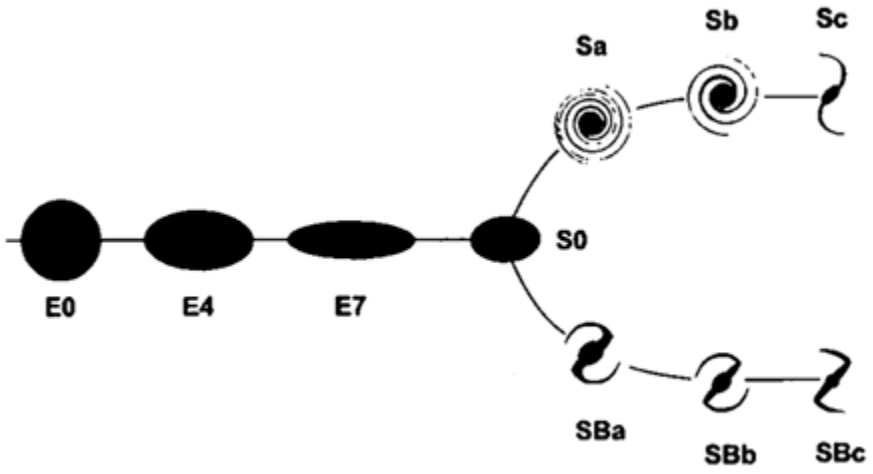
2001 Colorado Regional Science Olympiad **Name[s]:** _____

Division C: "Reach for the Stars" _____

Hubble's Universe



An American astronomer, Edwin Hubble, was the first to classify galaxies. His classification scheme, based solely upon appearance, grouped galaxies into four basic types – **ellipticals**, **spirals**, **barred spirals**, and **irregulars**. Although this classification scheme may appear to suggest an evolutionary sequence of galaxy formation, be careful for this has not yet been proven nor may it ever be.

The galaxies at the left of Hubble's "Tuning Fork" diagram sketched above are **ellipticals**. These galaxies have been classified according to their apparent degree of oblateness … from the nearly perfectly round E0 to the elongated, lens-shaped E7. Elliptical galaxies have no spiral arms and few exhibit any sign of a flattened galactic disk or internal structure. Most ellipticals contain little or no gas or dust. Stellar density, the number of stars per given volume, increases from their outer fringes to their very center. Most stars within ellipticals are old, low in mass, and reddish in color. Movement of stars within elliptical galaxies appears chaotic rather than orderly. Be aware that differences exist between the vast number of ellipticals, so expect to find exceptions to the characteristics cited in this paragraph.

1. Why would you not expect to find young stars or signs of on-going star formation within elliptical galaxies? _____

   _____

Spiral galaxies appear in the upper right portion of Hubble's tuning fork. A spiral galaxy displays a galactic bulge at the center of a flattened disk with outward spiraling arms, surrounded by a halo of scattered stars and star clusters. Stellar density is greatest within the galactic nucleus at the center of the bulge. The bright blue stars located in the spiral arms contrast with prominent reddish stars in the central bulge and surrounding

halo. Dust and gasses, revealed by photographs and spectra, prove densest within the spiral arms.

Spiral galaxies, denoted with a capital S, are subdivided into a, b, and c classes according to the size of their central bulge. Those with the largest bulges and tightened spiral arms are Sa; those with slightly smaller bulges and slightly less tightening of their spiral arms are Sb; and those with small bulges and poorly defined spiral arms are Sc. The latter spiral galaxies, denoted as Sc, often have scattered clumps of stars within their spiral arms. Although a correlation between the size of the central bulge and the tightness of the surrounding arms often provide clues as to the classification of a spiral galaxy, this correlation is not quite perfect.

Spiral galaxies, as observed from Earth, may appear face-on, edge-on or tilted at any angle between. The pattern of spiraling arms of those spiral galaxies viewed edge-on may be indistinguishable, but their darkened centers of densely packed dust particles, emitted gasses, and new stars may betray their otherwise hidden spiral form.

2. Where may new stars and on-going star formation be found within a spiral galaxy? __

   _____

3. List two clues that point to the location of new stars and on-going star formation within a spiral galaxy? a. _____

   b. _____

Barred spirals are a fascinating variation of normal spirals. These galaxies display an elongated bar of stellar and interstellar matter passing directly through their centers and extending well beyond their central bulge. The spirals radiate outward from the ends of the bars rather than from the central bulge as in normal spirals. Barred spirals are denoted as SB with further classification as a, b, and c, depending upon the size of the central bulge and the tightness of the spirals. It is often difficult to determine where the bars of SBc galaxies end and the spirals begin. Normal spirals and barred spirals are very similar both physically and chemically. Recent findings that the central bulge within our own Milky Way galaxy may be elongated has opened a debate as to whether it may actually be a barred galaxy rather than a normal galaxy as traditionally thought.

At the juncture of the fork is a hybrid type of galaxy, classifed as SO, that shares some traits of both spirals and ellipticals. These galaxies appear to have a thin disk and a flattened bulge with no gas and no spiral arms. If no bar is evident, they are classified as **SO**. If a faint sign of a bar is present, they are classified as **SBO**.

There exist a large number of galaxies with traits far different from those galaxies included within Hubble's tuning fork. These are the **irregulars**. They tend to be rich in young, blue stars and interstellar matter, but are lacking in regular structure. Irregular galaxies have been subdivided into two types – Irr I and Irr II. Those with the appearance of misshapen spirals, the more common of the two, are classified as Irr I. Those with a distinctive explosive or filamentary appearance have been classified as Irr II. The latter may have resulted during a collision or close encounter between separate systems.

4. Classify the galaxies on the accompanying photo sheet according to Hubble's Classification, i.e. Sa, Sb, Sc, E1, E2, E3, E4, E5, E6, E7, SBa, SBb, SBc, Irr-I and Irr-II.