Science
Grade Six
Topics C and D
Revised Edition
Grade Six
Topic C
Sky Science
## Materials List By Lesson
Optional items are in brackets [ ].

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Materials Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>2</td>
<td></td>
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<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>[self-adhesive stars], construction paper</td>
</tr>
<tr>
<td>5</td>
<td>shoe box, aluminum foil, pin, tape, paper</td>
</tr>
<tr>
<td>6</td>
<td>globe, Plasticine, toothpick, flashlight</td>
</tr>
<tr>
<td>7</td>
<td>metre stick, tall thin object</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>flashlight, globe, chalk, sheet of black construction paper</td>
</tr>
<tr>
<td>10</td>
<td>lamp with bare bulb, globe</td>
</tr>
<tr>
<td>11</td>
<td>lamp with bare bulb, globe</td>
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<tr>
<td>12</td>
<td></td>
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<tr>
<td>13</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>canteloupe (or ball of similar size), ping pong ball, globe, felt marker</td>
</tr>
<tr>
<td>15</td>
<td>softball, beach ball (or ball of similar size), lamp with bare bulb, tape</td>
</tr>
<tr>
<td>16</td>
<td>dark blue or black construction paper</td>
</tr>
<tr>
<td>17</td>
<td>dark blue or black roll paper</td>
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<tr>
<td>18</td>
<td></td>
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<td>19</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>dark blue or black construction paper (large size)</td>
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<td>21</td>
<td>roll paper</td>
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<tr>
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<td></td>
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<tr>
<td>24</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>
Comprehensive Materials List
(optional materials are in brackets)

- beach ball (or ball of similar size)
- canteloupe (or ball of similar size)
- chalk
- construction paper (small and very large)
- felt marker
- flashlight
- foil (aluminum)
- globe
- lamp with bare bulb
- metre stick
- pin
- ping pong ball
- Plasticine
- roll paper (usually comes in 36” width)
- [shoebox]
- softball
- [stars, self-adhesive]
- tape
- toothpicks
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Sky Science

Introduction

When you look up into the sky, what do you see? It all depends. What you can observe depends on where in the world you are, what time of day or night it is, what the weather is like, whether or not you are using a telescope, and many other factors. What scientists do know for sure is that so far humans have only discovered a tiny fraction of what there is to know about Earth, the other planets, moons, stars, and other heavenly bodies.

People have always been interested in heavenly bodies. They are the subjects of many myths and legends. Experts and other interested people have devoted their lives thinking about and investigating how these heavenly bodies were formed and why each is unique.

Ancient civilizations studied the movements of the Sun, stars, the Moon, and some of the planets as the days, seasons, and years went by. They used their observations to try to make sense of the world. This resulted in the creation of various types of calendars and festivals, the construction of structures that could accurately predict changes in seasons, and wall carvings that depicted events like shooting stars.

As technology improves, so does our understanding of the objects we see in the sky. Still, we know relatively little about them. For one thing, humans actually have first-hand knowledge of only two heavenly bodies. We know many things about Earth – it is our home. We know some things about the Moon, Earth’s nearest neighbour. Even then, only a handful of humans have ever visited the Moon.

People who study heavenly bodies are called astronomers. The branch of science that focuses on studying celestial (heavenly) bodies is astronomy. In this unit, Sky Science, you will learn more about all those celestial bodies that have fascinated people throughout history.

The ancient Greeks believed that Earth was at the centre of the universe. All other celestial bodies circled Earth. Their idea of how the universe is organized is called the geocentric model. According to the geocentric model, the Moon is Earth’s closest neighbour, followed by Mercury, Venus, the Sun, Mars, Jupiter, Saturn, and the fixed stars. Today astronomers know that the Sun, and not Earth is at the centre of our solar system, and that the Sun is just one of trillions of stars.
Part I:
The Earth, Sun, and Stars

Introduction

We can see celestial bodies because they seem to glow. However, astronomers have discovered that many of these heavenly bodies do not emit or give off their own light; they merely reflect light.

Sources and Reflectors of Light

Only the Sun and the stars are sources of light. All other celestial bodies reflect light. Astronomers have found that the Sun is just another star. It is the one closest to Earth so it appears to be the largest. The fact is that the Sun is not a very large star at all. It is average in size at best.

When we see the Moon in the night sky, it appears to be giving off a yellow, orange, or red colour. In reality, the Moon is only reflecting the Sun’s light.

Like the Moon, the planets are not sources of light. They can only reflect the Sun’s light. Other reflectors of light include the planets, the moons of other planets, and asteroids.

The stars, including the Sun, are the only heavenly bodies that are sources of light.

Satellites

A satellite is the name for any heavenly body that revolves around another. The Moon is a natural satellite of Earth. The planets are all satellites of the Sun. Not all heavenly bodies are satellites, however. The stars are not satellites. There are many heavenly bodies close to the planets that are not satellites. Some travel through space, and occasionally one will crash into one of the planets.

Humans have launched artificial satellites so that they will orbit Earth. These satellites are used mainly for viewing Earth from outer space, for communications, and for things like GPS (global positioning system).
Introduction

Ever since people populated the Earth, they have been interested in the heavenly bodies. Many myths, legends, and tales have been created about them. With improvements in technology, scientists are finding out more and more about stars, planets, moons, comets, and asteroids. To this day they remain a constant source of fascination for people.

Stars

Stars are the heat and light sources of the universe and come in all sizes, colours, compositions, and temperatures. They emit light through nuclear fusion, which happens deep inside the star. Next to the Sun, the star closest to us is called Proximal Centauri. A cluster of stars is called a galaxy. Our Sun is one of the stars in a galaxy called The Milky Way. There are about 200 000 000 000 stars in the Milky Way.

Sometimes it appears that a group of stars actually forms a pattern in the sky. This pattern is called a constellation. There are 88 constellations in the sky.

Sun

The Sun is the star that is at the centre of our solar system. The word solar means sun. Our solar system consists of eight planets, their moons, and several other smaller celestial bodies. The Sun emits light and gives off heat. Without the Sun there could be no life on Earth.

The Planets

There are eight planets that revolve around the Sun. They are satellites of the Sun because they revolve around it. The path each planet follows as it goes around the Sun is called an orbit. Beginning with the one that is closest to the Sun, the planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Each of the planets has its own unique characteristics. They vary in size, make up, and appearance.
Jupiter is the largest of the planets, while Mercury is the smallest. The amount of time it takes for a particular planet to revolve around the Sun one time is the length of that planet’s year. In general, planets closer to the Sun take less time to revolve around the Sun one time compared to those that are farther away. That is because the planets closer to the Sun have shorter orbits than those farther away.

The Earth, the fifth largest planet, is our home. The Earth is a satellite of the Sun. As far as we know, it is the only planet that has liquid water and a temperature that is suitable for life. Like some other planets, it has an atmosphere. It takes Earth 365 and one-quarter days to travel around the Sun one time. Therefore, a year on Earth is 365\(\frac{3}{4}\) days. Earth’s orbit is in the shape of an ellipse, not a circle. The Earth also rotates; that is, it spins around. It takes the Earth 24 hours or one day to rotate once.

The planets reflect the Sun’s light. They are not themselves sources of light. Venus can often be seen in the night sky. Venus is not really shining; it is only reflecting the Sun’s light.

**Moons**

Moons are the natural satellites of planets. Some planets like Mercury and Venus have no moons, while others like Jupiter have many. Earth has only one natural satellite. We call it the Moon. Like Earth the Moon is not a source of light. We can usually see it in the night sky because it reflects some of the Sun’s light. Half of the Moon’s surface is always in sunlight, while the other half is in darkness. The moon follows an orbit around the Earth.

**Other Heavenly Bodies**

Besides stars, planets, and moons there are several other types of celestial bodies. Comets travel in elliptical orbits around the Sun. They are made mostly of dirt and ice. They often have a “tail”.

Asteroids are mini-planets. Like the planets they travel in orbits around the Sun. They are found mainly between the orbits of Mars and Jupiter. Up until recently dwarf planet called Pluto was thought to be a planet. But scientists decided its characteristics were more like those of a dwarf planet than those of a regular planet.

Meteoroids are small solid bodies from outer space. They are really stars that fall toward the Earth. They are attracted to Earth by Earth’s gravity. Once they reach Earth’s atmosphere, they begin to glow. They are then referred to as meteors or shooting stars. Most meteor’s burn up before they reach Earth’s surface. Occasionally, a meteor will reach Earth’s surface in solid form. It is then called a meteorite.
Constellations are groups of stars that appear to form a pattern. Throughout history humans have had a fascination with the stars and have tried to make sense of them. One way to do this was to cluster them into groups and give them names according to what their patterns resembled.

The Ancient Greeks were one of the civilizations that named many of these star groups over 3000 years ago. Today we continue to refer to these constellations by the names given to them by the Greeks. As you will see, it took some imagination for them to spot particular star groups and imagine them to be animals, people, and other objects.

<table>
<thead>
<tr>
<th>Stars Groups as Seen in the Sky</th>
<th>Names of Constellations (What the Greeks Imagined)</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td>Cygnus, the Swan</td>
</tr>
<tr>
<td><img src="image2.png" alt="Image" /></td>
<td>Ursa Major and Ursa Minor</td>
</tr>
<tr>
<td><img src="image3.png" alt="Image" /></td>
<td>Orion, the Warrior</td>
</tr>
</tbody>
</table>
The Changing Positions of Constellations

It is likely that you have never stayed up all night looking at the stars. However, if you ever have the opportunity to do so, you will notice that the stars seem to be moving slowly from one part of the sky to another. Astronomers will tell you that the stars do not actually move. They just appear to be moving. This is because the Earth rotates on its axis. So it is you, as a person standing on Earth that has moved, not the stars.

The position of the stars in the sky from your particular viewpoint on Earth is constantly changing. Throughout any particular night you will notice very slight movement in star locations. But they also change from one day to the next. The change is so small that you may not notice it. If you compare the location of a particular constellation from one month to the next, you will find that its position has changed significantly. In addition, the constellation will have appeared to turn in a counter clockwise direction. This constellation rotation occurs because the Earth revolves around the Sun. In one year a constellation’s position will have made one complete rotation. Some constellations are referred to as summer or winter constellations depending on when they are visible.

The constellation Ursa Major is sometimes called The Big Dipper. It appears to rotate in a counterclockwise direction.

Star Maps

Star maps show the locations of stars at different times of the year. A star map always tells the time of year the stars will be in the location shown on the map. By examining star maps, you see how individual stars’ and constellations’ positions have changed. Following are star maps for some individual stars and constellations.
This map is best used at latitudes 40° to 50° north, but can be used for latitudes from 35° to 55° north. The circumference of the circle represents the horizon. The centre represents overhead. The given dates and times indicate when the map will best model the sky. However, the map is approximately correct for an hour before and after the given times.

When you are observing, remember to use a red light for map reading. Rotate the map so that the direction you are facing is at the bottom. Hold the map against the sky. Look directly above you to view the objects near the centre of the map.

**Viewing Dates** [Local Daylight Time]
March 21, 11:00 p.m.  April 7, 10:00 p.m.  April 21, 9:00 p.m.  May 7, 10:00 p.m.
This map is best used at latitudes 40° to 50° north, but can be used for latitudes from 35° to 55° north. The circumference of the circle represents the horizon. The centre represents overhead. The given dates and times indicate when the map will best model the sky. However, the map is approximately correct for an hour before and after the given times.

When you are observing, remember to use a red light for map reading. Rotate the map so that the direction you are facing is at the bottom. Hold the map against the sky. Look directly above you to view the objects near the centre of the map.

**Viewing Dates** [Local Daylight Time]
June 1, 1:00 a.m.   June 21, midnight   July 21, 10:00:00 p.m.   August 21, 8:00 p.m.
Star Map – Fall

This map is best used at latitudes 40° to 50° north, but can be used for latitudes from 35° to 55° north. The circumference of the circle represents the horizon. The centre represents overhead. The given dates and times indicate when the map will best model the sky. However, the map is approximately correct for an hour before and after the given times.

When you are observing, remember to use a red light for map reading. Rotate the map so that the direction you are facing is at the bottom. Hold the map against the sky. Look directly above you to view the objects near the centre of the map.

Viewing Dates [Local Daylight Time]
September 15, 1:00 a.m.       September 30, midnight       October 15, 11:00 p.m.
October 30, 9:00 p.m.
Star Map – Winter

This map is best used at latitudes 40° to 50° north, but can be used for latitudes from 35° to 55° north. The circumference of the circle represents the horizon. The centre represents overhead. The given dates and times indicate when the map will best model the sky. However, the map is approximately correct for an hour before and after the given times.

When you are observing, remember to use a red light for map reading. Rotate the map so that the direction you are facing is at the bottom. Hold the map against the sky. Look directly above you to view the objects near the centre of the map.

Viewing Dates [Local Standard Time]
December 21, 10:00 p.m. January 7, 9:00 p.m. January 21, 8:00 p.m.
February 7, 7:00 p.m. February 21, 6:00 p.m.
**Introduction**

The Sun is a huge, glowing ball of gases located at the centre of our solar system. The Earth and the other seven planets travel around it. The Sun is only one of three sextillion (That’s a three followed by 24 zeroes.) stars in the universe. As a star, there is nothing unusual about it. However, the Sun is more important to humans than any other star. Without the heat and light of the Sun, there could be no life on the lands and in the seas of the Earth.

The diameter of the Sun is 1,392,000 kilometres, about 109 times the diameter of Earth. Because the Sun is about 150,000 kilometres from the Earth, it does not appear larger than the moon. But the Sun’s diameter is 400 times larger than that of the Moon.

