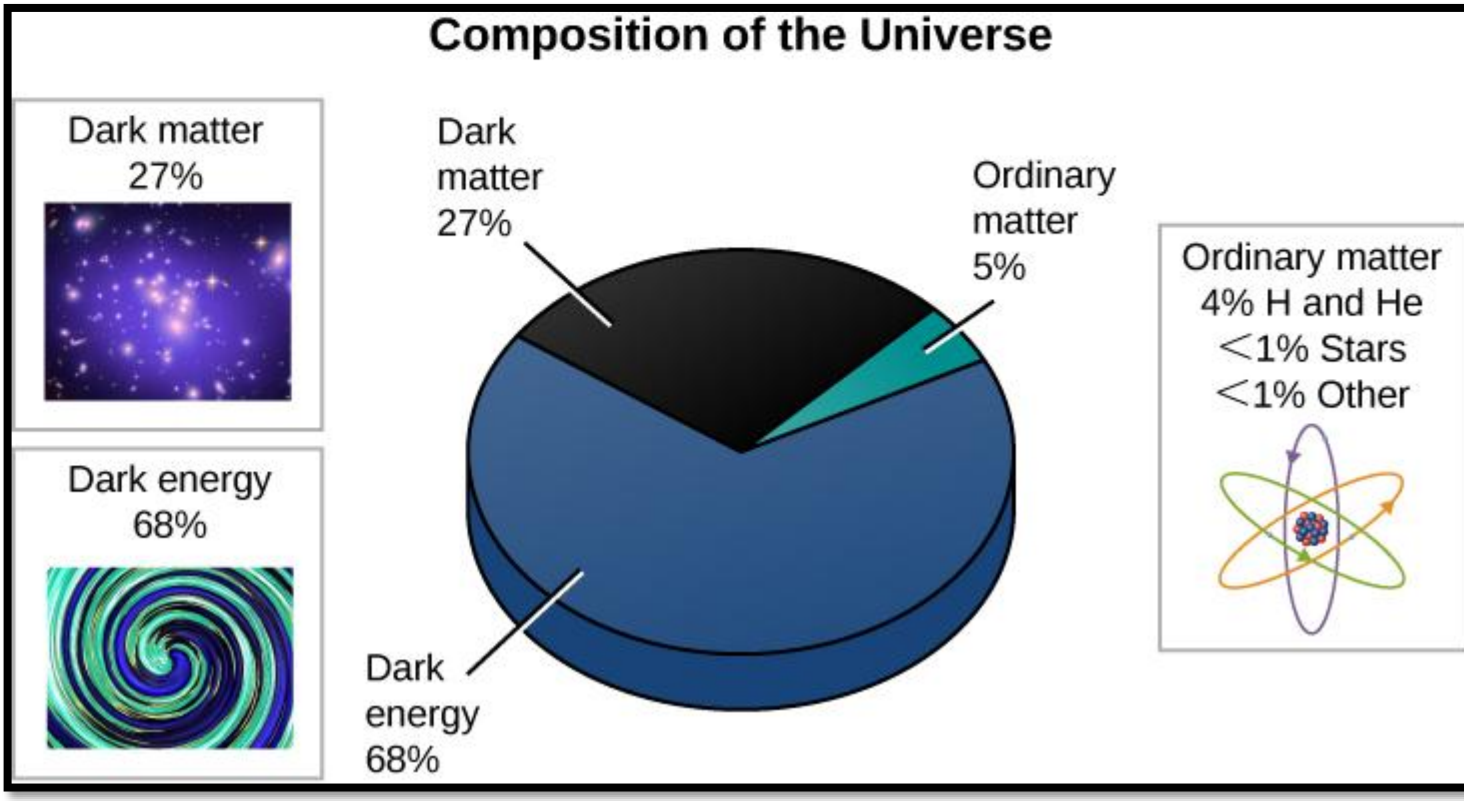
Science: Solar System - Structure of the Universe



