

# Formation and Motion of Galaxies

8<sup>th</sup> Grade Sample Lesson

www.stemscopes.com/science

# Scope (Unit) Formation and Motion of Galaxies

# Explore (Lesson) Activity - Gravity's Pull

The following pages introduce lesson resources that guide you through the STEMscopes NGSS 8th grade lesson. This sample lesson does not include all the elements and features of our digital and print science curriculum.

## **Resource List:**

The following resources, as well as additional Scope resources not listed, can be found in the digital curriculum 8th Grade Scope, Formation and Motion of Galaxies.

#### **Home**

- Standards Alignment
- Sample Lesson Plan
- Teacher Scope Presentation
- Teacher Background
- CCC and SEP Scoring Rubric
- Answer Keys
- Materials List

# **Engage**

- Investigative Phenomena Introductory activity that facilitates a connection between the content and real-world phenomena and encourages students to ask why or how something happens.
- Graphic Organizer Students fill this in as they work through the elements of this Scope.
- Accessing Prior Knowledge A brief probing activity to gauge students' prior knowledge before engaging in the inquiry process.
- Hook An engaging activity that includes instructor preparation, supplemental resources, and ready-made handouts for students.

# **Explore**

- Explore 1: Activity
- Explore 2: Activity This lesson sample.
- Explore 3: Activity

# **Explain**

- Picture Vocabulary Key terms explained through pictures and by definition.
- Linking Literacy Strategies to help students comprehend difficult informational text.
- STEMscopedia Reference materials that include parent connections, career connections, technology, and science news.
- Communicate Science A class activity in which students use different forms of communication to discuss scientific topics connected to the content of this Scope.
- Concept Review Game An interactive game that helps students review important concepts.
- Content Connections Video A short video that supports student understanding of the content.

#### **Elaborate**

- Math Connections
- Reading Science
- Career Connections
- Scientist Spotlight
- Data Literacy

#### **Evaluate**

- Claim-Evidence-Reasoning
- Open-Ended Response Assessment
- Multiple Choice Assessment

## Intervention

- Guided Practice
- Independent Practice
- Concept Attainment Quiz

#### **Acceleration**

- Extensions
- Science Art
- Books on Topic

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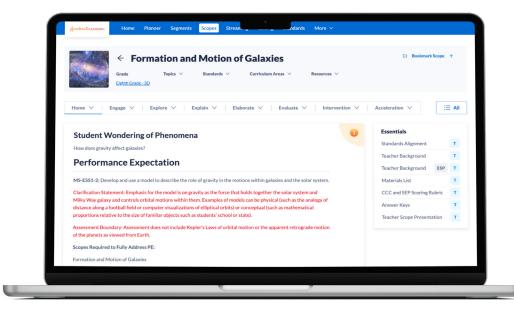
Math Connections, Page 18

Claim-Evidence-Reasoning, Page 19



# Scope (Unit) Overview

# **Scope (Unit) Formation and Motion of Galaxies**



# Student Wondering of Phenomena

How does gravity affect galaxies?

# **Performance Expectations**

**MS-ESS1-2:** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.

**Clarification Statement:** Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as students' school or state).

**Assessment Boundary:** Assessment does not include Kepler's Laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.

Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Developing and Using Models Develop and use a model to describe phenomena. (MS- ESS1-2)	ESS1.B: Earth and the Solar System The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS-ESS1-2)	Systems and System Models Models can be used to repre- sent systems and their interac- tions.

# **Formation and Motion of Galaxies**



# **Explore 2: Activity - Gravity's Pull**

# **Everyday Phenomena**

How is gravity like a magnet?

# Description

(SEP) Students use iron filings and a magnet to simulate the gathering of material in space, due to gravity's pull, that creates planets, stars, and galaxies.