Today, we know we must have the Sun as a source of heat, light, and other kinds of energy. All plants and animals depend on this energy from the Sun. Plants use sunlight to make their own food and in the process give off oxygen. Animals eat plants and breathe in oxygen. In turn, animals breathe out carbon dioxide, which plants combine with energy from sunlight and water from the soil to produce food.

**The Sun’s Brightness.**

The light and heat of the Sun come from its surface. The amount of light and heat stays fairly constant, so that the actual brightness of the Sun changes little. The changes in brightness that seem to take place result from weather conditions in the Earth’s atmosphere. These conditions affect the amount of sunlight that reaches any particular place on Earth. Sometimes a small increase in brightness may result from eruptions of gases on the Sun’s surface. Most of these eruptions, called **flares**, last from 10 minutes to an hour. But any changes in the total brightness of the Sun caused by flares are not visible to the naked eye.

The Sun’s energy is produced at its centre. This energy gradually flows to the surface. It is sent out into space as radiant energy in the form of heat and light. People once thought this heat and light came from something that was burning. Today, scientists know that the Sun’s light and heat come from **thermonuclear reactions** in the centre of the Sun. Such reactions occur when lightweight atoms join and form heavier atoms.

**What the Sun is Made Of.**

About three-fourths of the mass of the Sun consists of hydrogen, the lightest known element. Almost a fourth of the Sun’s mass consists of helium. Scientists discovered this gas on the Sun before they found it on Earth. More than 70 other elements make up between one and two percent of the mass of the Sun.

**Sunspots.**

Sometimes a strong loop of magnetic lines of force extends through the Sun’s surface. Where the lines cross through the surface, they lower the temperature of the gas. This gas does not shine as brightly as the surrounding gas, and it appears as a sunspot. A typical sunspot may have a diameter of about 32,000 kilometres. A sunspot can break into several sunspots that form a sunspot group.
Sunspots appear as irregular-shaped dark patches on the surface of the Sun. A spiral-shaped sunspot, to the right, the first of its kind ever viewed, was photographed from Kitt Peak National Observatory near Tucson, Arizona in 1982. It had a diameter of about 80,000 kilometres.

Solar Flares

After a sunspot group has existed for a long time, the magnetic lines of force usually become jumbled. As a result of the jumbling, magnetic energy is stored in the corona, the outermost atmosphere of the Sun. This energy may be released in a spectacular discharge called a flare. In a flare, the magnetic lines of force become reconnected into a simpler pattern. A flare may be as small as a sunspot or as large as a sunspot group. The temperature in a flare is about twice as high as the temperature at the Sun’s surface.

A solar flare releases a tremendous amount of the Sun’s energy. One of the most spectacular flares, to the right, spanned 591,000 kilometres above the Sun’s surface.

The Solar Wind

The solar wind is a continuous flow of gases from the Sun. It results chiefly from the expansion of gases in the corona. The Sun’s corona is so hot that all its gases continually expand away from the Sun. This flow of gases continues until the gases mix with those near the outer planets of the solar system. The flow of gases is called the solar wind. When the solar wind reaches the Earth’s orbit, it is travelling 1.6 to 3.2 million kilometres per hour. The solar wind confines the Earth’s magnetic field into a specific volume of space called the magnetosphere. The boundary of the magnetosphere is about 64,000 kilometres from the Earth.

Like all the planets, Earth is affected by the solar wind.
Viewing the Sun

Unless it is cloudy, we see the Sun everyday. Since the Sun is too far away and much too hot for humans, astronomers must observe the Sun from Earth, if they want to learn more about it. Their knowledge of the Sun’s composition, sunspots, and solar flares all comes from direct observation. Astronomers are particularly interested in observing such phenomena as solar eclipses that occur very rarely. A solar eclipse takes place when the Moon is between the Sun and a particular part of the Earth.

A solar eclipse is a rare event. It occurs when the Moon comes between the Earth and the Sun. Solar eclipses happen about once every 18 months somewhere on Earth. They are only visible once every 360 – 410 years from any one particular location, however. For this reason, people are very interested in viewing this phenomenon. Like any other instance where observing the Sun is involved, people must follow certain safety rules.

Astronomers have learned that viewing the Sun must be done safely, and that means never looking directly at the Sun with the naked eye. Sunlight contains invisible rays called ultraviolet rays. These are the rays that make your skin tan. Ultraviolet rays can damage the retinas of your eyes. Because the retina has no pain sensors, you cannot feel the ultraviolet rays “burning” your retina. Nonetheless, the effect of concentrated ultraviolet rays on the retina can be partial or even total blindness.

Rules for Viewing the Sun

1. Peek, don’t stare.
2. Without special filters, it is best to view the Sun when it is projected onto another surface. This is what pinhole cameras and binocular projections do.
3. Use specially designed filters when viewing the Sun using binoculars or telescopes.
4. Use No. 14 welding glasses or special Mylar plastic specifically manufactured for solar observation.
Shadows

In the photograph you can see a few people sitting in the shade of a wall. The structure is located in the Valley of the Kings in Egypt. You know from your own experiences that it feels much cooler in the shade than out in the open.

Shade is really created when the Sun casts a shadow. A shadow forms when the direct rays from a light source are blocked by an opaque object.

Humans seem to have a particular interest in shadows. Shadows have had a great deal of influence on human activities. Like in the photo taken in Valley of the Kings, people have learned to use find a shady spot in which to escape the Sun’s heat. They have learned to use shadows in other ways too. Shadows were an essential part of early clocks, for example.

Hand shadow puppets provide entertainment. It takes a great deal of practice, but making images of animals by using a light source to cast shadows of your hands is fun for all. What animal heads has the man in the photo created using his hands?

Shadow Length Throughout the Day

What follows you wherever you go, but only on sunny days? By now you know the answer is your shadow. You may have noticed that during some parts of the day, a shadow is extremely long, while during other times it is quite short. The reason for this has to do with the angle of the sun.

During the early morning and the late afternoon, the Sun shines at a large angle, but around noontime, the Sun’s angle is smaller. The greater the Sun’s angle, the longer shadows it casts. No matter where you are in the world, during the early morning shadows are long. As the Sun rises further in the sky, shadows become increasingly short until they are shortest around noon when the Sun is highest. From that time on, shadows become longer until the sun sets during the late afternoon or early evening.

These children have used tape to show the lengths of the shadows of the stick (set up in the can) as the days goes by.
Graphing Shadow Length

The most popular choice for graphing shadow length throughout any particular day is the line graph. This is because a line graph is designed to show how one factor changes over a period of time. Shadow length changes gradually over the course of a day, so a line graph is particularly suited to show this. Bar graphs are also often used to show changes in shadows, but most agree that the line graph is the more appropriate choice.

Using a line graph is useful in a particular way. Take the line graph showing shadow length, to the right. You can see that the person did not take an actual measurement for 17:00 but did take it for 16:00 and 18:00. By connecting the dots for those two times, you can reasonably conclude that the shadow length for 17:00 was about 120 cm. When you make this kind of “reasonable guess”, it is called interpolating.

NOTE: During the late fall, winter, and early spring, shadows are shortest at 12:00. However, when we switch to daylight savings time, shadows are shortest at 13:00. Do you know why?
Shadow Direction Throughout the Day

As the Sun’s position in the sky changes throughout the day, so does the direction of the shadow. The object casting the shadow is always between the Sun and the shadow itself. If the object is on the ground, the shadow always starts at the place where the object touches the ground. The Sun, object, and the end of the shadow are always in a straight line. As the position of the Sun changes as the day goes on, so does the direction of the shadow.

Look back at the Shadow Stick at the top of page 19. You can see that as the day progresses, the length of the shadow cast by the shadow stick changes, but so does the direction of the shadow.

Sundials

Sundials have been in use for thousands of years. They are timepieces that use the idea that shadow direction changes as a day goes on. The Ancient Egyptians, Babylonians, and Chinese used them as early as 3500 BC. Because they use sunlight to tell time, sundials are typically located outdoors and made from materials that can withstand the forces of nature, such as stone or stone products. These materials are not harmed by sunlight, rain, wind, and other weather-related elements.

Sundials have two main parts. The **gnomon** is the part that is upright. Gnomons can be thin and long or a triangular shape. The gnomon casts a shadow on the **face**. The face is the part on which the shadow of the gnomon is cast. The face is marked with lines and letters and numbers to show the time of day. The gnomon is usually angled and placed so that it points toward the north.

This model of a sundial is made of stiff paper. The upright triangular piece is the gnomon. The flat part with the lines and numbers is the face.

Historians believed that shadow sticks were used to provide information about time of day. Later the Ancient Egyptians used obelisks, which were tall square columns topped with a pyramid to perform the same function. Obelisks were not constructed as time-telling devices, but to mark the place and time of important events.
Sundials Today

Some of the ancient sundials are still quite well preserved. However, most have been worn away by weather and pollution. Today’s sundials are not typically used as accurate timepieces. Instead they are used as more of a novelty item in public places and decorations in private gardens.

Sundials were a wonderful invention and could tell time fairly accurately. There are two main disadvantages of sundials:

- Sundials are big and heavy. They cannot be easily moved like a wristwatch. If they are moved, care must be taken to ensure that the gnomon faces exactly north. This can take time and effort.
- Sundials can only be used on sunny days. In some parts of the world, most days are sunny, but in most others there are many cloudy, rainy, and snowy days.

Sundials should not be forgotten, even today where technology has led to the invention many new and different types of timepieces. The Sun will always rise in the morning and set at night, making sundials one of the most reliable methods of telling time.
Introduction

In Alberta we have four distinct seasons: spring, summer, autumn, and winter. The change from one to the next is gradual, but once we are well into a particular season, it has certain familiar characteristics.

We can divide the Earth into climatic zones. Having four seasons is a phenomenon that all areas that have temperate climates share. Regions that have temperature climates are those in bands located about halfway between the equator and the north or south pole. These regions are called temperate zones. Other areas, such as the tropical zone (around the equator) and the frigid zones (regions around the poles) have more or less the same weather all year round.

It is important to understand that there is a gradual change from one zone to the next. Within each climatic zone there can be a wide variation in climates. But areas within each climatic zone share certain characteristics, including having four seasons.

Lines on the Map. There are imaginary lines on the map that divide the Earth into climatic zones.
E: Equator
1: Arctic Circle
2: Tropic of Cancer
3: Tropic of Capricorn
4: Antarctic Circle

Climatic Zones
A: Frigid Zone – from the Arctic Circle to the North Pole
B: Temperate Zone – from the Tropic of Cancer north to the Arctic Circle. All of Canada, including Alberta is in this zone.
C: Torrid Zone – from the Tropic of Cancer south to the Tropic of Capricorn. The equator runs midway through this zone.
D: Temperate Zone – from the Tropic of Capricorn south to the Antarctic Circle
E: Frigid Zone – from the Antarctic Circle to the South Pole
Direct and Slanted Rays

Scientists have determined that the main reason that we have different seasons has to do with the fact that during some times the year the Sun’s rays shine on particular regions more directly than others. You learned earlier that shadows are longest during the early morning and the late afternoon. This is because the angle of the Sun is greatest at these times. You may have noticed that these are usually the coolest times of the day. At noon the Sun’s rays shine more directly down on your part of the Earth. This makes midday the hottest time of day.

The Sun’s rays are more intense when they shine more directly on you.

The more slanted the Sun’s rays are, the larger the area on which they shine. This makes the Sun’s light and heat less intense. The more directly the Sun’s rays shine on you, the smaller the area on which they shine. This makes the Sun’s light and heat more intense or concentrated.

The Sun’s rays are more intense on some parts of the Earth than on others. Generally, the closer a place is to the equator, the more intense the Sun’s rays are. The Sun’s rays are more concentrated and the hotter it is. The closer a place is to the poles, the less concentrated the Sun’s rays are and the cooler it is.

The Sun’s rays hit some parts of the Earth more directly than others. This is why the Sun feels less intense in the winter than in the summer. Notice how light ray #1 hits the Earth directly. This corresponds to “directly overhead”. Ray #2 hits Earth at a slightly greater angle, and ray #3 at a greater angle still. Finally, ray #4 hits Earth at the greatest angle. This is part of the reason why the polar regions are colder than other parts of the Earth. As you go further from the equator, the sun’s rays are more slanted, and the temperatures are cooler.
The Reason for the Seasons

The Earth’s Axis

The Earth is tilted on an axis; that is, it spins at a slant. Picture an imaginary stick going through the north and south poles of Earth. Earth rotates about its axis once every 24 hours. However, this axis is not straight up and down as the Earth goes through its orbit about the Sun. Instead, it is tilted approximately 23°. The result is that at some times of the year locations on Earth receive more direct sunlight than at other times of the year.

The Earth rotates on its axis. The degree of slant of the axis does not change as the Earth orbits the Sun. It always points in the same direction.

Earth’s Orbit

Earth’s orbit around the Sun is elliptical in shape (like an oval). This means that at some times during the year it is closer to the Sun than at other times. The average distance from the Earth to the Sun is 149 600 000 kilometres. At the aphelion is the Earth is farthest from the Sun, a distance of 152 100 000 kilometres. It occurs during the first few days of July. At the perihelion the Earth is closest to the Sun, a distance of 147 100 000 kilometres. It occurs during the first few days of January.

When the Earth passes through the perihelion, the northern end of Earth’s axis is tilted away from the Sun, so that the areas beyond the Tropic of Cancer receive only slanting rays from a Sun that is low in the sky. Because of this temperatures are cooler. and it is winter. The southern end of Earth’s axis is tilted toward the Sun and receives much more direct Sun.