Name: ______________________________

Science: Solar System – Structure of the Universe

Big Idea (6): The solar system is part of the Milky Way, which is one of billions of galaxies.
Content (6): The overall scale, structure, and age of the universe
Content (6): The position, motion, and components of our solar system in our galaxy
Curricular Competency (6): Questioning and Predicting: Make predictions about the findings of their inquiry
Curricular Competency (6): Questioning and Predicting: Make observations in familiar or unfamiliar contexts
Curricular Competency (6): Planning and Conducting: Observe, measure, and record data, using appropriate tools, including digital technologies
Curricular Competency (6): Planning and Conducting: Use equipment and materials safely, identifying potential risks
Curricular Competency (6): Processing and Analyzing Data and Information: Compare data with predictions and develop explanations for results
Curricular Competency (5): Evaluating: Identify possible sources of error
Curricular Competency (5): Evaluating: Suggest improvements to their investigation methods
Curricular Competency (5): Applying and Innovating: Generate and introduce new or refined ideas when problem solving
Curricular Competency (5): Communicating: Communicate ideas, explanations, and processes in a variety of ways
First Peoples Principles of Learning: Learning is experiential

Background Information

Since the moment of the big bang nearly 14 billion years ago, the universe has been expanding. Astronomers first measured this phenomenon in the 1920s and have been refining their measurements ever since. Now scientists know that the universe is not only expanding, but also the rate at which it is expanding is increasing. Before this discovery, scientists had believed that gravity from matter within the universe would eventually slow the expansion.

The matter that makes up the observable universe does not have enough mass to account for the accelerating expansion of the universe. Cosmologists – people who study the origin and evolution of the universe – believe that in addition to the matter we can see, such as planets, moons, dust, and stars, the universe contains dark energy and dark matter. More is unknown than is known about dark energy and dark matter, but their presence can be inferred by the way they interact with the visible universe. We can determine how much dark energy exists by looking at how it influences the accelerating expansion of the universe. When it comes to dark matter, we can look at the gravitational effects on galaxy formation that can't be explained by visible matter alone.

Based on theoretical models of the universe, dark matter accounts for approximately 27% of the universe and dark energy makes up 68%. Ordinary matter, like what is found on the periodic table, accounts for less than 5% of the total mass of the universe. The energy (light, heat, radiation, etc.) and matter (planets, moons, stars, galaxies, gasses, etc.) that make up the observable universe account for less than 5% of the universe. About 27% of the universe is composed of what scientists call dark matter, and roughly 68% of the universe is dark energy.

Here are some of the observable components of the universe:

1. **Universe**
   - The biggest system we know.
   - Contains billions of galaxies, each with stars, planets, gas, dust, and **black holes**.
2. **Galaxy**
   - A huge group of stars, planets, gas, dust, and sometimes **supermassive black holes** at the center.
   - Our galaxy is called the **Milky Way**.
   - The Milky Way has **100–400 billion stars**, and our Sun is just one of them.
3. **Solar System**
   - A group of **planets, moons, asteroids, comets, and dwarf planets** orbiting a star (our Sun).
   - **Asteroids** are rocky objects, mostly found in the asteroid belt between Mars and Jupiter.
   - **Comets** are icy objects that sometimes grow glowing tails when they get close to the Sun.
   - A **planet** is a large, round object that orbits (goes around) a star, like the Sun. It is big enough that its gravity makes it round, and it has cleared other space rocks out of its path.
   - A **dwarf planet** is like a planet because it orbits the Sun and is round, but it is too small to clear other space rocks out of its path.
   - A **moon** is a natural object that orbits a planet. Moons can be big or small, rocky or icy, and planets can have one, many, or none at all.
   - Our solar system also contains moons and smaller objects like meteoroids. A **meteor** is a space rock that enters Earth's atmosphere and burns up, making a bright streak of light in the sky (a "shooting star"). If the rock doesn't burn up completely and lands on Earth, it's called a **meteorite.**
4. **Planet & Earth**
   - Earth is one small planet in the solar system.

