Student Information: Unit 4 Lesson 1

Introduction Space and Exploration

Suggested Time: 1.25 Hours

What’s important in this lesson:

- The vast size of our Universe.
- Earth’s motion and how it affects our planet.
- Night sky, and how the sky has been divided.

Complete these steps:

1. Complete the Diagnostic/Introductory Activity. Get this checked as being completed on your Course Checklist.

2. Use a textbook, either *Science 9* or *Science 9 Concepts and Connections* and get started on the student handout. If you are having difficulty with a section note this in the box below: Questions for Teacher and move on to the next activity in your student handout. You may need to use the internet for the last page on the student handout.

3. Once the Student Handout is complete check your answers or your teacher will with the Answer Key. Get this checked as being completed on your Course Checklist.

4. You’ll need at least 10 -15 minutes to complete the quiz on the material you’ve reviewed today. If you’ve got at least that much time ask your teacher for the quiz and hand the quiz in when you’re done. If you don’t have enough time move on to the Reflective Activity and try the quiz next day.

5. Complete the Reflective Activity. Get this checked as being completed on your Course Checklist.

Hand-in the following to your teacher:

1. The lesson quiz.

Questions for the teacher:

Diagnostic/Introductory Activity:
Unit 4 Lesson 1

Match the words in column A with the definitions found below. Place the corresponding letter in the space provided. Use the glossary of a Grade 9 textbook to help you.

#	**Column A**	**Definition**
1	Ecliptic	
2	Constellation	
3	Astronomical Unit (AU)	
4	Galeleo Galilei	
5	Galaxy	
6	Moon	

A. A unit of length used in measuring astronomical distances within the solar system equal to the mean distance from Earth to the Sun, approximately 150 million kilometers (93 million miles).

B. Italian astronomer (died 1642) and mathematician who was the first to use a telescope to study the stars; demonstrated that different weights descend at the same rate; perfected the refracting telescope that enabled him to make many discoveries.

C. A great circle inscribed on a terrestrial globe inclined at an approximate angle of $23^\circ 27'$ to the Equator and representing the apparent motion of the Sun in relation to the earth during a year.

D. Any of the 88 contiguous regions that cover the entire celestial sphere, including all of the objects in each region; also a configuration of stars often named after an object, a person, or an animal.

E. A natural satellite revolving around a planet.

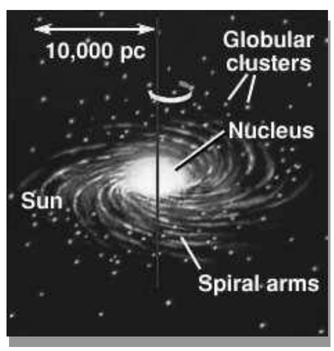
F. Any of numerous large-scale aggregates of stars, gas, and dust that constitute the Universe, containing an average of 100 billion (10^{11}) solar masses and ranging in diameter from 1,500 to 300,000 light-years. Also called nebula and held together by gravity.

Student Handout: Introduction to Space and Exploration

Helpful hint: as you read through this handout please use different coloured highlighters to highlight the following types of information;

1. Where is Earth located in our solar system?
2. What are asteroids?
3. What does AU mean?
4. What is the difference between rotation and revolution of Earth?
5. What is Polaris and why is it important?
6. What factors affect Earths' seasons?
7. What are the types of galaxies?
8. How do Sun dials work?
9. What are the important constellations?

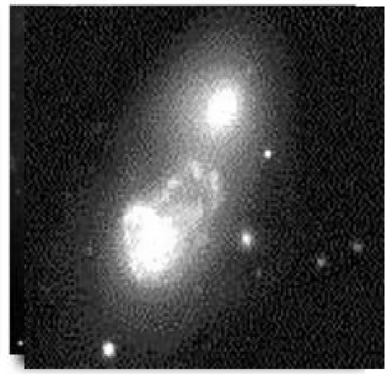
Have you ever looked into the night sky and tried to count the stars on a dark night? There is said to be about 5000 stars visible to the unaided eye on a dark night. When you look in to a dark sky, particularly in the summer, you will see the faint glow of the center of the Milky Way (**fig.1)** directly overhead. This is our galaxy!. The Milky Way is what we call a spiral galaxy. Our solar system is located slightly to the outside of one of the spiral arms of the Milky Way Galaxy.



