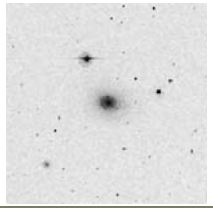
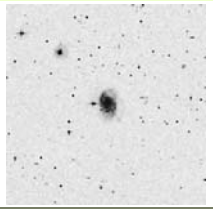
THE HUBBLE LAW

Gallery of Galaxies

	On-line: click on the picture of the galaxy to view the enlarged image.			
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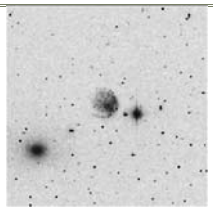	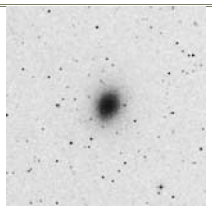	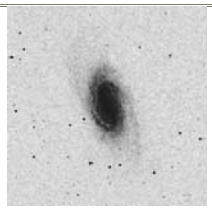	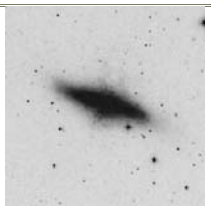	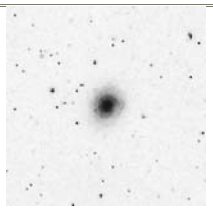
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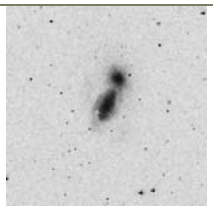	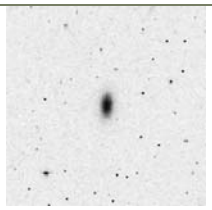	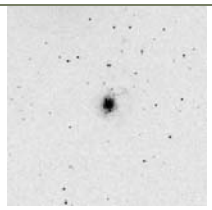	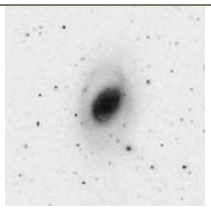	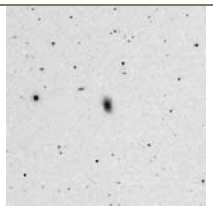
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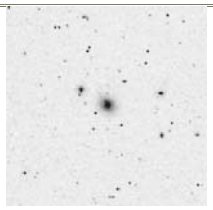	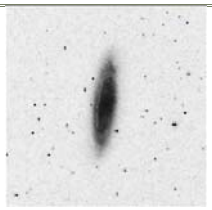	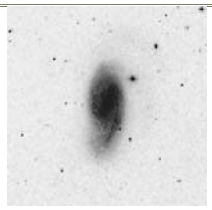	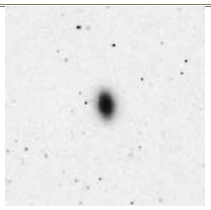	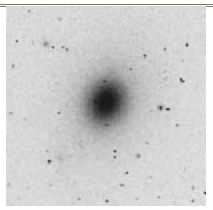
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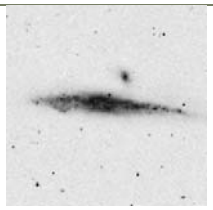	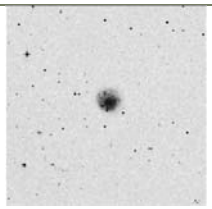	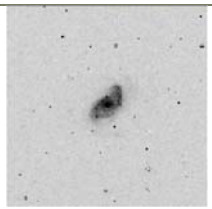	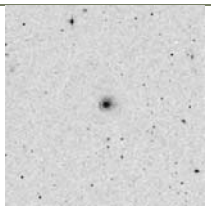	
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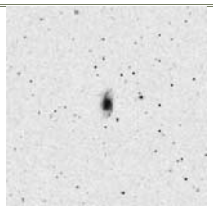
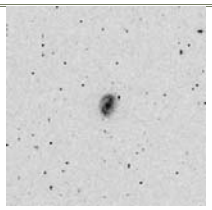
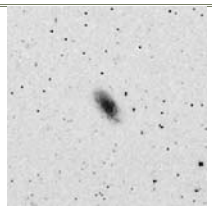
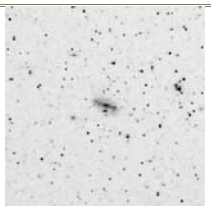
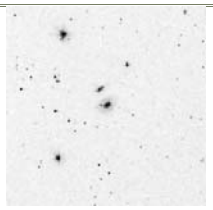
				
NGC 6181	NGC 6217	NGC 6643	NGC 6764	NGC 7469

Procedure

Step 1: Getting to Know the Galaxies

Our first step will be to become familiar with the images and the spectra of the galaxies with which we will be working. These images and spectra are **real** data, and were obtained using a CCD (charge-coupled device) on a couple of large (2 - 4 meter), ground-based telescopes.