# **Materials**

#### **Printed Materials**

- 1 Gravity's Pull (per student)
- 1 Galaxy Shapes (per group)

#### Reusable

- 1 Container of iron filings (per group)
- 1 Magnet (per group)
- 1 Round pan (per group)
- 1 Paper or cloth towel (per group)
- 1 Baggies (per group)

# **Preparation**

- Print one copy of Gravity's Pull for each student.
- Print one copy of Galaxy Shapes, in color if possible, for each group. Laminate or place in a sheet protector for repeated use.
- Place the magnets in the plastic bags at each table. This will make it easier to remove the iron filings from the magnets. Simply move the magnet up in the bag while holding the bag down and the filings will fall off.
  - \*\*Safety note: Students should not use their hands/fingers to pull the iron filings off of the magnet if they do get stuck to it.
- Gather materials and place in an area easily accessible by students.

#### **STEMcoach in Action**

An essential aspect of facilitating student understanding is insight into student thinking. This insight is best provided by observing how students are able to communicate their understanding. When we say "facilitating questioning and discourse", we are describing the effective questioning and meaningful communication that the teacher uses to establish what students know and are able to do. For further information on Facilitating Questioning and Discourse, please click on the provided link.

Site

# ESTIMATED 30 min - 45 min

# **Procedure and Facilitation Points**

- 1. First, hand out a copy of Gravity's Pull to each student.
- 2. Introduce the idea that the universe has been expanding since the Big Bang occurred about 14 billion years ago.
- 3. Introduce the following vocabulary word: big bang theory
  - a. A theory that says the universe began as a small point that expanded rapidly about 13.7 billion years ago
- 4. Introduce the following vocabulary word: dust
  - a. Tiny particles of matter floating in space; condenses under gravity to form stars and planets
- 5. Introduce the following vocabulary word: gas
  - a. A form of matter with indefinite shape and volume
- 6. Discuss that after the Big Bang, everything in the universe was dust and gas.
- 7. Have students place their iron filings in the center of the pan in a single clump.
- 8. Next, ask students what the parts of their model currently represent:
  - a. First, place all the iron filings in the center of your pan. What do these represent? The iron filings represent all matter and energy before it was spread throughout space due to the Big Bang.
  - b. Next, gently shake the pan to safely spread the iron filings throughout the pan. What does this force represent? The force of spreading everything around represents the Big Bang itself.
  - c. What force do you think took over after the initial explosion? The force of gravity
- 9. Introduce the following vocabulary word: gravity
  - a. The force that causes objects with mass to attract one another
- 10. Each pan should now have the iron filings distributed throughout. Make sure that students know the iron should be evenly spread at this point.
- 11. Now, explain that modeling gravity is difficult in the classroom due to the influence of Earth's gravity and larger objects that surround us. However, we are going to use magnets to simulate gravity's pull on the iron filings—which still represent matter.
- 12. First, have the students hold their magnet right above the center of the pan, but not close enough to attract the iron filings.
- 13. To simulate orbital motion, have the student begin to move the magnet in a circular motion above the pan.
- 14. Slowly, have students start to lower the magnet closer to the pan as they continue the circular motion. Warn students that the magnetic attraction (again, representing gravitational attraction in this model) will start to gather the iron together.
- 15. Make sure that students know the goal is not to gather the iron, but rather maintain a consistent motion and speed with the magnet.
- 16. After a few seconds, have students use the towel to remove the iron on the magnet into a clump somewhere along their orbital path.
- 17. Use these questions to guide understanding:
  - a. (CCC) What does the magnet represent in this model? Why do we have to use a magnet instead of the actual force? The magnet represents the force of gravity. We use it because we cannot observe gravity's effects on tiny objects apart from Earth's pull.
    - i. Record this example of a system on the class crosscutting concept chart. Discuss other examples of systems and system models that the students have previously explored. Charts can be found in the teacher toolbox.
  - b. What is the object we created by gathering iron in the center of the pan? This central clump represents the Sun. It forms first and contains the most mass in a star system.
  - c. What does this new clump of iron represent? This new clump represents a planet that is orbiting the star.
  - d. Why are we using a circular motion when gathering the iron together? What does this represent? Gravity combined with initial velocities of matter create orbital pathways that objects travel in.
- 18. Introduce the following vocabulary word: solar system
  - a. The Sun together with the group of planets and other celestial bodies that are held by its gravitational attraction and revolve around