Milky Way (fig.1)
Note: 1pc (parsec) = 3.26 light years

Elliptical galaxy (fig.2)

Spiral galaxy (fig. 3)



Irregular galaxy (fig. 4)

Introduction to the Sky

The sky has captivated people for thousands of years. The Sun dominates the daytime sky with its radiance, the day beginning and ending with beautiful sunrises and startling sunsets. But with the disappearance of the Sun, the night sky comes alive. The Moon is the brightest and most recognizable object in the sky at night, and is the closest celestial body to the Earth. A full Moon drowns out stars with its light, but a sky devoid of the the moon lit night reveals thousands of stars. From a dark site away from city lights, we can see nearly 3000 stars (compared to only a few hundred from the city).

In addition to the Moon and the stars, a few of the planets are clearly visible in our sky. Because planets are further away than the Moon, they appear like the distant stars as points of light. Venus is the brightest object in the sky after the Sun and Moon, and is usually visible just before sunrise or after sunset as a bright “star” low in the sky. Mars, Jupiter and Saturn are also easily visible to the unaided eye (without a telescope). Mercury is visible as well, although it is much more difficult to spot.

There are many objects in the night sky that are extremely far away and too faint for us to see without binoculars or a telescope. A telescope reveals an incredible Universe we cannot see while looking up at the night sky from our backyard. There are billions of other stars, small rocks (**asteroids**), dirty snowballs (**comets**), gases which glow from the light of nearby stars (**nebulae**), as well as billions of galaxies that can be classified as elliptical (**fig. 2**), spiral (**fig. 3**) or irregular (**fig. 4**). It is truly unbelievable what treasures our night sky holds. They are simply too far away and too faint to be seen with our eyes.

Student Handout: Unit 4 Lesson 1

To give you an idea of the distance, the Sun is 150,000,000 kilometers away (150 million kilometers) from Earth. Astronomers call this distance 1 astronomical unit (AU). Although an AU is a very large distance, it is considered too small to measure the distance between stars. The closest star to Earth is about 282,000 AU. Most stars are much further. Using AU's to measure this distance is not practical. Therefore the distance between stars is measured in light years. A light year is the distance light travels in one year. What does this mean?

- Light travels about 300,000 kilometers per/second
- There is 31,536,000 seconds in a year
- Therefore, light will travel approximately 10 trillion kilometers in one year
- This equals about 125 million around the word trips in one year.

The following chart is a summary of the distance between the Sun and individual planets.

Planet	Astronomical Units	Kilometers
Mercury	0.4	58,000,000
Venus	0.7	108,000,000
Earth	1	150,000,00
Mars	1.5	230,000,000
Jupiter	5.2	778,000,000
Saturn	9.5	1,427,000,000
Uranus	19.2	2,870,000,000
Neptune	30.1	4,500,000,000
Pluto	39.4	5,900,000,000

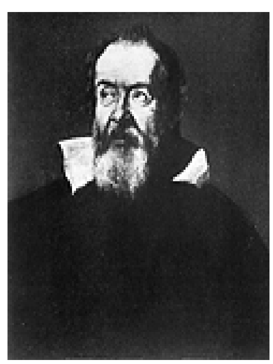
Activity 1:

True or False – complete the table below

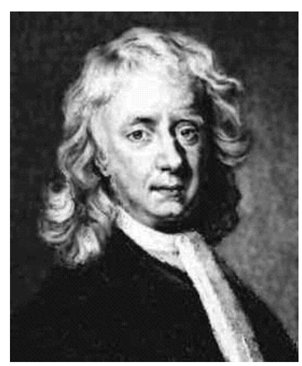
	1.	Scientists can count all the stars in the Universe
	2.	You can see more stars in the city night compared to the country side.
	3.	Earth is located on the outer edge of the Milky Way galaxy.
	4.	The Milky Way is a spiral galaxy.
	5.	Our Sun is not part of the Milky Way galaxy.
	6.	Venus is a bright star in the early morning sky.
	7.	Mars, Jupiter and Saturn are visible in the night sky to the unaided eye (with out a telescope)
	8.	Comets are frozen ice (like a large snowball) gliding through our universe.