Goal

To better understand what the universe is made of. To create models to show where everything is.

Materials

- A sheet of fabric
- 2-3 different size balls (marble, tennis ball, etc)
- Balloon
- Sharpie
- Stickers
- Tray
- Dirt / powder
- Sticks / rulers
- Tape
- Scissors
- Scrap paper
- String

Overview

- Expanding universe in a balloon
- Black holes on a sheet
- Asteroids and Meteors in a tray
- Comets on a string
- Planets for scale
- Moons and gravity

Curricular Competency (6): Planning and Conducting: Use equipment and materials safely, identifying potential risks owing information

How will you ensure safety during this lab? Read through the rest of this lab, and discuss all of the ways that you can keep yourself safe, others safe, and the learning environment safe:

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Curricular Competency: Questioning and Predicting: Make **predictions** about the findings of their inquiry

EXPANDING UNIVERSE IN A BALLOON

You will be watching a balloon expand, to simulate the universe expanding. You will be asked to draw some dots and light waves on a balloon, and watch what happens when it expands. What are your predictions?

As you breathe air into the balloon, will the 'galaxies' (dots) move farther apart from each other? Will they get closer to each other?

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What will happen to the stretching light waves, as they "travel across space over time"? ______________________

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BLACK HOLES

You will be rolling marbles around a sheet of fabric, to simulate the gravitational pull of a black hole. You will build a physical model of the space curvature around a massive object and observe the effect on a less massive object.

You are asked to make some predictions. Write down your thoughts:

1) When do you think humans appeared on the calendar, if the age of the universe were squished into one calendar year? ____________

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Why is that? ____

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ASTEROIDS AND METEORS

You will be dropping a variety of objects into dirt, from varying heights, to simulate an asteroid hitting the earth.

You are asked to make some predictions. Write down your thoughts:

1) Does height relate to impact? The higher you drop the object from, will that create a bigger hole?

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Why is that? ____

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BLACK HOLES

Background information:

A black hole is a region in space where **gravity** is so strong that nothing that enters it can escape, not even light! Black holes form when a massive star runs out of fuel and becomes unable to support its heavy outer layers of gas. If the star is large enough—approximately 25 solar masses—then gravity pulls on the gas and causes the star to grow smaller and smaller until its density reaches infinity at a single point. This is called a 'singularity'.

After the black hole forms, it can continue to grow by absorbing mass from its surroundings, such as other stars and other black holes. If a black hole absorbs enough material, growing to over one million solar masses, it becomes a 'supermassive black hole'. It is believed that supermassive black holes exist in the centres of most galaxies, including the Milky Way.

A black hole is made up of three parts: the singularity (the collapsed star), the 'inner event horizon' (the region around the singularity where nothing, not even light, can escape), and the 'outer event horizon' (where objects will still feel the gravity of the black hole but not become trapped).

Curricular Competency: Planning and Conducting: Observe, measure, and record data, using appropriate tools, including digital technologies

Steps.

1. Acquire a piece of fabric. Have two people hold/stretch the fabric horizontally until it becomes taut (tight) to represent two-dimensional 'space'. Hold the fabric still so that your movements do not affect the experiment.

2. Have a third person place the lightest ball (marble, small bouncy ball, etc) on the fabric, and make it roll across its surface. The marble's path should follow a straight line, similar to that of a ray of light travelling through space.

3. Swap the marble for a heavier ball. Have the third person roll it on the fabric. When they place it on the fabric, you will see how it deforms the fabric of 'space'. 'Space' becomes curved around the heavy object.

