Preface

This book contains a collection of astronomy assignments like no other book available. The lessons in *Engaging in Astronomical Inquiry* reflect an innovative approach to learning astronomy by putting you, the learner, at the center of each and every lesson. In these lessons, you decide what specific topics you want to study, create your own research questions, design your own strategies to pursue evidence, and defend your scientific conclusions based on the data that you collect. If this sounds like you are responsible for your own learning in these lessons, you are exactly right. In *Engaging in Astronomical Inquiry*, you are the astronomer out there collecting data about objects in the cosmos.

These lessons use a carefully structured in a multi-step approach to help you learn how astronomers conduct their trade. But don't worry; we won't just turn you loose without any direction. In these lessons, during your first experience with inquiry, you are guided through the entire scientific inquiry process, from given research questions to the appropriate content and format for a scientific conclusion. Then, in your second experience, you will generate your conclusions independently, with the previous experience set out as a guide for content and format. This will help you make sense of astronomical data that has been purposefully planned, collected, and analyzed with the guidance of your instructor. You will first construct and defend conclusions based upon data that is, provided for you. By the time you reach your third inquiry, you have been exposed to two experiences in which you were guided through the process of data collection and analysis. During this third inquiry data collection and analysis becomes an independent task. By the fourth inquiry, you will have received explicit instruction on the connection between the research questions or hypotheses, and the procedure undertaken to address them three times. By then, you will be prepared to take responsibility for creating a plausible method for collecting data given a research prompt. By the fifth inquiry, you will have now seen four examples of quality research questions/hypotheses, and their relationship to procedures, data collection and conclusions. At this point you will be positioned to successfully conduct an entire inquiry cycle in astronomy. This strategy is specifically designed to provide you with repeated success in doing science and a sense of how the pieces of the scientific process connect to each other.

We know that astronomy might initially sound like a far-out science, and indeed it is in many ways. To help you learn how astronomy is done, we welcome you to engage in these lessons and begin to see the Universe as an astronomer does – as a wonderful and fascinating world in which to pursue questions of your own choosing. We invite you to engage in astronomical inquiry.

Stephanie J. Slater
Laramie, WY

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1 What's Way Out There? The Hubble Ultra Deep Field

Big Idea: The Hubble Space Telescope image "Hubble Ultra Deep Field" reveals a variety of previously unknown objects in the very distant Universe that can be systematically and scientifically counted, organized, and classified.

Computer Setup and/or Materials Needed:

a) Access to the image at: http://www.spacetelescope.org/images/screen/heic0406a.jpg

b) Access to the *SkyWalker* website at: http://www.aip.de/groups/galaxies/sw/udf/swudfV1.0.html

c) Note: *There is no expectation that students have studied galaxies prior to completing this research project.*

Phase I: Exploration

1) Access the online Hubble Space Telescope Image at http://www.spacetelescope.org/images/screen/heic0406a.jpg *You might be able to make it larger and smaller by "left clicking" on the image with your mouse*. Most of these objects are galaxies far, far from Earth. However, a few objects are nearby stars, as indicated by "four points" on the image, like shown at left.

How many stars can you find? _____

2) 2. Again, most of these objects are not individual stars, but actually distant galaxies—*isolated collections of millions or billions of stars that look like a tiny dot or cloud*. Determine how many galaxies are found in the image. *One strategy to count the number of galaxies in the image is to just count the number of objects in ¼ of the image (the bottom left corner for example) and then multiply the number of galaxies times four to get the total number.*

Total number of galaxies in this image? _____

3) Some of the galaxies are orange-red in color, while others are white, and others are blue. What is the most common color of galaxy in the image? *Precisely explain how you determined this*.

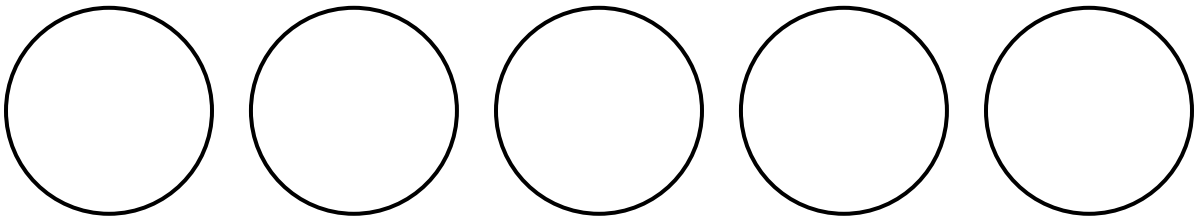
4) If we assume that all of the galaxies in this image have the same diameter, the ones that are close appear larger and the ones that are more distant appear smaller. Are most of the galaxies in this image relatively near or relatively far? What is your evidence?

Phase II – Does the Evidence Match a Given Conclusion?

5) Access the interactive Ultra Hubble Deep Field site through the *SkyWalker* website at: http://www.aip.de/groups/galaxies/sw/udf/swudfV1.0.html

The green circle in the top left hand corner is a sort of "magnifying glass" that you can drag around that will let you look at close up portions of the Hubble Ultra Deep Field. *Note that the picture is about 8 green circles wide and 10 green circles tall, for a total of about 80 green circles over the whole image*.

Make rough sketches of the five closest galaxies you can find in the image.



Consider the research question, "What is the most common type of nearby galaxy?" If a fellow student proposed a generalization that "nearby galaxies are equally split between circular-round and elongated spiral shapes," would you agree, disagree with the generalization based on the evidence you collected by counting how many of each shape you found? *Explain your reasoning and provide specific evidence either from the above tasks or from new evidence you yourself generate using the SkyWalker Web Site.*

Phase III – What Conclusions Can You Draw From This Evidence?

The Hubble Ultra Deep Field is one of most important images in astronomy because it shows some of the most distant galaxies in the Universe. What conclusions and generalizations can you make from the following data collected by a student by randomly positioning the green circle in an effort to determine WHAT IS THE GENERAL DISTRIBUTION OF GALAXY COLORS? *Explain your reasoning and provide the specific evidence you are using, with sketches or pie charts or graphs if necessary, to support your reasoning*.

GREEN CIRCLE SAMPLE NUMBER	NUMBER OF RED-ORANGE GALAXIES	NUMBER OF BLUE-WHITE GALAXIES
1	7	27
2	10	16
3	15	19
4	10	29
5	12	27

Data collected at http://www.aip.de/groups/galaxies/sw/udf/swudfV1.0.html

6) *Evidence-based Conclusion*:

Phase IV – What Evidence Do You Need To Pursue?

Imagine your team has been assigned the task of writing a news brief for your favorite news blog about the differences between the numbers of nearby and extremely distant galaxies in the Universe. Describe precisely what evidence you would need to collect, and how you would do it, in order to answer the research question of, "Are there more nearby galaxies or more extremely distant galaxies?" You do not need to actually complete the steps in the procedure you are writing.

7) *Create a detailed, step-by-step description of evidence that needs to be collected and a complete explanation of how this could be done—not just "move the green circle around and look at how many big and how many small," but exactly what would someone need to do, step-by-step, to accomplish this. You might include a table and sketches-the goal is to be precise and detailed enough that someone else could follow your procedure.*

Phase V – Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using the interactive *Ultra Hubble Deep Field* site (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about the characteristics of galaxies in our Universe, which you have not completed before.

Research Report:

Specific Research Question:

Step-by-Step Procedure, with Sketches if Needed, to Collect Evidence:

Data Table and/or Results (use additional pages if needed):

Evidence-based Conclusion Statement:

Phase VI – Summary

PRINT YOUR NAME_____

Create a 50-word summary, in your own words, that describes the characteristics and distribution of galaxies in our Universe. You should cite specific evidence you have collected in your description, not describe what you have learned in class or elsewhere. Feel free to create and label sketches to illustrate your response.

2 Observing the Sun's Position and Motion

Big Idea: Sky objects have properties, locations, and predictable patterns of movements that can be observed and described. Those motions explain such phenomena as the day, the year, the seasons, phases of the moon, and eclipses.

Goal: Students will conduct a series of inquiries about the motion of the Sun in the sky using prescribed Internet simulations and learn how the Sun follows different pathways at different times of the year.

Computer Setup:

Access http://www.heavens-above.com/ and

a) Find SELECT FROM MAP link under *Configuration* and set your observing location and time zone

b) Find WHOLE SKY CHART link under *Astronomy*

Phase I: Exploration PART A:

1) On a map of the United States, north is toward the top of the page and west is to the left. On all of the star charts, north is toward the top of the page and west is to the right. How do you account for this difference?

2) This is the current sky. Find the YELLOW dot marking the current location of the SUN. Which constellation is it closest to right now? *If you do not see the Sun, it might be set to night-time—add or subtract enough hours until you do see it.*

3) Change the time by increasing it one hour and pressing submit. Exactly how has the Sun's position change on the map?

4) Slowly increase the time to later and later in the day. This system probably uses 24-hr "military time" or "Zulu" time. So, 6pm is actually entered as 18-hours. Determine EXACTLY what time, hours and minutes that the Sun will set tonight.

Sunset: _____

5) Which constellation was the Sun closest to when it set?

6) Is this the same or different than where the Sun was earlier in the day?

7) What generalization can you make about the relative speeds that the Sun and the stars move through the sky over the course of a day?

8) What generalization can you make about the direction the Sun and the stars move through the sky over the course of a day?

Phase I: Exploration PART B:

When looking at the star map set for SUNSET TONIGHT:

9) On what part of the map (left, right, top, bottom or center) is the star group that appears highest in the night sky? What is the name of this star group?

Circle one: left | right | top | bottom | center NAME:

10) On what part of the map (left, right, top, bottom or center) is the star group that appears near the southern horizon? What is the name of this star group?

Circle one: left | right | top | bottom | center NAME:

11) On what part of the map (left, right, top, bottom or center) is the star group that appears near the eastern horizon? What is the name of this star group?

Circle one: left | right | top | bottom | center NAME:

When l**ooking at the star map set for THREE HOURS after tonight's** Sunset:

12) On what part of the map (left, right, top, bottom or center) is the star group that now appears highest in the night sky? What is the name of this star group?

Circle one: left | right | top | bottom | center NAME:

13) Where did the stars that used to be at this position move?

14) On what part of the map (left, right, top, bottom or center) is the star group that now appears near the southern horizon? What is the name of this star group?

Circle one: left | right | top | bottom | center NAME:

15) Where did the stars that used to be at this position move?

16) On what part of the map (left, right, top, bottom or center) is the star group that now appears near the western horizon, where the Sun sets? What is the name of this star group?

Circle one: left | right | top | bottom | center NAME:

17) Where did the stars that used to be at this position move?

18) On what part of the map (left, right, top, bottom or center) is the star group that now appears near the eastern horizon, where the Sun rises? What is the name of this star group?

Circle one: left | right | top | bottom | center NAME:

19) Where did the stars that used to be at this position move?

20) If you were to change the time to midnight, predict what would be different about the positions of the stars.

21) What generalization statement can you make about how the stars change position over the course of the night?

Phase II – Does the Evidence Match the Conclusion?

Let's consider the research question, "how does the time of sunset change over the course of a year at this location?"

22) From before, precisely what time (hours and minutes) will the Sun set below the western horizon tonight?

23) Using the sky chart, precisely what time the Sun will set one month from now?

24) Using the sky chart, precisely what time the Sun will set two months from now?

25) Using the sky chart, precisely what time the Sun will set three months from now?

26) Using the sky chart, precisely what time the Sun will set six months from now?

27) Using the sky chart, precisely what time the Sun will set nine months from now?

28) Using the sky chart, precisely what time the Sun will set twelve months from now?

29) If a student proposed a generalization that, "Sunset time changes about one hour per month, setting earlier and earlier in the fall and then setting later and later in the spring," would you agree, disagree with the generalization based on the evidence you collected by analyzing the pattern of sunset times? *Explain your reasoning and provide evidence either from the above questions or from evidence you yourself generate using the star map program.*

Phase III – What Conclusions Can You Draw From the Evidence?

Most of us would agree that the Sun sets in the general direction of west. What conclusions and generalizations can you make from the following data collected by a student in terms of HOW DOES THE DIRECTION THE SUN SETS CHANGE? *Explain your reasoning and provide evidence to support your reasoning*.

Date	Sunset Time	Azimuth (west = 270°)	Direction
August 15	7:00 pm	289°	Northwest
September 15	6:10 pm	274°	West
October 15	5:20 pm	258°	West Southwest
November 15	4:40 pm	245°	Southwest
December 15	4:30 pm	238°	South Southwest

Evidence collected in standard time from http://www.heavens-above.com/ using SUN AND MOON DATA FOR TODAY under the *Astronomy* section and/or http://aa.usno.navy.mil/data/docs/AltAz.php for Laramie, WY

30) *Evidence-based Conclusion*:

Phase IV – What Evidence Do You Need?

Imagine your team has been assigned the task of writing a news brief for your favorite news blog about how the noon-time Sun's position, altitude, or distance above southern horizon changes over the course of the semester. Describe precisely what evidence you would need to collect in order to answer the research question of, "How does the noon-time Sun**'s position above the southern horizon change over the semester?**" You do not need to actually complete the steps in the procedure you are writing.