Early astronomers believed that the planets and the Sun revolved around Earth. During the Sixteenth Century, scientists such as Nicholas Copernicus **(fig. 5)** and Galileo Galilee **(fig. 6)** were challenging this theory. Although the **heliocentric theory** (planets orbit the Sun) later became widely accepted, the belief that the planets moved at constant speeds and in circular paths was still prevalent. Johannes Kepler, working with Tycho Brahe's data, discovered that the paths of the planets were slightly elliptical and that the planets moved at different speeds at various points in their orbits. This discovery was later supported by Isacc Newton's **(fig. 7)** laws of gravity. Newton found that the gravitational force between two bodies grows weaker the farther apart they are. Not only does the force of gravity depend on distance between the centers of mass, but on their masses as well.

Nicholas Copernicus **(fig. 5)**



Galileo Galilee **(fig. 6)**

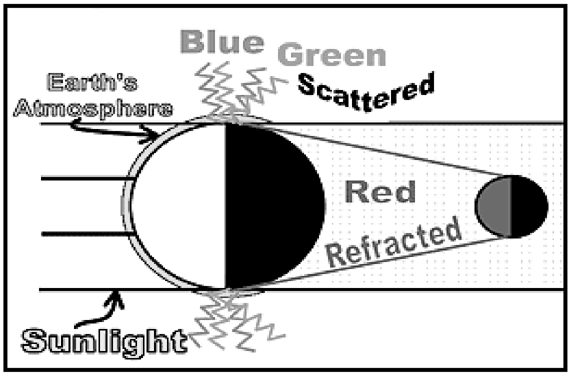


Isaac Newton's **(fig. 7)**

Day and Night

The Sun makes the daytime sky very different from the night sky. During the day, the Sun's brilliance floods the sky and drowns out the light from the other objects in the sky. The Sun's light appears a yellowish white, but is composed of the full spectrum of light.

Our atmosphere **refracts** the blue component of sunlight down to the surface, but it reflects the other colours back into space. This is why the daytime sky appears blue **(fig. 8)**. In contrast, the sky at night is void of the Sun's light and as a result it is dark, allowing the light from thousands of stars to twinkle in our sky. Stars remain present during the day, (the brightest ones visible with a telescope), but cannot be seen because the Sun overwhelms them.

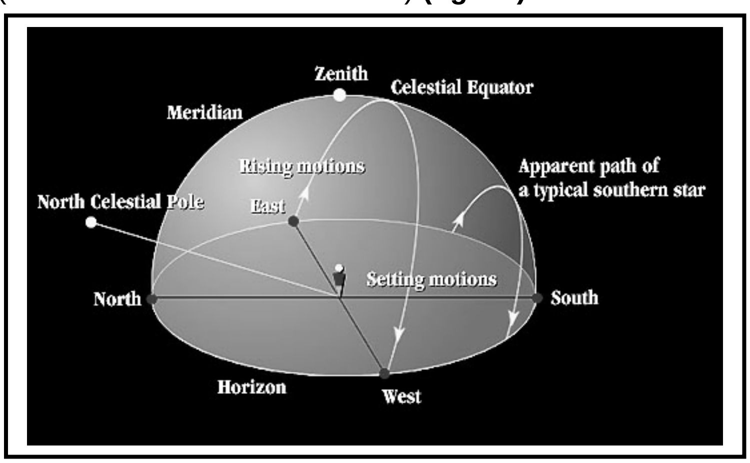


Atmosphere refracts Sun light: (**fig. 8)**

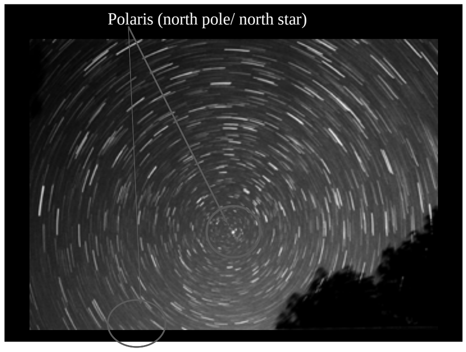
Celestial Sphere

The stars in our night sky have remained unchanged for many years. Although stars do have their own motion in space, they are so far away we cannot detect their movement unless observed over many years; their positions relative to each other will not change noticeably within our lifetime. The patterns we see in the sky are virtually no different than the patterns our ancestors saw when they looked up at the sky. The first astronomers believed that the stars were fixed on a celestial sphere surrounding the Earth. Although we now know this to be untrue (the Universe is three-dimensional and stars are located at various distances from the Earth), it still helps to use this illustration to better visualize and understand the night sky.