4. Make the same little marble roll close the heavy object. Its trajectory should now be altered by the deformation of the bandage. This is similar to what happens to light passing close to a massive object that deforms the space surrounding it. Try varying the speed of the marble to see how its path changes. The more concentrated the central mass (i.e. the heavier the large ball), the more curved the fabric will be. This increases the depth of the 'gravitational well' from which the marble will not be able to escape.

5. Have the third person try to roll the smaller ball as close to the big ball (without it touching the big ball), and make it to the other side of the fabric. You might notice that as the marble passes close to the large ball, it starts to revolve around the 'black hole' and eventually falls in. Once it is there, you can see how things may easily fall into a black hole but cannot come back out. This is what happens with black holes: their gravity deforms space in such a way that light or other objects fall in and cannot escape.

In the space below, draw a diagram of what you did. Make sure to label everything. Then, write down your observations:

Diagram	Observations
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EXPANDING UNIVERSE

Curricular Competency: Planning and Conducting: Observe, measure, and record data, using appropriate tools, including digital technologies

Steps.

1. Acquire a balloon. On the balloon, draw a wiggly line (like in the photo) in sharpie, from the tip/end of the balloon, to the opening. Place 4 stickers on the balloon (mark where they are on the balloon in case they fall off), and number them 1-4. Take some measurements:

Distance from the opening of the balloon to the end	Length of the light wave	Distance between galaxy 1 and 2	Distance between galaxy 2 and 3	Distance between galaxy 3 and 4	Distance between galaxy 4 and 1

2. Inflate the balloons just enough that they take shape. Hold the balloon closed without tying it off. The balloon represents the universe. Take some measurements:

Distance from the opening of the balloon to the end	Length of the light wave	Distance between galaxy 1 and 2	Distance between galaxy 2 and 3	Distance between galaxy 3 and 4	Distance between galaxy 4 and 1

3. Blow up the balloon half way. Take some measurements:

Distance from the opening of the balloon to the end	Length of the light wave	Distance between galaxy 1 and 2	Distance between galaxy 2 and 3	Distance between galaxy 3 and 4	Distance between galaxy 4 and 1

4. Blow up the balloon all the way. Take some measurements:

Distance from the opening of the balloon to the end	Length of the light wave	Distance between galaxy 1 and 2	Distance between galaxy 2 and 3	Distance between galaxy 3 and 4	Distance between galaxy 4 and 1

In the space below, draw a diagram of what you did. Make sure to label everything. Then, write down your observations:

Diagram	Observations
	______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________

ASTEROIDS AND METEORS

Curricular Competency: Planning and Conducting: Observe, measure, and record data, using appropriate tools, including digital technologies

Background information:

Asteroids

- Asteroids are **rocky objects** left over from the early formation of the solar system (about 4.6 billion years ago).
- Most are found in the **asteroid belt**, a region between Mars and Jupiter.
- They come in different sizes: some are tiny pebbles, and others are hundreds of kilometers wide.
- Unlike planets, asteroids are **too small and irregularly shaped** to be round.
- They don't have atmospheres, so their surfaces are covered in craters.

Meteors

- A meteor starts as a **meteoroid**, which is a small piece of rock or dust traveling through space.
- When a meteoroid enters **Earth's atmosphere**, it burns up from friction with the air. This creates a bright streak of light in the sky, which we call a **meteor** or "shooting star."
- If part of it survives and lands on Earth, it is called a **meteorite**.
- Meteors can come from comets or asteroids that break apart.

Key Differences

- **Asteroid** = big space rock orbiting the Sun.
- **Meteoroid** = small piece of rock in space.
- **Meteor** = the streak of light when it burns in Earth's atmosphere.
- **Meteorite** = the leftover piece if it lands on Earth.

Asteroids and meteors create craters when they hit planets and moons. We will practice making craters.

Steps.

1. Acquire a tray. Place a layer of dirt in the tray, and another layer (grass / woodchips / different colour dirt, etc) on top.