31) *Create a detailed, step-by-step description of evidence that needs to be collected and a complete explanation of how this could be done—not just "measure the position of the Sun," but exactly what would someone need to do, step-by-step, to accomplish this.*

Phase V – Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using heavens-above (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about some motion or position of the Sun in the sky which you have not completed before.

Research Report:

Specific Research Question:

Step-by-Step Procedure to Collect Evidence:

Data Table and/or Results:

Evidence-based Conclusion Statement:

Phase IV – Summary

PRINT YOUR NAME_____

Create a 50-word summary, in your own words, that describes how the Sun's motion and position changes over the day and over the year. Feel free to create and label sketches to illustrate your response.

3 Monitoring the Moving Constellations

Big Idea: Sky objects have properties, locations, and predictable patterns of movements that can be observed and described.

Goal: Students will conduct a series of inquiries about the position and motion of constellations using prescribed Internet simulations and learn how different stars are visible at different times of the year in different locations in the sky.

Computer Setup:

Access http://www.heavens-above.com/ and

c) Find SELECT FROM MAP link under *Configuration* and set your observing location and time zone

d) Find WHOLE SKY CHART link under *Astronomy*

e) NOTICE that the star charts are set such that north is toward the top and west is to the right, which is different than a map of the United States.

Phase I: Exploration

1) When you first turn on the star map, the yellow dot marking the Sun is probably visible (if not, change the time until it is above the south-western horizon). If you were to go outside right now, could you see these stars shown on the map? *Explain why or why not.*

2) Which constellation of stars is the Sun closest to?

3) If you increase the time by one hour, remembering to use a 24-hour clock, toward which direction does the Sun move? *Circle one*: North | South | East | West

4) Now, 1-hr later than when you started, which constellation of stars is the Sun now closest to?

5) If you advance the time to Sunset, which constellation of stars is the Sun closest to at Sunset?

6) Advance the time to Sunrise, which constellation of stars is the Sun closest to at Sunrise?

7) What generalization statement, in a complete sentence, can you make about how the Sun and the stars appear to move together in the sky?

Phase II – Does the Evidence Match the Conclusion?

Consider the research question, "Which direction does the Sun move compared to the background constellations?

8) Set the star map to noon today. If you could see the stars hidden behind the brilliantly shining Sun, which constellation of stars is the Sun closest to?

9) Using the sky chart, which constellation of stars is the Sun closest to tomorrow?

10) Using the sky chart, which constellation of stars is the Sun closest to one week later?

11) Using the sky chart, which constellation of stars is the Sun closest to two weeks from now?

12) Using the sky chart, which constellation of stars is the Sun closest to three weeks from now?

13) Using the sky chart, which constellation of stars is the Sun closest to one month from now?

14) Using the sky chart, which constellation of stars is the Sun closest to two months from now?

15) Using the sky chart, which constellation of stars is the Sun closest to three months from now?

16) Using the sky chart, which constellation of stars is the Sun closest to six months from now?

17) Using the sky chart, which constellation of stars is the Sun closest to nine months from now?

18) Using the sky chart, which constellation of stars is the Sun closest to one year from now?

19) Using the sky chart, which constellation of stars is the Sun closest to two years from now?

20) If a student proposed a generalization that "the constellations seem to slowly drift westward compared to the position of the Sun, with the Sun covering constellations at a rate of about one per week," would you agree, disagree with the generalization based on the evidence you collected by analyzing the pattern of how the Sun's position changes compared to the constellations? *Explain your reasoning and provide evidence either from the above questions or from evidence you yourself generate using the star map program.*

Phase III – What Conclusions Can You Draw From the Evidence?

Orion is a prominent constellation visible in the winter time, usually being hidden by the shining Sun in the summer. What conclusions and generalizations can you make from the following data collected by a student in terms of how the WHEN IS ORION VISIBLE DIRECTLY ABOVE THE SOUTHERN HORIZON? *Explain your reasoning and provide evidence to support your reasoning*.

Date	Time above Southern Horizon	Azimuth (west = 270°)	Direction
October 1	5:00 am	180°	South
November 1	3:00 am	180°	South
December 1	1:00 am	180°	South
January 1	11:00 pm (2300 hrs)	180°	South
February 1	9:00 pm (2100 hrs)	180°	South

Evidence collected in standard time from http://www.heavens-above.com/ for Laramie, WY

21) *Evidence-based Conclusion*:

Phase IV – What Evidence Do You Need?

Imagine your team has been assigned the task of writing a news brief for your favorite news blog about when one of your team member's horoscope birth sign is covered by the Sun. Describe precisely what evidence you would need to collect in order to answer the research question of, "Over what precise period of time is my horoscope birth sign being covered by the Sun and is thus unable to be observed? You do not need to actually complete the steps in the procedure you are writing.

22) *Create a detailed, step-by-step description of evidence that needs to be collected and a complete explanation of how this could be done—not just "look and see when the Sun is nearby," but exactly what would someone need to do, step-by-step, to accomplish this.*

Phase V – Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using heavens-above (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about some motion or position in the sky for the constellations which you have not completed before.

Research Report:

Specific Research Question:

Step-by-Step Procedure to Collect Evidence:

Data Table and/or Results:

Evidence-based Conclusion Statement:

Phase IV – Summary PRINT YOUR NAME_____

Create a 50-word summary, in your own words, that describes which constellations are visible at night and how this changes over the night and over the year. Feel free to create and label sketches to illustrate your response.

4 Inquiring about Earth's Weather

Big Idea: Weather is a snap-shot description of Earth's atmospheric conditions at a particular location and at a particular time that is characterized by temperature, humidity, cloud cover, precipitation, barometric pressure, and wind speed.

Goal: To complete several scientific inquires about changing weather conditions at various locations.

Computer Setup and/or Materials Needed: Internet access to http://www.wunderground.com/history/ (*yes, you need the last slash in the URL*)

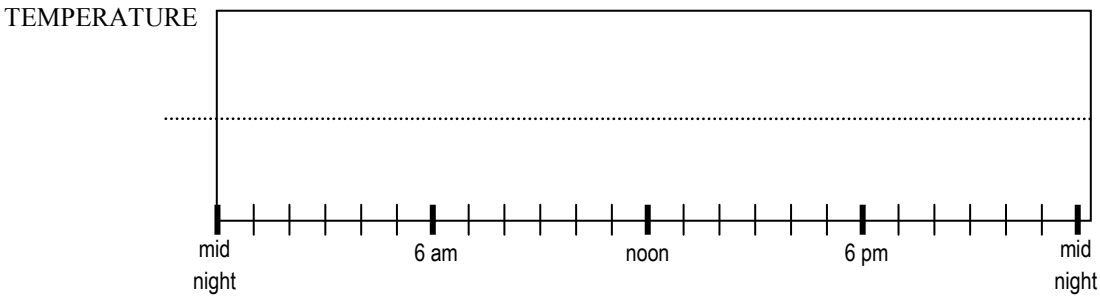
Phase I: Exploration

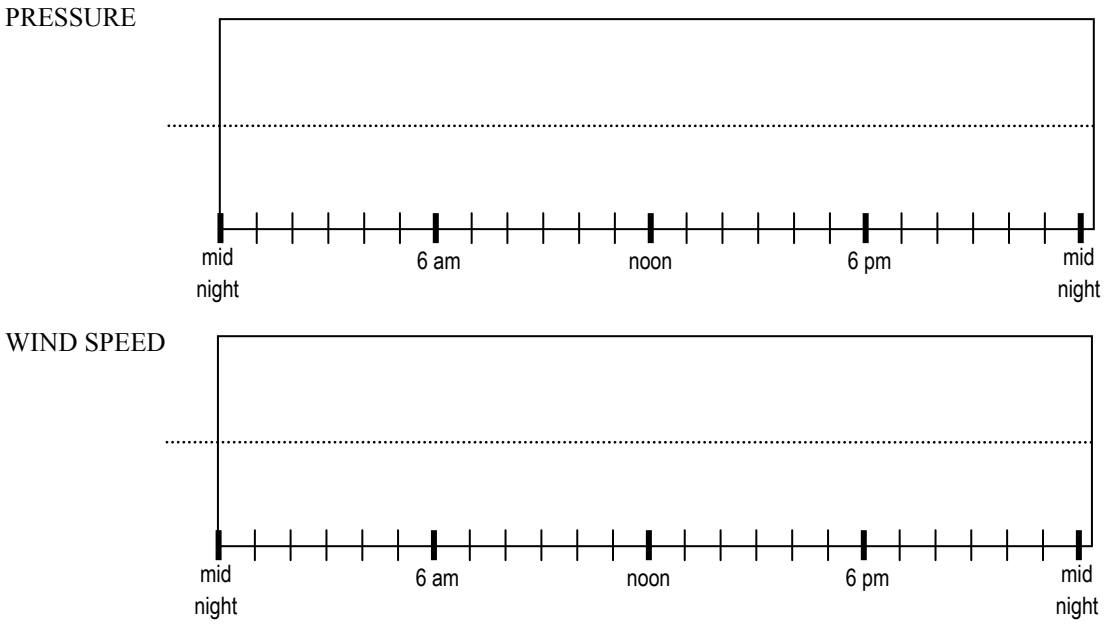
1. In the Location box, enter in your current location for today and complete the first blank column of the table below. Then, change the date to yesterday and then one year ago today and complete the remaining two columns.

Location:	TODAY	YESTERDAY	ONE YEAR AGO TODAY
Maximum Temperature (using °F)			
Minimum Temperature (using °F)			
Average Humidity (using %)			
Day's Precipitation (using inches)			
Barometric (or Sea Level) Pressure*			
Wind Speed (mph)			

* (using inches Hg)

2. For YESTERDAY, make a few rough sketches of how the temperature, barometric pressure, and wind speed have changed throughout that day. *Be sure to clearly label the vertical axis.*





3. Consider the research question, "How are the weather conditions here today different than yesterday?" In order to pursue evidence for this question, first create a short, written description of today's weather by describing the important characteristics and measurements. Then, create a second, short, written description of yesterday's in much the same way. Finally, complete your full response by composing a description of how the two days are different. *Be sure to include temperature humidity, precipitation, pressure, and wind speed.*

Phase II – Does the Evidence Match a Given Conclusion?

4. Consider the research question of "How much does the weather change year to year?" If a student proposed a generalization that "the temperature here today is about the same as it was at this same location on this same date, but back in the year you **were born"** would you agree, disagree with the generalization based on patterns you can find in the evidence you collected in the previous section or using new evidence.? *Explain your reasoning and provide specific evidence either from the above questions or from any new evidence you yourself generate using this web site.*

Phase III – What Conclusions Can You Draw From This Evidence?

Wind is caused when air rapidly moves from one place to another. What conclusions and generalizations can you make from the following data collected by a student in terms of WHAT TIME OF YEAR IS IT THE MOST WINDY IN LARAMIE, WYOMING? By analyzing which season (Winter, Spring, Summer, or Fall) has the greatest average wind speed average. *Explain your reasoning and provide specific evidence from data, with sketches if necessary, to support your reasoning*.

Date (2008)	Average Wind Speed (mph)	Wind Direction	Precipitation (in.)	Humidity (%)
Jan 15	*21*	*WNW*	*Trace Snow*	*62*
Feb 15	4	WSW	0	82
Mar 15	*9*	*South*	*0*	*62*
Apr 15	22	SW	0	26
May 15	*11*	*NNW*	*0.02*	*65*
June 15	8	SSE	0	40
July 15	*7*	*South*	*0*	*34*
Aug 15	6	ENE	0.48	86
Sept 15	*6*	*SSE*	*0*	*54*
Oct 15	10	SSW	0	57
Nov 15	*5*	*South*	*0*	*58*
Dec 15	11	SSW	0	62

5. *Evidence-based Conclusion*:

Phase IV – What Evidence Do You Need To Pursue?

6. Imagine your team has been assigned the task of designing a scientific observation plan for determining where to build windmills for electricity. Describe precisely what evidence you would need to collect and how to collect it in order to answer the research question of, "**Where is it windiest in my state?"** You do not need to actually complete the steps in the procedure you are writing, but you might need to sketch a map of your state.

Create a detailed, step-by-step description of evidence that needs to be collected and a complete explanation of how this could be done—not just "look and see where it is windiest," but exactly what would someone need to do, step-by-step, to accomplish this. You might include a table and sketches-the goal is to be precise and detailed enough that someone else could follow your procedure.

Phase V – Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data, and create an evidence-based conclusion about an aspect which you have not completed before.

Research Report:

Specific Research Question:

Step-by-Step Procedure to Collect Evidence:

Data Table and/or Results:

Evidence-based Conclusion Statement:

Phase IV – Summary PRINT YOUR NAME_____

Create a 50-word summary, in your own words, that describes the nature of weather at different locations and how this changes over the year. Feel free to create and label sketches to illustrate your response.