# 8th Grade Sample Lesson

- 19. Next, have students repeat this process without your guidance to try to recreate our solar system in the pan. Remind them that since our Sun holds the majority of the gravitational force in our solar system, that also implies that it was the first object that formed. Instruct students to record their observations and final model in their student journal.
- 20. Introduce the vocabulary word: galaxy
  - a. A large grouping of stars in space
- 21. Finally, give students a Galaxy Card and have them try to create the specific shape of the galaxy in their pan model. Explain that our Milky Way is simply one of many galaxies throughout the universe. While galaxies are much larger and more complex than our solar system, gravity is still the main force that shapes and governs its motion.

# Connection to the Investigative Phenomena

Once students have completed the activity, have them refer to the Investigative Phenomena question, anchor their learning, and revise their thinking.

#### **Math Moment**

#### Sixth Grade Math Moment

This learning task is connected to math standard:

6.RP.A.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

• Ask students to describe the proportional relationship between the size of a celestial body and its gravity.

Possible student answer: The larger the celestial body, the more gravity it has.

• Ask students to compare the amount of gravity of Jupiter to that of Mercury.

Possible student answer: Jupiter is bigger than Mercury; therefore, it has more gravitational force than Mercury does.

Possible student answer: Each graph should be linear, or directly proportional.

• Ask students how can the graph be used to describe the effects of mass on an object's gravitational force.

Possible student answer: From the graph, it is easy to see that as the mass of an object increases, the gravitational force it exerts also increases and vice versa.

#### Seventh Grade Math Moment

This learning task connects to math standard:

7.EE.B.6 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.

- Ask students if the relationship between an object's mass and its gravitational force are proportional.
- Have students explain their answer.

Possible student answer: Yes, because as one increases, so does the other and vice versa.

• Have students create an equation or inequality, based on our galaxy, to describe the proportional relationship between an object's mass and the amount of gravitational force it exerts.

Possible student answer: Mg/MI = Fg/FI (greater mass/less mass = greater gravitational force/less gravitational force) MI = FI (less mass = less gravitational force)

• Ask students to create a line graph to show this relationship of mass and gravitational force.

Possible student answer: Each graph should be linear, or directly proportional.

- Ask students how the graph can be used to describe the effects of mass on an object's gravitational force.
- Ask students to describe the proportional relationship represented in the graph.

Possible student answer: From the graph, it is easy to see that as the mass of an object increases, the gravitational force it exerts also increases and vice versa. This is the proportional relationship.

#### **Eighth Grade Math Moment**

NGSS specifies no Common Core Math alignment; however, we suggest extending this learning task by making the connection to math standard:

MP.4 Model with mathematics.

• Ask the students what the difference between weight and mass is.

Possible student answer: The students should know that the mass of an object never changes, but the weight of an object may change due to differences in gravity.

- Have the students write down what their mass is (this would be what they commonly refer to as weight).
- Have them find their mass in kilograms. They can take their mass in pounds and divide it by 2.2. Tell them that the force of gravity on Earth is 9.8 m/s2. To find their weight, in Newtons, they simply multiply their mass by the force of gravity. They can then divide this number by 4.45 to find their weight in pounds.

Possible student answer: A 100 pound student would divide 100 by 2.2, or 100/2.2 = 45.5 kg. To find their weight in newtons, multiply this by 9.8, or 45.5 \* 9.8 = 445.9 N. To convert back to pounds, divide this answer by 4.45, or 445.9/4.45 = 100.2.

• Now have the students calculate their weight, in pounds, on other planets. The force due to gravity on the Moon is 1.63 m/s2. The force due to gravity on Venus is 8.83 m/s2. The force due to gravity on Jupiter is 26.0 m/s2. The force due to gravity on Saturn is 11.2 m/s2.

