallow" the LMC. While the LMC as a distinct physical entity will cease to exist, its stars will live on as part of the larger Milky Way Galaxy. The LMC is visible to the naked eye in the Southern Hemisphere in the constellations of Dorado. *Image courtesy AURA/NOAO/NSF.*

8) **Arp 252** -- The interaction between these two spiral galaxies has distorted their spiral arms, stretching them out into long tails. These long tails are characteristic of galaxy collisions and interactions. Arp 252 gets its name from a catalog of peculiar and interacting galaxies, put together by astronomer Halton C. Arp, that helped draw attention to these unusually shaped galaxies. It is located about 450 million light years away in the direction of the constellation Hydra. *Image courtesy William C. Keel, of the University of Alabama, Tuscaloosa, and the European Southern Observatory.*

9) **NGC 4565** -- This is an edge-on Sb spiral galaxy. Dust in the thin disk blocks light from the central bulge of stars. All spiral galaxies would look like this if we could see them from the side. Compare this to another edge-on spiral galaxy (image 12) to see how the prominence of the central bulge can vary from galaxy to galaxy. NGC 4565 is about the same size as the Milky Way and is located roughly 31 million light years away in the direction of the constellation Coma Berenices. *Image courtesy William C. Keel, University of Alabama, Tuscaloosa*

10) **M81** -- This Sb spiral galaxy had a close encounter with the small irregular galaxy M82 (image 5) a few tens of million years ago. Although only about half the size of the Milky Way, it is more than twice M82's size. M81's gravity caused the chaotic distortions seen in M82, and the close encounter initiated M82's burst of star formation. The encounter may have also had an effect on

M81's spiral pattern, making it more pronounced. M81 and M82 are now roughly 150,000 light years apart, about as far as the LMC is from the Milky Way. M81 is located about 12 million light years away in the direction of the constellation Ursa Major. *Image courtesy AURA/NOAO/NSF.*

11) **M87** -- This giant elliptical galaxy (E0 or E1) appears almost completely circular. Astronomers don't know for sure if elliptical galaxies look the same from all angles, so it's not known for certain if M87 is perfectly spherical, or if it might look more flattened if viewed from another angle. Over 100,000 light years across, M87 may contain enough matter to make several thousand billion Suns. Although M87 looks very much like M32 (image 1), M87 is more than 40 times larger. It is a prominent member of the Virgo Cluster of galaxies, one of the nearest rich groups of galaxies (about 50 million light years away). Astronomers think M87 may have formed from the merger of several spiral galaxies tens of billions of years ago. It is located in the constellation Virgo. *Image courtesy AURA/NOAO/NSF.*

12) **M104** -- Also known as the "Sombrero Galaxy," this Sa or Sb spiral galaxy is seen edge-on, i.e., from the side. Because it is seen from the side, it's difficult to tell how tightly wound its spiral arms are -- a factor in why its galaxy type is not certain. Dust in its thin disk blocks out light from the central bulge of stars, clearly showing the dimensions of the disk. The central bulge in M104 is much more prominent than that in another edge-on spiral, NGC 4565 (image 9). M104 is generally thought to be a member of the Virgo Cluster of galaxies, which would put it at roughly 50 million light years distant. It is about 80,000 light years across, and is located in the constellation Virgo. *Image courtesy AURA/NOAO/NSF.*

13) **NGC 2146** -- This is a peculiar Sab spiral galaxy. Dust in one of its spiral arms blocks out light from the central bulge of stars. NGC 2146 is located about 42 million light years away in the constellation Camelopardus (the Giraffe). *Image courtesy AURA/NOAO/NSF.*

14) **NGC 1365** -- This is one of the most prominent barred spiral galaxies in the sky, with spiral arms that extend from the ends of the central bar. The bar and spiral pattern in this SBb galaxy rotate clockwise, taking about 350 million years to complete one rotation. With a diameter of about 200,000 light years, NGC 1365 is a supergiant galaxy located about 60 million light years away in the constellation Fornax (the Furnace). *Image courtesy of the European Southern Observatory.*

15) **NGC 4650A** -- This Irregular galaxy is an example of a class known as "polar ring galaxies." Only about 100 polar ring galaxies are known. Located about 130 million light years away, NGC4650A is thought to be the result of a collision between two galaxies at least a billion years ago. The remnants of one galaxy form what looks like a flattened elliptical galaxy in the center. Gas from a smaller galaxy that came too close was then stripped from its original host galaxy and pulled into a ring of gas, dust and stars that orbits at right angles the remnants of the first galaxy. The ring in NGC 4650A is seen nearly edge-on. The galaxy is located in the constellation Centaurus. *Image courtesy Hubble Heritage Team (AURA/STScI/NASA).*

16) **NGC 6946** – This face-on spiral galaxy has the rather unusual classification of SAB(rs)cd, which refers to the fact that it has a poorly-developed bar across the middle (the AB in the classification), a small core with a number of well-developed spiral arms (the cd), and an inner confused ring (the rs). NGC 6946 is over 70,000 light years across and is located nearly 20 million light years away in the constellation of Cygnus. *Image courtesy AURA/NOAO/NSF.*

17) **Leo I** -- This loose grouping of stars is a dwarf elliptical galaxy (E3). It is a member of the Local Group of galaxies that includes the Milky Way. Located about 600,000 light years away, it is a mere 1000 light years across. Small, faint galaxies like this one may be the most common galaxies in the universe, but, because they are small and dim, they can be very hard to detect. *Image courtesy David Malin, Anglo-Australian Observatory.*

18) **NGC 253** – This Sc spiral galaxy is seen nearly edge-on. It is located about 8 million light years away in the constellation Sculptor. Notice that the central bulge of stars is not very prominent in this galaxy. *Image courtesy European Southern Observatory.*

19) **M59** -- This E5 elliptical galaxy is significantly flattened. Compare its shape to that of the E0 galaxy M87 (image 11) and the E2 galaxy M32 (image 1), and look for the increasingly flattened shapes as you go from E0 to E5. M59 is a member of the Virgo Cluster of galaxies. At a rough distance of 50 million light years, it has a diameter of about 75,000 light years, smaller than M87. M59 is located in the constellation Virgo. *Image courtesy AURA/NOAO/NSF.*

20) **NGC 1073** -- This SBc barred spiral has a fairly prominent bar that passes through its center. Its arms spiral outward from points that are offset slightly from the ends of the bar. The galaxy's central bulge is rather small and of comparable brightness to its spiral arms, leading to its designation as a type "c" barred spiral. NGC 1073 is located about 56 million light years away in the constellation Cetus. *Image courtesy SEDS.*