Using this representation, the stars do not move with respect to each other, but they do move in our night sky due to the Earth's rotation on its axis. As the Earth rotates within the celestial sphere, stars will rise in the east and will travel across our sky from east to west **(fig. 9).**
Stars appear to circle around the north celestial pole, which happens to be near the star called Polaris (better known as the North Star) **(fig. 10).**



Diurnal motion (**fig. 9)**

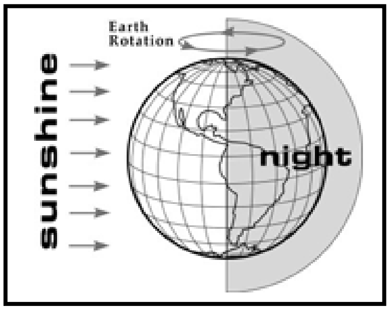


North Star **(fig. 10)**

Just as the North Pole of the Earth is stationary while the Earth turns, the north celestial pole also appears to be stationary. This phenomenon is clearly visible in time lapse photography of the night sky over a few hours; stars will leave trails that circle around Polaris. This motion is apparent simply by looking at a recognizable or prominent star early in the evening and returning a few hours later to see how the star's position has shifted in the sky. The further north one is from the Equator, the higher the North Star will be in the sky, until at the North Pole, where Polaris will be directly overhead at the zenith. As the apparent position of the north celestial pole rises in the sky with the increasing latitude on the Earth, more of the sky becomes circumpolar. Circumpolar stars are ones which do not set below the horizon through the course of a year.

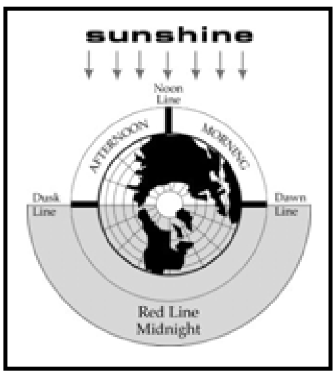
Earth's Rotation

The nightly changes in the sky are caused by the Earth's rotation **(fig. 11)**, but the Earth is simultaneously in orbit around the Sun. Because of this, every time the Earth completes one rotation on its own axis (with respect to the celestial sphere), it has moved slightly in its path around the Sun.



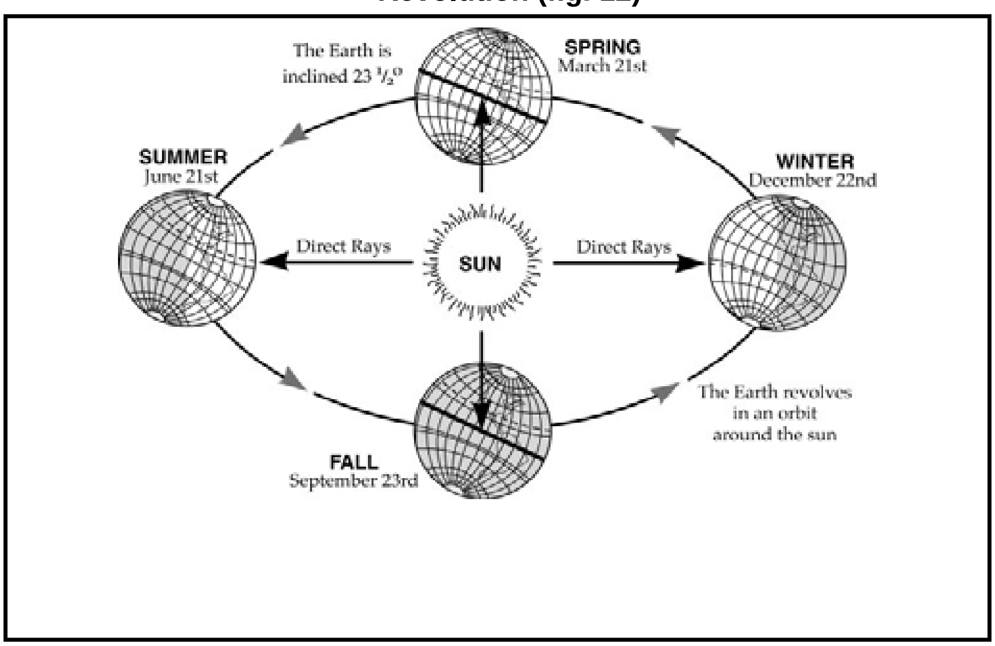
Side view
Earth's rotation **(fig. 11)**

