Name: Date:

**Galaxy Zoo**

**Objectives:**

* Distinguish between different types of galaxies
* Identify the various features of each subclass
* Contribute data that will be used by astronomers in their work
* Learn to study galaxies in systematic way

**Materials**

* Computer
* Internet connection

**Introduction**

Galaxies evolve on timescales that dwarf human experience. So our best chance at understanding their complex evolution is to observe large samples of galaxies at different points in their lives to try to reconstruct a single galaxy’s evolution from the various snapshots.

Thanks to new generations of astronomical surveys we now have images of millions of galaxies. But going through this much data is a time intensive task. We can train computers to do a lot of the work, but human eyes are still better than computer algorithms at picking out subtle galaxy features in many cases.

To this end, Galaxy Zoo was developed to enlist the help of the public. Millions of eyes view each galaxy, analyzing and recording its appearance. Eventually a consensus is reached and the galaxy becomes a part of a catalog that astronomers use in their research projects.

**Activity**

**Part 1: Types of Galaxies**

Before we start, what is a galaxy? Write your own definition of a galaxy. Then, draw a sketch of what a galaxy looks like (or draw multiple sketches if necessary):

In general, there are two types of galaxies: spirals and ellipticals (a third category, irregulars, includes everything else). Here are two examples:



Spiral Galaxy Elliptical Galaxy

Both of these images show galaxies composed of billions of stars, gas and dust. Create two detailed lists of the characteristics of each that will allow you to distinguish one galaxy type from the other:

|  |  |
| --- | --- |
| **Observable characteristics of a spiral galaxy** | **Observable characteristics of an elliptical galaxy** |
|  |  |

**Part 2: Computer Setup**

* Go to: [www.galaxyzoo.org](http://www.galaxyzoo.org)
* Read through the description of the project
* Click on “Sign up” (on the upper right)
* Create a Zooniverse account
* Go to the bottom of the main page, and click on “Navigator”
* Under the “Select Group” tab, select “Wyoming Workshop”
* Click on “Classify in Group”

**Part 3: Classifying Galaxies**

Galaxy zoo will show you a galaxy at random, and will ask you a series of questions about what you see. Click the buttons that best describe the galaxy. If you want help with what to look for, click on the “Examples” button. Look carefully at each image! Sometimes using the “invert” button can help bring out details you don’t initially see.

Classify at least 15 galaxies, circling answers in the tables below as you do (Ignore boxes that don’t apply — the line of questioning changes depending on your responses).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Image  1 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Image  2 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

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| Image  3 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

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| Image  4 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Image  5 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Image  6 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Image  7 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

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| Image  8 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

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| Image  9 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

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| Image  10 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

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| Image  11 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

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| Image  12 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

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| Image  13 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

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| Image  14 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

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| Image  15 | 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 | Arm  # | Bar  No  bar | No  Bulge  Noticeable  Obvious  Dominant |

Notes:

Rate the relative difficulty you had distinguishing the various characteristics.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Rate the difficulty of classifying each of the following:* | Nearly  Impossible | Challenging | Some easy, some not | Pretty easy | Notes |
| Presence of spiral arms |  |  |  |  |
| Roundness of galaxies |  |  |  |  |
| Tightness of spiral arms |  |  |  |  |
| Number of spiral arms |  |  |  |  |
| Evidence of central bar |  |  |  |  |
| Dominance of central bulge |  |  |  |  |

Additional Notes:

Click on the yellow “Group” button to go back to the group page, and then click on “My Galaxies”. Galaxy Zoo will show you the galaxies you have classified so far, and how your initial classification (smooth, spiral, artifact) stacks up to what others have chosen. How did you do, comparatively?

Choose a galaxy where your answers differed from the majority. Why do you think your responses differed?

**Part 5: Visualizing data and drawing conclusions**

Consider the research question: “How many spiral arms does a typical spiral galaxy have?”

It isn’t likely that a large fraction of the galaxies you analyzed in Part 3 were spirals. Go back to classifying galaxies in Galaxy Zoo until you have analyzed at least 15 spirals. Record the number of spiral arms you see in each galaxy (to save time, you can copy over the information from the spirals you already examined earlier):

|  |  |
| --- | --- |
| **Spiral galaxy** | **# of spiral arms** |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |
| 6 |  |
| 7 |  |
| 8 |  |
| 9 |  |
| 10 |  |
| 11 |  |
| 12 |  |
| 13 |  |
| 14 |  |
| 15 |  |

A good way to examine the distribution of data is to make a histogram. Open Excel, and in cell 1 enter the number of galaxies with 1 spiral arm, in cell 2 enter the number of galaxies with two spiral arms, etc. In the last cell, enter the number of galaxies for which you couldn’t determine the number of arms. Highlight the data, and insert a column chart. This will produce a histogram of your data — each bar shows you how many galaxies there are (y-axis) with a given number of spiral arms (x-axis). Roughly sketch the histogram below:

Based on this histogram, draw some conclusions about the typical number of spiral arms a spiral galaxy has:

Now, compare your histogram to those of others. How are they similar or different? Why do you think differences exist (if they do)?

Based on your analysis of your plot along with several others’, draw new conclusions about the typical number of spiral arms in a spiral galaxy. Why did your conclusion change or stay the same?

**Part 7 (optional): Formulate a question, pursue evidence, and justify your conclusion**

Your task is to design an answerable research question (like the one above). Once you have done this, propose a plan to pursue evidence, collect data using Galaxy Zoo (or another source pre-approved by your instructor), and create an evidence-based conclusion. You are welcome to use other tools in the Galaxy Zoo navigator, such as the plots for our group.

Specific Research Question:

Step-by-step procedure to collect evidence:

Data and/or results:

Evidence based conclusion statement:

**Part 8: Summary**

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, not describe what you have learned elsewhere.