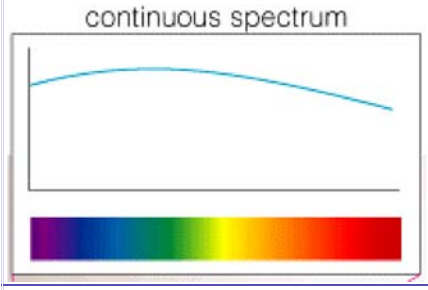
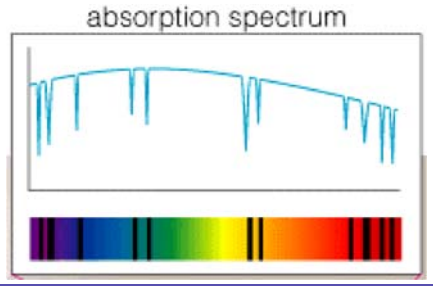
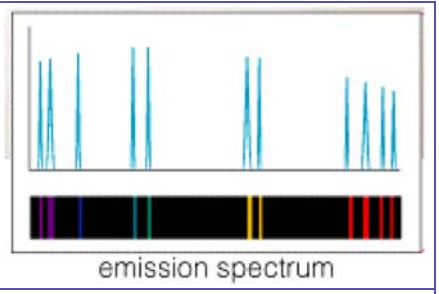
The Images

Examine closely the 27 galaxies linked from the pages showing each galaxy and its spectrum. Note any substructure, irregularities, or other defining characteristics for each galaxy. These features may be difficult to see for the more distant galaxies. On the galaxy overview sheet, **sketch each galaxy**, and give your best guess of its general Hubble type (spiral, barred spiral, elliptical, irregular).

The Spectra

Examine closely the 27 spectra shown on these full spectra pages. You are looking at the **relative intensity** of the total light radiated from each galaxy as a function of wavelength. The overall shape or curve of each spectrum is due to the continuous spectra from the stars (thermal radiation). Where you see dips in the spectrum of a galaxy, that is where radiation is being absorbed. Where you see sharp spikes in the spectrum of a galaxy, that is where radiation is being emitted. Unlike our "idealized" spectra of earlier in the quarter where we examined individual stars, the spectra from these galaxies reflect the total of all of the light from all of the objects in them.

Figure 1: A Short Review of the Kinds of Spectra

		
Continuous spectrum of thermal radiation	Spectrum showing absorption of light from thermal radiation passing through a cooler, thin gas.	Emission spectrum of hot, thin gas seen against a cooler background.

There are a couple of features you should especially note when trying to decipher these spectra:

1. Not all of the "jiggly" lines come from the light of the galaxy. Each spectrum contains noise; we just cannot get away from it. You should notice that some of the spectra are much "noisier" than other spectra. This noise tends to hamper accurate identification of some of the lines.
2. Most of the spectra show strong hydrogen emission lines along with some absorption lines. Note that the "relative intensity" axes are not all at the same scale. Some spectra will look "flat", when, in fact, the scaling had to be adjusted to accommodate an intense, hydrogen emission line, usually the one at 656.28 nm (6562.8 Angstroms). The relative intensity for some spectra ranges from 0 to 1.2; for others, from 0 to 15.
3. Some spectra show **only** absorption lines, or absorption lines with very weak hydrogen emission lines.
4. What you should be looking for are absorption lines of ionized calcium, lines designated by "H" and "K" [rest wavelengths of 396.85 and 393.37 nm (3968.5 and 3933.7 Angstroms)] and the emission of the *H-alpha* line of hydrogen [rest wavelength of 656.28 nm (6562.8 Angstroms)]. **Remember**: these spectra are of galaxies that are moving away from us and so the lines are going to be **redshifted**, some, you will find out, by a large amount.

After looking closely at the corresponding spectrum for each galaxy, write a short description of the spectrum in the space provided on the galaxy overview sheet. You will be using these sketches, classifications and descriptions shortly to eliminate some of the galaxies from further consideration.

What these spectra tell us

These plots of "jiggly lines" are telling us all about these galaxies, just as stellar spectra tell us all about stars. Remember the primary objects found in spiral galaxies: stars of all ages, masses, and composition; dust; and HII regions. We expect, because the bright HII regions and massive OB stars will dominate the light of a spiral galaxy, to see strong emission lines of hydrogen.

On the other hand, most elliptical galaxies contain old, cool stars. There is little or no free dust and gas in ellipticals, and certainly no massive star formation. We expect to see absorption lines dominating the spectra of elliptical galaxies, especially lines of ionized calcium (CaII H & K) and hydrogen. The spectrum of a galaxy will represent the total light coming from those objects that are **contributing the most** to the light of the galaxy. These objects will be those that far outnumber other objects, or are the most luminous, or both.