5 Assessment Case Studies #1

Assessing & Improving Research Projects

Big Idea: Designing a fruitful plan for conducting research has many pitfalls. By assessing the research reports of others, scientists can improve their own ability to design attractive research plans. With better research designs, researchers can improve the support for the claims they make with better and better evidence.

Goal: Students will assess a series of research reports and then select one project to redesign and conduct in order to more productively pursue the original research question.

Assess Research Projects & Identify Inconsistencies in their Lines of Inquiry

Your task is to improve research projects similar to those you have already completed. Work improving only on one research report at a time. Make sure to specify which report you are using by completely writing out the research question. Answer each of the questions by circling *yes*, *no*, or *maybe*, and then provide a short, but detailed, explanations of your reasoning citing specific information from the provided research reports.

Inquiry Research Report #11
Monitoring the Moving Constellations

Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using heavens-above (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about some motion or position in the sky for the constellations which you have not completed before.

Research Report:

Specific Research Question:

During which season is the constellation Orion high in the southern sky just after sunset?

Step-By-Step Procedure to Collect Evidence:

Using heavens-above.com to make observations:
1. Chose a day of the month to observe
2. On each observation day, just after the sunset determine if *Orion* is visible and determine in which part of the sky it is located
3. Repeat the observation once a month for a year

Data Table and/or Results:

Date	Visible	Location		Date	Visible	Location
4/1/09	yes	high SW sky		10/1/09	no	n/a
5/1/09	yes	low W sky		11/1/09	no	n/a
6/1/09	no	n/a		12/1/09	no	n/a
7/1/09	no	n/a		1/1/10	yes	low E sky
8/1/09	no	n/a		2/1/10	yes	high SE sky
9/1/09	no	n/a		3/1/10	yes	high S sky

Evidence-based Conclusion Statement:

From the evidence above, we can see that the constellation Orion appears to move from low in the Eastern sky to low in the Western sky from January to May.

CASE STUDY RESEARCH REPORT #11:

1. Specific Research Question:_____

What list of things might you observe to pursue this research question?

2. Step-by-Step Procedure to Collect Evidence:

Is the plan presented going to yield the necessary evidence needed to fully answer the listed research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

3. Conclusions Drawn from Data Table and/or Results of Evidence

Has enough evidence been collected for this specific research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

Have they claimed more than the evidence supports?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

4. Evidence-based Conclusion Statement:

Have assumptions impacted their results?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

Does the claim directly answer the original research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

5. Precisely, what should the researchers have done or reported differently to improve their inquiry research project?

Inquiry Research Report #12
Observing the Sun's Position and Motion

Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using heavens-above (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about some motion or position of the sun in the sky which you have not completed before.

Research Report:

Specific Research Question:

Over the course of a year, how does the amount of sunlight each day at the equator compare to that of Laramie, WY?

Step-By-Step Procedure to Collect Evidence:

Use heavens-above.com to make observations:
1. Choose a number of days over the course of a year to make observations.
2. Observe and record the sunrise and sunset times on each of the of the observation days in Laramie, WY and at the equator.
3. Use the sunrise and sunset times to calculate the total amount of daylight on each of the observation days and at both locations.

Data Table and/or Results

(All times are Mountain Standard Time)

Date	Laramie Sunrise	Laramie Sunset	Total Daylight	Equator Sunrise	Equator Sunset	Total Daylight
3/8/2009	6:25 am	5:50 pm	11:35	6:10 am	6:08 pm	11:58
3/15/2009	6:15 am	6:00 pm	11:45	6:09 am	6:06 pm	11:57
3/22/2009	6:00 am	6:05 pm	12:05	6:08 am	6:04 pm	11:56
3/29/2009	5:50 am	6:15 pm	12:25	6:05 am	6:02 pm	11:57

Evidence-based Conclusion Statement:

Over the course of a year, the sun rises earlier and sets later in the summer than in winter in Laramie, WY, so there is more daylight in summer and less in winter. The equator does not experience seasons so there is no change in the amount of daylight as the year progresses.

CASE STUDY RESEARCH REPORT #12:

6. Specific Research Question:_____

What list of things might you observe to pursue this research question?

7. Step-by-Step Procedure to Collect Evidence:

Is the plan presented going to yield the necessary evidence needed to fully answer the listed research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

8. Conclusions Drawn from Data Table and/or Results of Evidence

Has enough evidence been collected for this specific research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

Have they claimed more than the evidence supports?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

9. Evidence-based Conclusion Statement:

Have assumptions impacted their results?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

Does the claim directly answer the original research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

10. Precisely, what should the researchers have done or reported differently to improve their inquiry research project?

Inquiry Research Report #13
Monitoring the Zodiac Constellations

Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using heavens-above (or another suitable source pre-approved by your lab instructor).

Research Report:

Specific Research Question:

Does the altitude of the line of the Zodiac constellations through the sky change over the course of a year in the same way as the path of the Sun? That is, does it move higher and higher above the southern horizon in spring and move lower and lower toward the southern horizon in fall?

Step-by-Step Procedure to Collect Evidence:

Use heavens-above.com to make observations:
1. Choose a day of the month to observe the Zodiac
2. Each month, right after sunset, record the direction & time the Zodiac is rising
3. For clarity, label directions as; northeast, NE; east-northeast, ENE; east, E; east-southeast, ESE; etc.

Data Table and/or Results:

Date: Day of the year for observation; Time: Time after sunset when Zodiac was observed
Direction: The direction on the horizon where the zodiac was rising

Date	Time	Direction		Date	Time	Direction
1/15/2009	5:00pm	ENE		7/15/2009	8:30pm	ESE
2/15/2009	5:30pm	ENE		8/15/2009	8:00pm	ESE
3/15/2009	7:15pm	E		9/15/2009	7:15pm	E
4/15/2009	7:45pm	E		10/15/2009	6:15pm	E
5/15/2009	8:15pm	ESE		11/15/2009	4:45pm	ENE
6/15/2009	8:45pm	ESE		12/15/2009	4:30pm	ENE

Evidence-based Conclusion Statement:

Every month the path of the Zodiac appears to move lower and lower from summer all the way through fall. After winter starts, the path moves higher and higher above the horizon throughout spring until summer. This is nearly identical

to the changes that the path of the Sun takes throughout the year, and also accounts for the changes in the seasons.

CASE STUDY RESEARCH REPORT #13:

11. Specific Research Question:_____

What list of things might you observe to pursue this research question?

12. Step-by-Step Procedure to Collect Evidence:

Is the plan presented going to yield the necessary evidence needed to fully answer the listed research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

13. Conclusions Drawn from Data Table and/or Results of Evidence

Has enough evidence been collected for this specific research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

Have they claimed more than the evidence supports?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

14. Evidence-based Conclusion Statement:

Have assumptions impacted their results?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

Does the claim directly answer the original research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

15. Precisely, what should the researchers have done or reported differently to improve their inquiry research project?

Choose One Research Project to Redesign, Improve, and Conduct

Your task is to choose one of the research projects (either report 12 or report 13) to redesign and carry out. You should re-use the exact same research question as the previous researchers, but make sure to improve the research design so that you eliminate all the problems you were able to identify. At the end, check over your research by answering the assessment questions about your own inquiry report.

Your *Redesigned* Research Report:

Specific Research Question:

Step-by-Step Procedure to Collect Evidence:

Data Table and/or Results:

Evidence-based Conclusion Statement:

REDESIGNED RESEARCH REPORT:

16. Specific Research Question:_____

What list of things might you observe to pursue this research question?

17. Step-by-Step Procedure to Collect Evidence:

Is the plan you used going to yield the necessary evidence needed to fully answer the listed research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

18. Conclusions Drawn from Data Table and/or Results of Evidence

Has enough evidence been collected for this specific research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

Have you claimed more than the evidence supports?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

19. Evidence-based Conclusion Statement:

Have assumptions impacted your results?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

Does the claim directly answer the original research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

20. Precisely, what has been done or reported differently improving the original inquiry research project?

Phase VI – Summary PRINT YOUR NAME_____

Write a 50 word summary of what makes a solid inquiry research project. Include reason(s) why you elected to improve the project you did, explain what the biggest problems were, and how you corrected them. Be sure to describe details about how your changes improved the line of inquiry.

In general, what are some common problems you need to avoid in designing a solid research project?

In general, what are some important things to consider about assumptions you make in your research design?

6 Observing Jupiter's Moons

Big Idea: Sky objects have properties, locations, and predictable patterns of movements that can be observed and described.

Goal: Students will conduct a series of inquiries about the position and motion of Jupiter's moons using prescribed Internet simulations.

Computer Setup:

Access http://space.jpl.nasa.gov// and

a) Select THE MOON in the "Show me _____ " drop down menu

b) Select THE SUN in the "as seen from _____ " drop down menu

c) Select the radio button "I want a field of view of ____ degrees" and set the drop down menu to 0.5

d) Select the check box for EXTRA BRIGHTNESS and then Select "Run Simulator"

Phase I: Exploration

1. The resulting image shows what one would see looking through a special telescope. In this picture, where is the observer with the special telescope located?
2. How does the image change if you INCREASE the field of view?
3. What is the exact date of the image?
4. Astronomers typically mark images based on the time it currently is in Greenwich, England, called UTC. What is the precise listed on the image?
5. Using a ruler to measure the distance on the screen between the middle of Earth and the middle of the Moon, what is the measured distance? You do NOT need to know the exact number of kilometers, but simply a ruler-measurement you can compare other measurements you make later. *Alternately, you can use the edge of a blank piece of paper held in the landscape orientation and mark the positions of Earth and Moon or the Squidgit ruler found near the end of these instructions.*

6. Use the browser's BACK button to return to the Solar System Simulator homepage. Now, advance the time by 1 hour and determine the new distance between the Earth and Moon. Record the distance here.

7. Use the browser's BACK button to return to the Solar System Simulator homepage. Now, advance the time by one day from when you started and determine the new distance between the Earth and Moon.

8. Use the browser's BACK button to return to the Solar System Simulator homepage. Now, advance the time by three days from when you started and determine the new distance between the Earth and Moon.

9. Use the browser's BACK button to return to the Solar System Simulator homepage. Now, advance the time by five days from when you started and determine the new distance between the Earth and Moon.

10. Use the browser's BACK button to return to the Solar System Simulator homepage. Now, advance the time by 10 days from when you started and determine the new distance between the Earth and Moon.

11. Use the browser's BACK button to return to the Solar System Simulator homepage. Now, advance the time by two weeks from when you started and determine the new distance between the Earth and Moon.

12. Use the browser's BACK button to return to the Solar System Simulator homepage. Now, advance the time by one month from when you started and determine the new distance between the Earth and Moon.

13. Use the browser's BACK button to return to the Solar System Simulator homepage. Now, advance the time by three months from when you started and determine the new distance between the Earth and Moon.

14. Consider the research question of, "how long does it take the Moon to orbit Earth?" It has been said that it takes about one "moon-th" for the Moon to go around Earth. Which of your observations confirms or contradicts this statement? *Explain*.

Phase II – Does the Evidence Match the Conclusion?

15. Consider the research question, "How long does it take one of Jupiter's moons to orbit Jupiter?" Set the Solar System Simulator to observe Jupiter from the Sun, where Jupiter takes up 10% of the image and measure the distance between Jupiter and Io shown on the image.

16. Advance the "time" by one day, and record the distance between Jupiter and Io.

17. Advance the "time" by two days from when you started, and record the distance between Jupiter and Io.

18. Advance the "time" by three days from when you started, and record the distance between Jupiter and Io.

19. Advance the "time" by four days from when you started, and record the distance between Jupiter and Io.

20. Advance the "time" by five days from when you started, and record the distance between Jupiter and Io.

21. Advance the "time" by six days from when you started, and record the distance between Jupiter and Io.

22. If a student proposed a generalization that "Io orbits the Jupiter about every 48 hours," would you agree, disagree with the generalization based on the evidence you collected by noting patterns in the time it takes for Io to return to its original position from where it started? *Explain your reasoning and provide specific evidence either from the above questions or from evidence you yourself generate using the Solar System Simulator*.

Phase III – What Conclusions Can You Draw From the Evidence?

Europa is one of the four largest moons orbiting Jupiter. The others are Io, Callisto, and Ganymede. What conclusions and generalizations can you make from the following data collected by a student in terms of HOW LONG DOES IT TAKE EUROPA TO ORBIT JUPITER? *Explain your reasoning and provide specific evidence, with sketches if necessary, to support your reasoning*.

Time	Measured Distance from Jupiter	Appearance Notes
11pm Monday	0 squidgets	Not visible, likely behind Jupiter
11pm Tuesday	5.0 squidgets	On Jupiter's right side
11pm Wednesday	1.5 squidget	On Jupiter's right side
11pm Thursday	5.0 squidgets	On Jupiter's left side
11pm Friday	No observations	Cloudy

23. *Evidence-based Conclusion*:

Phase IV – What Evidence Do You Need?

Imagine your team has been assigned the task of writing a news brief for your favorite news blog about the length of time it takes Ganymede, the largest moon in the entire solar system, to orbit Jupiter once. Describe precisely what evidence you would need to collect in order to answer the research question of, "Over what precise period of time does it take Ganymede to orbit Jupiter? You do not need to complete the procedure you've written.

