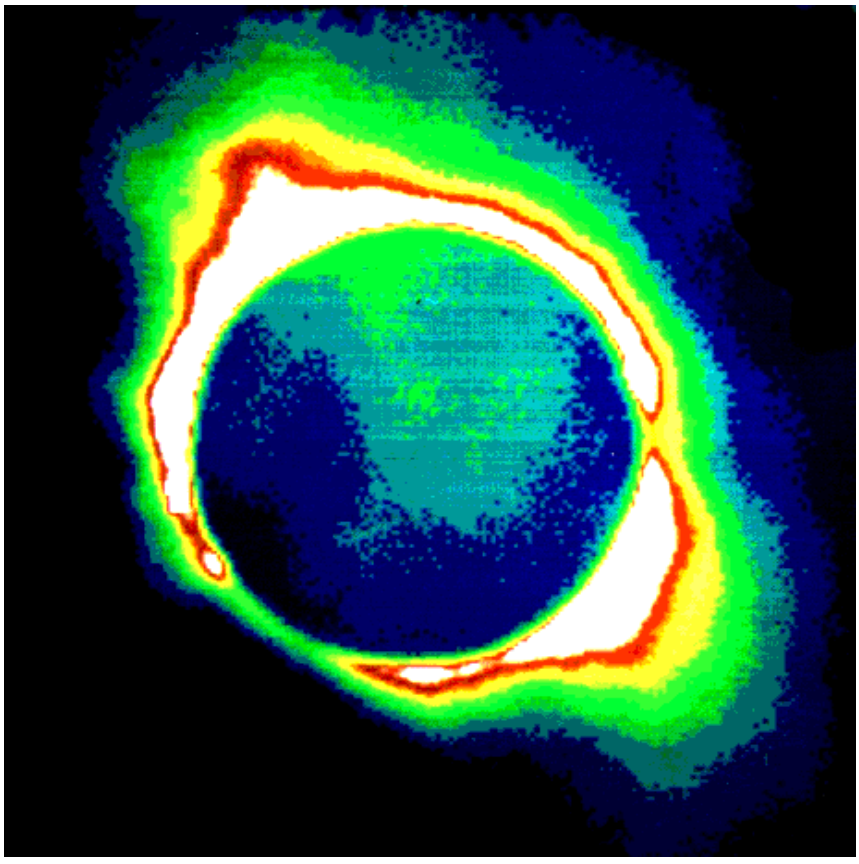
HANDS-ON UNIVERSE

HIGH SCHOOL SCIENCE AND MATH
IN THE CONTEXT OF ASTRONOMY
INVESTIGATIONS

Finding Features



by Lawrence Hall of Science
University of California, Berkeley
Lawrence Berkeley National Laboratory
and TERC of Cambridge, Massachusetts

HOU provides a visual and analytic way of exploring the universe.

Use HOU images from professional telescopes, along with HOU image processing software, to pursue investigations of astronomical objects, phenomena, and concepts. Opportunities available to HOU students can lead to accessing professional-grade telescopes via the World-Wide Web for observations as part of research projects such as searching for supernovae and asteroids.

- HOU has been developed and operated by staff at Lawrence Berkeley National Laboratory and Space Science Laboratories at the University of California at Berkeley, Californa, with generous support from the National Science Foundation (grant # ESI-9252915) and the US Department of Energy. The HOU curriculum was developed by TERC with contributions from the Berkeley staff and teachers. The educational center for HOU currently resides at Lawrence Hall of Science, University of California, Berkeley.

- The Berkeley staff responsible for the development of the HOU system includes:
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- The curriculum development team includes:
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- Lawrence Hall of Science HOU staff includes:
  Carl Pennypacker, Alan Gould, Miho Rahm Lulu Lin, and Amelia Marshall.

Finding Features

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Constants Sheet

Planetary Data:

Planet	Mass (kg)	Ave Radius (m)	Ave Orbital Radius(m)
Mercury	3.32×10^{23}	2.44×10^{6}	5.79×10^{10}
Venus	4.87×10^{24}	6.08×10^{6}	1.08×10^{11}
Earth	5.97×10^{24}	6.36×10^{6}	1.49×10^{11}
(Moon)	7.35×10^{22}	1.74×10^{6}	
Mars	6.42×10^{23}	3.40×10^{6}	2.28×10^{11}
Jupiter	1.90×10^{27}	6.80×10^{7}	7.78×10^{11}
Saturn	5.69×10^{26}	5.70×10^{7}	1.43×10^{12}
Uranus	8.69×10^{25}	2.51×10^{7}	2.87×10^{12}
Neptune	1.03×10^{26}	2.44×10^{6}	4.50×10^{12}
Pluto	1.30×10^{22}	1.50×10^{6}	5.90×10^{12}

Physical and Astronomical Constants:

Gravitational Constant = G = 6.673×10^{-11} N-m^2/kg^2
Speed of Light in a vacuum = c = 2.9979×10^{8} m/s
Earth-Sun Distance = Astronomical Unit = AU = 1.496×10^{11} m
Earth-Moon Distance = 3.844×10^{8} m
Parsec = pc = 206265 AU = 3.26 ly = 3.09×10^{16} m
Light year = ly = 9.5×10^{15} m
Mass of the Sun = 1.989×10^{30} kg
Luminosity of the Sun = 3.83×10^{26} W
Radius of the Sun = 6.96×10^{8} m

Messier Catalog

Key to Column Headings: M# is Messier number, NGC# is the New General Catalog number, Type is the type of object as identified below, RA is Right Ascension, Dec is Declination, Con is Constellation that the object is found in, and m(v) is the apparent magnitude through a v filter.

