Exploring the Galaxy Zoo

<u>Main Topic</u>: The countless galaxies that fill our universe have a variety of characteristics that can be observed and classified.

<u>Goal</u>: Conduct a structured series of scientific inquiries about the nature of observed galaxies through the use of the publicly available data from the Sloan Digital Sky Survey as accessed by the Galaxy Zoo project, specifically Galaxy Zoo 1.

<u>Assignment details</u>: For this activity, you will be working in groups of 2-3. However, each individual will be expected to record their answers either as a hand-written or typed document. Some parts of the activity will require that you fill out pre-designed data tables that will be available in class. The completed data tables will be turned in along with your hand-written responses or typed document. If you choose to type your responses, send them to me with a direct message via Slack by uploading the file. Also, if you type your responses, you may still have to make some sketches on paper. You should include those sketches with the completed paper handout. Make sure you name is on the assignment and associated materials, regardless of whether it is typed or hand-written. All responses should be labeled with their corresponding question number.

Part 1: Galaxy basics and exploring galaxy properties

1.1) Using your own prior knowledge or the internet, come up with a reasonably good definition of what a galaxy is and record this definition in your assignment. In addition, produce a rough sketch of what a galaxy looks like.

1.2) Imagine that each of the following two images show a galaxy containing billions of stars:

Spiral Galaxy   Elliptical Galaxy

Record a detailed listing of the observable characteristics for both the spiral galaxy and the elliptical galaxy, separately.

1.3) Now you're going to set up a user account on the Galaxy Zoo website so that you can try your hand at classifying real astronomical images of galaxies. Each member of the team will register for their own account, but for some parts of the activity we'll only use the account for one of the team members. Also, we'll actually be using a previous generation of the Galaxy Zoo as it contains additional tutorial components that are not available in the current version, so make sure to point your browser to:

http://zoo1.galaxyzoo.org

Once there, click where it says "Register" in the "Log In" panel on the right. Make sure you either record your username and password somewhere or commit it to memory, as you'll need to make sure you can log back into your account should you get logged our for any reason and so that you can log during a future class session. Once each team member has created an account, go to the "How to take part" section of the Galaxy Zoo 1 webpage and complete the tutorial using the corresponding tables in the handout — **make sure to record your responses on the handout before looking at the answers on the webpage! Also, do not move onto the next section until all members of your team have completed the tutorial.**

IMPORTANT NOTE: At this point, you should have all completed the tutorial and are ready to try classifying galaxies. For the remainder of this activity you will work together using a single Galaxy Zoo account on one computer.

1.4) Now that you have all completed the tutorial, you must complete the trial process to see if your classifications match those of the Galaxy Zoo scientists. From here on, you will work collaboratively as a team to classify galaxies and answer the subsequent questions. At the end of tutorial section, click where it says "PROCEED TO THE TRIAL", you will be shown 15 images and at least 8 of your classifications must match those of the Galaxy Zoo scientists in order for you to move forward. Make sure you record answers on the tables provided in the handout.

1.5) Once you've completed your classifications, discuss with your fellow team members the difficulties you encountered distinguishing the various galactic features listed on the table in the handout and record any specific comments that come up in your discussion.

Part 2: Assessing conclusions based on evidence

2.1) Now go to the "Galaxy Analysis" section of the webpage and collectively classify 15 galaxies and record your results in the table in the handout.

2.2) Suppose you were asked the research question, "What type of galaxy is the most common?" and one of your classmates quickly proposed the generalization that "**most galaxies are elliptical.**" Would you agree or disagree with this generalization based on the evidence you've collected *so far*? Analyze the evidence contained in your data tables of galaxy types to pursue this question and *explain your reasoning*, citing specific evidence that you've acquired from the above questions or from additional evidence that you generate using Galaxy Zoo.

Part 3: Drawing conclusions from evidence

3.1) Observed galaxies have numerous different shapes. Consider the research question, "Which direction do spiral galaxies usually spin?" If you were presented with the following data collected by a fellow student who was trying to answer the question, "**Do spirals generally spin clockwise or anti-clockwise?**", what conclusions and generalizations can you make?

	Clockwise Spin	Anti-Clockwise Spin	Edge-on/Unclear
Tally:	36	21	16

Explain your reasoning and provide specific evidence to support it. You can also include any sketches that might help support your argument.

Part 4: Defining evidence to answer questions

4.1) Suppose that you and your team have been given the task of designing a scientific observing plan as part of a project that focuses on galaxies that collide and merge into a single, larger galaxy. Your goal is to describe the evidence that you would need to collect in order to answer the research questions, "**What fraction of galaxies observed appear to be in the process of merging with other galaxies?**"

Specifically, create a detailed, step-by-step description of the evidence that needs to be collected and a complete explanation of how this could be done. This should go beyond "just look and see how many galaxies are merging" and should be detailed enough that someone else could follow your procedure and reproduce your results. Include any tables or sketches that you deem necessary/useful. You *do not* need to actually go through this process and collect the evidence, you just need to formulate the plan.

Part 5: Form a question, pursue your evidence, and justify your conclusion

5.1) Using your experience thus far, your team must now generate an *answerable* research question, propose a plan for acquiring evidence, use Galaxy Zoo to collect data, and create an evidence-based conclusion about the nature and/or frequency of galaxies that we observe in our universe.

You must generate a research report that includes the following:

- Your specific research question
- Your step-by-step procedure, with sketches if necessary, to collect evidence.
- Your data table and/or results
- Your evidence-based conclusion statement.

Part 6: Communicating science

6.1) For this last component, you will work individually to generate a 50-word summary, in your words, that describes the nature and frequency of galaxies that we observe in the universe. You should cite specific evidence in your description and not simply summarize what you may have learned in this class or elsewhere. Again, feel free to create and label sketches to illustrate your response, if you wish.

References:

Spiral Galaxy source: http://hubblesite.org/newscenter/archive/releases/2006/10/image/a/

Elliptical galaxy source: http://hubblesite.org/newscenter/archive/releases/galaxy/elliptical/2007/08/image/a/warn/

This activity was inspired by and adapted from "*Engaging in Astronomical Inquiry*" by Slate, Slater and Lyons 2010.