24. *Create a detailed, step-by-step description of evidence that needs to be collected and a complete explanation of how this could be done—not just "look and see when the Ganymede is first on one side and then on the other,," but exactly what would someone need to do, step-by-step, to accomplish this. You might include a table and sketches-the goal is to be precise and detailed enough that someone else could follow your procedure.*

Phase V – Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using Solar System Simulator (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about some motion or changing position of a moon of the solar system, which you have not completed before.

Research Report:

Specific Research Question:

Step-by-Step Procedure, with Sketches if Needed, to Collect Evidence:

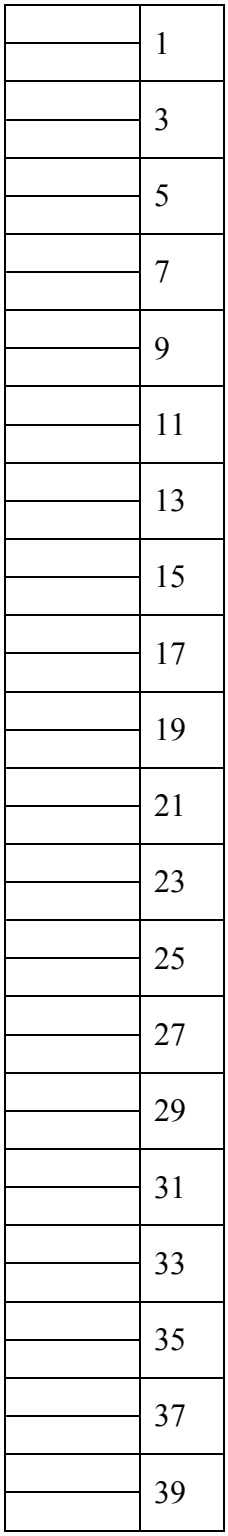
Data Table and/or Results:

Evidence-based Conclusion Statement:

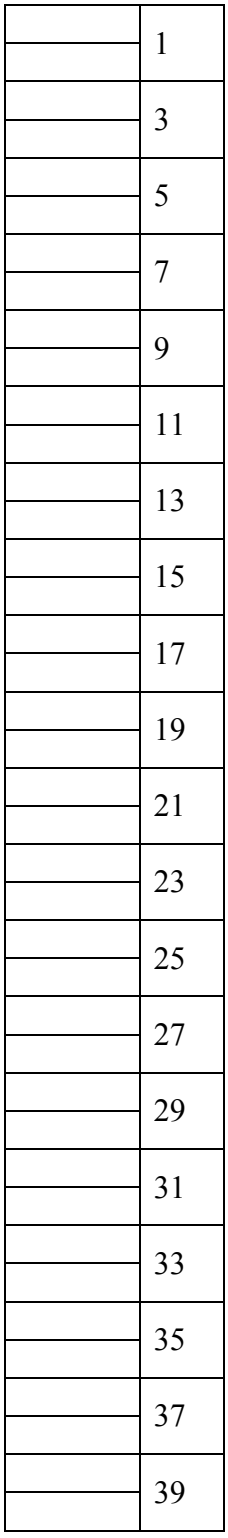
Phase VI – Summary PRINT YOUR NAME_____

Create a 50-word summary, in your own words, that describes the motions, orbits, or rotations of Jupiter's moons and how this changes over time. You should cite specific evidence you have collected in your description, not describe what you have learned in class or elsewhere. Feel free to create and label sketches to illustrate your response.

Astronomical Ruler
(in units of squigits)



Astronomical Ruler
(in units of squigits)



7 Studying Extra-solar Planets

Big Idea: Planets orbiting other stars have orbital characteristics similar and different to our own solar system of planets orbiting our Sun

Goal: Students will conduct a structured series of scaffolded scientific inquiries about the nature of observed extra-solar planets using the Internet sites prescribed, particularly the *Interactive Extra-solar Planets Catalog*.

Computer Setup: Access URL http://exoplanet.eu/catalog-all.php

Needed Resources: Solar System Data Table, calculator, and these instructions

SOLAR SYSTEM DATA TABLE

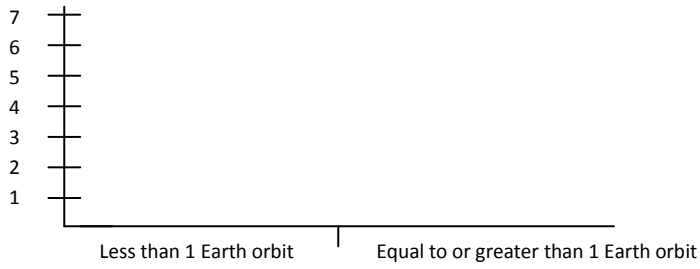
NAME	MASS (M_{Earth})	MASS ($M_{Jupiter}$)	PERIOD (Earth-Years) [*Earth-Days*]	SEMI-MAJOR AXIS DISTANCE (AU)
Object Name	*How many times larger than (or fraction of) planet Earth's mass*	*How many times larger than (or fraction of) planet Jupiter's mass*	*How many Earth-years the planet takes to orbit our Sun*	*How many Earth-Sun distances away the planet orbits our Sun*
Mercury	0.06	0.0002	0.24 [*88*]	0.39
Venus	0.82	0.003	0.62 [*226*]	0.72
Earth	1.00	0.003	1.00 [*365*]	1.00
Mars	0.11	0.0003	1.88 [*687*]	1.52
Jupiter	318	1.00	11.86 [*4,328*]	5.20
Saturn	95.2	0.299	29.5 [*10,775*]	9.54
Uranus	14.5	0.046	84.0 [*30,681*]	19.2
Neptune	17.1	0.054	165 [*60,266*]	30.1
Pluto *	0.002	0.00001	249 [*90,947*]	39.5

Note: Pluto may or may not currently be defined as a planet by the International Astronomical Union. Numerical data obtained from http://www.nasm.si.edu/research/ceps/etp/ss/ss_planetdata.html*

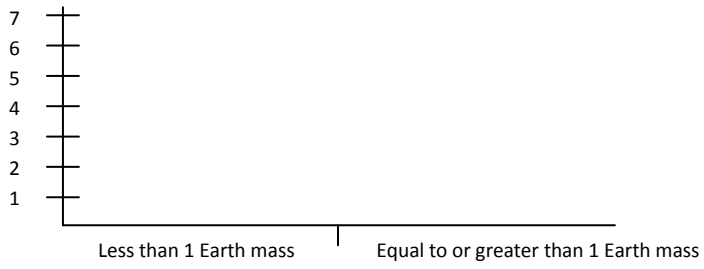
Phase I: Exploration Part A

Consider the research question, "how are characteristics of extra-solar planets distributed?" A *histogram* is a bar-chart showing the number of objects in a particular category. Use the SOLAR SYSTEM DATA TABLE and sketch histograms for each of the following.

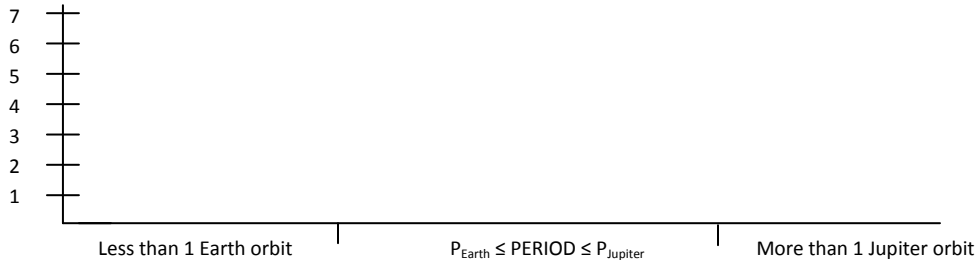
1) Title: Distribution of Orbital Distance: Number of Planets Closer and Farther than Earth's Orbital Distance



2) Title: Distribution of Masses: Number of Planets with Masses Less than Earth's Mass and Greater than Earth's Mass



3) Title: Distribution of Orbital Periods: $P < P_{Earth}$; $P_{Earth} \leq PERIOD \leq P_{Jupiter}$; $P > P_{Jupiter}$

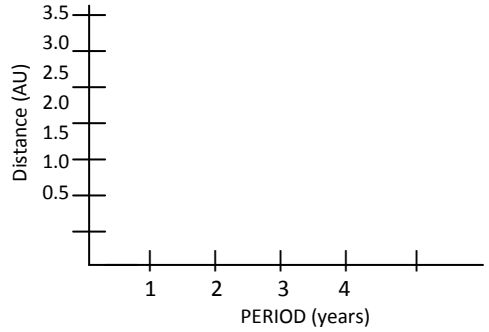


Phase I: Exploration Part B

Consider the research question, "what is the distribution of orbital distances for extra-solar planets?" A *correlation-diagram* is a graph of dots showing how two characteristics, or variables, are related. Use the SOLAR SYSTEM DATA TABLE and sketch a correlation-diagram for each of the following.

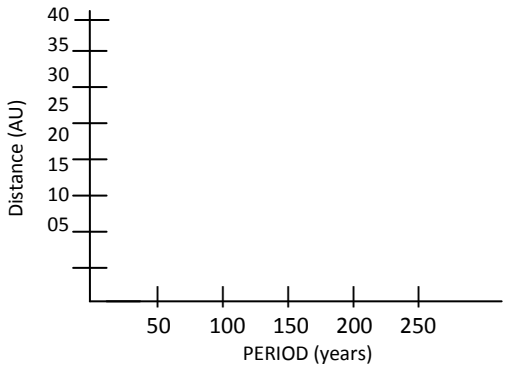
4) Title: Distance (AU) vs. Period (Years) for Planets Closer than Jupiter (*not including Jupiter*)

(Vertical Y-axis Distance versus Horizontal X-axis Period)

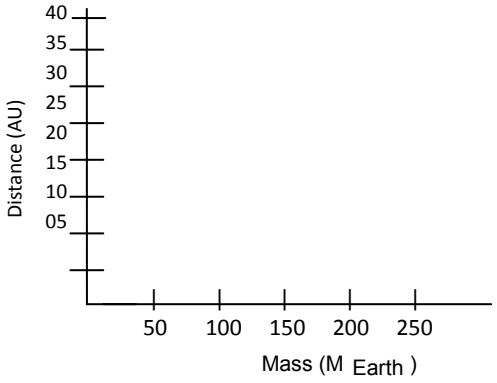


5) Title: Distance (AU) vs. Period (Years) for Planets With Orbits Jupiter-sized and larger

(Vertical Y-axis Distance versus Horizontal X-axis Period)



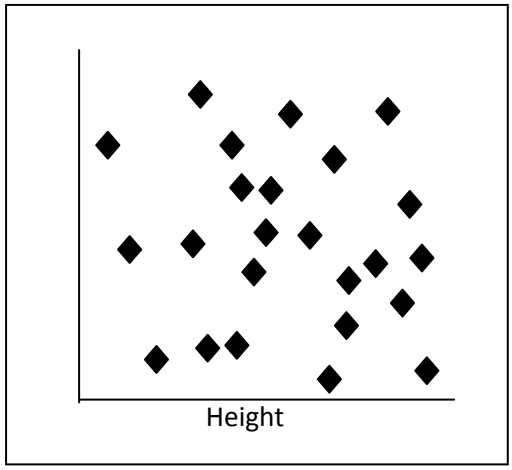
6) Title: Distance (AU) vs. Mass (M_{Earth}) for all Solar System Planets
(Vertical Y-axis Distance versus Horizontal X-axis Mass)



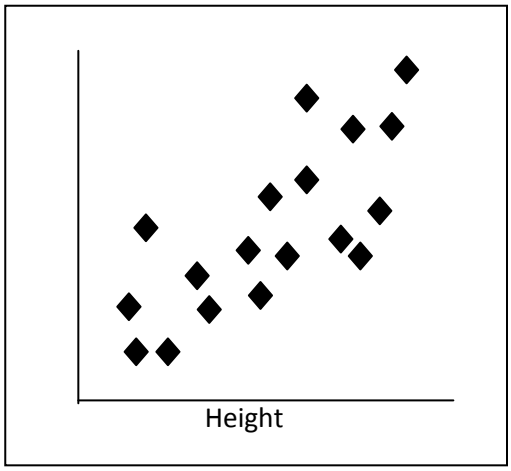
Phase I: Exploration Part C

Consider the research question, "which characteristics of extra-solar planets are most highly correlated with distance?" The notion of *correlation* is the idea that two characteristics are closely related to one another. *IMPORTANT NOTE: CORRELATION IS NOT THE SAME AS CAUSE-AND-EFFECT.*

7) One of the two graphs below is *Intelligence versus Height* and the other is *Weight versus Height*. In the space below, precisely explain your reasoning about why which is which.



A



B

Explanation of why which graph is which:

8) Based on your work above on analyzing the planets of our solar system, which variable, PERIOD or MASS, seems to be more highly correlated to DISTANCE? Explain your reasoning, using labeled sketches to illustrate your answer.

Phase II – Does the Evidence Match a Given Conclusion?