Key to Types: OC = Open Cluster, GC = Galactic Cluster, SNR = Supernova Remnant, PN = Planetary Nebula, EN = Emission Nebula, RN = Reflection Nebula, SG = Spiral Galaxy, EG = Elliptical Galaxy, DS = Double Star

M#	NGC #	Type	RA	Dec	Con	m(v)	remarks
M1	1952	SNR	05h34.5m	+22°01'	Tau	8.4	Crab Nebula
M2	7089	GC	21h33.5m	-00°49'	Aqr	6.5	
M3	5272	GC	13h42.2m	+28°23'	CVn	6.4	Contains variables
M4	6121	GC	16h23.6m	-26°32'	Sco	5.9	Bright globular
M5	5904	GC	15h18.6m	+02°05'	Ser	5.8	Beautiful globular
M6	6405	OC	17h40.1m	-32°13'	Sco	4.2	Butterfly Cluster
M7	6475	OC	17h53.9m	-34°49'	Sco	3.3	good in binoculars
M8	6523	EN	18h03.8m	-24°23'	Sgr	5.8	Lagoon Nebula
M9	6333	GC	17h19.2m	-18°31'	Oph	7.9	
M10	6254	GC	16h57.1m	-04°06'	Tau	6.6	
M11	6705	OC	18h51.1m	-06°16'	Sct	5.8	Wild Duck Cluster
M12	6218	GC	16h47.2m	-01°57'	Oph	6.6	
M13	6205	GC	16h41.7m	+36°28'	Her	5.9	Hercules Cluster
M14	6402	GC	17h37.6m	-03°15'	Oph	7.6	
M15	7078	GC	21h30.0m	+12°10'	Peg	6.4	
M16	6611	EN+OC	18h18.8m	-13°47'	Ser	6.0	Eagle Nebula with OC
M17	6618	EN	18h20.8m	-16°11'	Sgr	7	Swan or Omega Neb.
M18	6613	OC	18h19.9m	-17°08'	Sgr	6.9	
M19	6273	GC	17h02.6m	-26°16'	Oph	7.2	
M20	6514	E/RN	18h02.6m	-23°02'	Sgr	8.5	
M21	6531	OC	18h04.6m	-22°30'	Sgr	5.9	
M22	6656	GC	18h36.4m	-23°54'	Sgr	5.1	
M23	6494	OC	17h56.8m	-19°01'	Sgr	5.5	
M24			18h16.9m	+18°29'	Sgr	4.5	Rich star cloud
M25	IC4725	OC	18h31.6m	-19°15'	Sgr	4.6	
M26	6694	OC	18h45.2m	-09°24'	Sct	8.0	
M27	6853	PN	19h59.6m	+22°43'	Vul	8.1	Dumbbell Nebula
M28	6626	GC	18h24.5m	-24°52'	Sgr	6.9	
M29	6913	OC	20h23.9m	+48°26'	Cyg	6.6	
M30	7099	GC	21h40.4m	-23°11'	Cap	7.5	
M31	224	SG	00h42.7m	+41°16'	And	3.4	Andromeda Galaxy
M32	221	EG	00h42.7m	+40°52'	And	8.2	companion to M31
M33	598	SG	01h33.9m	+30°39'	Tri	5.7	
M34	1039	OC	02h42.0m	+42°47'	Per	5.2	
M35	2168	OC	06h08.9m	+24°20'	Gem	5.1	
M36	1960	OC	05h36.1m	+34°08'	Aur	6.0	
M37	2099	OC	05h52.4m	+32°33'	Aur	5.6	
M38	1912	OC	05h28.7m	+35°50'	Aur	6.4	
M39	7092	OC	21h32.2m	+48°26'	Cyg	4.6	
M40		DS	12h22.4m	+58°05'	UMa	8.0	
M41	2287	OC	06h47.0m	-20°01'	CMa	4.5	
M42	1976	EN	05h35.4m	-05°27'	Ori	4	Orion Nebula