2. Use 5 different objects to drop into the tray, from different heights. Record your results below (and write in the names of the objects on the top line of the table):

	Object #1	**Object #2**	**Object #3**	**Object #4**	**Object #5**
Depth of hole, when dropped from 1 inch					
Width of hole when dropped from 1 inch					
Depth of hole, when dropped from 5 inches					
Width of hole when dropped from 5 inches					
Depth of hole, when dropped from 10 inches					
Width of hole when dropped from 10 inches					

Choose 3 different objects. Create a diagram for each, and write down your observations. What did you notice? How was the reaction/result different from a different object or height?

Diagram	Observations

Diagram	Observations

Diagram	Observations

COMET ON A STRING

Curricular Competency: Planning and Conducting: Observe, measure, and record data, using appropriate tools, including digital technologies

Background information:

A **comet** is a chunk of ice, rock, and gas flying through space. When they get close to the sun, they heat up. We can see their glow and long tails.

Comet vs. Asteroid

Asteroid

- Made mostly of **rock and metal**.
- Found mainly in the **asteroid belt** between Mars and Jupiter.
- Usually looks like a big, bumpy space rock.
- Orbits the Sun but does **not** have a tail.

Comet

- Made mostly of **ice, dust, and rock** (like a "dirty snowball").
- Found in the far, cold parts of the solar system (Kuiper Belt and Oort Cloud).
- When a comet gets close to the Sun, the ice melts and creates a **glowing tail** of gas and dust.
- The tail always points **away from the Sun** because of the solar wind.

Easy way to remember:

- **Asteroid = rock.**
- **Comet = icy snowball with a tail.**

Comet tails are created by the Sun's heat and always face away from it.

Steps:
1. Acquire a ruler.
2. Attach some long strips of cut paper to the tip of the ruler using tape
3. Wave the ruler around in the air in either circles, figure eights, or back and forth.
4. Wave the ruler around at different speeds

What did you notice? Write down your observations. Be sure to label your diagram:

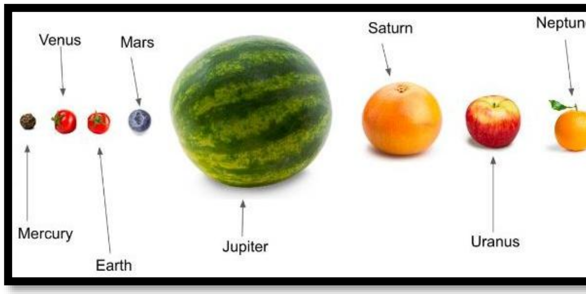
Diagram	Observations
	______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________ ______________________________________

PLANET SCALE

Curricular Competency: Planning and Conducting: Observe, measure, and record data, using appropriate tools, including digital technologies

Background information:

The solar system has 8 planets that orbit the Sun. Even though Earth feels big to us, it is tiny compared to the Sun — and the gas giants (Jupiter, Saturn, Uranus, Neptune) are much larger than Earth. Scientists use **scale models** to help us picture these size differences. When we compare the planets to eachother, Jupiter is enormous... but once we introduce the sun



Steps:

1. Acquire a large ball (basketball, etc).

2. Acquire scrap paper, and make paper balls equivalent to the sizes mentioned in the 'object example' column, for each planet.

3. Order the planets and the sun, in the same order as they are listed on the chart to the right.

If you are feeling extra adventurous, you can use confetti / paper shreds / miniscule objects to represent the moons that are listed below:

Planet Size Scale (example with a 1 m Sun = beach ball)

Planet	Real Diameter (km)	Scale Diameter (mm)	Object Example
Sun	1,392,000	1000 mm (1 m)	Beach ball
Mercury	4,880	3.5 mm	Peppercorn
Venus	12,100	9 mm	Small marble
Earth	12,700	9.5 mm	Small marble
Mars	6,800	5 mm	Lentil/bean
Jupiter	142,000	100 mm (10 cm)	Orange
Saturn	120,000	85 mm (8.5 cm)	Apple
Uranus	51,000	37 mm (3.7 cm)	Large marble
Neptune	49,000	35 mm (3.5 cm)	Large marble

What did you notice? Be sure to label your diagram. Write down your observations.