9) PART A: Access the Interactive Extra-Solar Planets Catalog [http://exoplanet.eu/catalog-all.php] and skim the data to determine which planet was most recently discovered/updated and record data about it here (*including units*).

NAME: _____

MASS: _____

PERIOD: _____

SEMI-MAJOR AXIS LENGTH: _____

User Notes On Using The Interactive Extra-solar Planet Catalog Table

1) Notice that the first column gives the extra-solar planet's NAME.
2) Notice that the second column is the extra-solar planet MASS. The MASS is given in terms of how many times bigger (or smaller) than the mass of our planet Jupiter, M_{Jup}.
3) Notice that the fourth column shows the extra-solar planet's PERIOD. The period is the length of time in Earth-days it takes the extra-solar planet to go around its central host star once. *You can switch this to Earth-years by clicking on the unit days*.
4) Notice that the fifth column shows the SEMI-MAJOR AXIS. This is another name for how far the planet orbits its star, on average. The units of distance are AU, or Astronomical Unit. IMPORTANT: One AU is the average distance our Earth orbits our Sun.

10) Is this planet more massive than Earth? *Circle one*: Yes No

If so, how many times more massive? _____

11) Is this planet more massive than Jupiter? *Circle one*: Yes No

If so, how many times more massive? _____

PART B: Select HISTORGRAMS and choose the reference to be: PLANET SEM MAJ AXIS with the minimum orbital distance plotted at 0 AU and the maximum orbital distance at 10 AU. *Remember that Earth orbits our Sun at a distance of 1 AU and Jupiter orbits at about 5 AU.*

12) How many extra-solar planets are shown in this data set?	
13) How many of the currently known extra-solar planets have orbits larger than Jupiter's orbit about our Sun?	
14) What is the percentage of currently known extra-solar planets that have orbits larger than Jupiter's orbit about our Sun?	
15) How many of the currently known extra-solar planets have orbits smaller than Earth's orbit about our Sun?	
16) What is the percentage of currently known extra-solar planets that have orbits smaller than Earth's orbit about our Sun?	

PART C: Select HISTORGRAMS and choose the reference to be: PLANET PERIOD with the minimum length of time for the planet to orbit its star as 0 days and the maximum period to be 900 days. *Remember that Earth orbits our Sun once every 365 days and Jupiter orbits once about every 4,300 days.*

17) How many extra-solar planets in total are shown in this particular data set?	
18) What percentage of the planets shown have orbital periods similar to our planet Mercury?	
19) What percentage of the planets shown have orbital periods similar to our planet Venus?	
20) What percentage of the planets shown have orbital periods similar to our planet Earth?	
21) What percentage of the planets shown have orbital periods similar to our planet Mars?	
22) What percentage of the planets shown have orbital periods similar to our planet Jupiter? (*you will likely need to change the min/max setting*)	

23) Consider the research question, "how long do extra-solar planets take to orbit their star?" If a student proposed a generalization that "most extra-solar planets discovered take about the same length of time to orbit their star as Earth takes to orbit our Sun," would you agree or disagree with the generalization based on the evidence you collected by looking at the range of possible orbital periods? *Explain your reasoning and describe specific evidence either from the above questions or from evidence you yourself generate using The Interactive Extra-solar Planets Catalog.*

Phase III – What Conclusions Can You Draw From the Evidence?

Extra-solar planets are so difficult to see that we rarely actually observe their exact position. What conclusions and generalizations can you make from the data organized using a correlation diagram in terms of how does the size an extra-**solar planet's orbit** compare to its orbital period? *Explain your reasoning and provide specific evidence, with sketches if necessary, to support your reasoning.*

> EVIDENCE: Select CORRELATION DIAGRAMS and choose horizontal X-axis to be: PLANET SEMI-MAJOR AXIS and the vertical Y-axis to be PLANET PERIOD. Select the radio buttons for both to be linear scale. (Use the same MIN and MAX values as before.) You can always get a close up of a particular data set by setting a Min. and a Max. if needed. In this case, set the PLANET PERIOD to have a Min. of 1 day and a Max. of 4 days.

24) *Evidence-based Conclusion*:

Phase IV – What Evidence Do You Need?

Imagine your team has been assigned the task of predicting how far a newly discovered extra-solar planet would orbit from its central star. Describe precisely what evidence you would need to collect in order to answer the research question of, "If an extra-solar planet was discovered to have an orbital period of 21 days, what would you predict its semi-major axis orbital distance to be using a correlation diagram? (This time the orbital period is the "independent", or X-axis variable, and the semi-major axis of the planet's orbit would be the "dependent", or Y-axis variable.) You do not need to actually carry out the procedure you've written.

25) *Create a detailed, step-by-step description of evidence that needs to be collected and a complete explanation of how this could be done—not just "look and see how many are merging," but exactly what would someone need to do, step-by-step, to accomplish this. You might include a table and sketches-the goal is to be precise and detailed enough that someone else could follow your procedure.*

Phase V – Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using the assigned Internet data set (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about the characteristics of known extra-solar planets.

Research Report:

Specific Research Question:

Step-by-Step Procedure, with Sketches if Needed, to Collect Evidence:

Data Table and/or Results:

Evidence-based Conclusion Statement:

Phase VI – Summary

PRINT YOUR NAME_____

Create a 50-word summary, in your own words, that describes the nature and frequency of extra-solar planets and systems we have discovered so far. (It may be helpful to make comparisons between our solar system and the extra-solar planets just like you did earlier.) You should cite specific evidence you have collected in your description, not describe what you have learned in class or elsewhere. Create and label sketches to illustrate your response.

8 Observing Features on the Sun

Big Idea: The Sun has surface features in different wavelengths and those features have predictable patterns of movements that can be observed and described.

Goal: Students will conduct a series of inquiries about the nature and motion of features in different wavelengths on the Sun using prescribed Internet simulations that access actual solar images taken by satellites.

Computer Setup:

Access http://cse.ssl.berkeley.edu/Segwayed/lessons/Sunspots/activity.html

a) Read through the information and watch the QuickTime movie that shows the comparison of visible and X-ray images over time. You may need to slowly step through the video frame by frame to see what is happening.

b) Click the Next button at the bottom of the page. Carefully read through the information on this second page.

   Images in this program are taken in what two types (wavelengths) of light? *Fill in the blanks below.*

   _____ and _____.

   Approximately how large is each pixel of the smallest brush size which you can paint?

   _____

c) About halfway down the page is a "launch program" button (on page 2 of 5). Click it. *Note: You will need a Java compatible browser for this.*

[This lesson created by Kendra Sibbernsen, Metropolitan Community College]

Phase I: Exploration

1. Select one of the images in the soft X-ray. Notice that there are two images taken for each day, one in the soft X-ray and one in white light (*visible*).

2. Identify a feature (active X-ray region) and then select the soft X-ray image one day later. Which way did the feature move?

   Circle one: left | right | up | down

3. Select the soft X-ray image one more day later. Did it appear to shift the same amount in the same direction?

   Circle one: yes | no

4. Consider the research question, "is there a relationship between the positions of sunspots in the visible light image and the X-ray image?" Find your feature on the X-ray image and then open the white light image for that same day. Is there clear evidence for a relationship between the precise position of the sunspots and the active X-ray regions?

   Circle one: yes | no

5. Create sketches as evidence to illustrate your evidence in the space below.

Phase II – Does the Evidence Match the Conclusion?

6. Select the smallest brush size for painting.

7. Select a white light image with several sunspots on it.

8. Paint a few sunspots and note the width of the sunspot in pixels.

   Width: _____

9. Consider the research question, "how large are sunspots, on average?" If a student proposed a generalization that "An average sunspot is approximately the width of 10 Earth diameters," would you agree or disagree with the generalization based on the evidence you collected or new evidence you need to collect? *Explain your reasoning and provide specific evidence either from the above questions or from evidence you yourself generate using the online data.*

Phase III – What Conclusions Can You Draw From the Evidence?

Imagine a solar scientist decided to look for evidence proving a relationship between the amount of area of sunspot activity and the area of X-ray activity resulting in the following data table. The program recorded a number of pixels for each area painted. What conclusions and generalizations can you make from the following data collected by a solar scientist related to the research question, **"How large are X-ray features compared to white light features?"** *Explain your reasoning and provide specific evidence, with sketches if necessary, to support your reasoning*.

Date	X-ray	White Light
01/06/92	347 pixels	52 pixels
01/09/92	380 pixels	64 pixels
01/12/92	183 pixels	21 pixels
01/15/92	83 pixels	11 pixels
01/17/92	150 pixels	10 pixels

10. *Evidence-based Conclusion*:

Phase IV – What Evidence Do You Need?

11. Describe precisely what evidence you would need to collect and how you would collect it in order to answer the research question of, "Over what precise period of time does it take an active region in the soft X-ray image near the Sun**'s equator** to complete one rotation?

Create a detailed, step-by-step description of evidence that needs to be collected and a complete explanation of how this could be done—not just "look and see when the region returns to the same point," but exactly what would someone need to do, step-by-step, to accomplish this. You might include a table and sketches-the goal is to be precise and detailed enough that someone else could follow your procedure.

Phase V – Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using the online data (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about some relationships between features seen in images of different wavelengths or changing position of a solar feature, which you have not completed before.

Research Report:

Specific Research Question:

Step-by-Step Procedure, with Sketches if Needed, to Collect Evidence:

Data Table and/or Results:

Evidence-based Conclusion Statement:

Phase VI – Summary

PRINT YOUR NAME_____

Create a 50-word summary, in your own words, that describes the features in different wavelengths on the Sun and how the motions or shapes of these features change over time. You should cite specific evidence you have collected in your description, not describe what you have learned in class or elsewhere. Feel free to create and label sketches to illustrate your response.

9 Exploring GalaxyZoo – One

Big Idea: The countless galaxies of stars spread throughout the Universe have characteristics that can be observed and classified.

Goal: Students will conduct a structured series of scaffolded scientific inquiries about the nature of observed galaxies using the Internet sites prescribed, particularly the *Sloan Digital Sky Survey* via the original *Galaxy Zoo* [http://zoo1.galaxyzoo.org/]

Computer Setup:

Access http://zoo1.galaxyzoo.org/ and

a) Select REGISTER and set up a username as:
WHF __ __ __ __ __
(where the five blanks are numbers) and a password that is identical to your username. *Record this information on this sheet.*

Userid: WHF___ ___ ___ ___ ___
Password: *same as above*

Email: _____

Security Question: _____

Answer: _____

b) Use one of your team member's email addresses. *Record it in the box.*

c) Create and enter a security question and answer. *Record it in the box.*

d) Select CREATE USER and, when set up, select CONTINUE.

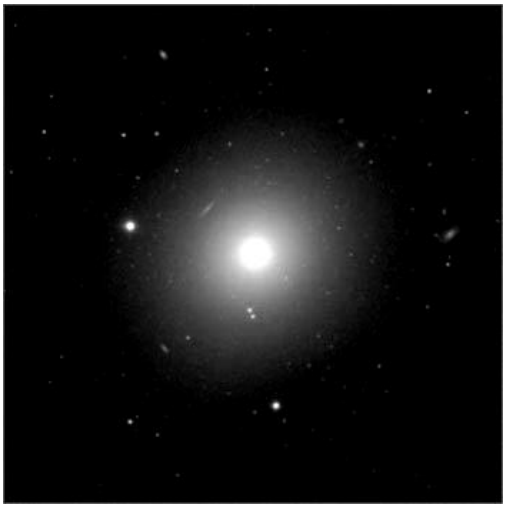
Phase I: Exploration

1. From your book, your class notes, or from the Internet, find a reasonably good definition of a galaxy and write it in the space below. *Include one rough sketch of what one looks like.*

   Definition and sketch of GALAXY:

2. Imagine that each of the two images below show a single galaxy of billions of stars.

Spiral Galaxy



Elliptical Galaxy

In the space below, create a detailed listing of the characteristics of each that allow you to distinguish one galaxy from the other.

Observable Characteristics of a Spiral Galaxy	Observable Characteristics of an Elliptical Galaxy

After logging into http://zoo1.galaxyzoo.org/, if you aren't already in, select HOW TO TAKE PART and complete the online TUTORIAL, completing the table below as you go along.

3. TUTORIAL PART 1A: SPIRAL or ELLIPTICAL

First record your answers in the blocks above corresponding to the Tutorial Part 1A. Then, check your answers and in the event your answer does not agree, mark a single line through your response. *There is no penalty for having an incorrect answer.*

4. TUTORIAL PART 1B: SPIRAL or ELLIPTICAL

First record your answers in the blocks above corresponding to the Tutorial Part 1B. Then, check your answers and in the event your answer does not agree, mark a single line through your response. *There is no penalty for having an incorrect answer.*

5. TUTORIAL PART 1C: MERGING or NOT MERGING

First record your answers in the blocks above corresponding to the Tutorial Part 1C. Then, check your answers and in the event your answer does not agree, mark a single line through your response. *There is no penalty for having an incorrect answer.*

6. TUTORIAL PART 1D: SPIRAL or ELLIPTICAL

First record your answers in the blocks above corresponding to the Tutorial Part 1D. Then, check your answers and in the event your answer does not agree, mark a single line through your response. *There is no penalty for having an incorrect answer.*

7. TUTORIAL PART 2B: CLOCKwise or ANTI-clockwise or EDGE on/can't tell

First record your answers in the blocks above corresponding to the Tutorial Part 2B. Then, check your answers and in the event your answer does not agree, mark a single line through your response. *There is no penalty for having an incorrect answer.*

8. TUTORIAL PART 3: GALAXY or "?"

First record your answers in the blocks above corresponding to the Tutorial Part 3. Then, check your answers and in the event your answer does not agree, mark a single line through your response. *There is no penalty for having an incorrect answer.*

Now you are ready to move forward!