M#	NGC #	Type	RA	Dec	Con	m(v)	remarks
M43	1982	EN	05h35.6m	-05°16'	Ori	9	part of Orion Nebula
M44	2632	GC	08h40.1m	+19°59'	Cnc	3.1	Beehive Cluster
M45	1952	OC	03h47.0m	+24°07'	Tau	1.2	Pleiades
M46	2437	OC	07h41.8m	-14°49'	Pup	6.1	
M47	2422	OC	07h36.6m	-14°30'	Pup	4.4	
M48	2548	OC	08h13.8m	-05°48'	Hya	5.8	
M49	4472	EG	12h29.8m	+08.00'	Vir	8.4	
M50	2323	OC	07h03.2m	-08°20'	Mon	5.9	
M51	5194	SG	13h29.9m	+47°12'	CVn	8.1	Whirlpool Galaxy
M52	7654	OC	23h24.2m	+61°35'	Cas	6.9	
M53	5024	GC	13h12.9m	+18°10'	Com	7.7	
M54	6715	GC	18h55.1m	-30°29'	Sgr	7.7	
M55	6809	GC	19h40.0m	-30°58'	Sgr	7.0	
M56	6779	GC	19h16.6m	+30°11'	Lyr	8.2	
M57	6720	PN	18h53.6m	+33°02'	Lyr	9.0	Ring Nebula
M58	4579	SG	12h37.7m	+11°49'	Vir	9.8	
M59	4621	EG	12h42.0m	+11°39'	Vir	9.8	
M60	4649	EG	12h43.7m	+11°33'	Vir	8.8	
M61	4303	SG	12h21.9m	+04°28'	Vir	9.7	face-on spiral
M62	6266	GC	17h01.2m	-30°07'	Oph	6.6	
M63	5055	SG	13h58.8m	+42°02'	CVn	8.6	Sunflower Galaxy
M64	4826	SG	12h56.7m	+21°41'	Com	8.5	Black-eye Galaxy
M65	3623	SG	11h18.9m	+13°05'	Leo	9.3	
M66	3627	SG	11h20.2m	+12°59'	Leo	9.0	
M67	2682	OC	08h50.4m	+11°49'	Cnc	6.9	
M68	4590	GC	12h39.5m	-26°45'	Hya	8.2	
M69	6637	GC	18h31.4m	-32°21'	Sgr	7.7	
M70	6681	GC	18h43.2m	-32°18'	Sgr	8.1	
M71	6838	GC	19h53.8m	+18°47'	Sge	4.4	
M72	6981	GC	20h53.5m	-12°32'	Aqr	9.4	
M73	6994	OC	20h58.9m	-12°38'	Aqr	4.4	
M74	628	SG	01h36.7m	+15°47'	Psc	9.2	
M75	6864	GC	20h06.1m	-21°55'	Sgr	8.6	
M76	650	PN	01h42.4m	+51°34'	Per	11.5	Little Dumbbell
M77	1068	SG	02h42.7m	-00°01'	Cet	8.8	a Seyfert Galaxy
M78	2068	RN	05h46.7m	+00°03'	Pup	8	
M79	1904	GC	05h24.5m	-24°33'	Lep	8.0	
M80	6093	GC	16h17.0m	-22°59'	Sco	7.2	
M81	3031	SG	09h55.6m	+69°04'	UMa	6.8	
M82	3034	SG	09h55.8m	+69°41'	UMa	8.4	the 'exploding' galaxy
M83	5236	SG	13h37.0m	-29°52'	Hya	10.1	
M84	4374	EG	12h25.1m	+12°53'	Vir	9.3	
M85	4382	EG	12h25.4m	+18°11'	Com	9.3	
M86	4406	EG	12h26.2m	+12°57'	Vir	9.2	
M87	4486	EG	12h30.8m	+12°24'	Vir	8.6	visible jet
M88	4501	SG	12h32.0m	+14°25'	Com	9.5	
M89	4552	EG	12h35.7m	+12°33'	Vir	9.8	
M90	4569	SG	12h36.8m	+13°10'	Vir	9.5	
M91	error in Messier catalog						
M92	6341	GC	17h17.1m	+43°08'	Her	6.5	
M93	2447	OC	07h44.6m	-23°52'	Pup	6.2	
M94	4736	SG	12h50.9m	+41°07'	CVn	8.1	

M95	3351	SG	10h44.0m	+11°42'	Leo	9.7	
M96	3368	SG	10h46.8m	+11°49'	Leo	9.2	
M97	3587	PN	11h14.8m	+55°01'	UMa	11.2	Owl Nebula
M98	4192	SG	12h13.8m	+14°54'	Com	10.1	nearly edge-on
M99	4254	SG	12h18.8m	+14°25'	Com	9.8	nearly face-on
M100	4321	SG	12h22.9m	+15°49'	Com	9.4	face-on
M101	5457	SG	14h03.2m	+54°21'	UMa	7.7	Pinwheel Galaxy
M102	error in Messier catalog						
M103	581	OC	01h33.2m	+60°42'	Cas	7.4	
M104	4594	SG	12h40.0m	-11°37'	Vir	8.3	Sombrero Galaxy
M105	3379	EG	10h47.8m	+12°35'	Leo	9.3	
M106	4258	SG	12h19.0m	+47°18'	CVn	8.3	
M107	6171	GC	16h32.5m	_13°03'	Oph	8.1	
M108	3556	SG	11h11.5m	+55°40'	UMa	10.0	nearly edge-on
M109	3992	SG	11h57.6m	+53°23'	UMa	9.8	
M110	205	EG	00h40.5m	+41°41'	And	8.0	

HANDS-ON UNIVERSE™

BROWSER'S GUIDE TO THE UNIVERSE UNIT

Perform the following with each of the files, *Browser1* through *Browser7*

• Click on the file folder icon or use the **Open** command in the **File** menu to open the file and bring the image up on the screen. If the files are not already available on your computer, a local network attached to your computer, or on a floppy disk, refer to Activity V: Download an Image, in the *Introduction to Image Processing Unit*.

• Use the **Zoom** option on the tool bar to enlarge the image, and adjust **Min** and **Max** or choose **Log** scaling to see if they enhance the quality of the image.

1. Describe the appearance of each object, noting any particular features or characteristics.

2. Without any further research, make a hypothesis about what type each object might be and why it looks the way it does. Here are just a few suggested questions to think about. They may not all apply to each object, and you may choose other questions to explore.

Is it solid or gaseous?
Why is it dark or bright in certain areas ?
Are we looking at it from a side view or top down view?

• Select various palettes from the **Tool Bar** or using the **Load Color Palette** option under **File** and choose the one you prefer. Using this palette with your favorite Browser image, adjust the **Min** and **Max** and try **Log** Scaling.

3. Record your settings for the best display of this image.

• Print out or save your image (both options are under the **File** menu). If your printer is a black and white one, you probably should use the *grey* or *igrey* palettes.