When the Sun returns to the same spot in the sky, we will have rotated through slightly more than one rotation with respect to the celestial sphere, so the stars will appear to have shifted. The same star will rise almost four minutes earlier every night, and during the course of a year the Sun will appear to have moved through the fixed background stars. This progression of the Sun relative to the stars causes some stars to be visible only at certain times of the year. We can imagine that at any given time, half of the stars in the celestial sphere will be visible while the other half will be on the daytime side of the sky. A star that is in the visible half of the sky will in six months be in the sunlit half because the Earth is on the other side of the Sun **(fig. 12).** This movement is referred to as Earth's revolution. In order to complete one revolution it takes 365 days, or 1 year. Consequently, Earth's seasons depend on Earth's inclination of 23½ and Earth's position (orbit) around the Sun (we will look at this in more detail in lesson 2).



Polar view

Earth's Revolution (fig. 12)

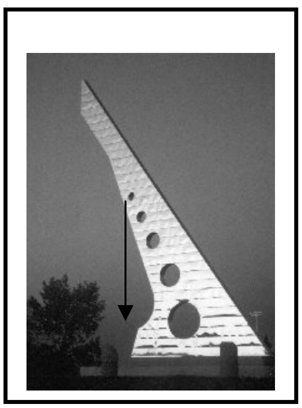


Activity 2: True or False

T or F	**1.**	Heliocentric theory refers to planets orbiting the Sun.
	2.	Isaac Newton's laws of gravity helped explain the varying speeds and orbits of the planets in our solar system.
	3.	Earth's atmosphere refracts the blue component of light towards Earth's surface.
	4.	In the night sky stars rise in the west and set in the east.
	5.	Polaris (north star) does not appear stationary in the northern night sky.
	6.	Polaris would be a good point of reference to use in navigation.
	7.	Earth's rotation helps explain the cycle of day and night.
	8.	Earth's revolution helps explain the cycle of our seasons.

Sundials

The easiest way to detect the Earth's rotation is by observing the path of the Sun across the sky throughout an entire day. Doing this very thing, the ancients determined that by tracking the location of the Sun in the sky, they could decipher the time of day. To do this, they invented sundials. A sundial consists of a Gnomon standing vertically on a hemispherical base **(fig. 13).** Aligning the sundial to the Earth's axis of rotation, the Sun's progression through the sky casts shadows which correspond to the time of day.



Hemispherical base, (fig. 13**)**

Gnomon

The largest sundial in Canada is located in Lloydminster, AB and is over 60 metres across **(fig 13).** The largest sundial in the world was constructed c. 1724 in Jaipur, India **(fig. 10)** and stands over 30 metres high and occupies an area of nearly one acre. Astronomers claim that the Jaipur sundial is accurate to within mere fractions of a second. At the top of the gnomon, sits an observatory.

Relative Motion

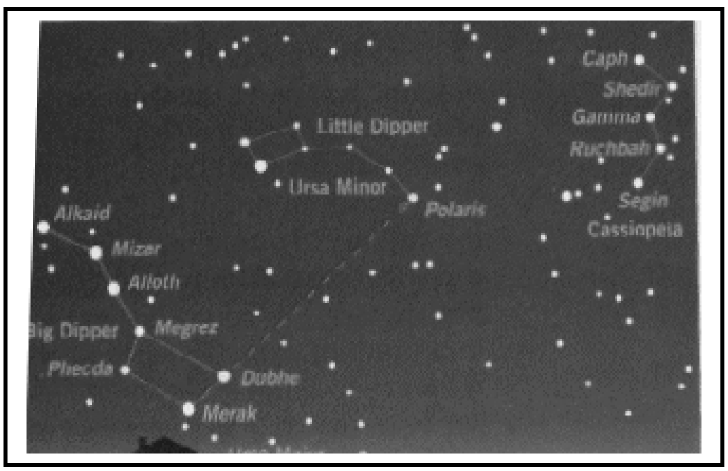
Sun Dial Jaipur, India **(fig. 10)**

The stars do not change their positions relative to each other because they are very far away from the Earth. The Moon and planets, however, are relatively close and are in constant motion in their own orbits around the Earth (the Moon) and the Sun (the planets). As a result their locations in the sky will vary on a nightly and yearly basis. The Moon will rise about an hour later each day until it returns to approximately the same rise time 27.3 days later, when the cycle begins again.