When the Earth passes through the aphelion, the northern end of the Earth’s axis is tilted toward the Sun, so that the areas beyond the Tropic of Cancer receive much more direct Sun, which is higher in the sky. This results in higher temperatures and this region enjoys summer. The southern end of Earth’s axis is tilted away from the Sun, and southern areas receive more slanted rays.
Science Grade 6 Topic C Sky Science
Mini Textbook

The areas between the Tropic of Cancer and the Tropic of Capricorn receive direct Sun all year round. When it is summer in the northern temperate zone, it is winter in the southern temperate zone. When it is winter in the northern temperate zone, it is summer in the southern temperate zone.

When it is summer in the northern temperate zone (where we live), Earth’s axis is tilted toward the Sun. This area receives more direct sunlight, which results in warmer temperatures. When it is winter in the northern temperate zone, Earth’s axis is tilted away from the Sun. The Sun’s rays hit this zone at a slant, resulting in cooler temperatures.
The Seasons

Astronomers decide on the first day of each season by the positions of the Earth and the Sun. Each of the four seasons begins at approximately the same date each year. (The dates shown can vary a day or two on either side from year to year.) The dates shown mark the beginnings of the seasons for those regions in the northern temperate zone.

First Day of Summer (June 21)
- Called the Summer Solstice: Sun appears to be highest in the sky (about 60° above the horizon).
- Beginning of the aphelion: When the Sun reaches it farthest point from Earth
- Sun is shining directly on the Tropic of Cancer
- We experience the longest day and the shortest night.
- We get the most direct sunlight
- Temperature are warm to very hot

First Day of Autumn (September 21)
- Called the Autumnal Equinox
- Sun is shining directly on the equator
- Days and nights are equal in length
- Sun is lower in the sky (about 36°)
- Temperatures are cooler than in summer

First Day of Winter (December 21)
- Called the Winter Solstice: Sun appears to be lowest in the sky
- Beginning of the perihelion: When the Sun approaches its nearest point from Earth
- Sun is shining directly on the Tropic of Capricorn
- Days are short and nights are long
- Sun is at its lowest angle (about 13°)
- Temperatures are cool to very cold

First Day of Spring (March 31)
- Called the Vernal Equinox
- Sun is shining directly on the equator
- Days and nights are of equal length
- Sun is getting higher in the sky than in winter (about 36°)
- Temperatures are getting warmer

For regions in the southern temperate zone the seasons are reversed.

<table>
<thead>
<tr>
<th>The Southern Temperate Zone Seasons</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date</strong></td>
</tr>
<tr>
<td>June 21</td>
</tr>
<tr>
<td>September 21</td>
</tr>
<tr>
<td>December 21</td>
</tr>
<tr>
<td>March 21</td>
</tr>
</tbody>
</table>
The Sun’s Position and the Seasons

Sun’s position through the year

Midsummer
Equinoxes
Midwinter

Sun’s heating effect through the year

midsummer area
equinox sun
midwinter sun

small area
medium area
large area
**Summer and Winter**

**SUMMER**
In our Summer, the northern hemisphere is tipped toward the sun.

**WINTER**
In our Winter, the northern hemisphere is tipped away from the sun.

In Summer, with the sun high overhead, the sun's rays hit the earth more directly, warming the ground most effectively.

In Winter, with the sun always low in the sky, its rays are spread over a larger area of ground. Each patch of earth does not receive as much energy as it does in Summer.
Part II: The Moon and the Planets

Introduction

Part I of Sky Science concentrated on examining the stars, and in particular, the star closest to Earth – the Sun. You also learned how Earth’s rotating on its axis and revolving around the Sun affects shadows, temperature, and seasons. Part II of Sky Science focuses on the heavenly bodies in our solar system. The solar system includes the Sun, the planets and their moons, dwarf planets, asteroids, comets, and other smaller bodies.

Throughout history humans have been fascinated by the celestial bodies they could view. Apart from what they could observe with the naked eye, ancient peoples did not know a great deal about the origins and composition of the Moon and the planets. They discovered that the same ones appear on a regular basis in the night sky and speculated about whether or not they could support life.

The invention of the telescope in Europe in the early 1600s changed astronomy. The telescope enabled astronomers to get a closer view of many of heavenly bodies and uncover many interesting facts about them.

Early depiction of a “Dutch telescope” from 1624.

Telescopes continue to become more powerful, enabling astronomers to gain more information about the Moon and planets. Missions into space have enabled humans to visit the Moon and space vehicles to land on Mars.

On July 20, 1969 American astronaut Neil Armstrong became the first human to set foot on the Moon.
The Moon

The Moon, our closest neighbour in space, is a satellite of the Earth. The proper term for moons, those bodies that orbit planets, is satellites. The Moon is about one-fourth the size of the Earth. The Moon moves in an elliptical orbit about 400 000 kilometres above the Earth. It travels at an average speed of 3 700 km/h. The Moon rotates on its axis once in about the same period of time it takes to complete one revolution around the Earth. That is why the same side of the Moon is always facing the Earth. The Moon travels in a counterclockwise path around the Earth.

Like Earth, the Moon has a gravitational pull. The force of the Moon’s gravitational pull is about one-sixth that of Earth’s. A person weighing 60 kilograms on Earth will only weigh about 10 kilograms on the Moon. The moon’s gravitational pull causes ocean tides on Earth. Tides occur when the level of the ocean rises or falls at a shoreline. The Moon’s gravity actually pulls the ocean waters toward it, causing the waters to bulge out a little. So when the Moon is facing one side of the Earth, the ocean waters on that side of the Earth actually bulge out, causing the level of the ocean at the shoreline to rise. This is called high tide. The oceans on the opposite the Moon side also bulge a little. At the same time the levels of the ocean on sides not facing the Moon are low. This is called low tide.

Like the Earth the Moon has no light of its own. When we see the Moon in the night sky, we are seeing the Sun’s light reflecting off the Moon. Just as half the Earth has day while the other half has night, half the Moon is lit while the other half is dark. As the Moon makes its monthly orbit around the Earth, it looks like it is changing shape. These apparent changes in shape are called the Phases of the Moon. The Moon is not really changing shape. What does change is the part of the side of the Moon that is lit by the Sun that we can see from Earth.

You may have noticed that sometimes the Moon appears completely dark from Earth and at other times it is fully lit. When the Moon is completely dark, it is called a new moon. When it is completely lit, it is called a full moon. A full moon can light up the sky. This is because at this time we are able to see all the side of the Moon on which the Sun is shining. Following the new moon phase, we can gradually see more and more of the Moon until we can see its full face. This takes about two weeks, and we say the moon is waxing. Following the full moon phase, the amount we can see gradually decreases until we cannot see it at all. It is then back to the new moon phase. From full moon to new moon takes about two weeks. This decrease is called waning.
Something quite unusual happens some time during a full moon. The Earth will come between the Sun and the Moon, and direct sunlight cannot reach the Moon. This is called an **eclipse of the moon** or **lunar eclipse**.

At other times the Moon is between the Earth and the Sun; the disk of the Moon perfectly matches that of the Sun. The result is one of the most beautiful sights in the world – an **eclipse of the sun** or **solar eclipse**. During a solar eclipse the light from the Sun is blocked out and we see only the **corona** or atmosphere of the Sun.

During a solar eclipse, the Moon is between the Earth and the Sun. From Earth we can only see the Sun’s corona.

During a lunar eclipse, the Earth is between the Moon and the Sun. From Earth we cannot see the Moon.

The invention and early development of the telescope by Europeans such as Hans Lippershey, Zacharias Janssen, and Galileo Galilei opened up the heavens to investigation. One of the outcomes of this investigation is that humans have used rockets to actually go to the Moon. We are just beginning to understand all the mysteries of the Moon. Maybe someday we can all go to the Moon for a vacation.
Phases of the Moon

You have no doubt noticed that the Moon does not always have the same shape. Sometimes it is big, bright, and full; other times you cannot see it at all. And still at other times it is only partially lit. Those who study the Moon have discovered that there is a pattern to how the shape of Moon changes. They have found that the part of the Moon that is visible to those on Earth goes through stages or phases. The order of these phases does not change. The change from stage to stage is gradual and continual.

When we talk about the phases of the Moon, we are referring to the part of the Moon that is visible to those on Earth, in the night sky.

Following are some facts that will help you understand the phases of the Moon:

- The same side of the Moon always faces Earth, but all of this side is not always lit by the Sun.
- The Moon rotates in a counterclockwise manner. It revolves around Earth in a counterclockwise manner.
- The half of the Moon facing the Sun is always lit.
- We cannot always see the half of the Moon that is facing the Sun because the Moon is revolving around the Earth. How much of the lit part of the Moon we can see from Earth depends on where the Moon is as it orbits Earth.
- When the Moon is exactly between the Sun and Earth, the half of the Moon that is visible from Earth is completely in shadow, and we cannot see it.
- When the Earth is exactly between the Sun and the Moon, we can see the entire half of the lit side of the Moon.
The position of the Moon in relation to the Earth and the Sun determines how much of the lit side of the Moon we can see from Earth. The above illustration shows the various positions of the Moon and the shape of the part of the Moon we can see.
The Names of the Phases

New Moon
- Cannot see the Moon
- Moon is between the Sun and Earth
- During this phase the side of the Moon in shadow faces Earth

Waxing Crescent
- Looks like a backwards C
- The Moon has moved 1/8 of a revolution around Earth in a counterclockwise direction

First Quarter
- Half of the Moon appears to be visible
- The Moon has moved another 1/8 of a revolution around Earth.
- It is called the First Quarter because the Moon has travelled one-quarter of its orbit around Earth.

Waxing Gibbous
- Between one-half and three-quarters of the Moon appears to be visible.
- The moon has moved another 1/8 of a revolution around Earth

Full Moon
- Entire moon appears lit.
- Earth is between the Moon and the Sun
Waning Gibbous
- Moon seems to have decreased in size to about three-quarters.

Last Quarter
- We can see about half the lit side of the Moon.

Waxing Crescent
- Part of the Moon we can see is shaped like a C

Phases of the Moon, as seen looking southward from the Northern Hemisphere.

Lunar Month

The time between two full moons (a lunar month) is about 29.53 days, on average.

A harvest moon is always big, full and bright. It gets its name from the fact that it appears in the fall. The term “harvest moon is given to the first full moon following the autumnal equinox.
Introduction

The Solar System refers to the Sun and all the heavenly bodies that are held in orbits around the Sun by its gravitational pull. They include the eight planets and their moons, dwarf planets and their moons, asteroids, comets, and other smaller bodies.

The planets revolve around the Sun in a counterclockwise direction. They are of different sizes and travel in their orbits at slightly different speeds. The farther away from the Sun, the greater is the length of any particular planet’s orbit.

All planets rotate on an axis. The speed with which they rotate varies from planet to planet.

The planets in order from closest to farthest from the Sun are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

<table>
<thead>
<tr>
<th>PLANETARY DISTANCES FROM THE SUN (kilometres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planet</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Mercury</td>
</tr>
<tr>
<td>Venus</td>
</tr>
<tr>
<td>Earth</td>
</tr>
<tr>
<td>Mars</td>
</tr>
<tr>
<td>Jupiter</td>
</tr>
<tr>
<td>Saturn</td>
</tr>
<tr>
<td>Uranus</td>
</tr>
<tr>
<td>Neptune</td>
</tr>
</tbody>
</table>

Pluto, a Dwarf Planet

Pluto was discovered in 1930. When it was first spotted through a very powerful telescope, astronomers thought they had found a ninth planet. Since the 1970s several other heavenly bodies with the same characteristics as Pluto have been discovered. Almost all were in the regions beyond Neptune. In 2006, the majority of astronomers decided that it was time to name a new category of heavenly body, dwarf planet. Dwarf planets had some of the same characteristics of planets, but not all of them. They put Pluto in the dwarf planet category. Today, with improved technology, astronomers have discovered many new dwarf planets. Pluto is the second largest of them after one named Eris.

Many older representations of the solar system show Pluto as a planet. However, most more up-to-date representations do not show Pluto as a planet.
The Solar System

The diagram shows the orbits of the planets around the Sun.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Mean distance from Sun (km)</th>
<th>Diameter (km)</th>
<th>Orbits Sun in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>57,900,000</td>
<td>4,878</td>
<td>88 days</td>
</tr>
<tr>
<td>Venus</td>
<td>108,200,000</td>
<td>12,104</td>
<td>225 days</td>
</tr>
<tr>
<td>Earth</td>
<td>149,600,000</td>
<td>12,756</td>
<td>365 1/4 days</td>
</tr>
<tr>
<td>Mars</td>
<td>227,900,000</td>
<td>6,796</td>
<td>687 days</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778,400,000</td>
<td>142,984</td>
<td>4,333 days</td>
</tr>
<tr>
<td>Saturn</td>
<td>1,429,400,000</td>
<td>120,536</td>
<td>10,759 days</td>
</tr>
<tr>
<td>Uranus</td>
<td>2,875,000,000</td>
<td>51,118</td>
<td>30,685 days</td>
</tr>
<tr>
<td>Neptune</td>
<td>4,504,300,000</td>
<td>49,500</td>
<td>60,160 days</td>
</tr>
</tbody>
</table>
Besides the Sun, other stars have planets too. Astronomers have discovered hundreds of them.

The word planet comes from the Greek for "wandering star".

Did You Know?

The Babylonians wrote an astronomy book in the seventh century BCE.

The Ancient Greeks thought that the Sun and the Moon were both planets that revolved around Earth.

In 499 CE an Indian astronomer, Aryabhata came up with the idea that Earth rotated on an axis that was tilted.

All of the planets are named after ancient Roman gods except for Neptune (Greek god) and Earth (Old English for "soil").