Diagram	Observations
	______________________________
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Moons in Our Solar System

- **Mercury → 0 moons**
- **Venus → 0 moons**
- **Earth → 1 moon** (we just call it "the Moon")
- **Mars → 2 moons** (Phobos and Deimos, small and lumpy)
- **Jupiter → 95 moons** (the biggest are the Galilean moons: Io, Europa, Ganymede, Callisto)
- **Saturn → 146 moons** (Titan is the largest, even bigger than Mercury!)
- **Uranus → 28 moons** (the biggest are Titania and Oberon)
- **Neptune → 16 moons** (the largest is Triton, which orbits backward)

MOON AND GRAVITY

Curricular Competency: Planning and Conducting: Observe, measure, and record data, using appropriate tools, including digital technologies

Background information:

A **moon** is a natural object in space that **orbits a planet or a dwarf planet**. Earth has one moon, but some planets have dozens. Scientists also call moons **"natural satellites."**

How Do Moons Work?

- Moons stay in orbit because of **gravity**.
- The planet pulls the moon toward it, while the moon's motion keeps it moving forward.
- This balance creates a **circle or oval path** around the planet.

Moons can be made of **different materials**, depending on which planet they orbit and how they formed.

Rocky Moons

- Many moons are made of **rock and metal**, like small planets.
- Example: **Earth's Moon** — mostly rock, with a crust, mantle, and small iron core.
- Example: **Mars' moons** (Phobos & Deimos) — look like captured space rocks (asteroids).

Icy Moons

- Moons farther from the Sun are often made of a mix of **ice and rock**.
- Example: **Europa (Jupiter)** — icy surface with a salty ocean underneath.
- Example: **Enceladus (Saturn)** — ice-covered with geysers shooting water into space.

Gassy or "Thick-Atmosphere" Moons

- Some moons have **thick atmospheres**, which is unusual for moons.
- Example: **Titan (Saturn)** — mostly rock and ice, but with a dense orange atmosphere. It even has rivers and lakes of liquid methane!

Steps:
1. Find one large ball (like a basketball), and one small ball (like a tennis ball, or marble).
2. Tape a string (the string represents gravity), connecting the two balls
3. Spin the large ball, and watch what happens to the moon
4. Try spinning at different speeds and intensities.

What did you notice? Be sure to label your diagram. Write down your observations.

Diagram	Observations
	____________________ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________

Curricular Competency: Processing and Analyzing Data and Information: Compare data with predictions and develop explanations for results

How did your predictions compare with your findings?

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Curricular Competency (5): Applying and Innovating: Generate and introduce new or refined ideas when problem solving

Now that you have learned more about our universe, how could someone use this knowledge to come up with a new idea, or to solve a problem?

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Curricular Competency (5): Evaluating: Identify possible sources of error

Every lab has potential flaws in it. What are some of the ways that the lab itself (not you), could lead people to different results?

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Curricular Competency (5): Evaluating: Suggest improvements to their investigation methods

How could you have improved your investigation methods?

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Emerging	Developing	Proficient	Extending
Some sections are completed. Decipherable answers show initial understanding of the concepts, and sometimes incorporate specific vocabulary terms and reasoning.	All sections are completed. Answers show a growing understanding of the concepts, with some correct use of vocabulary and reasoning. Students are beginning to make connections and explain ideas with increasing clarity.	All sections are completed. Answers are reasonable, show clear understanding of the concepts, and include appropriate vocabulary and logical reasoning.	All sections are completed thoroughly. Answers are reasonable, insightful, and demonstrate clear connections to bigger ideas, with precise vocabulary, effective reasoning, and reflect awareness of multiple perspectives or broader implications of the concept.