Possible student answer: Assume all calculations are for a 100-pound student with a mass of  $45.5 \, \text{kg. Moon} - 45.5 \, \text{*} \, 1.63 = 74.2 \, \text{N}$ .  $74.2/4.45 = 16.7 \, \text{pounds Venus} - 45.5 \, \text{*} \, 8.83 = 401.8 \, \text{N} . \, 401.8/4.45 = 90.3 \, \text{pounds Jupiter} - 45.5 \, \text{*} \, 26.0 = 1,183 \, \text{N} . \, 1,183/4.45 = 265.8 \, \text{pounds Saturn} - 45.5 \, \text{*} \, 11.2 = 509 \, \text{N} . \, 509/4.45 = 114.4 \, \text{pounds}$ 



Formation and Motion of Galaxies Explore 2

Name: \_\_\_\_\_ Date:

# **Gravity's Pull**

# Part I: Modeling the Big Bang

Approximately 14 billion years ago, all matter and energy that currently occifrom a single point in space.

Explore Lesson

- 1. First, place all the iron filings in the center of your pan. What do these rep
- 2. Illustrate your pan and its contents in the Before column below.
- 3. Next, gently shake the pan to safely spread the iron filings throughout the pan. What does this force represent?
- 4. Illustrate your pan and its contents in the After column below.
- 5. What force do you think took over after the initial explosion?

Before	After



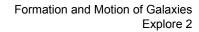
Formation and Motion of Galaxies Explore 2

# Part II: Modeling the Formation of Our Solar System

Like all star systems, the star itself is the first to form from the cosmic dust. Eventually, the planets and other objects orbiting the star will form as it begins to pull everything into orbit around it.

- 1. First, make sure that your iron filings are evenly spread throughout the pan. Draw what it looks like in the Before column below.
- 2. Begin by taking your magnet and holding it an inch above the pan.
- 3. Using a circular motion, hover the magnet above the pan and gather enough iron filings in the center.
- 4. What does the magnet represent in this model? Why do we have to use a magnet instead of the actual force?
- 5. What is the object we created by gathering iron in the center of the pan?
- 6. Next, using a circular motion, gather the iron in a clump 1–2 inches away from the center.
- 7. What does this new clump of iron represent?
- 8. Why are we using a circular motion when gathering the iron together? What does this represent?
- 9. Continue gathering the clumps in varying distances from the center until all the loose iron is collected into clumps. Draw what it looks like in the After column below.

Before	After





# Part III: Modeling Galaxies

Gravity works on multiple scales. Star systems are part of bigger structures called galaxies. These systems vary in size and shape, but overall they are shaped by the same force as everything else.

- 1. First, make sure that your iron filings are evenly spread throughout the pan. Draw what it looks like in the Before column below.
- 2. Use the Galaxy Shapes images as a guide for your galaxies.
- 3. In this model, the iron filings represent star systems.
- Begin by taking your magnet and holding it an inch above the pan. Using a circular motion, hover the magnet above the pan and attempt to shape the material into the shape of your galaxy.
- 5. Choose a galaxy and try to form its shape using your model. Draw what it looks like in the After column below.

Before	After



Formation and Motion of Galaxies Explore 2

Name:	D	ate:

# **Gravity's Pull**

# Part I: Modeling the Big Bang

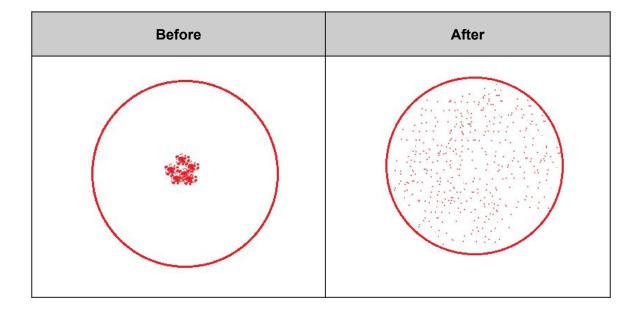
Approximately 14 billion years ago, all matter and energy that currently occupies space exploded from a single point in space.