So far astronomers have discovered five dwarf planets.

Mercury is the only planet that does not tilt when it rotates on its axis.
## The Planets – Quick Facts

<table>
<thead>
<tr>
<th>Planet</th>
<th>Distance from Sun (millions of kilometres)(^1)</th>
<th>Period of Rotation (Earth units)(^1)</th>
<th>Period of Revolution (Earth units)(^1)</th>
<th>Diameter (kilometres)(^1)</th>
<th>Number of Moons(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>57.9</td>
<td>59 days</td>
<td>88 days</td>
<td>4 880</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>108.2</td>
<td>243 days</td>
<td>224.7 days</td>
<td>12 100</td>
<td>0</td>
</tr>
<tr>
<td>Earth</td>
<td>149.6</td>
<td>24 hours</td>
<td>365 days</td>
<td>12 756</td>
<td>1</td>
</tr>
<tr>
<td>Mars</td>
<td>227.9</td>
<td>24 hours</td>
<td>687 days</td>
<td>6 787</td>
<td>2</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778.3</td>
<td>10 hours</td>
<td>12 years</td>
<td>143 200</td>
<td>63</td>
</tr>
<tr>
<td>Saturn</td>
<td>1 427</td>
<td>11 hours</td>
<td>29 years</td>
<td>120 000</td>
<td>61</td>
</tr>
<tr>
<td>Uranus</td>
<td>2 871</td>
<td>17 hours</td>
<td>84 years</td>
<td>51 800</td>
<td>27</td>
</tr>
<tr>
<td>Neptune</td>
<td>4 497</td>
<td>16 hours</td>
<td>165 years</td>
<td>49 528</td>
<td>13</td>
</tr>
</tbody>
</table>

### NOTES:

1. Some of the numbers have been rounded off. For example, in the table above Earth’s period of rotation is shown as 24 hours. It is really 23 hours and 56 minutes.
2. You may notice that the number of moons that a planet has can vary slightly from table to table, especially those planets that are far away from Earth. This is because astronomers are continually discovering new moons using improved technology.

### Two Kinds of Planets

The small inner planets – Mercury, Venus, Earth, and Mars are referred to as the **terrestrial planets**. They are Earth-like. They are made mostly of rocky materials. The outer planets – Jupiter, Saturn, Uranus, and Neptune are referred to as the **gaseous planets** because they are composed mainly of gases. The largest planets in our solar system are gaseous.
Mercury

Mercury is the planet in our solar system closest to the Sun. Because it is small and near the Sun, it is often hard to see from Earth without the aid of a telescope. A telescope is a tool that makes faraway objects seem closer and larger. At certain times of the year, Mercury can be seen just after sunset. At other times, it can be seen just before sunrise.

Mercury moves around the Sun faster than any other planet does. The ancient Romans named it Mercury after the speedy messenger of the gods in ancient Roman stories.

Like the Moon, Mercury is covered with a thin layer of minerals. It also has wide, flat areas of land, steep cliffs, and many deep craters (holes), like those on the Moon.

The inside of Mercury is probably like that of Earth. Many scientists think that the inside of both planets is made up mostly of iron.

Mercury is dry, very hot, and has almost no air. The Sun is much stronger on Mercury than it is on Earth. Scientists believe there is no life on Mercury.

The United States Mariner 10 was the first and only spacecraft to reach Mercury. The spacecraft took pictures of Mercury in 1974 and 1975. These pictures tell us all we know about the surface of the planet.
Venus

Venus is a planet. It is closer to the Sun than any other planet except for Mercury. Venus is known as Earth’s “twin” because the two planets are about the same size. No other planet is nearer in size to Earth than Venus.

From Earth, Venus looks brighter than any other planet or even any star in the night sky. At certain times of the year, Venus is the first planet or star that can be seen in the western sky in the evening. At other times, it is the last planet or star that can be seen in the eastern sky in the morning. When Venus is bright, it can be seen even in daylight.

Venus is the second planet from the sun. Venus is known as Earth’s “twin” because the two planets are about the same size.

Mountains and volcanoes rise over much of the planet, and canyons and craters mark the surface. The plants and animals that live on Earth could not live on Venus. Venus is covered with thick clouds of deadly sulphuric acid. It is also much too hot. The temperature on the surface of Venus is about 460°C, hotter than most ovens. Scientists do not think anything lives on Venus.

Scientists have sent spacecraft to Venus to explore the planet. The first spacecraft to pass near Venus was Mariner 2 in 1962.
Earth

Earth is the planet we live on. Earth is a huge sphere, or ball, that goes around the Sun in a circle. It is covered with water, rock, and soil, and surrounded by air. Animals and plants live almost everywhere on Earth’s surface. They can live on Earth because it is just the right distance from the Sun. Living things need the Sun’s warmth and light. But if Earth were closer to the Sun, it would be too hot for living things. If Earth were farther from the Sun, it would be too cold for anything to live. Also, Earth has plenty of water. Most living things need water.

**Seen from space, Earth is a blue ball covered with white clouds. This picture was taken by a satellite far out in space.**

Earth in Space

Earth is one of the eight planets that travel through space around the Sun. Earth is always moving. It spins like a top, and at the same time it travels around the Sun. Human beings use these movements to measure the length of days and years on Earth. One day is the time it takes Earth to spin around once. One year is the time it takes Earth to travel once around the Sun. Earth has a ball-shaped moon that travels around it the same way that Earth travels around the Sun.

Outside Earth

Earth is not perfectly round. It is a little bit flattened at the poles. The North Pole is at Earth’s top, and the South Pole is at its bottom. Halfway between the poles is an imaginary circle around Earth’s centre. The circle is called the equator. The equator cuts Earth into two halves called the Northern Hemisphere and the Southern Hemisphere.

- From World Book Discovery Encyclopedia
Mars

Mars is the fourth planet from the Sun. It is a reddish planet covered with rocks and craters (big holes). Mars was named after the ancient Roman god of war. Some scientists believe life may have existed on Mars billions of years ago, but there is no proof that anything is alive on the planet today.

Mars travels around the Sun in an elliptical, or oval-shaped, orbit. It takes about 687 earth days for Mars to go all the way around the Sun. Mars has two small moons called Phobos and Deimos.

The surface of Mars looks more like Earth’s than the surface of any other planet does. Even so, the plants and animals that live on Earth could not live on Mars. Its ground is too cold – it is usually below 0°C, the freezing point of water. Also, the air of Mars has almost no oxygen. People and animals need oxygen to breathe.

Scientists have studied Mars through telescopes for many years. In 1965, the United States spacecraft Mariner 4 flew near Mars and took pictures of its surface. In 1976, the U.S. Viking 1 and Viking 2 were the first spacecraft to land on Mars. They took pictures and collected soil samples. The U.S. Pathfinder probe landed on Mars in 1997. All these spacecraft were controlled by radio signals from Earth. As yet, no people have set foot on Mars.

*Mars* is the fourth planet from the sun.

*From World Book Discovery Encyclopedia*

On August 6, 2012 a United States spacecraft named *Curiosity* landed on the red planet. It is the same size as a very small car. Its mission is to search for water beneath the surface of Mars.
Jupiter

Jupiter is the fifth planet from the Sun and the largest planet in the solar system. More than 1 000 Earths would fit inside Jupiter. When viewed from Earth, Jupiter appears brighter than most stars. Among the planets, only Venus is brighter. Jupiter is named after the king of the Roman gods.

Jupiter is a giant ball of gas and liquid. It has little or no solid surface. Instead, the planet’s surface is made of thick red, brown, yellow, and white clouds. The clouds have dark and light-coloured areas. These areas circle the planet and give it a striped appearance. It looks like a TV weather display of a hurricane. Astronomers have observed a place called the Giant Red Spot, which varies from brick-red to brownish. Jupiter has three thin rings around its middle. They seem to be made mostly of dust particles.

Jupiter rotates, or spins, faster than any other planet. Jupiter’s day — that is, the time it takes to spin around once — is only about 10 hours long. By comparison, Earth’s day is 24 hours long. Jupiter takes about 12 years to travel once around the Sun, while Earth takes one year.

Jupiter has 63 or more known moons. These moons revolve around Jupiter the way our moon revolves around Earth. Scientists have discovered volcanoes on the moon called Io. They believe that the moon called Europa contains water.

- From World Book Discovery Encyclopedia
Saturn

Saturn is the second largest planet. Only Jupiter is larger. Saturn has several thin, flat rings around it. The rings are made up of many thin ringlets, or small rings. The ringlets are made up of small pieces of ice. All these shiny pieces travel around the planet, making Saturn one of the most beautiful objects in space. Jupiter, Neptune, and Uranus are the only other planets known to have rings.

Saturn can be seen from Earth. However, the rings of Saturn cannot be seen from Earth without a telescope.

Saturn is the sixth closest planet to the Sun. It travels around the Sun in an oval-shaped orbit, or path. The planet takes about 10 759 earth-days, or 29½ earth-years, to go around the Sun. Earth takes about 365 days, or one year, to travel around the Sun.

Saturn rotates, or spins around, faster than any other planet except Jupiter. Saturn spins around once in only 10 hours and 39 minutes. Earth rotates once in 24 hours, or one day.

Most scientists believe Saturn is a giant ball of gas that has no solid, or hard, surface. However, the planet seems to have a hot, solid centre of iron and rocky material. Scientists do not think that any form of life exists on Saturn.

Saturn has at least 61 moons. The largest is Titan.

- From World Book Discovery Encyclopedia
Uranus

Uranus is the seventh planet from the Sun. Only Neptune is farther. Uranus is the most distant planet we can see without a telescope.

Uranus is a giant ball of gas and liquid. It is about four times the size of Earth. Scientists believe that the surface of Uranus is made up of blue-green clouds of methane, a gas. Beneath the surface are thick layers of water mixed with another gas called ammonia. The centre of the planet may be a rocky core, just like Earth’s. Scientists do not think there is any life on Uranus.

Uranus was the first planet discovered since ancient times. William Herschel discovered it in 1781. Herschel was a British astronomer. Scientists have learned much about Uranus from the flight of the United States spacecraft Voyager 2. The spacecraft travelled close to Uranus and took pictures. It sent these pictures back to Earth.

Uranus moves around the Sun in an oval path. It takes about 84 Earth-years for Uranus to go around the Sun. Like Earth, Uranus also slowly spins on its axis, a make-believe line through the centre of the planet. Uranus takes 17 hours 14 minutes to spin once.
Neptune

Neptune cannot be seen from Earth without a telescope. Bright blue clouds cover Neptune’s surface. Because these clouds look like water, the planet was named after the ancient Roman god of the sea, Neptune.

Scientists believe that Neptune is made up mostly of gases, water, and minerals. Plants and animals that live on Earth could not live on Neptune. It is much too cold, and the air has no oxygen. People and animals need oxygen to breathe.

Neptune travels around the sun in an elliptical, or oval-shaped, orbit. It takes about 165 years for Neptune to go all the way around the Sun.

Neptune is about four times as big as Earth. It has 13 moons, and there are rings around the planet. Only two of the moons, Triton and Nereid, can be seen by telescopes on Earth. Six other moons and rings were discovered in 1989 by the United States spacecraft Voyager 2. It took the first close-up pictures of Neptune. Scientists first saw Neptune through a telescope in 1846.

Bright blue clouds surround Neptune. They are made of frozen methane, a gas. Because these clouds looks like water, the planet was named after Neptune, the ancient Roman god of the sea.

- From World Book Discovery Encyclopedia
Periods of Rotation and Revolution

Period of Rotation

Each planet rotates on its axis. The length of time it takes for a planet to rotate once is the length of that planet’s day. This is called its **period of rotation**.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Period of Rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58.0 days</td>
</tr>
<tr>
<td>Venus</td>
<td>243.0 days</td>
</tr>
<tr>
<td>Earth</td>
<td>1.0 day</td>
</tr>
<tr>
<td>Mars</td>
<td>1.0 day</td>
</tr>
<tr>
<td>Jupiter</td>
<td>10.0 days</td>
</tr>
<tr>
<td>Saturn</td>
<td>10.0 hours</td>
</tr>
<tr>
<td>Uranus</td>
<td>16.0 hours</td>
</tr>
<tr>
<td>Neptune</td>
<td>18.0 hours</td>
</tr>
</tbody>
</table>

Period of Revolution

Each planet revolves around the Sun in an orbit. The length of time it takes for a planet to make one complete revolution is the length of that planet’s year. This is called its **period of revolution**.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Period of Revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>88 days</td>
</tr>
<tr>
<td>Venus</td>
<td>225 days</td>
</tr>
<tr>
<td>Earth</td>
<td>365 days</td>
</tr>
<tr>
<td>Mars</td>
<td>687 days</td>
</tr>
<tr>
<td>Jupiter</td>
<td>12 years</td>
</tr>
<tr>
<td>Saturn</td>
<td>30 years</td>
</tr>
<tr>
<td>Uranus</td>
<td>84 years</td>
</tr>
<tr>
<td>Neptune</td>
<td>165 years</td>
</tr>
</tbody>
</table>

Size of Planets

The planets differ in their sizes. From smallest to largest they are Mercury, Mars, Venus, Earth, Neptune, Uranus, Saturn, and Jupiter.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Diameter (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>4 878</td>
</tr>
<tr>
<td>Venus</td>
<td>12 104</td>
</tr>
<tr>
<td>Earth</td>
<td>12 756</td>
</tr>
<tr>
<td>Mars</td>
<td>6 787</td>
</tr>
<tr>
<td>Jupiter</td>
<td>142 800</td>
</tr>
<tr>
<td>Saturn</td>
<td>120 000</td>
</tr>
<tr>
<td>Uranus</td>
<td>51 118</td>
</tr>
<tr>
<td>Neptune</td>
<td>49 528</td>
</tr>
</tbody>
</table>
# Solar System Statistics

