# GALAXY CLASSIFICATION

## OBJECTIVES

1. To gain an understanding of Hubble's Tuning Fork and how galaxies are classified.
2. To be able to identify and classify the different types of galaxies.
3. To understand how astronomical images are produced, how CCD cameras work, and how and why filters are used.

## INTRODUCTION

There are many beautiful images of galaxies and other celestial objects that astronomers use to learn more about these objects and to show the public how amazing astronomy can be. However, when these same objects are viewed directly through a telescope, they appear much less vibrant and colorful. Astronomers use various techniques and tools to create the beautiful images seen in posters and on the Internet.

Our eyes can only see a very small portion of the light in the Universe (visible light) and in order to incorporate the remaining light, that we cannot see, astronomers use different filters to view the objects. Filters only allow a certain wavelength (or type) of light to pass through them, such as ultraviolet, visible, or infrared. The cameras used to record this light are called Charge Coupled Devices (or CCDs). CCDs only record the number of photons (or light "particles"), not each photon's wavelength. This means that the colors that you see have to be added to the picture later. For example, one could take images of the same galaxy using three different filters- ultraviolet, visible, and infrared- then assign a color to each image- typically blue, yellow, and red. The last step is to combine the three colored images to make one vibrant and colorful image of that galaxy. Not only does this create beautiful images, it also allows astronomers to better understand the structure of the object and where the gas, stars, dust, and other important features are located.

The main goal of this lab is to look through images- some colored, some not- of various galaxies and to identify what type of galaxy it is. Astronomers are still working on identifying the many galaxies that have been discovered in recent years, and they often seek the help of the public through programs such as Galaxy Zoo.

One major tool used to identify galaxies is Hubble's Tuning Fork, which organizes galaxies based on their photographic appearance. Edwin Hubble worked extensively on galaxies in the early 1900's trying to understand how they changed over time. Through this work he noticed that there were two main types of galaxies: elliptical and spiral. Some spiral galaxies have central bar-like features going through them; these are called "barred spirals". From there he developed his tuning fork. The handle of the fork contains the elliptical galaxies, showing how they

become more elongated, and the fork shows spirals at the top and barred spirals at the bottom.

Initially Hubble believed that he had created an evolutionary sequence for galaxies where they begin their lives as ellipticals then develop spiral shaped arms over time. Later it was discovered that elliptical galaxies are much older than spirals because they have no star formation or gas. As you can see in the diagram below, both the spiral and barred spiral galaxies' arms become more loosely wound, and their central bulges become smaller as you progress down the fork.

The S0, or lenticular, galaxies are a bit different. They are somewhere between elliptical and spiral galaxies. Lenticulars have very large central bulges, like an elliptical, and a very small, faint disk with no spiral arms (almost like a spiral). They are easier to classify when viewed from the side since you can more easily see the faint disk.
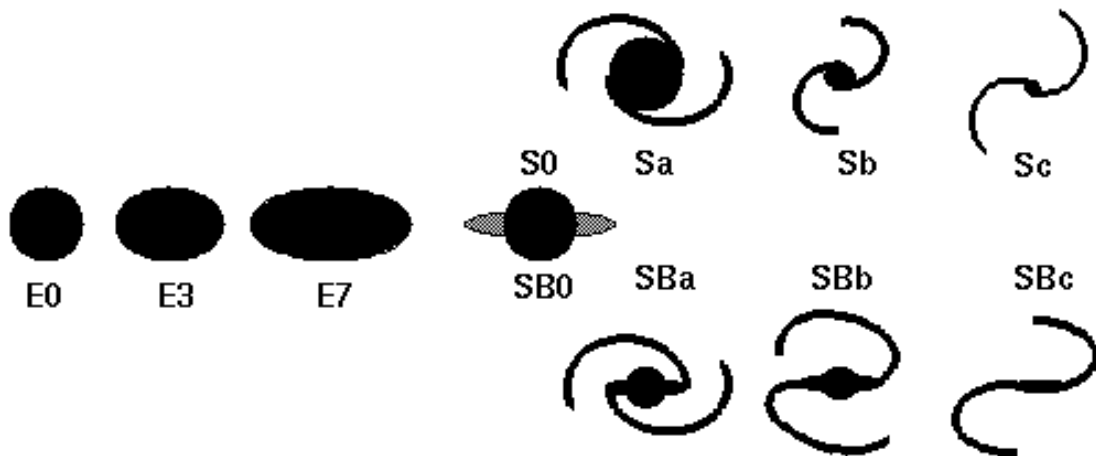


Irregular galaxies, not shown, are a class of galaxies that don't fall into any of the standard categories on the tuning fork. They have no clear structure and appear highly disorganized and even chaotic in shape.

# PROCEDURE

### Part I: Galaxy Classification

Go to the following website: http://www.chara.gsu.edu/~riedel/labstuff/classification.html
It provides images of galaxies that have a known classification. The links are at the top; images show on the left. The unknown galaxies have links at the bottom and are shown on the right. Use the copy of Hubble's Tuning Fork above and click through the reference images provided on the webpage to identify the galaxy type of each

unknown galaxy image (numbered 1-25) to the best of your ability. You will also need to note for each galaxy whether or not there was a visible spiral structure, ring structure, and/or a bar feature. (Hint: you typically only see these in spiral galaxies.) Also record any other notable features, e.g. supernovae, jets, excess star formation, etc.

## Part II: Questions

Using the information provided in the introduction, as well as by your TA, answer the first page of questions, in your own words and in complete sentences.

## Part III: Tuning Fork

On the provided, blank diagram draw and label the galaxies as they appear on Hubble's Tuning Fork. Label the names of each class of galaxy and the individual types (make sure you include irregular galaxies in your drawing). Be sure to fully answer the last question in complete sentences and in your own words.