Date: _____ Name: _____

Answer Sheet

Browser's Guide to the Universe Unit

1. A description of the appearance of each object, including any particular features or characteristics.

Browser1:

Browser2:

Browser3:

Browser4:

Browser5:

Browser6:

Browser7:

2. My hypothesis on what type each object might be and why it looks the way it does.

Browser1:

Browser2:

Browser3:

Browser4:

Browser5:

Browser6:

Browser7:

3. Settings for my favorite image:

Image:

color palette:

Min/Max: Log scaling (y/n):

Date: _____ Name: _____

HANDS-ON UNIVERSE
MOON MATCH UNIT

There are three separate parts to this investigation:

Match the Image,

Match the Slice, and

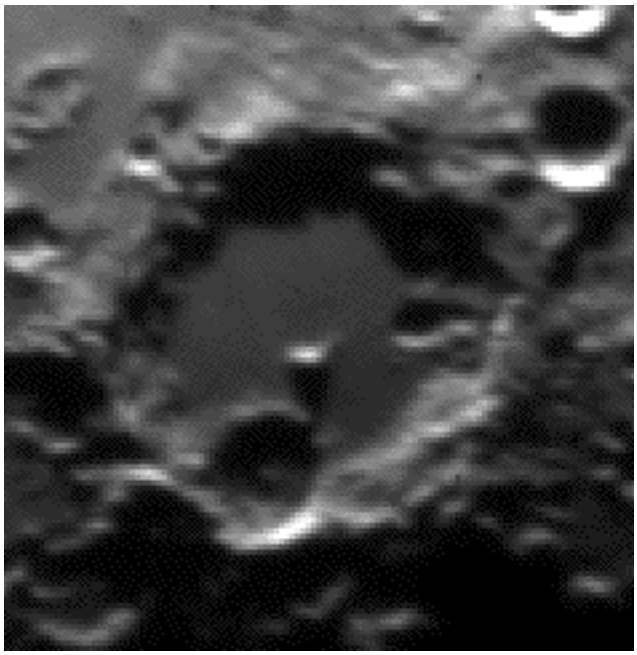
Create Your Own Challenge.

Screen Setup: *moon* image.

Activity I. Match the Image - Given the Image, What Was the Processing?

Can you match the images shown on this page and the next 2 pages? Each one is a Xerox of a version of the *moon* image. For each image, indicate what image processing changes you made to the original image in order to match the printed version.

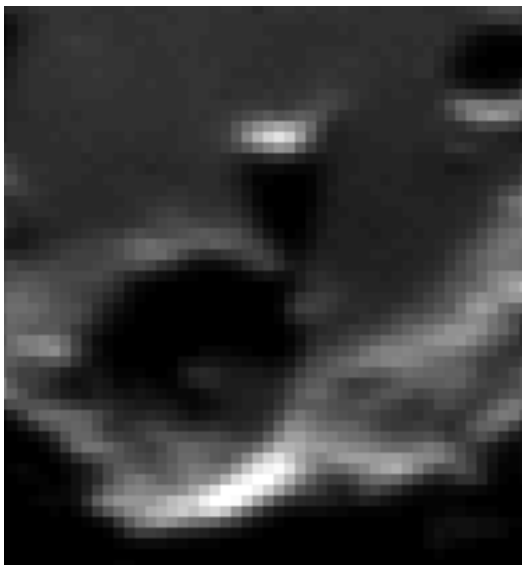
1.



How did you match?

Zoom: _ _ _
Box (y/n): _ _
Min: _ _ _ Max: _ _ _
Other: _ _ _ _

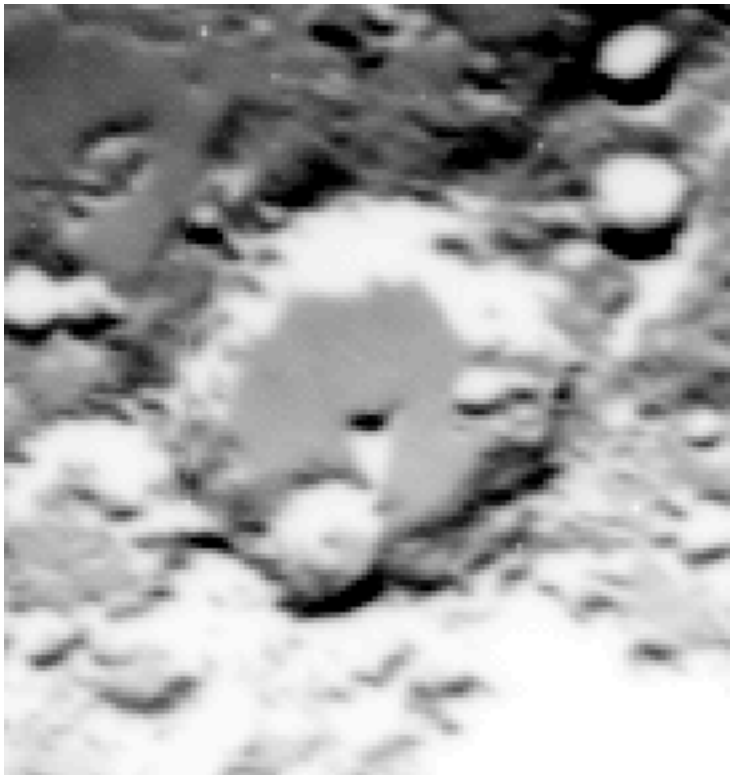
2.



How did you match?