<table>
<thead>
<tr>
<th>Categories</th>
<th>Sun</th>
<th>Mercury</th>
<th>Venus</th>
<th>Earth</th>
<th>Mars</th>
<th>Jupiter</th>
<th>Saturn</th>
<th>Uranus</th>
<th>Neptune</th>
<th>Pluto</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean Distance From Sun (millions of Kilometers)</strong></td>
<td>—</td>
<td>57.9</td>
<td>108.2</td>
<td>149.6</td>
<td>227.9</td>
<td>778.3</td>
<td>1,427</td>
<td>2,871</td>
<td>4,497</td>
<td>5,914</td>
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<tr>
<td><strong>Period of Revolution</strong></td>
<td>—</td>
<td>88 days</td>
<td>224.7</td>
<td>365.3</td>
<td>687</td>
<td>11.86 years</td>
<td>29.46 years</td>
<td>84 years</td>
<td>165 years</td>
<td>248 years</td>
</tr>
<tr>
<td><strong>Equatorial Diameter (Kilometers)</strong></td>
<td>1,390,000</td>
<td>4,880</td>
<td>12,100</td>
<td>12,756</td>
<td>6,786.8</td>
<td>143,200</td>
<td>120,000</td>
<td>51,800</td>
<td>49,528</td>
<td>2,330</td>
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<tr>
<td><strong>Atmosphere (Main Components)</strong></td>
<td>Hydrogen</td>
<td>Helium</td>
<td>Virtually none</td>
<td>Carbon Dioxide</td>
<td>Nitrogen Dioxide</td>
<td>Carbon Dioxide</td>
<td>Hydrogen Helium</td>
<td>Helium</td>
<td>Hydrogen Methane</td>
<td>Methane +?</td>
</tr>
<tr>
<td><strong>Moons</strong></td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>16</td>
<td>18</td>
<td>15</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td><strong>Rings</strong></td>
<td>—</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1,000(?)</td>
<td>11</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td><strong>Inclination of Orbit to Ecliptic</strong></td>
<td>—</td>
<td>7°</td>
<td>3.4°</td>
<td>0°</td>
<td>1.85°</td>
<td>1.3°</td>
<td>2.5°</td>
<td>0.8°</td>
<td>1.8°</td>
<td>17.1°</td>
</tr>
<tr>
<td><strong>Eccentricity of Orbit</strong></td>
<td>—</td>
<td>.206</td>
<td>.007</td>
<td>.017</td>
<td>.093</td>
<td>.048</td>
<td>.056</td>
<td>.046</td>
<td>.009</td>
<td>.248</td>
</tr>
<tr>
<td><strong>Rotation Period</strong></td>
<td>26.8 days</td>
<td>59 days</td>
<td>243 days retrograde</td>
<td>23 hours 56 min.</td>
<td>24 hours 37 min.</td>
<td>9 hours 55 min.</td>
<td>10 hours 40 min.</td>
<td>17 hours 12 min. retrograde</td>
<td>16 hours 7 min. retrograde</td>
<td>6 days 9 hours 18 min. retrograde</td>
</tr>
<tr>
<td><strong>Inclination of Axis</strong></td>
<td>7.25°</td>
<td>Near 0°</td>
<td>177.2°</td>
<td>23° 27'</td>
<td>25° 12'</td>
<td>3° 5'</td>
<td>26° 44'</td>
<td>97° 55'</td>
<td>28° 48'</td>
<td>120°</td>
</tr>
</tbody>
</table>
Introduction

When we think of a moon we think of Earth’s natural satellite. However the term moon refers to any natural satellite of a planet. To distinguish “our” moon from the others, we often spell it “M-o-o-n” (with a capital letter).

Most, but not all planets have moons. The two closest to the Sun do not have any moons; all the others do. Scientists are fairly certain that they know exactly how many moons revolve around the terrestrial planets – Mercury, Venus, Earth, and Mars. This is not the case for the gaseous planets, however. With improved technology, new moons for the gaseous planets are being discovered on a regular basis.

The Planets and Their Moons

The number of moons for each planet is listed in the table below.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Number of Moons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>0</td>
</tr>
<tr>
<td>Earth</td>
<td>1</td>
</tr>
<tr>
<td>Mars</td>
<td>2</td>
</tr>
<tr>
<td>Jupiter</td>
<td>63</td>
</tr>
<tr>
<td>Saturn</td>
<td>61</td>
</tr>
<tr>
<td>Uranus</td>
<td>27</td>
</tr>
<tr>
<td>Neptune</td>
<td>13</td>
</tr>
</tbody>
</table>

2011

Just like the planets, moons have their own distinct characteristics.

Four of Jupiter’s satellites: Io, Callisto, Ganymede, and Europa
The Moons of Mars

Phobos is the larger of Mars’ two moons. It is an oblong moon measuring 27 X 21 X 19 km. It orbits Mars with a period of 7.3 hours, less than a Martian day. This makes the moon appear to rise in the west and set in the east. Phobos is heavily cratered with interesting parallel grooves about 150 m long and 25 m deep. The grooves seem to radiate from the largest crater to an oddly shaped area on the other end of the moon. Because of this, it is presumed that the grooves may have formed with the impact of the largest crater by small heavenly body.

Deimos appears to have little surface detail because it is covered with a thick layer of dust. The dust fills craters and covers some surface detail. The reason Phobos may not have as much dust and debris on its surface is because of its close orbit to Mars where the planet’s gravity would tend to pull debris off the moon.

Deimos is also oblong shaped, 15 X 12 X 11 km and orbits Mars in 30.3 hours.

Both Phobos and Deims are probably about two billion years old and appear to have a composition very similar to carbonaceous chondrites (meteorites rich in water and organic content). Since carbonaceous chondrites form in the asteroid belt, it is considered highly probable that both Phobos and Deimos are captured asteroids. That is, they were asteroids that were pulled into orbits around Mars by Mars’ gravity.

Both moons have a density of about 2 g/cm$^3$, lower than Mars at 4 g/cm$^3$. This, along with their appearance makes astronomers think that Phobos and Deimos are more similar to the asteroids than to Mars. They were both discovered in 1877.
The Moons of Jupiter

Jupiter has 63 moons that we know of. The four largest are Io, Ganymede, Europa, and Callisto.

Io. Jupiter’s moon, Io, is one of the most exotic places in the solar system. It is slightly larger than Earth’s moon and is the most colourful of Jupiter’s satellites. Its surface is covered by deposits from actively erupting volcanoes, hundreds of lava flows, and volcanic vents, which are visible as small dark spots. Several of Io’s volcanoes are very hot; at least one reaches a temperature of 2000°C.

Io’s mountains are much taller than those found on Earth. Some are more than 16 kilometres high. (Earth’s tallest mountain is about 8.5 kilometres high.)

Most of Io is bright, yellowish and white while its polar caps are darker and covered by reddish materials.

Io was discovered in 1610 by an Italian astronomer named Galileo Galilei.

Europa

Europa is a unique moon of Jupiter that has fascinated scientists for hundreds of years. Its surface is among the brightest in the solar system, a consequence of sunlight reflecting off a relatively young icy crust. Its face is also among the smoothest. Lines and cracks wrap the exterior as if a child had scribbled around it. It is possible that under the surface, there may be liquid water, which could support life. We do not know this for sure.

Some parts of Europa are bright white and blue; others mottled brown, some a reddish colour, and this others a mottled yellow.

Europa has a mass of about eight times that of Earth. It was discovered in 1610.
Ganymede

Ganymede is larger than the planet Mercury and is Jupiter’s largest moon. It has a diameter of 5,262 kilometres. If Ganymede orbited the Sun instead of Jupiter, it could be classified as a planet. Its surface is characterized by patches of dark and light terrain. Bright frost is visible at its north and south poles. It has mountains, valleys, craters, and lava flows. The ridges and craters form complex patterns.

Ganymede is most likely composed of a rocky core with a covering of rock, ice, and water. It has no known atmosphere. Scientists have detected ozone at its surface, but the amount of ozone is small compared to Earth.

Ganymede was discovered in 1610.

Callisto

Callisto is the second largest of Jupiter’s moons and the third largest in the solar system. It is about the same size as the planet Mercury. It orbits just beyond Jupiter’s main radiation belt. Callisto has more craters than any other moon in the solar system.

Callisto does not have any mountains. This is probably because its surface is icy. Most of its craters have been made when large meteorites have hit its surface. One of the largest craters is called Valhalla. It is a multi-ringed structure and has a diameter of about 4000 kilometres. Although many crater rims are covered with bright ice rocks, a dark layer can be seen inside many of them.

Callisto has no known atmosphere. It was discovered in 1610.
The Moons of Saturn

Titan

Titan is the largest moon of Saturn and the second largest moon in the solar system. Only Jupiter’s Ganymede is bigger. We learned a lot about Titan when a spacecraft, Voyager, was sent into space to take pictures of many of the bodies in the solar system. Unfortunately, Titan is covered with thick layers of clouds, so they did not reveal many details of its surface landscape. Titan is one of the most interesting places in the solar system.

Although Titan is classified as a moon, it is larger than the planet Mercury. It has a planet-like atmosphere, which is denser than those of Mercury, Earth, and Mars. The atmospheric pressure is about 60 percent greater than that on Earth. Titan’s air is made up mostly of nitrogen. It is orange-like in colour.

Titan’s surface temperature appears to be about -178°C. Scientists believe that Titan’s surface has lakes made of ethane.

Titan was discovered in 1655 by a Dutch astronomer, Christiaan Huygens. It is 2575 kilometres in diameter and has a mass that is about two and one-quarter times that of Earth’s.

Hyperion

Hyperion is one of the strangest moons ever observed close up. It is one of the smaller moons of Saturn and has a strange, spongy-looking body with dark-floored craters that speckle its surface. Hyperion has a reddish tint.

Hyperion has a pock-marked body and a very irregular shape.
The Moons of Uranus

Miranda

Miranda is a small satellite with a diameter of 470 kilometres. Its surface is unlike anything in the solar system with features that are jumbled together in a haphazard fashion. Miranda consists of huge fault canyons as deep as 20 kilometres across, terraced layers, and a mixture of old and young surfaces. The younger surfaces might have been produced when lighter materials made their way to the surface. Some scientists believe that Miranda may have been shattered as many as five times during its formation. After each shattering the moon would have reassembled from the remains of its former self with portions of its core exposed and portions of its surface buried.

Given Miranda’s small size and low temperature (-187°C), the degree and diversity of its crust movement has surprised scientists.

Miranda was discovered in 1948.

The Moons of Neptune

Triton

Triton is the largest moon of Neptune, with a diameter of 2700 kilometres. It was discovered by a British astronomer named William Lassell in 1846. Triton is colder than any other measured object in the solar system with a surface temperature of −235°C. It has an extremely thin atmosphere. Nitrogen ice particles might form thin clouds, a few kilometres about its surface. Triton is the only large satellite in the solar system to circle a planet in a retrograde direction – in a direction opposite the rotation of the planet.

Triton contains more rock in its interior than the icy satellites of Saturn and Uranus do. Scientists believe that it was attracted to Neptune (or captured) by Neptune’s strong pull of gravity. It is scarred by enormous cracks. It also has active geyser-like eruptions, spewing nitrogen gas and dark dust particles several kilometres into the atmosphere. Its mass is more than three and a half times Earth’s.
Man’s Quest for Knowledge About the Universe

Ever since humans set foot on the Earth, they have been curious about the Moon, stars, and other celestial bodies. In the early years people did not have the technology to make thorough investigations of the universe like we can today. Of course, as time goes on, our own technology will become increasingly more efficient and effective; and we will discover many new things about our world and the universe.

In the second century CE a Greek astronomer named Ptolemy put forth the idea that the Earth was the centre of the universe. The Sun, planets, and stars all revolved around Earth. People accepted this idea as true for many years.

It was not until the early 1500s that an astronomer from Poland named Nicolaus Copernicus put forth the idea that the Earth and the other planets revolved around the Sun, and that the Earth is not at the centre of the universe as Ptolemy had suggested.

Galileo Galilei was an Italian astronomer and scientist who accepted Copernicus’s theory. Like the others he was curious about the universe. He built on the work of others to invent a workable telescope in early 1600s. This proved to “open up the heavens” to investigators about the universe. With the telescope Galileo discovered some of Jupiter’s satellites. He was able to observe sunspots and the mountainous nature of the Moon.

Since Galileo’s invention of the telescope, people have gazed upward with wonder. New telescopes have now been invented that are bigger and more able to gather light from celestial bodies.

In the 1960s and 1970s the United States of America and the former Soviet Union were engaged in a “space race”. Each country wanted to outdo the other. First, there was the race to see who could get a man to go out in space in a spacecraft. As it turns out, a Soviet cosmonaut (astronaut) named Yuri Gagarin was the first man to do this.

Next came the quest to land a man on the Moon. This time it was the United States who came out on top when Neil Armstrong set foot on the Moon in 1969.

Then the United States sent spacecraft named Pioneer and Voyager to explore other planets like Venus, Mars, Jupiter, and Saturn. These spacecraft, called probes, could actually send photographs of the surfaces of planets back to Earth, as they got near to them.

The Hubble Space Telescope has given us a very clear look at nebulae, distant galaxies, and nearby stars. With each new discovery we learn a little bit more as we attempt to unravel the mysteries of space.