9. At the bottom of the HOW TO TAKE PART – TUTORIAL page, select the PROCEED TO THE TRIAL button. Your team will be asked to fully classify 15 galaxies. If your classification agrees with scientists' classifications 8 or more times, you will be able to enter the GalaxyZoo scientific database to conduct your research. *You can repeat this step if necessary.*

   Record the results of your TRIAL data collection here:

	Circle One		
Image #1	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image #2	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image #3	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image #4	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image #5	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image #6	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image #7	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image #8	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image #9	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image #10	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		

	Star Don't Know	Merging Galaxies

Image #11	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image #12	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image #13	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image #14	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image #15	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

10. Rate the relative DIFFICULTY your team has distinguishing the following by circling one on each line.

Rate the difficulty of classifying each of the following: *Circle one*	Nearly Impossible	Challenging	Some easy, some not	Pretty Easy
Elliptical Galaxies	Imposs.	Chall.	Varies	Easy
Spiral Galaxies	Imposs.	Chall.	Varies	Easy
Edge-on Spiral Galaxies	Imposs.	Chall.	Varies	Easy
Merging Galaxies	Imposs.	Chall.	Varies	Easy
Stars	Imposs.	Chall.	Varies	Easy
Cosmic Rays or Satellite Streaks	Imposs.	Chall.	Varies	Easy

Phase II – Does the Evidence Match the Conclusion?

Enter the GALAXY ANALYSIS Galaxy Zoo scientific database and classify ten (10) images. Keep a record of your results in the "Tally Sheet" below using tick marks. 𝍸

TALLY SHEET Data Table #1	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

11. Consider the research question, "what type of galaxy is most common?" If a student proposed a generalization that "most galaxies are elliptical," would you agree, disagree with the generalization based on the evidence you collected SO FAR? Analyze the evidence of how many of each type of galaxy show up in your data tables to pursue this question. *Explain your reasoning and provide specific evidence either from the above questions or from evidence you yourself generate using GalaxyZoo.*

Phase III – What Conclusions Can You Draw From the Evidence?

Galaxies are observed to have numerous different shapes. Consider the research question, "which direction do spiral galaxies usually spin?" What conclusions and generalizations can you make from the following data collected by a student in terms of DO SPIRALS GENERALLY SPIN CLOCKWISE OR ANTI-CLOCKWISE? *Explain your reasoning and provide specific evidence, with sketches if necessary, to support your reasoning.*

TALLY SHEET Data Table #2	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	36	21	16

12. *Evidence-based Conclusion*:

Phase IV – What Evidence Do You Need?

Imagine your team has been assigned the task of designing a scientific observation plan for your favorite news blog about galaxies that collide and merge into a single, larger galaxy. Describe precisely what evidence you would need to collect in order to answer the research question of, "What fraction of galaxies observed appear to be in the **process of merging with other galaxies?"**

13. *Create a detailed, step-by-step description of evidence that needs to be collected and a complete explanation of how this could be done—not just "look and see how many are merging," but exactly what would someone need to do, step-by-step, to accomplish this. You might include a table and sketches-the goal is to be precise and detailed enough that someone else could follow your procedure.*

Phase V – Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using *GalaxyZoo* (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about the nature and/or frequency of galaxies we observe.

Research Report:

Specific Research Question:

Step-by-Step Procedure, with Sketches if Needed, to Collect Evidence:

Data Table and/or Results:

Evidence-based Conclusion Statement:

Additional GalaxyZoo1 Data Table:

http://zoo1.galaxyzoo.org/

	Circle One		
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Additional GalaxyZoo1 Data Table:

http://zoo1.galaxyzoo.org/

	Circle One		
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Phase VI – Summary PRINT YOUR NAME_____

14. Create a 50-word summary, in your own words, that describes the nature and frequency of galaxies we observe in the universe. You should cite specific evidence you have collected in your description, not describe what you have learned in class or elsewhere. Feel free to create and label sketches to illustrate your response.

10 Exploring GalaxyZoo - Two

Big Idea: The countless and varied galaxies observed throughout the Universe have characteristics that can be classified.

Goal: Students will conduct a structured series of scaffolded scientific inquiries about the nature of observed galaxies using the Internet sites prescribed, particularly the *Sloan Digital Sky Survey* via *Galaxy Zoo*

Computer Setup: *SKIP THIS STEP IF YOU ALREADY HAVE GalaxyZoo ID*

Access http://galaxyzoo.org// and

a) Select REGISTER and set up a username as:
WHF __ __ __ __ __
(where the five blanks are numbers) and a password that is identical to your username. *Record this information on this sheet.*

b) Use one of your team member's email addresses. *Record it in the box.*

Userid: W H F __ __ __ __ __

Password: _____

Email: _____

Security Question: _____

Answer: _____

c) Create and enter a security question and answer. *Record it in the box.*

d) Select CREATE USER and, when set up, select CONTINUE.

Phase I: Tutorial: After logging into galaxyzoo.org, if you aren't already in, select HOW TO TAKE PART and complete the online GALAXY ZOO 2 TUTORIAL, completing the tables below as you go along.

1. Q: Is the galaxy simply smooth and rounded, with no sign of a disk? (*circle one*)

Smooth Features or Disk Star or Artifact	Smooth Features or Disk Star or Artifact	Smooth Features or Disk Star or Artifact	Smooth Features or Disk Star or Artifact	Smooth Features or Disk Star or Artifact
Smooth Features or Disk Star or Artifact	Smooth Features or Disk Star or Artifact	Smooth Features or Disk Star or Artifact	Smooth Features or Disk Star or Artifact	Smooth Features or Disk Star or Artifact

First record your answers in the blocks above. Then, check your answers and, in the event your answer does not agree, mark a single line through your response to help you keep track. *There is no penalty for having an incorrect answer.*

2. Q: How rounded is it? (*circle one*)

Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped
Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped
Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped	Completely Round In Between Cigar Shaped

First record your answers in the blocks above. Then, check your answers and, in the event your answer does not agree, mark a single line through your response to help you keep track. *There is no penalty for having an incorrect answer.*

3. Q: Could this be a disk viewed edge-on? (*circle one*)

Yes, edge-on No, not edge-on	Yes, edge-on No, not edge-on	Yes, edge-on No, not edge-on	Yes, edge-on No, not edge-on	Yes, edge-on No, not edge-on
Yes, edge-on No, not edge-on	Yes, edge-on No, not edge-on	Yes, edge-on No, not edge-on	Yes, edge-on No, not edge-on	Yes, edge-on No, not edge-on

First record your answers in the blocks above. Then, check your answers and, in the event your answer does not agree, mark a single line through your response to help you keep track. *There is no penalty for having an incorrect answer.*

4. Q: Does the galaxy have a bulge at its centre? If so, what shape? (*circle one*)

Rounded Boxy No Bulge	Rounded Boxy No Bulge	Rounded Boxy No Bulge	Rounded Boxy No Bulge	Rounded Boxy No Bulge
Rounded Boxy No Bulge	Rounded Boxy No Bulge	Rounded Boxy No Bulge	Rounded Boxy No Bulge	Rounded Boxy No Bulge

First record your answers in the blocks above. Then, check your answers and, in the event your answer does not agree, mark a single line through your response to help you keep track. *There is no penalty for having an incorrect answer.*

5. Q: Is there any sign of a spiral arm pattern? (*circle one*)

Spiral No Spiral	Spiral No Spiral	Spiral No Spiral	Spiral No Spiral	Spiral No Spiral
Spiral No Spiral	Spiral No Spiral	Spiral No Spiral	Spiral No Spiral	Spiral No Spiral

First record your answers in the blocks above. Then, check your answers and, in the event your answer does not agree, mark a single line through your response to help you keep track. *There is no penalty for having an incorrect answer.*

6. Q: How tightly wound do the spiral arms appear? (*circle one*)

Tight Medium Loose	Tight Medium Loose	Tight Medium Loose	Tight Medium Loose	Tight Medium Loose
Tight Medium Loose	Tight Medium Loose	Tight Medium Loose	Tight Medium Loose	Tight Medium Loose
Tight Medium Loose	Tight Medium Loose	Tight Medium Loose	Tight Medium Loose	Tight Medium Loose

First record your answers in the blocks above. Then, check your answers and, in the event your answer does not agree, mark a single line through your response to help you keep track. *There is no penalty for having an incorrect answer.*

7. Q: How many spiral arms are there? (*circle one*)

1 2 3 4 >4 ?	1 2 3 4 >4 ?	1 2 3 4 >4 ?	1 2 3 4 >4 ?	1 2 3 4 >4 ?
1 2 3 4 >4 ?	1 2 3 4 >4 ?	1 2 3 4 >4 ?	1 2 3 4 >4 ?	1 2 3 4 >4 ?
1 2 3 4 >4 ?	1 2 3 4 >4 ?	1 2 3 4 >4 ?	1 2 3 4 >4 ?	1 2 3 4 >4 ?

First record your answers in the blocks above. Then, check your answers and, in the event your answer does not agree, mark a single line through your response to help you keep track. *There is no penalty for having an incorrect answer.*

8. Q: Is there a sign of a bar feature through the centre of the galaxy? (*circle one*)

Bar No Bar	Bar No Bar	Bar No Bar	Bar No Bar	Bar No Bar
Bar No Bar	Bar No Bar	Bar No Bar	Bar No Bar	Bar No Bar
Bar No Bar	Bar No Bar	Bar No Bar	Bar No Bar	Bar No Bar

First record your answers in the blocks above. Then, check your answers and, in the event your answer does not agree, mark a single line through your response to help you keep track. *There is no penalty for having an incorrect answer.*

9. Q: How prominent is the central bulge, compared with the rest of the galaxy?

No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant
No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant
No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant	No Bulge Just Noticeable Obvious Dominant

First record your answers in the blocks above. Then, check your answers and, in the event your answer does not agree, mark a single line through your response to help you keep track. *There is no penalty for having an incorrect answer.*

10. Q: Can you identify an odd feature: a ring or an arc, or is the galaxy disturbed or irregular or is there a merger going on? (*circle one*)

Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger
Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger
Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger	Ring Arc Disturbed Irregular Other Merger

First record your answers in the blocks above. Then, check your answers and, in the event your answer does not agree, mark a single line through your response to help you keep track. *There is no penalty for having an incorrect answer.*

[*Note: more detailed descriptions of these characteristics are defined is available online at: http://www.galaxyzoo.org/how_to_take_part*]

Now you are ready to move forward!

11. At the top or bottom of the page, select CLASSIFY to start making your own observations. Make 10 observations and circle the appropriate response. (*Ignore boxes that do not apply.)*

Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes

Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes

Image #	Smooth Features/Disk Star/Artifact	Round In between	Edge-on Not edge-	Round Boxy No	Spiral No spiral	Tight arms Medium	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes

		Cigar shape	on	bulge		Loose				
Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes
Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes
Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes
Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes

Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes
Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes
Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes

12. Rate the relative DIFFICULTY your team has distinguishing the following by circling one.

Rate the difficulty of classifying each of the following:	Nearly Impossible	Challenging	Some easy, some not	Pretty Easy	Notes or Comments
Presence of Spiral Arms	Imposs.	Chall.	Varies	Easy	
Roundness of Galaxies	Imposs.	Chall.	Varies	Easy	
Tightness of Spiral Arms	Imposs.	Chall.	Varies	Easy	
Number of Spiral Arms	Imposs.	Chall.	Varies	Easy	
Evidence of Central Bar	Imposs.	Chall.	Varies	Easy	
Dominance of Central Bulge	Imposs.	Chall.	Varies	Easy	

Phase II – Does the Evidence Match the Conclusion?

Enter the CLASSIFY Galaxy Zoo scientific database and classify ten (10) additional images. Keep a record of your results in the "Tally Sheet" below using tick marks. 

Use two different colored pens or pencils to separate data for galaxies with spiral arms and galaxies without spiral arms.

TALLY SHEET Data Table "A"	Spiral arms	Round	Edge-on	Round	Spiral	Tight arms	Bar	No bulge
		In between		Boxy		Medium		Noticeable
	No spiral	Cigar shape	Not edge-on	No bulge	No spiral	Loose	No Bar	Obvious
								Dominant

13. Consider the research question, "which shape of elliptical galaxy is most common?" If a student proposed a generalization that "most elliptical galaxies are cigar-shaped," would you agree, disagree with the generalization based on all the evidence you collected SO FAR? Pursue this evidence by considering how many galaxies are cigar-shaped compared to the total number of elliptical galaxies you have observed. *Explain your reasoning and provide specific evidence either from the above questions or from evidence you yourself generate using GalaxyZoo.*

Phase III – What Conclusions Can You Draw From the Evidence?