The positions of the planets in our sky also vary from day to day and from year to year. A planet may be visible only during the summer this year, whereas several years ago it was only visible during the winter. The independent orbits of the planets combined with our own orbit around the Sun cause their positions in our sky to constantly change.

Constellations, Patterns in the Sky

When looking up at the stars, there are discernable patterns in the sky called constellations. Different cultures saw different patterns, and stories were told of their origins. The ancient Greeks envisioned the constellations we use today, and we still use their Latin designations. While looking up at the night sky it can be very difficult to identify any of the constellations; the sky appears to be a puzzling clutter of hundreds of points of light, and most constellations bear little resemblance to their definitions. In addition to this, the imaginary lines which are drawn to join the stars (called **asterisms**) often differ from source to source. The most prominent and easily recognizable constellations in Canada are the Big Dipper (an asterism within the constellation Ursa Major) and Orion the Hunter. To help identify other constellations, we can use pointer stars. The best example of this is using the two right stars of the Big Dipper's bowl to point up to Polaris, the North Star **(fig. 15).**



Big Dipper (**fig. 15)**

In addition to the few constellations which are easy to identify, there are several others which are nearly impossible to identify. In 1930, astronomers divided the entire sky into 88 constellations, which are officially recognized today. We cannot see all 88 constellations in Canada because we are never exposed to the stars in the southern celestial sphere; the Earth literally blocks our view of the southern sky. The stars visible to the Southern Hemisphere are different than the stars we see because the Southern Hemisphere faces a different spot on the celestial sphere.

The ancient civilizations who first named the constellations lived in the Northern Hemisphere and could not see the southern sky. The constellations in this portion of the celestial sphere were not created and named until European explorers traveled to the southern regions of the world. While the northern constellations were created from mythological stories, the southern constellations were named during the 17th and 18th Centuries after important inventions of that time period. As a result, the southern constellations are not as interesting and imaginative; Antlia the Air Pump and Caelum the Chisel are two examples.

The 88 constellations can be detected with the help of sky atlases which show the positions of numerous stars and the divisions between the constellations. Star maps can be very simple and show only the brightest stars, or can go into more detail and show small portions of the sky with the positions of thousands of stars. There are also many computer programs that can plot the positions of millions of stars. The stars and the patterns they create can be complicated, but with a good atlas and some patience, it is not difficult to identify numerous constellations.

You can visit: ***www.edu-observatory/starcharts*** for Star maps, Sky atlas and more information about our Universe.

Activity 3:

Matching

Match each term in column A with its description in Column B. Write the correct answer in the space provided.

Answer	**Column A**	**Column B**
	1. Constellation	A. standing vertically
	2. Orion the Hunter	B. named after inventions
	3. Polaris	C. Big Dipper is part of
	4. Gnomon	D. North Star
	5. Ursa Major	E. Lloydminster, AB
	6. Sun dial	F. Easily seen from Canada
	7. Southern constellations	G. different star patterns

Adapted from Module 1: Introduction to the Day and Night Sky – The Canadian Space Agency
http://www.space.gc.ca/asc/eng/educators/resources/astronomy/module1/content.asp (accessed April 2005)

Assessment and Evaluation: Unit 4 Lesson 1

Multiple Choice

1. With respect to the Milky Way, where is Earth located?

a) the central part of the spiral
b) at the base of a spiral arm
c) slightly to the outside of a spiral arm
d) beside Jupiter and Neptune

2. Asteroids are?

- a) large planets
- b) dirty snowballs
- c) small stars
- d) small rocks

3. AU is short for,

- a) Astronomers units
- b) Astronomers union
- c) Astronomical unit
- d) Astronomical union

4. Stars appear to move in the night sky and rise in the east because

- a) rapid star movement
- b) the revolution of the Earth
- c) the rotation of the Earth
- d) the rotation of the Moon