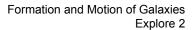
- 1. First, place all the iron filings in the center of your pan. What do these represent?
  - The iron filings represent all matter and energy before it was spread throughout space due to the Big Bang.
- 2. Illustrate your pan and its contents in the Before column below.
- 3. Next, gently shake the pan to safely spread the iron filings throughout the pan. What does this force represent?

The force of spreading everything around represents the Big Bang itself.

- 4. Illustrate your pan and its contents in the After column below.
- 5. What force do you think took over after the initial explosion?

The force of gravity







# Part II: Modeling the Formation of Our Solar System

Like all star systems, the star itself is the first to form from the cosmic dust. Eventually, the planets and other objects orbiting the star will form as it begins to pull everything into orbit around it.

- 1. First, make sure that your iron filings are evenly spread throughout the pan. Draw what it looks like in the Before column below.
- 2. Begin by taking your magnet and holding it an inch above the pan.
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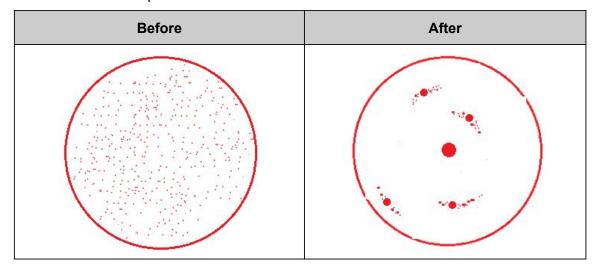
The magnet represents the force of gravity. We use it because we cannot observe gravity's effects on tiny objects apart from Earth's pull.

- What is the object we created by gathering iron in the center of the pan?
   This central clump represents the Sun. It forms first and contains the most mass in a star system.
- 6. Next, using a circular motion, gather the iron in a clump 1–2 inches away from the center.
- 7. What does this new clump of iron represent?

  This new clump represents a planet that is orbiting the star.
- 8. Why are we using a circular motion when gathering the iron together? What does this represent?

Gravity combined with initial velocities of matter create orbital pathways that objects travel in.

9. Continue gathering the clumps in varying distances from the center until all the loose iron is collected into clumps. Draw what it looks like the in After column below.





Formation and Motion of Galaxies Explore 2

# Part III: Modeling Galaxies

Gravity works on multiple scales. Star systems are part of bigger structures called galaxies. These systems vary in size and shape, but overall they are shaped by the same force as everything else.

- 1. First, make sure that your iron filings are evenly spread throughout the pan. Draw what it looks like in the Before column below.
- 2. Use the Galaxy Shapes images as a guide for your galaxies.
- 3. In this model, the iron filings represent star systems.
- Begin by taking your magnet and holding it an inch above the pan. Using a circular motion, hover the magnet above the pan and attempt to shape the material into the shape of your galaxy.
- 5. Choose a galaxy and try to form its shape using your model. Draw what it looks like in the After column below.

Before	After
	Varies depending on shape of galaxy student chose to model

**Big Bang Theory** Picture Vocabulary

# Formation and Motion of Galaxies

Picture Vocabulary

A theory that says the universe began as a expanded rapidly about 13.7 billion small point that