Zoom: _ _ _
Box (y/n): _ _
Min: _ _ _ Max: _ _ _
Other: _ _ _ _

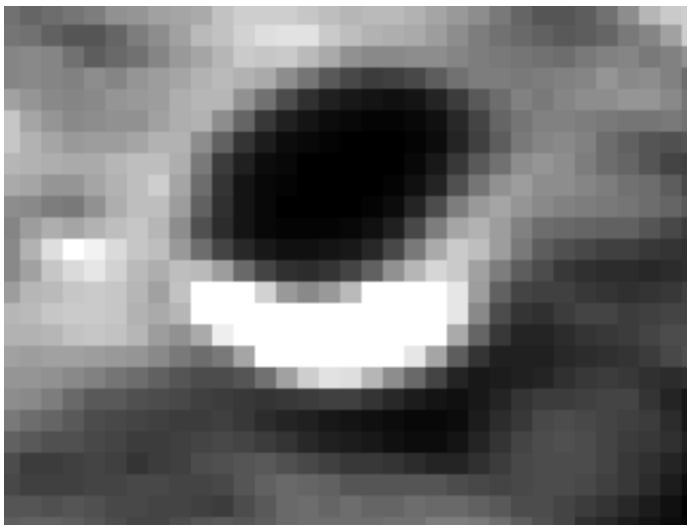
3.



How did you match?

Zoom: _ _ _
Box (y/n): _ _
Min: _ _ _ Max: _ _ _
Other: _ _ _ _

4.



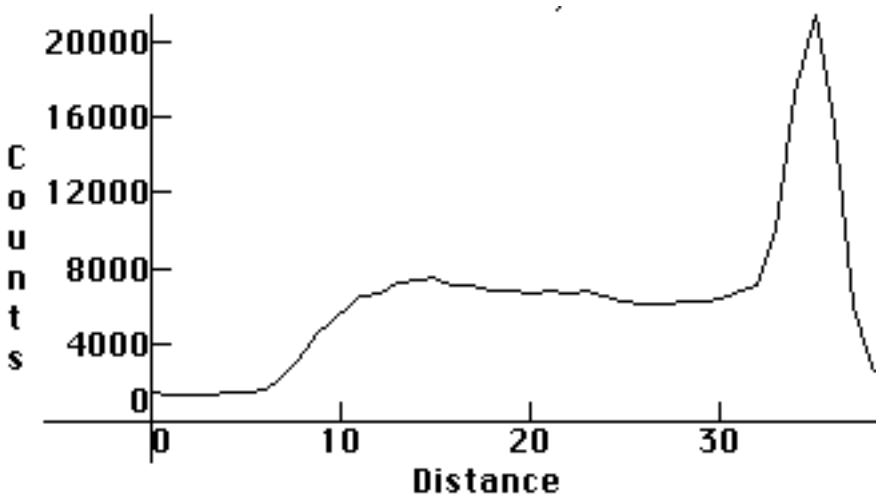
How did you match?

Zoom: _ _ _
Box (y/n): _ _
Min: _ _ _ Max: _ _ _
Other: _ _ _ _

Activity II. Match the Slice - Given the Graph, Where Was the Slice?

Make vertical Slices on the *moon* image to get matching graphs.

5.

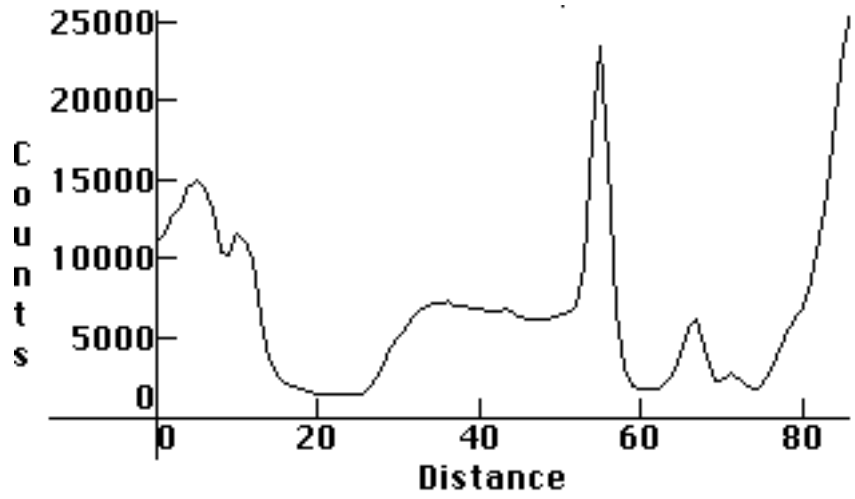


Slice Coordinates:

Beginning (x,y): _ _

Ending (x,y): _ _

6.

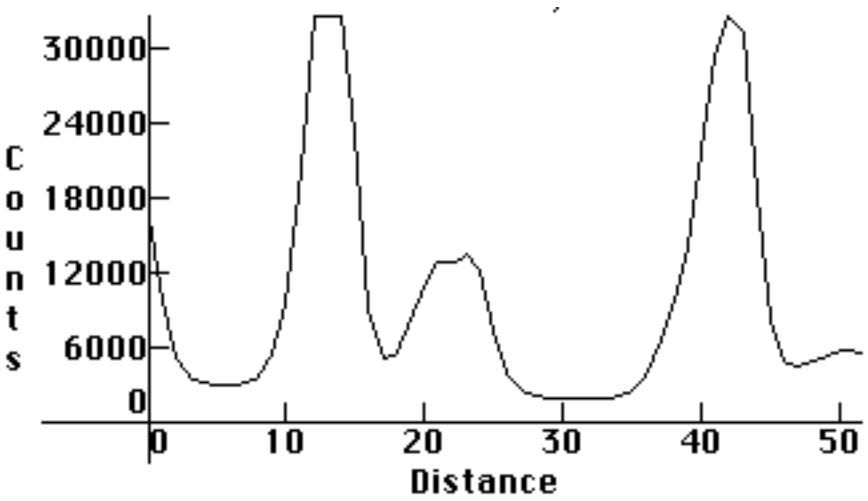


Slice Coordinates:

Beginning (x,y): _ _

Ending (x,y): _ _

7.