The future will see bigger and better telescopes that can look farther and more clearly into space. We will send more probes to the outer planets and maybe, in the not-too-distant future, we will again travel to another world just as we did in the 1970s when we travelled to the Moon.
Galaxies

Galaxies are large groupings of stars, space dust, and the remains of stars that have burnt out. There are probably more than 170,000,000,000 galaxies in the universe. The number of stars in each galaxy ranges from as few as 10,000,000 to more than 100,000,000,000. The stars and other matter that form a galaxy are held in place by some kind of gravitational pull.

Galaxies are categorized according to their shape. There are so many galaxies that almost all do not have names, but numbers.

**Elliptical** galaxies are oval in shape. They are given an “E” (for elliptical) number that tells how long they are.

*Galaxy M32 is an elliptical galaxy that is only slightly oval. It is rated as an E2 elliptical galaxy. A much longer elliptical galaxy would have a high E number. When examining this photo you might think the galaxy is one large star, but there are trillions.*

**Spiral** galaxies are common. They appear as if the stars are swirling about a centre point called a nucleus. Our Sun is part of a spiral galaxy called the *Milky Way.*

*NGC 4414 is a spiral galaxy that is about 60 million light-years from Earth.*

**Irregular** galaxies do not have any particular shape. Most smaller galaxies are irregular.

*Galaxy NGC 2366 is an irregular galaxy. It is not symmetrical nor does it appear to have any definite shape.*
Our Sun is a star in a spiral galaxy called the Milky Way. Our Sun is located near the outer part of the galaxy on a section called the Orion Arm.

**Where Are We in the Universe?**

At times we may think that our part of the universe is quite large. In reality Alberta occupies a very tiny part of the Earth. In turn, the Earth is only a very tiny part of the solar system. The Sun is only but a speck in the Milky Way. And the Milky Way is a mere minute dot in the universe.

Our part of the universe is important, but as far as physical space is concerned, it occupies only a pinprick in the universe.
Science
Grade Six

Topic C: Sky Science

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About Part I

Part I of *Sky Science* introduces students to the idea that Earth is just one of billions of celestial bodies. It is part of the solar system that centres around the Sun. In turn, the Sun is part of a galaxy called the Milky Way.

The foci of Part I are the celestial bodies in the universe that are sources of light – the stars – and the influence they have on humans. Students learn how Earth movements affect the relative positions of the stars throughout the year.

The sun’s importance to living things on Earth is another focus of Part I. Students learn how the Sun position affects shadows and seasons and how this impacted life long ago and in modern times.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Concept</th>
<th>Mini Textbook Pages</th>
<th>Hands On?</th>
<th>Non Hands On Option?</th>
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<tbody>
<tr>
<td>1</td>
<td>Celestial Bodies: Sources or Reflectors of Light</td>
<td>5 – 7</td>
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<td>2</td>
<td>Constellations</td>
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<td>3</td>
<td>The Changing Positions of Constellations</td>
<td>9 – 13</td>
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<td>Researching the Sun</td>
<td>14 - 15</td>
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<td>Making a Sundial</td>
<td>19 – 20</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
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<td>Amount and Intensity of Light: The Sun’s Light</td>
<td>21 – 22</td>
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<td>Yes</td>
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<td>The Reason for the Seasons</td>
<td>23 - 27</td>
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<td>Yes</td>
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<tr>
<td>11</td>
<td>Review of the Seasons</td>
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<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>Sky Science – Part I Review</td>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
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<td>13</td>
<td>Sky Science – Part I Test</td>
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</table>
Lesson One

Concept: Celestial Bodies: Sources or Reflectors of Light

Resources/Materials: Mini Textbook, pages 5 – 7
Worksheet #6C.1 (student copies)
globe small ball

Introduction: Discuss how such devices as air seeders and global positioning systems (GPS) use satellite technology. Tell students that a satellite is any heavenly body that revolves around another. Air seeders and GPS use human-made satellites that are launched and then programmed to circulate around Earth. (Demonstrate the term revolve using the globe and a small ball.)

Explain that in this new science unit, we will be exploring more about celestial bodies like the stars, our sun, Earth, planets, moons, comets, and so on. Most rockets that are launched into space are designed to help scientists called astronomers do research on celestial bodies.

Procedure:

1. Explain that of all the celestial bodies, only the Sun and the stars are sources of light. All other heavenly bodies are merely reflectors of light.

2. The Sun is one of billions of stars. It is the star closest to us, and it is the star from which we get light to grow plants and heat to keep us warm.

3. In nature, a satellite is any heavenly body that revolves around another. So the Earth and the other seven planets are satellites of the Sun. The Moon is a satellite of Earth. Most of the other planets also have satellites or moons. There are some heavenly bodies that are not satellites. They do travel through space, however, and occasionally one will crash into one of the planets.

4. On the board, write the names of the more common heavenly bodies: Earth, planet, Sun, star, Moon, moons, comet, asteroid. Explain that we capitalize Earth because it is the name of a specific planet. Moon is the name of our moon, so we capitalize it too.

Have students make a chart in their notebooks, classifying the heavenly bodies written on the board as sources or reflectors of light.

Heavenly Bodies

<table>
<thead>
<tr>
<th>Sources of Light</th>
<th>Reflectors of Light</th>
</tr>
</thead>
</table>


6. Distribute Worksheet #6C.1. Go over the directions, if necessary.

Assignments:

1. Make a chart classifying heavenly bodies as sources or reflectors of light.
2. Read Mini Textbook, page s5 – 7
3. Do Worksheet #6C.1.
The Heavenly Bodies in Our Universe

Directions: Use Mini Textbook, pages 5 – 7 to help you answer the questions. You may answer each question in a phrase.

1. What is a galaxy? ________________________________

2. Our Sun is part of what galaxy? ________________________________

3. What is the name for a group of stars that form a pattern in the sky? _______________________

4. What is the name of the star that is closest to Earth? ________________________________

5. True or false? A star is a source of light. ________________________________

6. The name for the Sun, its planets, and their moons is ________________________________

7. How many planets revolve around the Sun? ________________________________

8. How many of the planets are sources of light? ________________________________

9. What is a satellite? ________________________________

10. What is the name of the path on which a planet travels around the Sun? __________________

11. Name the planets starting with the one closest to the Sun. ________________________________

12. What is the name of the largest planet? ________________________________

13. What is the name of the smallest planet? ________________________________

14. Is Venus a source of light or does it reflect the Sun’s light? ________________________________

15. How long does it take for Earth to orbit the Sun one time? ________________________________

16. How long does it take for the Earth to rotate once? ________________________________

17. How many natural satellites does Earth have? ________________________________

18. True or false? The Moon is a source of light? ________________________________

19. What is the difference between a meteor and a meteorite? ________________________________

Worksheet #6C.1
The Heavenly Bodies in Our Universe

Directions: Use Mini Textbook, pages 5 – 7 to help you answer the questions. You may answer each question in a phrase.

1. What is a galaxy? _cluster of stars_

2. Our Sun is part of what galaxy? _The Milky Way_

3. What is the name for a group of stars that form a pattern in the sky? _constellation_

4. What is the name of the star that is closest to Earth? _Proximal Centauri_

5. True or false? A star is a source of light. _true_

6. The name for the Sun, its planets, and their moons is _solar system_.

7. How many planets revolve around the Sun? _eight_

8. How many of the planets are sources of light? _none_

9. What is a satellite? _body that revolves around another_

10. What is the name of the path on which a planet travels around the Sun? _orbit_

11. Name the planets starting with the one closest to the Sun. _Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune_

12. What is the name of the largest planet? _Jupiter_

13. What is the name of the smallest planet? _Mercury_

14. Is Venus a source of light or does it reflect the Sun’s light? _reflects Sun’s light_

15. How long does it take for Earth to orbit the Sun one time? _365 1/4 days or 1 year_

16. How long does it take for the Earth to rotate once? _24 hours or 1 day_

17. How many natural satellites does Earth have? _one_

18. True or false? The Moon is a source of light? _false_

19. What is the difference between a meteor and a meteorite? _A meteorite is a meteor that has reached the Earth’s surface._
Lesson Two

Concept: Constellations

Resources/Materials: Mini Textbook, page 8
  Worksheets #6C.2a, #6C.2c, and #6C.2e (transparencies, student copies)
  Worksheets #6C.2b, #6C.2d, and #6C.2f (transparencies)
  Worksheet #6C.2g (student copies)

Introduction: Review some of the facts about stars. Write them on the board for students to copy later into their notebooks. Example:

Stars
  • are sources of light
  • are sources of heat
  • have different sizes, colours, compositions, and temperatures
  • The Sun is our star.

Ask students if they remember the name for a large cluster of stars (galaxy) and the name of the galaxy to which our Sun belongs (Milky Way). Add to the notes:

Galaxy
  • the name for a large cluster of stars
  • The Sun is part of the Milky Way

Then ask students if they remember the name for a group of stars that seems to form a pattern or picture (constellation). Tell students that today we will be learning more about constellations.

Constellation – name for a group of stars that seems to form a pattern

Procedure:

1. Discuss how the Ancient Greeks had a fascination with stars and they tried to make sense of them. One way was to cluster them into groups and give them names according to what the patterns resembled.

  ADDITIONALLY/ALTERNATELY. Do the following:
  Put up Master #2A on the overhead. Join the dots to make the Little Dipper. (You may have to explain what a dipper is.) Then do the same for the Big Dipper. Tell them that the Ancient Greeks actually imagined these two constellations to be bears. Put up Master #2b. Point first to Ursa Minor. Tell students that ursa is Greek meaning bear; minor means smaller. Have students draw in the bear using the stars as reference points.

  Now refer to Ursa Major. It not only involves the stars of the Big Dipper, but several others. To imagine Ursa Major, it helps to connect the stars with straight lines before actually drawing the bear.

  The brightest star in the night sky is called Polaris. It is at the end of the Little Dipper’s handle (or the tip of Ursa Minor’s nose). Have students find and label Polaris.

(continued)
Lesson Two (continued)

3. Put up the transparency of Worksheet #6C.2c and distribute Worksheet #6C.2d. Explain that there are three constellations on this page. Join the lines to show the Big Dipper on the transparency and have students do the same on Worksheet #6C.2d.

Point out the constellation of Cynus the Swan. Point out stars that stand for the head, wings and bodies. Have students try to draw in the swan. Then draw the swan in on the transparency.

Explain that the top right cluster is called Cassiopeia. Cassiopeia is the name of a queen. On the worksheet, she is upside down and she is sitting. Have students turn their pages upside down and try to imagine her lap, trunk and skirt. (See below.)

4. Next put up the transparency of Worksheet #6C.2e. Explain that this is a constellation of Orion – a warrior. Point out various parts of Orion’s body and his shield. Then distribute copies of Worksheet #6C.2f, so they can see the details for themselves.

5. Distribute Worksheet #6C.2g. Go over the directions, if necessary.

Assignments:

1. Draw in the “pictures” and label the important stars on Worksheets #6C.1a, #6C.1c, and #6C.1e, using Worksheets #6C.1b, #6C1d, and #6C.1f.

2. Do Worksheet #6C.2g.
Ursa Major and Ursa Minor
Constellations #2
Cygnus, Cassiopeia, and Ursa Major

STAR Deneb

CYGNUS
the SWAN

POLARIS

CASSIOPEIA

BIG DIPPER
(part of Ursa Major)
Orion’s Belt

- Betelgeuse
- Bellatrix
- Orion Nebula
- Saiph
- Rigel
Directions: Use the star maps to find the names of some of the stars and constellations that are visible in our night skies. The first two or three letters are given.

PO ___ ___ ___ UR ___ MA ___ ___ UR ___ MI ___ ___
CASS ___ ___ ___ ___ BET ___ ___ ___ ___ RI ___ ___
OR ___ ’ ___ ___ ___ ___ BELL ___ ___ ___ ___ ST ___ ___ ___ ___
OR ___ ___ ___ ___ ___ ___ CYG ___ ___ ___ ___ ___ ___
SA ___ ___

Now classify each of the above as individual stars or as constellations.

<table>
<thead>
<tr>
<th>Individual Stars</th>
<th>Constellations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
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<td></td>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Directions:** Use the star maps to find the names of some of the stars and constellations that are visible in our night skies. The first two or three letters are given.

- **Polaris**  
- **Cassiopeia**  
- **Orion’s Belt**  
- **Orion Nebula**  
- **Saph**  

- **Ursa Major**  
- **Betelgeuse**  
- **Bellatrix**  
- **Cygnus**  
- **The Swan**  

Now classify each of the above as individual stars or as constellations.

<table>
<thead>
<tr>
<th>Individual Stars</th>
<th>Constellations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polaris</td>
<td>Ursa Major</td>
</tr>
<tr>
<td>Betelgeuse</td>
<td>Ursa Minor</td>
</tr>
<tr>
<td>Rigel</td>
<td>Cassiopeia</td>
</tr>
<tr>
<td>Bellatrix</td>
<td>Orion’s Belt</td>
</tr>
<tr>
<td>Star Deneb</td>
<td>Cygnus the Swan</td>
</tr>
<tr>
<td>Orion Nebula</td>
<td></td>
</tr>
<tr>
<td>Saph</td>
<td></td>
</tr>
</tbody>
</table>
Lesson Three

**Concept:** The Changing Positions of Constellations

**Resources/Materials:** Mini Textbook, pages 9 - 13
- Worksheet #6C.3a (transparency)
- Worksheets #6C.3b and #6C.3c (student copies)
- Worksheet #6C.3d (optional, student copies)
- Self-adhesive stars (optional)

**Introduction:** Explain that the stars, including the Sun, are stationary. However, the Earth rotates or spins around. That is why it appears that the Sun is moving throughout the course of a day. Really, it is the Earth that is rotating. The same goes for the stars at night. The stars seem to change position through the night. Explain that today we will examine the changing positions of the stars.