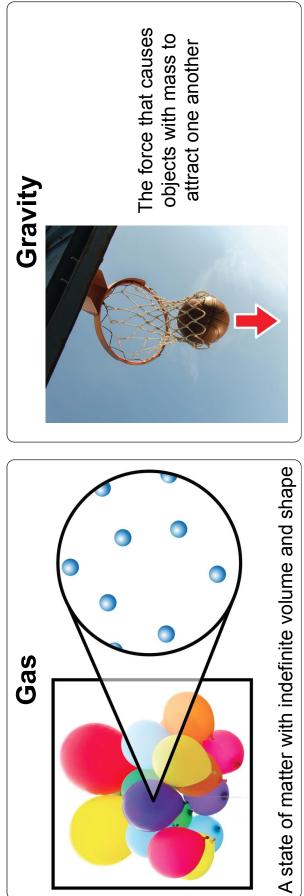
years ago



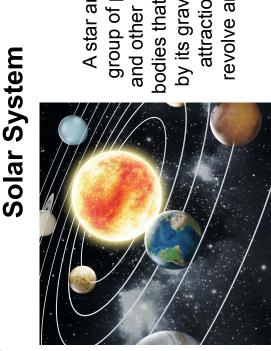
condense under gravity to form stars and planets Tiny particles of matter floating in space;



A large grouping of stars in space



Gas



bodies that are held group of planets and other celestial by its gravitational attraction and revolve around it A star and the

Math Connections

**Math Connections** 

Formation and Motion of Galaxies

Name:	Date:	
	_	

# Formation of the Solar System

Gravity is a force of attraction between two or more masses. Everything that has mass has gravity. The more mass an object has, the stronger its gravitational pull is on other objects.

1. Use the information in the table to help you order the celestial bodies from the the one with the most mass to the one with the least mass.

Celestial Body	Mass (x10 <sup>24</sup> kg)	Gravity (m/s²)
Jupiter	1,898	23.1
Sun	1,988,500	274
Earth	5.97	9.8
Saturn	568	9
Mars	0.642	3.7
Neptune	102	11
Venus	4.87	8.9
Mercury	0.330	3.7
Uranus	86.8	8.7

Most Mass and Gravitational Pull
Least Mass and Gravitational Pull

A planet's gravitational force is affected by its proximity to other planets and the Sun. A planet's gravity in relation to Earth's is used to help calculate how much something weighs on that planet.

Celestial Body	Ratio of Gravity in Relation to Earth
Earth	1.00
Moon	0.166
Venus	0.91
Mars	0.38
Jupiter	2.14
Saturn	0.91
Uranus	0.86
The Sun	28.00

- 2. If the Sun has 28 times more gravity than Earth, what is your weight on the Sun? Create an equation to solve the problem.
- 3. How much would a person weighing 150 pounds on Earth weigh on Uranus?
- 4. The space shuttle weighs 165,000 pounds on Earth. How much would it weigh on the Moon?
- 5. There is a plan to send people to Mars by the year 2030. Why would it be necessary to use a conversion like this when planning for the trip? Answer on the back of this sheet.



Name: \_\_\_\_\_ Date: \_\_\_ CER

Assessment

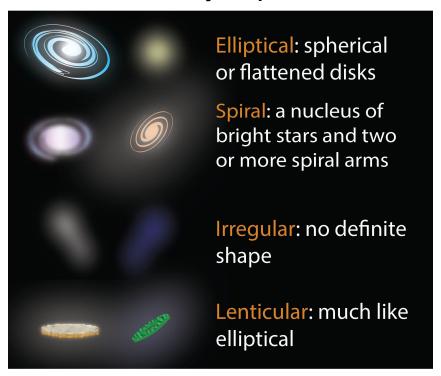
Formation and Motion

# **Scenario**

There are billions of galaxies like our Milky Way galaxy. They can be one of four shape spiral, lenticular, or irregular.

# **External Data**

# **Galaxy Shapes**



The Milky Way



Formation and Motion of Galaxies



# **Claim-Evidence-Reasoning**

Elliptical	Spiral	Lenticular	Irregular
Flattened disks	Nucleus of bright stars	Disk (spiral) that has lost most matter	No definite shape
	Two or more spiral arms	Very little ongoing star formation	
Mostly made of older stars	Older stars near the center, younger stars	Mostly made of older stars	No definite shape
Few or no dust lanes	in the "arms"  Strong gravitational pull	Few or no dust lanes	Small  Little gravitational force