Slice Coordinates:

Beginning (x,y): _ _

Ending (x,y): _ _

Activity III. Create Your Own Challenges

A Challenge Image.

Make your own version of the *moon* image as a challenge for someone else to try to match. You could change the contrast, get a box of a portion of the moon image, zoom, or all three.

Keep notes on the changes you make.

Save it as a new image file, using the **Save As** option in the **File** menu, or the **Save** icon. Name your file "mmchxx", replacing “xx” with your initials. Add a number after your initials if you create more than one challenge.

If a printer is available, print out a copy of your moon challenge image, using the **Print** option in the **File** menu or the **Print** icon.

Exchange challenges with a classmate.

Describe how you matched your classmate's challenge image.

A Challenge Graph.

Use **Slice** to make a graph of brightness across a part of the image. To keep the graph challenge feasible, limit your slices to vertical ones.

Record the beginning and ending coordinates for your slice.

Make a copy of the graph and exchange graph challenges with a classmate.

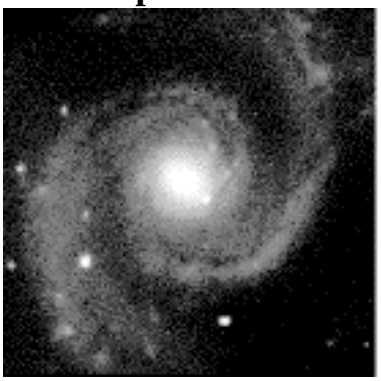
Describe how you matched your classmate's challenge graph.

HANDS-ON UNIVERSE™

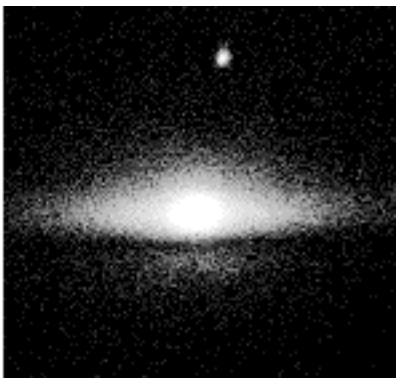
GALAXY FEATURES UNIT

When you look up at the sky on a clear dark night, you can see thousands of stars shining down on you. These stars are very much like our sun-- they are balls of hot gas whose light has traveled billions and often trillions of miles to reach our eyes. In the mountains, in the desert, or any other place far from city lights, you can see another feature in the night sky. There is a large streak where there are many more stars than anywhere else. This is called the Milky Way, because of its milky appearance. Astronomers have studied this feature and have found that we live in a galaxy-- a huge collection of billions of stars. If we could go outside our galaxy, called the Milky Way Galaxy, it would look like this:

Top View



Side View



After the turn of the 20th century, astronomers discovered other galaxies than our own. Some are larger than our Milky Way Galaxy; many are smaller. One astronomer describes galaxies as cities and towns. A star is like a house. The Milky Way might be a medium sized city. An enormous galaxy with trillions of stars is like Los Angeles or New York. Just as we see few houses between cities, we do not see any stars between galaxies.

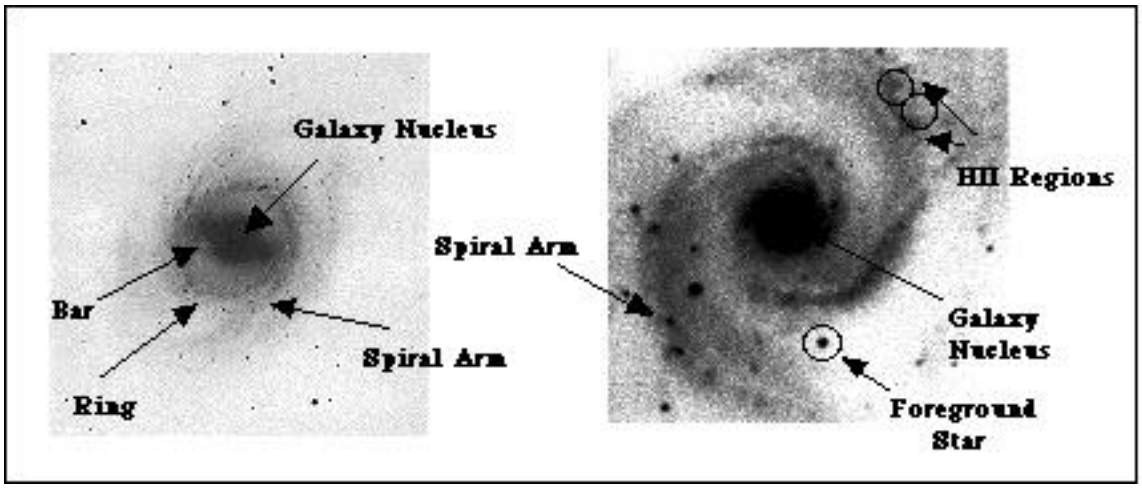
There are different types of galaxies. Many galaxies including our own look like a spiral which is why we are said to live in a "spiral galaxy". Spiral galaxies have a lot of dust and gas, and stars are forming right now in them. The famous Orion Nebula is a star-forming region in our own galaxy.