Galaxies are observed to have numerous different shapes. What conclusions and generalizations can you make from the following data collected by a student in terms of DO SPIRAL GALAXIES GENERALLY EXHIBIT A CLEAR CENTRAL BULGE? *Explain your reasoning and provide specific evidence, with sketches if necessary, to support your reasoning*.

TALLY SHEET Bulge Data Table	No Bulge 4	Noticeable Bulge 17	Obvious Bulge 19	Dominant Bulge 6

14. *Evidence-based Conclusion*:

Phase IV – What Evidence Do You Need?

15. Imagine your team has been assigned the task of designing a scientific observation plan for your favorite news blog about number of spiral arms a galaxy has. Describe precisely what evidence you would need to collect in order to answer the research question of, "**How many arms do spiral galaxies have?"**

Create a detailed, step-by-step description of evidence that needs to be collected and a complete explanation of how this could be done—not just "look and see how many arms are there," but exactly what would someone need to do, step-by-step, to accomplish this. You might include a table and sketches-the goal is to be precise and detailed enough that someone else could follow your procedure.

Phase V – Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using *GalaxyZoo* (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about the frequency of observable characteristics of galaxies.

Research Report:

Specific Research Question:

Step-by-Step Procedure, with Sketches if Needed, to Collect Evidence:

Data Table and/or Results:

Evidence-based Conclusion Statement:

Phase VI – Summary PRINT YOUR NAME_____

Create a 50-word summary, in your own words, that describes the nature and characteristics of galaxies we observe in the universe. You should cite specific evidence you have collected in your description, not describe what you have learned in class or elsewhere. Feel free to create and label sketches to illustrate your response.

Additional GalaxyZoo 2 Data Sheet (ignore unused cells)

Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes
Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes
Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes
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11 #2 Assessment Case Studies

Assessing & Improving Research Projects

Big Idea: Designing a fruitful plan for conducting research has many pitfalls. By assessing the research reports of others, scientists can improve their own ability to design attractive research plans. With better research designs, researchers can improve the support for the claims they make with better and better evidence.

Goal: Students will assess a series of research reports and then select one project to redesign and conduct in order to more productively pursue the original research question.

Assess Research Projects & Identify Inconsistencies in their Lines of Inquiry

Your task is to improve research projects similar to those you have already completed. Work improving only on one research report at a time. Make sure to specify which report you are using by completely writing out the research question. Answer each of the questions by circling *yes*, *no*, or *maybe*, and then provide a short, but detailed, explanations of your reasoning citing specific information from the provided research reports.

Inquiry Research Report #21
Investigating Extra-solar Planets

Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using heavens-above (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about some motion or position of the sun in the sky which you have not completed before.

Research Report:

Specific Research Question:

Is mass of an extra-solar planet correlated to the mass the star that it orbits?

Step-By-Step Procedure to Collect Evidence:

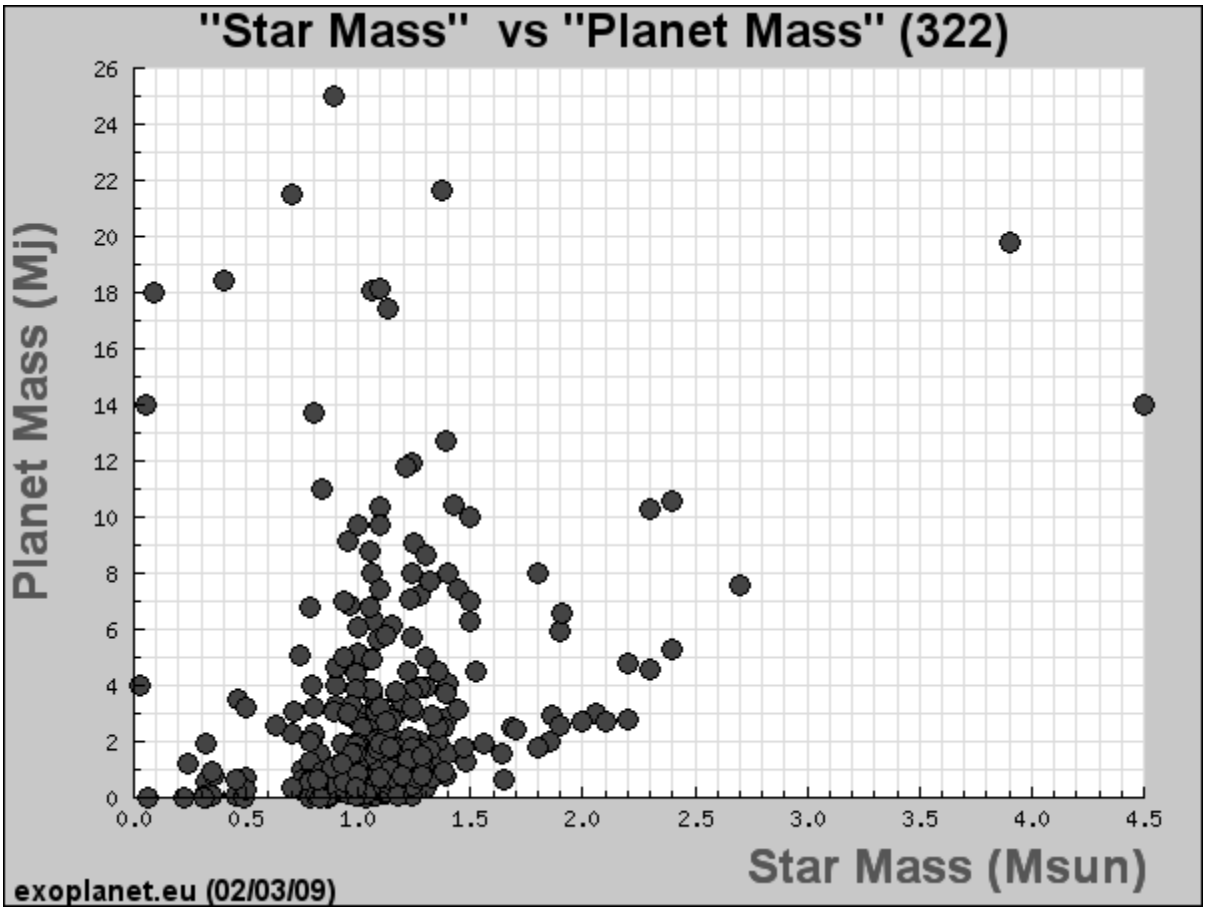
Using the Extrasolar Planets Encyclopedia at http://exoplanet.eu/catalog-all.php
1. Make measurements of the masses of all known extra-solar planets and the masses of the stars that these planets orbit.
2. Plot the masses of each of the extra solar planets against the mass of the stars they orbit. This means the y-axis is extra-solar planet mass in terms of Jupiter's mass and x-axis is the mass of the stars that extra-solar planets orbit in terms of the Sun's mass.

Data Table and/or Results

See next page

Evidence-based Conclusion Statement:

Only stars that have a mass very similar to the mass of the Sun have planets orbiting them.


"Star Mass" vs "Planet Mass" (322)
Planet Mass (Mj)
Star Mass (Msun)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
exoplanet.eu (02/03/09)

CASE STUDY RESEARCH REPORT #21:

0. Specific Research Question:_____

What list of things might you observe to pursue this research question?

1. Step-by-Step Procedure to Collect Evidence:

Is the plan presented going to yield the necessary evidence needed to fully answer the listed research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

2. Conclusions Drawn from Data Table and/or Results of Evidence

Has enough evidence been collected for this specific research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

Have they claimed more than the evidence supports?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

3. Evidence-based Conclusion Statement:

Have assumptions impacted their results?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

Does the claim directly answer the original research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

4. Precisely, what should the researchers have done or reported differently to improve their inquiry research project?

Inquiry Research Report #22
Observing The Moon

Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using Solar System Simulator (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about the orbit or motion of a planet or moon which you have not completed before.

Research Report:

1) Specific Research Question:

Exactly how many days is the Moon's orbital period around the Earth?

2) Step-By-Step Procedure to Collect Evidence:

Using the Solar System Simulator at http://space.jpl.nasa.gov// (observe from Sun's vantage point)
1. Beginning Feb.14th 2009, observe the Moon/Earth system every 4 days for 3 months.
2. For each observation, measure the distance between the centers of the Earth and Moon.
3. Making measurements with a *Squigit* ruler, mark down on which side of the Earth the Moon is located, left or right.
4. Record measurements in a table, and plot the data in a graph of Distance vs. Time to determine the orbit period of the Moon around the Earth.

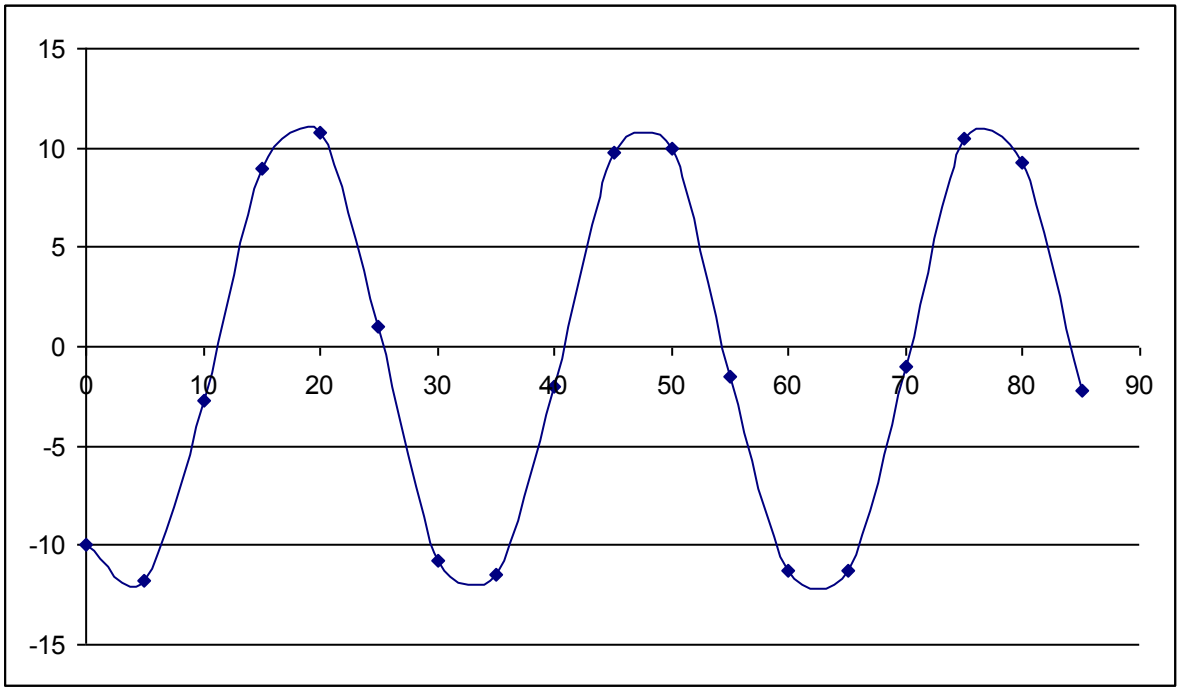
3) Data Table and/or Results:

See next page

4) Evidence-based Conclusion Statement:

Exactly 30 days.

Date	Distance	Left/Right
14-Feb	10	L
19-Feb	11.75	L
24-Feb	2.75	L
1-Mar	9	R
6-Mar	10.75	R
11-Mar	1	R
16-Mar	10.75	L
21-Mar	11.5	L
26-Mar	2	L
31-Mar	9.75	R
5-Apr	10	R
10-Apr	1.5	L
15-Apr	11.25	L
20-Apr	11.25	L
25-Apr	1	L
30-Apr	10.5	R
5-May	9.25	R
10-May	2.25	L



CASE STUDY RESEARCH REPORT #22:

5. Specific Research Question:_____

What list of things might you observe to pursue this research question?

6. Step-by-Step Procedure to Collect Evidence:

Is the plan presented going to yield the necessary evidence needed to fully answer the listed research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

7. Conclusions Drawn from Data Table and/or Results of Evidence

Has enough evidence been collected for this specific research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

Have they claimed more than the evidence supports?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

8. Evidence-based Conclusion Statement:

Have assumptions impacted their results?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

Does the claim directly answer the original research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

9. Precisely, what should the researchers have done or reported differently to improve their inquiry research project?

Inquiry Research Report #23
Classifying Extra-solar Planets

Formulate a Question, Pursue Evidence, and Justify Your Conclusion

Your task is design an answerable research question, propose a plan to pursue evidence, collect data using the online extra-solar planets database (or another suitable source pre-approved by your lab instructor), and create an evidence-based conclusion about extra-solar planets which you have not completed before.