# **Prompt**

Write a scientific explanation about the type of galaxy the Milky Way galaxy is	Write a scientific e	xplanation	about the ty	pe of galaxy	the Milky	Way galaxy	is.
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Claim:	·		, , ,	•	
Evidence:					
December					
Reasoning:					

PEER EVALUATION Peer Name: Rebuttal:



Formation and Motion of Galaxies

# **Rubric for Writing a Scientific Explanation**

Points Awarded	2	1	0
Claim	Not applicable	Answers the question and is accurate based on the data	No claim or does not answer the question
Evidence	Cites data and patterns within the data, and uses labels accurately	Cites data from the data source but not within the context of the prompt	No evidence, or cites changes but does not use data from the data source
Reasoning	Cites the scientifically accurate reason using correct vocabulary and connects this to the claim. Shows accurate understanding of the concept	Cites a reason, but it is inaccurate or does not support the claim; Reasoning does not use scientific terminology or uses it inaccurately.	No reasoning, or restates the claim but offers no reasoning
Rebuttal	Rebuttal provides reasons for different data or outliers in the data. Rebuttal can also provide relevance to the real world or other uses for the findings.	Rebuttal is not connected to the data or is not accurate.	Does not offer a rebuttal



Formation and Motion of Galaxies

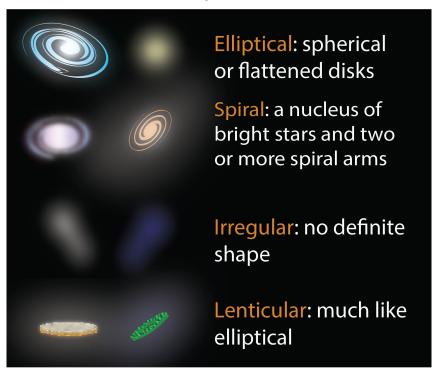
Name:	Date:
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# **Scenario**

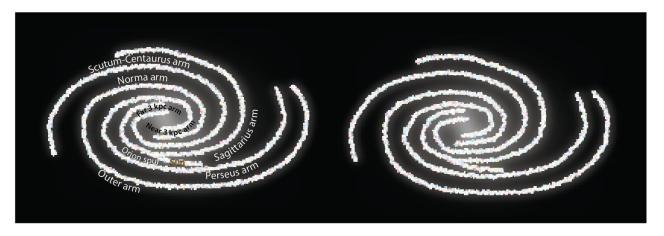
There are billions of galaxies like our Milky Way galaxy. They can be one of four shapes: elliptical, spiral, lenticular, or irregular.

# **External Data**

# **Galaxy Shapes**



The Milky Way





Formation and Motion of Galaxies

Elliptical	Spiral	Lenticular	Irregular
Flattened disks	Nucleus of bright stars  Two or more spiral arms	Disk (spiral) that has lost most matter  Very little ongoing star formation	No definite shape
Mostly made of older stars  Few or no dust lanes	Older stars near the center, younger stars in the "arms"  Strong gravitational pull	Mostly made of older stars  Few or no dust lanes	No definite shape Small Little gravitational force

# **Prompt**

Write a scientific explanation about the type of galaxy the Milky Way galaxy is.

#### Claim:

The Milky Way galaxy is a spiral galaxy.

## **Evidence:**

There are different shapes of galaxies. The Milky Way galaxy has a nucleus of bright stars and spiral arms. It has a strong gravitational pull. Younger stars form in the "arms" of spiral galaxies.

# Reasoning:

Our solar system is a relatively young star system and is located in an arm of the Milky Way galaxy. Younger stars are always located on the arms of spiral galaxies. Therefore, the Milky Way must be a spiral galaxy. Gravity determines the different shapes of galaxies. Galaxies with less gravity are less "formed" like the irregular galaxies; galaxies with more gravity have distinct shapes like the spiral.

Peer Evaluation Peer Name: Rebuttal:

Formation and Motion of Galaxies



# Claim-Evidence-Reasoning

# **Rubric for Writing a Scientific Explanation**

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