Other types of galaxies exist. Look at pictures of NGC 4636 and NGC 4697 in the "Galaxy Atlas" catalogue at the end of this unit. These do not look like the beautiful spirals we have already seen. In fact, these galaxies are simply a lot of stars clumped into the same region of space with no measurable interstellar dust or gas. Since there is almost no gas and dust in these galaxies, new stars are *not* forming now. The galaxies look like ellipses, so astronomers call them "elliptical galaxies".

Finally, there is a peculiar bunch of galaxies. In fact, that is what they are called: "peculiar galaxies". These galaxies do not fit into either the spiral or elliptical galaxy categories. Often galaxies are too small. Sometimes galaxies crash into each other. In any event, they are just different. The two peculiar galaxies in this unit, NGC 2146 and NGC 3034, are interesting because they have an enormous amount of dust and gas, so many stars are being born right now in them.

On your computer are images called "galaxy1", "galaxy2", etc. You will display each galaxy one at a time. Draw a quick sketch of the galaxy and compare it to the pictures at the end of the unit to find the galaxy's name. Looking at the image on your screen, you will be able to decide whether it is a spiral galaxy, an elliptical galaxy, or a peculiar galaxy. Once you decide the kind of galaxy, identify different objects in the picture. Some things to look for are described on the next page and shown in the diagrams below.

Note: All photographs in the "Galaxy Atlas" are from the *Atlas of Galaxies* (Allen Sandage) or from *A Revised Shapley-Ames Catalog of Bright Galaxies.* All images came from the Leuschner Observatory which is operated by the Astronomy Department of the University of California at Berkeley.



1. **Galaxy nucleus**: Almost all galaxies have a nucleus. It is the bright central part of the galaxy. Galaxy nuclei are made of millions of stars and tons of dust and gas (if available). There is reason to believe there might even be enormous black holes in the center of galaxy nuclei.

2. **Foreground Stars**: You know what stars look like. They are the bright points of light in your image. Foreground stars are ones inside our own galaxy that lie between us and other galaxies. They are <u>not</u> part of the galaxy in the image. We have so many stars in our Milky Way galaxy that all of the images in our collection include foreground stars .

3. **Spiral Arms**: The features that give spiral galaxies their name. Only spiral galaxies have them. They are spiral shaped regions of dust, gas, and stars where star formation is occurring.

4. **Bar:** An interesting feature in many spiral galaxies is a bar running through the middle of the galaxy nucleus. While there are many theories about why this feature forms, astronomers are not completely sure why they do. There are many things in astronomy that are not known.

5. **Ring**: Similar to the bar, except that this looks like a ring around the galaxy nucleus in some spiral galaxies. Like galaxy bars, astronomers are not 100% sure why the rings form or why they form in some galaxies and not in others.

6. **H II Regions** (pronounced "H 2 Regions"): Areas of star formation. Young, hot stars heat the dust and gas around them, causing the dust and gas to radiate light. These appear as faint balls of dust and gas. *Elliptical galaxies do not have H II regions*, because there is little dust and gas in these galaxies. HII Regions are made up of ionized hydrogen, the nuclei without its electron.

7. **Dust Lanes**: Dark bands of dust that block the light from a galaxy. If you look closely at the two peculiar galaxies, you will see that both have dust lanes.

8. **Companion Galaxies**: A galaxy that orbits around another galaxy the way the Earth orbits the Sun. These galaxies can interact with their parent galaxy and change the parent galaxy's appearance.

Instructions

- To display a galaxy image file, use **Open** in the **File** menu and double click on the filename or click on the **Open** icon in the **Tool Bar**.
- Change the Min, Max, and Log settings until you have displayed the galaxy in a way that brings out its features. Try selecting **Log** and moving the 'Min' up a little. This method is generally best with galaxy images. Log means log scaling which brings out dim features in images. Changing color palettes by selecting **Load Color Palette** from the **File** menu is often very helpful, too.

1. Fill out the Galaxy Information sheet.

Min, Max, and Log: Write down your Min, Max, and Log settings on your worksheet, marking the Log box with an "X" if you used log scaling. There is no right or wrong answer.

Rough Sketch: Sketch the image in the box labeled Rough Sketch.

Name: Compare the image on the screen with the pictures in the Galaxy Atlas found at the end of this unit. Which galaxy is it? Write down the name of the galaxy on your worksheet.

Features used to identify galaxy: Write down your reasoning. How were you able to identify the galaxy? What distinguishing characteristics gave you the answer?

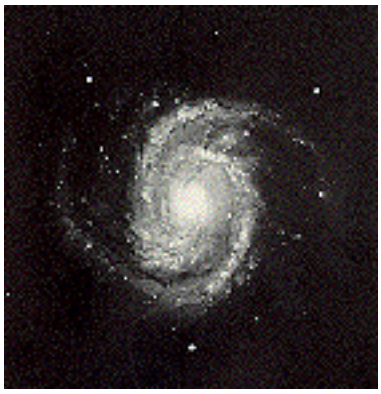
Galaxy type: What type of galaxy is it? Spiral, elliptical, or peculiar?

Spiral arms, Bar, Ring, HII Regions, Foreground Stars, Dust lane, and Companion Galaxy: Mark the appropriate boxes on your worksheet with an "X".