**Procedure:**

1. Explain that while the Earth is rotating, it is also revolving around the Sun. Because of this, the stars are in a different position in the night sky. The constellations also change position. They seem to be turned around a little. Some constellations are visible during some seasons, but not in others. **Some constellations are referred to usually as summer or winter constellations, depending on when they are visible.**

2. **In actuality, the stars are moving a little, but they are so far away that this movement makes little difference to their positions as seen from Earth.**

3. Put up the overhead of Worksheet #6C.3a (or distribute copies). It is of the Ursa Major, the Big Dipper. Notice how it seems to have rotated in a **counter clockwise direction** through the seasons. Note also that it seems to have rotated one-quarter turn each one-quarter year.


5. Distribute Worksheets #6C.3b and #6C.3c. Go over the directions, if necessary.

6. **OPTIONAL.** Have students make a star map from one of the seasons. Worksheet #6C.3d provides directions. If you have them, give students self-adhesive stars to use.

**Assignments:**

2. Do Worksheets #6C.3b and #6C.3c.
3. **OPTIONAL.** Make a star map for one of the seasons. Use Worksheet #6C.3d for directions.
The Big Dipper Throughout the Seasons

- March
- June
- September
- December
**The Changing Positions of the Stars**

**Directions:** Something is wrong with each of the statements below. Cross out the incorrect words and write the correct words above them.

1. All stars are moving relative to one another, but they are so close that this movement makes little difference to their position as seen from the Earth.

2. The apparent movement of the stars in the night sky is due to the Moon's spinning on its axis.

3. Patterns from by the stars are called galaxies.

4. The position of the constellations changes in a clockwise manner.

5. The position of a constellation during half a year will be a quarter turn.

6. A constellation would be called a summer constellation if it cannot be seen in the summer.

**Directions:** Choose the best answer.

1. The reason the constellation Orion is called a winter constellation is because
   
   a. winter is the time of year when it is closest to the North Star.  
   b. it is at its lowest position in the sky during the winter.  
   c. winter is the only time of year when it is visible.  
   d. it reflects sunlight during the winter.

2. The reason that the Big Dipper appears to have moved is that the
   
   a. stars randomly change their positions.  
   b. Moon's gravity causes the stars to change their positions.  
   c. Earth tilts closer to the Sun as it rotates during the night.  
   d. Earth rotates on its axis as it revolves around the Sun.
3. At 2:00 a.m. the position of the Big Dipper would be

a.  

b.  

c.  

d.  

4. Here is a picture of the Big Dipper at midnight in the night sky in June.

![Big Dipper Image]

Which of the following diagrams illustrates the position of the Big Dipper at midnight in the December sky?

a.  

b.  

c.  

d.  

Worksheet #6C.3c
Making a Star Map

Directions:

1. Trace a large circle onto black construction paper.

2. Choose one of the star maps. Using small and large stars, copy your map with the stars instead of the dots. Remember to label the directions (north, south, east, west). If you do not have any stars, use coloured crayons.

3. Label each star and constellation.

4. Cut out your circle and paste it onto a sheet of white or yellow construction paper. Be sure that NORTH is at the top.

5. Make a heading that tells which season your chart represents.

Grading:

You will be graded according to the following criteria:

1. The stars and constellations are in the correct positions.

2. The lines that join the stars of the constellations are made correctly.

3. The stars and constellations are labelled correctly and the names are spelled correctly.

4. The star map is neatly made.

5. The directions on the star map are labelled correctly, it is cut out neatly, it is pasted neatly, and there is an appropriate title.
**The Changing Positions of the Stars**

**Directions:** Something is wrong with each of the statements below. Cross out the incorrect words and write the correct words above them.

1. All stars are moving relative to one another, but they are so close that this movement makes little difference to their position as seen from the Earth.

2. The apparent movement of the stars in the night sky is due to the __Moon's__ spinning on its axis.

3. Patterns from by the stars are called __constellations__.

4. The position of the constellations changes in a __counter clockwise__ manner.

5. The position of a constellation during half a year will be a __half quarter__ turn.

6. A constellation would be called a summer constellation if it __cannot__ be seen in the summer.

**Directions:** Choose the best answer.

1. The reason the constellation Orion is called a winter constellation is because
   
   a. winter is the time of year when it is closest to the North Star.
   b. it is at its lowest position in the sky during the winter.
   c. winter is the only time of year when it is visible.
   d. it reflects sunlight during the winter.

2. The reason that the Big Dipper appears to have moved is that the
   
   a. stars randomly change their positions.
   b. Moon's gravity causes the stars to change their positions.
   c. Earth tilts closer to the Sun as it rotates during the night.
   d. Earth rotates on its axis as it revolves around the Sun.
3. At 2:00 a.m. the position of the Big Dipper would be

(a)

(b)

c.

d.

4. Here is a picture of the Big Dipper at midnight in the night sky in June.

Which of the following diagrams illustrates the position of the Big Dipper at midnight in the December sky?

(a)

(b)

c.

(d)
Lesson Four

Concept: Researching the Sun

Resources/Materials: Mini Textbook, pages 14 and 15
Worksheets #6C.4 (student copies)
Articles from encyclopedias or other reference books may be used instead of
Mini Textbook, pages 14 and 15

Introduction: Review that the star closest to Earth is the Sun. It provides us with heat and light. Without the Sun, nothing could live. Today you will find out more about the Sun by doing some research.

Procedure:

1. Explain that the first step in doing research is to figure out what we want to know. Explain that today you are going to give students a list of questions about the Sun. Each question should be answered in a paragraph in student notebooks.

2. Distribute Worksheet #6C.4. Go over the questions.

3. Have students read the information about the Sun on Mini Textbook, pages 14 and 15, or refer them to the encyclopedias and any other resources you may have.

4. ALTERNATELY. If you like, have students write a report about the Sun.

5. ALTERNATELY. Have students make up 10 questions about the Sun. Have them exchange papers for classmates to answer.

Assignment:

1. Answer the questions about the Sun on Worksheet #6C.4. Use the information Mini Textbook, pages 14 and 15 or other sources.

2. ALTERNATELY. Research and write a report on the Sun.

3. ALTERNATELY. Make up 10 questions about the sun. Exchange questions with a classmate.
Directions: In your notebooks answer each of these questions in a paragraph or two.

1. What is the Sun?

2. How big is the Sun?

3. In what ways is the Sun important to living things on Earth?

4. What accounts for the Sun’s brightness?

5. What is the composition of the Sun?

6. What are sunspots?

7. What are sunflares?

8. What are the effects of solar winds?
Lesson Five

Concept: Direct Viewing of the Sun

NOTE: This lesson involves students making a pin hole camera as a safe alternative to viewing the Sun directly. Pin hole cameras are limited in their effectiveness, but you may want to have students do the activity anyway. If you choose not to do the pin hole camera activity, it may be sufficient to warn students not to view the Sun directly. Sunglasses do not provide sufficient protection. Only special welding glasses are effective enough.

Resources/Materials: Mini Textbook, page 16
HANDS ON: shoe box aluminum foil pin
sheet of white paper tape
Worksheet #6C.5a (one copy per group)
NON HANDS ON: Worksheet #6C.5b

Introduction: Explain to students that light coming from the sun is so bright that looking at it without proper eye protection will permanently damage the eye. It could lead to blindness. Today we will be making a device that provides us with a safe way to view the sun.

Procedure:
HANDS ON
1. Explain that today students will make a pin hole camera. It is one way to view the Sun without damaging your eyes. In a pin hold camera, the sun’s light comes through a tiny hole in a box. These sun rays are then projected onto a white screen.

For the Teacher
The lens in your eye focuses the light onto the back part of the eye called the retina. This makes the light very intense. It takes only three seconds before damage can start to occur. There are no pain receptors in the retina, so there is not pain to warn us of damage being done. It is predominately invisible infrared wavelengths that can damage your skin and also the rays that damage your retina. If the retina is permanently scarred, partial or total blindness occurs. Some rules about viewing the sun:
• Peek, don’t stare.
• Without special filters, it is best to view the sun when it has been projected onto another surface. This is what a pinhole camera does.
• Use specially designed filters when using binoculars or telescopes.
• You can view the Sun directly if you use No. 14 welding glasses or special Mylar plastic, specifically manufactured for solar observation.
Viewing the Sun is especially tempting when viewing solar eclipses. The same rules apply.
2. Distribute Worksheet #6C.5a and the appropriate materials.
NON HANDS ON
Have students turn to Mini Textbook, page 16. Guide the reading, if possible
3. Distribute Worksheet #6C.5b. Go over the directions, if necessary.

Assignments:
1. HANDS ON. Make a pin hole camera. Use it to view the Sun.
Making a Pin Hole Camera

A pin hole camera is a safe way of viewing the Sun.

Materials: shoebox, foil, pin, tape, sheet of white paper

Procedure:

1. Cut a 5 cm square out of one end of a shoebox.
2. Cover with a piece of foil. Tape into place, making sure the foil is flat.
3. Poke a small hole in the centre of the foil with a pin.
4. Place a sheet of paper on the inside of the box at the opposite end from the foil.
5. To view, hold the box above your head with the pin hole facing the Sun. You will face the screen with your back to the Sun. An upside down image will form on the screen.
Directions: Use Mini Textbook, page 16 to help you answer the questions.

1. Use a dictionary to find the meaning of the word *eclipse*.

2. Explain what happens in a solar eclipse. Then draw a diagram showing the positions of the Sun, Earth, and Moon during a solar eclipse.

3. Why is it that it is dangerous to look at the Sun for more than just a moment?

4. Why do you think it is safe to view the Sun through No. 14 welding glasses or special Mylar plastic?

5. Examine the drawing of the boy viewing the Sun with the pinhole camera. Why is this safe?
Directions: Use Mini Textbook, page 16 to help you answer the questions.

1. Use a dictionary to find the meaning of the word *eclipse*.
   
   Obscuring (covering) of one celestial body by another

2. Explain what happens in a solar eclipse. Then draw a diagram showing the positions of the Sun, Earth, and Moon during a solar eclipse.
   
   Moon comes between the Earth and the Sun. The Sun is
   
   eclipsed by the Moon

3. Why is it that it is dangerous to look at the Sun for more than just a moment?
   
   Sun’s ultraviolet rays can damage the retina of your eye

4. Why do you think it is safe to view the sun through No. 14 welding glasses or special Mylar plastic?
   
   filter out or block ultraviolet rays

5. Examine the drawing of the boy viewing the Sun with the pinhole camera. Why is this safe?
   
   not looking directly at Sun, but at an image of the Sun
Lesson Six

Concept: Shadow Length Changes Throughout the Day

Resources/Materials: Worksheet #6C.6a (transparency or student copies)
    globe small piece of Plasticine,
    toothpick flashlight
    Worksheets #6C.6b, #6C.6c, #6C.6d, and #6C.6e (student copies)

Introduction: Discuss shadows and the fact that shadows are only cast on sunny days. Then ask if shadows
    are always the same length. Discuss times/seasons when shadows are shortest/longest. Have students speculate
    as to why.
    Explain that today’s lesson has to do with shadow length throughout the course of a day.

Procedure:

1. Using the globe, note how the Earth is tilted. Remind students that the Earth rotates on its axis as it
    revolves around the Sun.

2. Stick a piece of Plasticine on your community and stick a toothpick into the Plasticine.

3. Darken the room, if possible. Demonstrate day and night by shining a light on the globe you turn the
    globe slowly. Observe the toothpick in the Plasticine during one complete rotation. Note the varying
    length of the shadow cast by the toothpick as the Earth rotates.

4. Discuss:
    • How the shadow and the Sun are related.
    • At what time of day will the Sun cast the shortest shadows?
    • Why is the shadow not in the same place or the same length every day.

5. Tell students that just as we put the toothpick on the globe to make a shadow, we use other devices to
    measure shadows during the day. We will do this in a future class.

6. Distribute Worksheet #6C.6a or put up a transparency of it. Explain that the table shows the lengths of a
    shadow cast by a stick erected perpendicular to the ground at different times of the day. Show students
    how to make a bar graph from the information in the table. Also note that part of making a graph is
    labelling the axes.

7. Tell students they will now get some practice in making and interpreting graphs. Distribute Worksheets
    #6C.6b, #6C.6c, #6C.6d, and #6C.6e. Go over the directions, if necessary.

Assignment:

Do Worksheets #6C.6b, #6C.6c, #6C.6d, and #6C.6e.
SHADOWS

<table>
<thead>
<tr>
<th>Time</th>
<th>Length of Shadow (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00</td>
<td>191</td>
</tr>
<tr>
<td>9:30</td>
<td>186</td>
</tr>
<tr>
<td>10:00</td>
<td>177</td>
</tr>
<tr>
<td>10:30</td>
<td>168</td>
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<td>11:00</td>
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<td>12:30</td>
<td>145</td>
</tr>
<tr>
<td>1:00</td>
<td>159</td>
</tr>
<tr>
<td>1:30</td>
<td>163</td>
</tr>
<tr>
<td>2:00</td>
<td>179</td>
</tr>
<tr>
<td>2:30</td>
<td>182</td>
</tr>
</tbody>
</table>

Measuring the length of shadows cast by a stick at various points throughout the day, provides you with data that can easily be turned into a bar graph. Use the data in the table above to complete the graph.

(TITLE)

<table>
<thead>
<tr>
<th>Shadow Length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00</td>
</tr>
<tr>
<td>------</td>
</tr>
</tbody>
</table>

Time
1. Examine the table below. It shows the length of a grade one girl's shadow throughout the day.