5. Polaris is in line with Earth's,

- a) north pole
- b) south pole
- c) Equator
- d) magnetic poles

6. Earth is tilted at what angle?

- a) 25 ½
- b) 30 ¼
- c) 32 ½
- d) 23 ½

7. Earth’s inclination (tilt) and position with the sun results in Earth’s

a) night and day
b) seasons
c) tides
d) volcanoes

8. An ancient time device that is an excellent method for measuring Earth’s rotation?

a) sun dial
b) sand hour glass
c) pendulum clock
d) measuring tape

9. The most prominent constellation in Canada is,

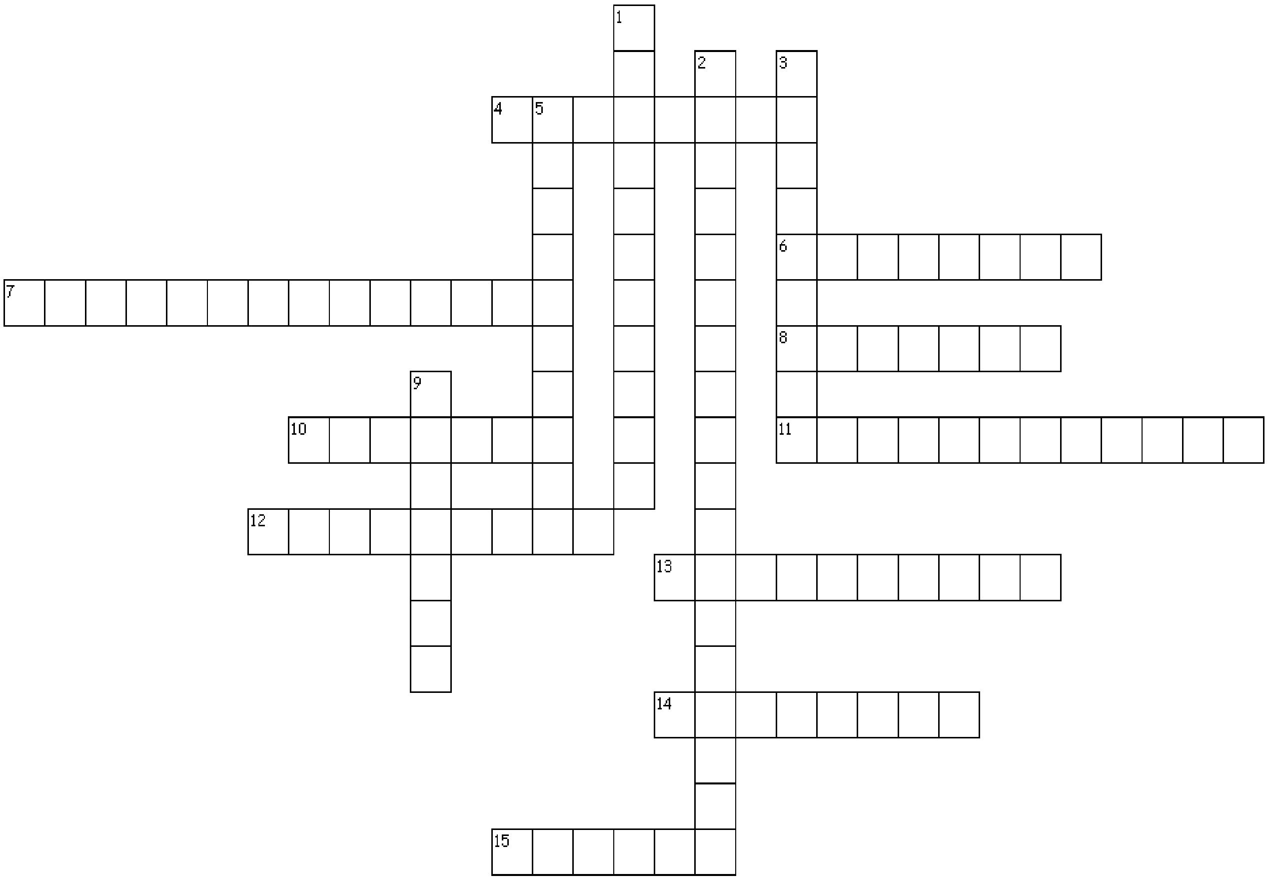
a) Little dipper
b) Big dipper
c) Ursa Major
d) Orion belt

10. The Milky Way is a?

a) Elliptical galaxy
b) Spiral galaxy
c) Irregular galaxy
d) Constellation

Reflection Activity: Unit 4 Lesson 1

Complete the following crossword based on the reading from lesson one:



Across
4. spiral and elliptical
6. day to night
7. total of 88
8. detects Earth's rotation
10. light from nearby stars
11. milky way (2 words)
12. points upward towards polaris (2 words)
13. season to season (2 words)
14. our galaxy
15. dirty snowballs

Down
1. laws of gravity (person)
2. heliocentric theory (person)
3. imaginary lines
5. refracts blue light downward
9. easily seen from Earth