2. Repeat until you have seen all eight galaxies.

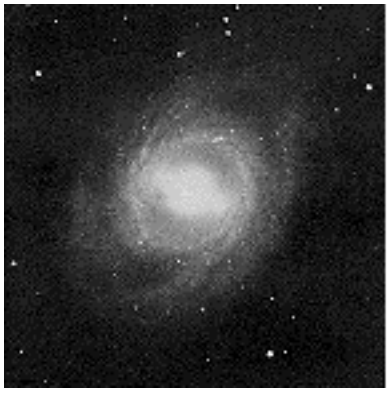
GALAXY ATLAS

Spiral Galaxies:

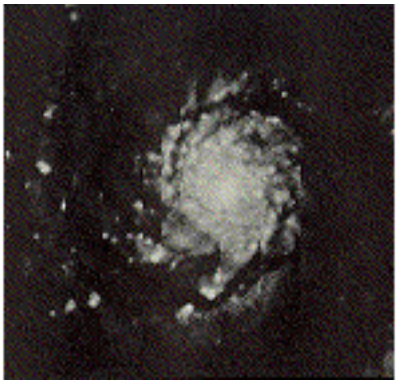


NGC 4321 (M100)

NGC 2841



NGC 3351 (M95)



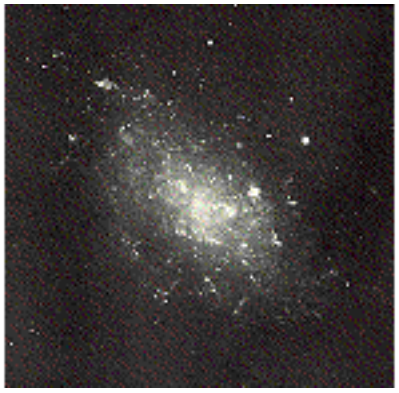
NGC 5194 (M51)

Elliptical Galaxies:

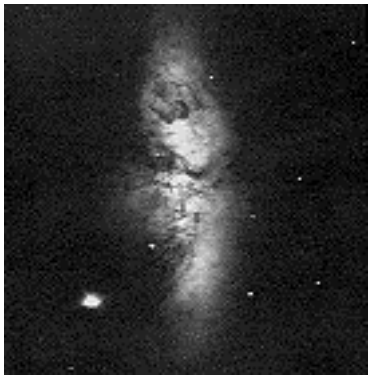
NGC 4636

NGC 4697

Peculiar Galaxies:



NGC 2146



NGC 3034 (M82)

Date: _____ Name: _____

Answer Sheet

Galaxy Features Unit

Galaxy 1: Display: Min: ___ Max: ___ Log ☐ Rough Sketch:

Name (see Galaxy Atlas): _____

Features used to identify galaxy: _____

_____

Galaxy Type:_____

Spiral Arms ☐ Bar ☐ Ring ☐

Dust Lane ☐ HII Regions ☐

Companion Galaxy ☐ Foreground Stars ☐

Galaxy 2: Display: Min: ___ Max: ___ Log ☐ Rough Sketch:

Name (see Galaxy Atlas): _____

Features used to identify galaxy: _____

_____

Galaxy Type:_____

Spiral Arms ☐ Bar ☐ Ring ☐

Dust Lane ☐ HII Regions ☐

Companion Galaxy ☐ Foreground Stars ☐

Galaxy 3: Display: Min: ___ Max: ___ Log ☐ Rough Sketch:

Name (see Galaxy Atlas): _____

Features used to identify galaxy: _____

_____

Galaxy Type:_____

Spiral Arms ☐ Bar ☐ Ring ☐

Dust Lane ☐ HII Regions ☐

Companion Galaxy ☐ Foreground Stars ☐

Galaxy 4: Display: Min: ___ Max: ___ Log ☐ Rough Sketch:

Name (see Galaxy Atlas): _____

Features used to identify galaxy: _____

_____

Galaxy Type:_____

Spiral Arms ☐ Bar ☐ Ring ☐

Dust Lane ☐ HII Regions ☐

Companion Galaxy ☐ Foreground Stars ☐

Galaxy 5: Display: Min: ___ Max: ___ Log ☐ Rough Sketch:

Name (see Galaxy Atlas): _____

Features used to identify galaxy: _____

_____

Galaxy Type:_____

Spiral Arms ☐ Bar ☐ Ring ☐

Dust Lane ☐ HII Regions ☐

Companion Galaxy ☐ Foreground Stars ☐

Galaxy 6: Display: Min: ___ Max: ___ Log ☐ Rough Sketch:

Name (see Galaxy Atlas): _____

Features used to identify galaxy: _____

_____

Galaxy Type:_____

Spiral Arms ☐ Bar ☐ Ring ☐

Dust Lane ☐ HII Regions ☐

Companion Galaxy ☐ Foreground Stars ☐

Galaxy 7: Display: Min: ___ Max: ___ Log ☐ Rough Sketch:

Name (see Galaxy Atlas): _____

Features used to identify galaxy: _____

_____

Galaxy Type:_____

Spiral Arms ☐ Bar ☐ Ring ☐

Dust Lane ☐ HII Regions ☐

Companion Galaxy ☐ Foreground Stars ☐

Galaxy 8: Display: Min: ___ Max: ___ Log ☐ Rough Sketch:

Name (see Galaxy Atlas): _____

Features used to identify galaxy: _____

_____

Galaxy Type:_____

Spiral Arms ☐ Bar ☐ Ring ☐

Dust Lane ☐ HII Regions ☐

Companion Galaxy ☐ Foreground Stars ☐