Galaxy Classification

Group Information Sheet

NIRCam & Karen Knierman
Steward Observatory, U. Arizona

Learning Objectives

1.Know that galaxies are collections of billions of stars that take a variety of forms.
2.Understand that galaxies are classified into three major categories.
3.Learn that the presence of gas and dust, the ages of stars, and the amount of star formation can be estimated from color images of galaxies.

Introduction

When stars are viewed through a telescope, they continue to appear as bright points of light without any apparent size or structure. However, there are some objects in the sky that, viewed through a telescope, look like "fuzzy" clouds. Some of these objects, like those shown in the Hubble Space Telescope image to the right, are actually islands of stars, called galaxies, that are much farther from us than the individual stars we see in the night sky. Galaxies are huge collections of millions to trillions of stars (and perhaps gas and dust) held together by gravity.

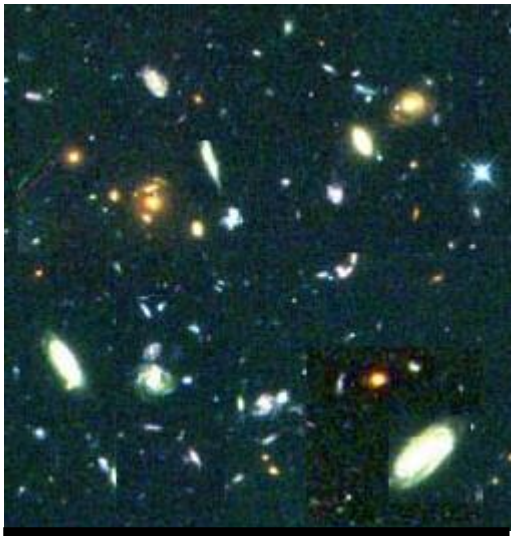


Image courtesy of NASA.

Part I: Developing a Classification Scheme

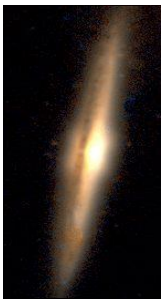
Included with this activity are several sets of sixteen galaxy photographs with ID numbers. The first task is to sort your galaxies by creating and applying a classification scheme based on appearance. Use the table below to record the results. The table has space for four categories but there is no requirement to use all four. It is important to remember that, by focusing on different properties of the galaxies, it is expected that different groups will develop widely different classification schemes. There are no right answers at this stage of the scientific process although ultimately some classification schemes are found to be more productive than others. Try to find patterns in terms of shape, color, or any other distinct features that appear in two or more images.

	Galaxy ID Numbers	**Defining Characteristics** *(provide enough detail so that anyone could use your scheme)*
Category I		
Category II		
Category III		
Category IV		

Part II: Applying Hubble's Classification Scheme
Using techniques just as you did in Part I, the astronomer Edwin Hubble developed a classification scheme in the 1920's. This scheme places galaxies into three categories: spiral, elliptical, and irregular.

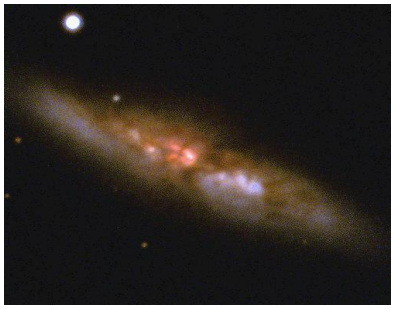
Spiral galaxies have spiraling arms in a disk and a bulge of stars in their centers. They can be seen in different orientations: face-on where the spiral arms are most visible, edge-on where the disk and bulge structures are most visible, and in between these two extremes.


Face-on spiral


Edge-on spiral

Elliptical galaxies can have the shape of a circle or ellipse and they are smooth without any features.

Irregular galaxies are, well, irregular. They do not have a well-defined shape and do not fit either of the above categories.



Now determine which of your galaxies fit into these 3 categories. Do you need to shift galaxies around from your own groups? Or perhaps combine a couple groups into one?

Hubble's Categories	**Galaxy ID Numbers**	**Defining Characteristics** *(describe the characteristics used by Hubble)*
Spiral		
Elliptical		
Irregular		

Part III: Physical characteristics of Galaxy Classes

You have just classified the galaxies into different categories according to their appearance, or morphology. We will now investigate what a galaxy's morphology can tell us about its physical characteristics. These physical characteristics include: a) the ages of the stars in the galaxy; b) the presence or absence of dust in the galaxy; and c) the presence or absence of gas and star formation. Keep in mind that these properties are linked together in a very physical way. The objective of these questions is for you to learn how these characteristics relate to galaxy morphology.

The ages of stars

Look at the images of the galaxies and pay special attention to the different colors you see. Qualitatively, these colors are an indication of the ages of the stars that make up the galaxy. Massive stars are hot, blue and very bright. They also burn their fuel rapidly and so die very quickly. Lightweight stars are cool, red, and dim, and burn their fuel slowly. A group of young stars will look blue because the massive stars will simply wash out the red ones. In an older population the massive stars will have already died, so we see only the red ones that are left. (For astronomers "red" is a relative term. Often these older groups of stars may look yellow or even white if they are not *very* old; they are just redder than a group of young stars.) Given this information, which galaxies appear to contain young stars? Write down the galaxy number and the class (Elliptical, Spiral, or Irregular). Do these same galaxies also have old stars? Make sure to note *where* in the galaxy the bluer or redder stars appear (e.g., spiral arms, bulge). Are there galaxies which seem to contain only old stars? To which class do they belong?

Dust in galaxies

Besides stars, galaxies sometimes also contain dust. This dust manifests itself as dark bands or patches across the galaxy. Which of the galaxies show evidence of dust? To which classes do these galaxies belong?

Gas and star formation in galaxies

Clumps of very blue, bright stars indicate places where stars are currently forming in large numbers. Stars need gas out of which to form. Also, dust is usually associated with gas. Using what you discovered earlier, decide which galaxies are likely to contain large quantities of gas. To which classes to they belong? What do you think this means for the future of these galaxies?

Tying it all together

In the three previous questions, we inferred some physical characteristics of the galaxies using color images:

- ages of stars
- dust
- gas and star formation

Now we want to make a connection between these physical properties and the Hubble types of the galaxies you have examined. In the following table fill in the ID #'s for all of the galaxies you have categorized into the Hubble classification scheme. Then answer **yes** or **no** to each of the five questions in the remaining columns. For example, do spirals have old stars? Young stars? Gas? Dust? Star Formation? Refer back to your answers to the previous questions to fill in this table. Remember, the answers are not absolute, as long as you can justify *why* you classified a galaxy the way you did!

Hubble Type	ID #	Old stars? (If yes, where?)	Young stars? (If yes, Where?)	Gas?	Dust?	Star Formation?
Elliptical						
Spiral						
Irregular						