Research Report:

Specific Research Question:

Do extra-solar planets with orbital distances similar to that of the Earth-Sun distance also have masses similar to that of Earth's mass? (*In other words, does Earth-distanced correlate to Earth-massed?*)

Step-By-Step Procedure to Collect Evidence:

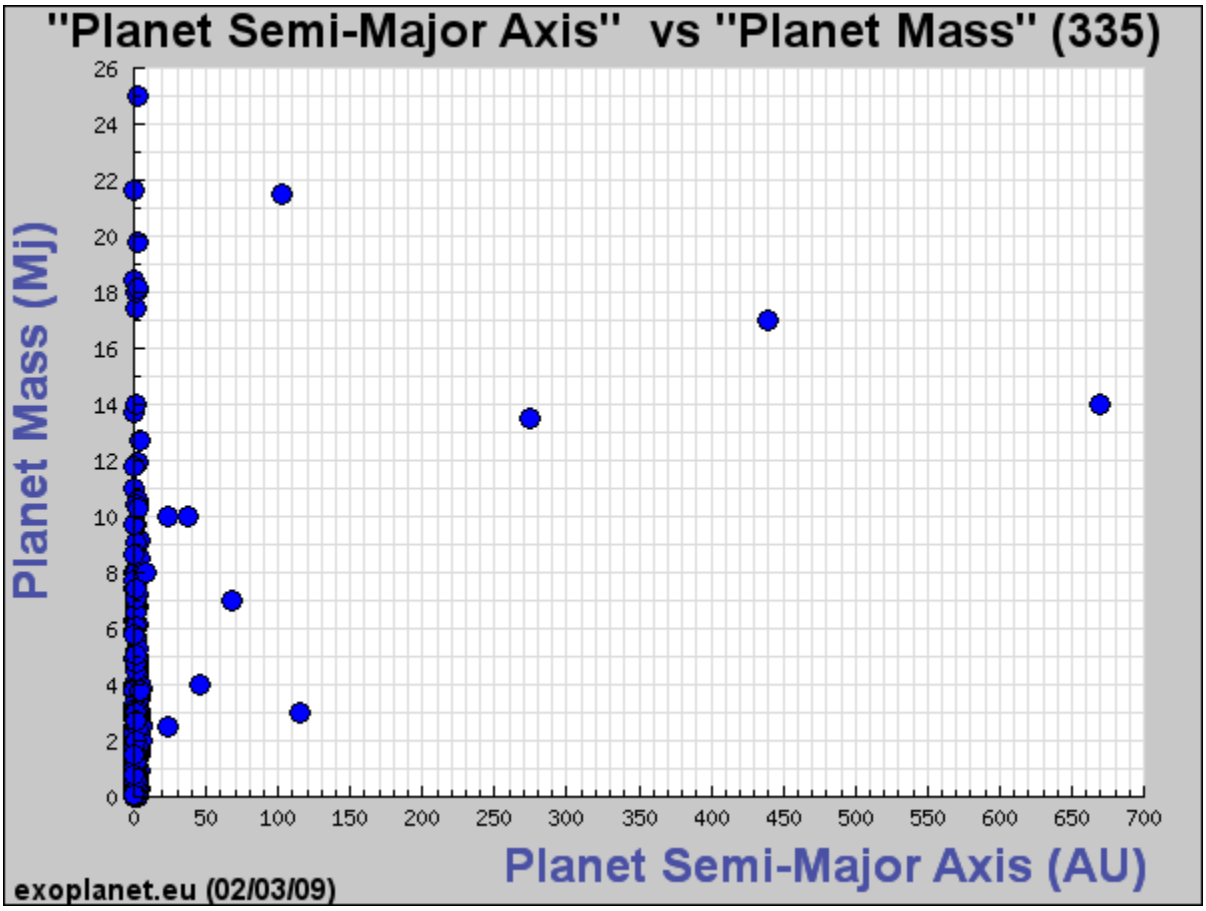
Using the Extrasolar Planets Encyclopedia at http://exoplanet.eu/catalog-all.php
1. Make measurements of the orbital distances and masses of all known extrasolar planets.
2. Plot the masses of each of the extra solar planets against their orbital distance (semi-major axis). This means the y-axis is extra-solar planet mass in terms of Jupiter's mass and the x-axis is the mass semi-major axis in units of AU.

Data Table and/or Results

See next page

Evidence-based Conclusion Statement:

There appears to be no correlation between a mass and orbital radius for planets with orbital distances similar to that of the Earth.


"Planet Semi-Major Axis" vs "Planet Mass" (335)
Planet Mass (Mj)
Planet Semi-Major Axis (AU)
exoplanet.eu (02/03/09)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700

CASE STUDY RESEARCH REPORT #23:

10. Specific Research Question:_____

What list of things might you observe to pursue this research question?

11. Step-by-Step Procedure to Collect Evidence:

Is the plan presented going to yield the necessary evidence needed to fully answer the listed research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

12. Conclusions Drawn from Data Table and/or Results of Evidence

Has enough evidence been collected for this specific research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

Have they claimed more than the evidence supports?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

13. Evidence-based Conclusion Statement:

Have assumptions impacted their results?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

Does the claim directly answer the original research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

14. Precisely, what should the researchers have done or reported differently to improve their inquiry research project?

Choose One Research Project to Redesign, Improve, and Conduct

Your task is to choose one of the research projects (either report 22 or report 23) to redesign and carry out. You should re-use the exact same research question as the previous researchers, but make sure to improve the research design so that you eliminate all the problems you were able to identify. At the end, check over your research by answering the assessment questions about your own inquiry report.

Your *Redesigned* Research Report:

Specific Research Question:

Step-by-Step Procedure to Collect Evidence:

Data Table and/or Results:

Evidence-based Conclusion Statement:

REDESIGNED RESEARCH REPORT:

15. Specific Research Question:_____

What list of things might you observe to pursue this research question?

16. Step-by-Step Procedure to Collect Evidence:

Is the plan you used going to yield the necessary evidence needed to fully answer the listed research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

17. Conclusions Drawn from Data Table and/or Results of Evidence

Has enough evidence been collected for this specific research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

Have you claimed more than the evidence supports?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

18. Evidence-based Conclusion Statement:

Have assumptions impacted your results?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered Yes or Maybe)

Does the claim directly answer the original research question?

Circle one: Yes | Maybe | No

Detailed Explanation: (only if you answered No or Maybe)

19. Precisely, what has been done or reported differently improving the original inquiry research project?

Phase VI – Summary PRINT YOUR NAME_____

Write a 50 word summary of what makes a solid inquiry research project. Include reason(s) why you choose that project to improve, and explain what the biggest problems were and how you corrected them. Be sure to cite the problems and provide details about how your changes improved the line of inquiry.

In general, what are some common problems you need to avoid in designing a solid research project?

In general, what are some important things to consider about assumptions you make in your research design?

Appendices

Inquiry Self-Assessment Success Guide

Use this page to help guide you as you design your research project

Specific Research Question:_____

What list of things might you observe to pursue this research question?

Step-by-Step Procedure to Collect Evidence:

Is the plan you used going to yield the necessary evidence needed to fully answer the listed research question?

Circle one: Yes | Maybe | No

Conclusions Drawn from Data Table and/or Results of Evidence

Has enough evidence been collected for this specific research question?

Circle one: Yes | Maybe | No

Have you claimed more than the evidence supports?

Circle one: Yes | Maybe | No

Evidence-based Conclusion Statement:

Have assumptions impacted your results?

Circle one: Yes | Maybe | No

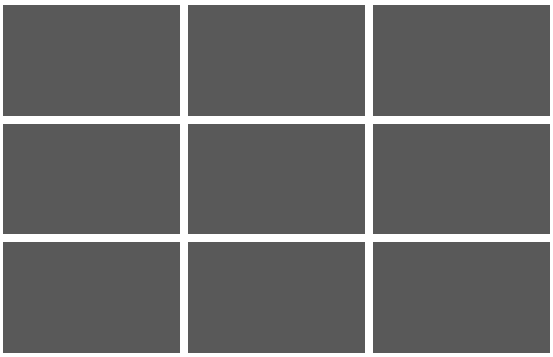
Does the claim directly answer the original research question?

Circle one: Yes | Maybe | No

Astronomy Mini-Conference Announcement

CALL FOR POSTER PRESENTATIONS

This announcement calls for contributed scientific research poster presentations describing an original inquiry research study done by a team of no more than three authors. You can improve an existing research study you've done or complete an entirely new one along the same lines. *It is possible that part of your Laboratory or class time for the week before will be allocated to this.*



DATE AND TIME:

GUIDELINES: Using no more than nine sheets of 8.5x11" paper in landscape orientation, present a data-based conclusion to a research question your group has designed. We recommend creating this as nine PowerPoint slides and tape these pages to the wall or poster board. This poster should include the following:

1. Research Focus: *Describe your research question*
2. Method: *Describe how you went about answering your question, what data did you collect and why is this the best data to answer your question*
3. Data Summary: *Describe and include a small representation of the graphs, tables, pictures, or figures you created to organize your data and how this is evidence*
4. Conclusion: *Concisely describe the insight the data provides to illuminate and answer your research question. This should briefly include all of the following:*
   - *What did your investigation try to do/find?*
   - *What did you expect to find, based on what you knew before you began your study?*
   - *What did you find (cite EVIDENCE)*
   - *How do your findings relate to the world beyond your study? (to your previous knowledge, to bigger ideas, etc.)*
   - *Based on what you found, what is the next logical question to ask and investigate?*

EVALUATION CRITERIA FOR INQUIRY PROJECTS

TITLE or AUTHOR(S) NAME(S)

	Definitely, With Clear Evidence	Somewhat, implicit, or inferred	Not Clearly Evident	NOTES
	Circle one			
1. Is the research question stated clearly and unambiguously?	3	2	1	
2. Does the project show creativity and originality in the question(s) asked?	3	2	1	
3. Was there an appropriate procedural plan for obtaining a solution? *(Does the plan closely match the question being asked?)*	3	2	1	
4. Is the data presented clearly?	3	2	1	
5. Was the graphic presentation of the data the best choice of possible alternatives?	3	2	1	
6. How completely was the problem investigated?	3	2	1	
7. Are there adequate data to support any conclusions?	3	2	1	
TOTAL POINTS =				

PRINT NAME:

Evaluation of Astronomy Research Project

Here you are asked to make an in-depth evaluation of one of the research posters you have viewed during the Mini-Conference.

Title and Authors:
(list the title and authors of the poster you have chosen to evaluate)

Specific Research Question:
(write out the specific research question that was investigated)

Results/Conclusions:
(*provide a brief summary of their conclusions citing specific results and how they are related to the research question)*

Evidence:
(Describe how the evidence was constructed and, what it looked like, and how well-suited this evidence was to answering the research question. You may wish to include sketches of table or graphs from the project poster)

PRINT NAME:

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Here you are asked to make an in-depth evaluation of one of the research posters you have viewed during the Mini-Conference.

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PRINT NAME:

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(write out the specific research question that was investigated)

Results/Conclusions:
(*provide a brief summary of their conclusions citing specific results and how they are related to the research question)*

Evidence:
(Describe how the evidence was constructed and, what it looked like, and how well-suited this evidence was to answering the research question. You may wish to include sketches of table or graphs from the project poster)

Additional GalaxyZoo1 Data Table:

http://zoo1.galaxyzoo.org/

	Circle One		
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Additional GalaxyZoo1 Data Table:

http://zoo1.galaxyzoo.org/

	Circle One			
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On	Unclear
	Elliptical Galaxy			
	Star Don't Know		Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On	Unclear
	Elliptical Galaxy			
	Star Don't Know		Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On	Unclear
	Elliptical Galaxy			
	Star Don't Know		Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On	Unclear
	Elliptical Galaxy			
	Star Don't Know		Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On	Unclear
	Elliptical Galaxy			
	Star Don't Know		Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On	Unclear
	Elliptical Galaxy			
	Star Don't Know		Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On	Unclear
	Elliptical Galaxy			
	Star Don't Know		Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On	Unclear
	Elliptical Galaxy			
	Star Don't Know		Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On	Unclear
	Elliptical Galaxy			
	Star Don't Know		Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On	Unclear
	Elliptical Galaxy			
	Star Don't Know		Merging Galaxies	
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On	Unclear
	Elliptical Galaxy			
	Star Don't Know		Merging Galaxies	

Additional GalaxyZoo1 Data Table:

http://zoo1.galaxyzoo.org/

	Circle One		
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don't Know	Merging Galaxies	

Additional GalaxyZoo1 Data Table:

http://zoo1.galaxyzoo.org/

	Circle One		
Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
	Elliptical Galaxy		
	Star Don’t Know	Merging Galaxies	

Image	Clockwise Spiral	Anticlockwise Spiral	Edge On Unclear
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	Star Don’t Know	Merging Galaxies	

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Additional GalaxyZoo 2 Data Sheet ignore unused cells)

Image #	Smooth Features/Disk Star/Artifact	Round In between Cigar shape	Edge-on Not edge-on	Round Boxy No bulge	Spiral No spiral	Tight arms Medium Loose	Number	Bar No Bar	No bulge Noticeable Obvious Dominant	Notes

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