**Shadow Length Throughout the Day**

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of Shadow (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00 A.M.</td>
<td>177</td>
</tr>
<tr>
<td>11:20 A.M.</td>
<td>164</td>
</tr>
<tr>
<td>11:40 A.M.</td>
<td>154</td>
</tr>
<tr>
<td>12:00 Noon</td>
<td>146</td>
</tr>
<tr>
<td>12:20 P.M.</td>
<td>141</td>
</tr>
<tr>
<td>12:40 P.M.</td>
<td>138</td>
</tr>
<tr>
<td>1:00 P.M.</td>
<td>137</td>
</tr>
<tr>
<td>1:20 P.M.</td>
<td>138</td>
</tr>
<tr>
<td>1:40 P.M.</td>
<td>140</td>
</tr>
<tr>
<td>2:00 P.M.</td>
<td>145</td>
</tr>
<tr>
<td>2:20 P.M.</td>
<td>152</td>
</tr>
<tr>
<td>2:40 P.M.</td>
<td>161</td>
</tr>
</tbody>
</table>

a. Use the information in the table to make a bar graph.

(Title)
b. You can infer from this chart that the sun is at its highest point in the sky at __________.

c. The length of the shadow was measured every ______________ minutes.

d. Estimate the time in the afternoon when the shadow will be 175 mm.

_____________________

2. Examine the bar graph below. Then answer the questions.

![Bar graph showing shadow length during the day]

a. What do you think will be the length of the shadow at 3:00 P.M.? _______________

b. What do you think was the length of the shadow at 9:00 A.M.? _______________

c. At what time of the day was the sun at its highest point in the sky? ______________

d. At what two periods of the day will shadows be the longest?

__________________________   __________________________
3. Examine the table showing shadow length. Then answer the question.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of Shadow</th>
<th>Time of Day</th>
<th>Length of Shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30 A.M.</td>
<td>470 cm</td>
<td>12:30 P.M.</td>
<td>76 cm</td>
</tr>
<tr>
<td>8:00 A.M.</td>
<td>300 cm</td>
<td>1:00 P.M.</td>
<td>70 cm</td>
</tr>
<tr>
<td>8:30 A.M.</td>
<td>240 cm</td>
<td>1:30 P.M.</td>
<td>54 cm</td>
</tr>
<tr>
<td>9:00 A.M.</td>
<td>204 cm</td>
<td>2:00 P.M.</td>
<td>34 cm</td>
</tr>
<tr>
<td>9:30 A.M.</td>
<td>142 cm</td>
<td>2:30 P.M.</td>
<td>69 cm</td>
</tr>
<tr>
<td>10:00 A.M.</td>
<td>135 cm</td>
<td>3:30 P.M.</td>
<td>90 cm</td>
</tr>
<tr>
<td>11:00 A.M.</td>
<td>102 cm</td>
<td>4:30 P.M.</td>
<td>160 cm</td>
</tr>
<tr>
<td>11:30 A.M.</td>
<td>84 cm</td>
<td>6:00 P.M.</td>
<td>293 cm</td>
</tr>
<tr>
<td>12:00 Noon</td>
<td>80 cm</td>
<td>7:00 P.M.</td>
<td>360 cm</td>
</tr>
</tbody>
</table>

Which of the following graphs illustrates the data in the chart?

a. ![Graph a](image)

b. ![Graph b](image)

c. ![Graph c](image)

d. ![Graph d](image)
4. Here is a graph showing shadow length. Examine it and then make up three questions about it.

My Questions:

Question: ____________________________________________________________
Answer: ____________________________________________________________

Question: ____________________________________________________________
Answer: ____________________________________________________________

Question: ____________________________________________________________
Answer: ____________________________________________________________
### SHADOWS

<table>
<thead>
<tr>
<th>Time</th>
<th>Length of Shadow (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00</td>
<td>191</td>
</tr>
<tr>
<td>9:30</td>
<td>186</td>
</tr>
<tr>
<td>10:00</td>
<td>177</td>
</tr>
<tr>
<td>10:30</td>
<td>168</td>
</tr>
<tr>
<td>11:00</td>
<td>150</td>
</tr>
<tr>
<td>11:30</td>
<td>147</td>
</tr>
<tr>
<td>12:00</td>
<td>149</td>
</tr>
<tr>
<td>12:30</td>
<td>145</td>
</tr>
<tr>
<td>1:00</td>
<td>159</td>
</tr>
<tr>
<td>1:30</td>
<td>163</td>
</tr>
<tr>
<td>2:00</td>
<td>179</td>
</tr>
<tr>
<td>2:30</td>
<td>182</td>
</tr>
</tbody>
</table>

Measuring the length of shadows cast by a stick at various points throughout the day, provides you with data that can easily be turned into a bar graph. Use the data in the table above to complete the graph.

**Length of Shadows**

(Title)
1. Examine the table below. It shows the length of a grade one girl’s shadow throughout the day.

### Shadow Length Throughout the Day

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of Shadow (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00 A.M.</td>
<td>177</td>
</tr>
<tr>
<td>11:20 A.M.</td>
<td>164</td>
</tr>
<tr>
<td>11:40 A.M.</td>
<td>154</td>
</tr>
<tr>
<td>12:00 Noon</td>
<td>146</td>
</tr>
<tr>
<td>12:20 P.M.</td>
<td>141</td>
</tr>
<tr>
<td>12:40 P.M.</td>
<td>138</td>
</tr>
<tr>
<td>1:00 P.M.</td>
<td>137</td>
</tr>
<tr>
<td>1:20 P.M.</td>
<td>138</td>
</tr>
<tr>
<td>1:40 P.M.</td>
<td>140</td>
</tr>
<tr>
<td>2:00 P.M.</td>
<td>145</td>
</tr>
<tr>
<td>2:20 P.M.</td>
<td>152</td>
</tr>
<tr>
<td>2:40 P.M.</td>
<td>161</td>
</tr>
</tbody>
</table>

a. Use the information in the table to make a bar graph.

---

**Shadow Length Throughout the Day**

(Title)
b. You can infer from this chart that the sun is at its highest point in the sky at ___________ 1:00 P.M. ___________.

c. The length of the shadow was measured every _______ 20 _______ minutes.

d. Estimate the time in the afternoon when the shadow will be 175 mm. 

around 3:00 P.M.

2. Examine the bar graph below. Then answer the questions.

<table>
<thead>
<tr>
<th>Time of day</th>
<th>Shadow length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00 A.M.</td>
<td>180</td>
</tr>
<tr>
<td>11:00 A.M.</td>
<td>140</td>
</tr>
<tr>
<td>12:00 P.M.</td>
<td>120</td>
</tr>
<tr>
<td>1:00 P.M.</td>
<td>160</td>
</tr>
<tr>
<td>2:00 P.M.</td>
<td>180</td>
</tr>
<tr>
<td>3:00 P.M.</td>
<td>140</td>
</tr>
</tbody>
</table>

a. What do you think will be the length of the shadow at 3:00 P.M.? ______ 180 mm _______

b. What do you think was the length of the shadow at 9:00 A.M.? ______ 180 mm _______

c. At what time of the day was the sun at its highest point in the sky? ______ 12:00 P.M. _______

d. At what two periods of the day will shadows be the longest?

early morning _______ late afternoon _______
3. Examine the table showing shadow length. Then answer the question.

### Shadow Length

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of Shadow</th>
<th>Time of Day</th>
<th>Length of Shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30 A.M.</td>
<td>470 cm</td>
<td>12:30 P.M.</td>
<td>76 cm</td>
</tr>
<tr>
<td>8:00 A.M.</td>
<td>300 cm</td>
<td>1:00 P.M.</td>
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<td>12:00 Noon</td>
<td>80 cm</td>
<td>7:00 P.M.</td>
<td>360 cm</td>
</tr>
</tbody>
</table>

Which of the following graphs illustrates the data in the chart?

a. ![Graph](image_a)

b. ![Graph](image_b)

c. ![Graph](image_c)

d. ![Graph](image_d)
4. Here is a graph showing shadow length. Examine it and then make up three questions about it.

Examples:

**My Questions:**

**Question:** At what time was the Sun shining most directly?  
**Answer:** 12:00

**Question:** At what time will the shadow most likely be 500 mm again?  
**Answer:** 15:00

**Question:** Estimate the shadow’s length at 09:30.  
**Answer:** 450 mm
Lesson Seven

NOTE: A DAY MUST BE SET ASIDE TO TAKE SHADOW DATA BEFORE THIS LESSON CAN BE COMPLETED. ON THIS DAY, LESSON EIGHT ON MAKING A SUNDIAL MAY BE A GOOD ACTIVITY.

Concept: Gathering Shadow Data and Making a Shadow Graph

Resources/Materials: Mini Textbook, pages 17 and 18
   HANDS ON: tall thing object (like a ruler or a baseball bat) metre stick
   Worksheets #6C.7a and #6C.7b (student copies)
   NON HANDS ON: Mini Textbook, pages 17 and 18
   Worksheets #6C.7c and #6C.7d (student copies)

Introduction: Recall with students their work with tables and graphs dealing with shadow length. Ask them if there was any relationship between time of day and shadow length. Explain that students will have a chance to find out for themselves.

Procedure:

HANDS ON
1. Explain that students will measure the shadow cast by an object once every hour for a whole day.
2. Explain that this will be somewhat like a fair test. The time of day will be the manipulated variable. The particular object, the place where the object is placed, and how the object will be positioned are all constants. The responding variable will be the length of the shadow cast.
3. Take the students outside with an object and a metre stick. Give them pointers such as
   • Pick a place that is flat all around (like a sidewalk)
   • Pick a place that gets direct sunlight all day.
   • Position your object perpendicular the ground.
   • Put your object in the same place and position for each measurement.
   • For each measurement, measure the longest part of the shadow.
4. Distribute Worksheet #6C.7a. Have them write the times they will be measuring in the first column.
   (Note: It is usually best to measure at hourly intervals. Example: 8:45, 9:45, 10:45, etc. Choose times that suit your school timetable. If possible, have students take measurements at the appropriate times before and after English School as well.)
5. On the first sunny day, take the measurements. Record the shadow lengths in the table. This will no doubt disrupt some of your other classes, but it’s only one day in the school year.
6. During the class, following the day students gathered their data, distribute Worksheet #6C.7b. Have students make a graph of their findings.

NON HANDS ON
8. Distribute Worksheets #6C.7c and #6C.7d. Go over the directions, if necessary.

Assignments:
1. HANDS ON. Record shadow lengths on Worksheet #6C.7a. Make a bar graph showing the data on Worksheet #6C.7b.
2. NON HANDS ON. Read Mini Textbook, pages 17 and 18. Do Worksheets #6C.7c and #6C.7d.
**Gathering Shadow Length Data**

**Directions:** Fill in the table below with the times you plan to measure the shadow length of your object. Then measure the lengths of the shadows and record them in the appropriate boxes.

<table>
<thead>
<tr>
<th>Time</th>
<th>Length of Shadow (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(Title)

Time

1. Describe the pattern or trend formed by your graph.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

2. How did the length of the shadow change throughout the day?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Shadow Direction Throughout the Day

Directions: Use Mini Textbook, pages 19 and 20 to figure how which words go in the spaces in the sentences below. Write the words in the spaces and then use the words in the crossword puzzle on Worksheet #6C.7d.

Across

4 _______________ is most often used to make sundials because it is not harmed by sunlight, rain, wind, and other weather-related elements.

8 The _______________ of the shadow cast by a shadow stick changes, but so does the direction of the shadow.

9 Sundials are _______________ that use the idea that shadow direction changes as the day goes on.

10 Sundials are typically located _______________ and made from materials that can withstand the forces of nature.

11 _______________ were not constructed as time-telling devices, but to mark the places and times of important events.

13 _______________ have been in use for thousands of years.

14 Today, sundials are used as more of a _______________ item in public places and decorations in private gardens.

15 Sundials can only be used on _______________ days.

Down

1 The gnomon is usually _______________ and placed so that it points toward the north.

2 As the Sun’s position in the sky changes throughout the day, so does the _______________ of shadow.

3 The _______________ is the part on which the shadow of the gnomon is cast.

5 The upright part of a sundial is called the _______________.

6 If the object is on the ground, the _______________ always starts at the place where the objects touches the ground.

7 The Sun, object, and the end of the shadow are always in a _______________ line.

12 A disadvantage of sundials is that they are big and _______________, making them difficult to move.
Science Grade 5 Topic C Sky Science – Part I
Worksheets
Shadow Direction Throughout the Day

CROSSWORD PUZZLE

angled  direction  face  gnomon
heavy  length  novelty  obelisks
shadow  stone  straight  outdoors
sundials  sunny  timepieces
Shadow Direction Throughout the Day

Directions: Use Mini Textbook, pages 19 and 20 to figure how which words go in the spaces in the sentences below. Write the words in the spaces and then use the words in the crossword puzzle on Worksheet #6C.7d.

Across

4. Stone _______ is most often used to make sundials because it is not harmed by sunlight, rain, wind, and other weather-related elements.

8. The _______ of the shadow cast by a shadow stick changes, but so does the direction of the shadow.

9. Sundials are _______ that use the idea that shadow direction changes as the day goes on.

10. Sundials are typically located _______ and made from materials that can withstand the forces of nature.

11. _______ were not constructed as time-telling devices, but to mark the places and times of important events.

13. _______ have been in use for thousands of years.

14. Today, sundials are used as more of a _______ item in public places and decorations in private gardens.

15. Sundials can only be used on _______ days.

Down

1. The gnomon is usually _______ and placed so that it points toward the north.

2. As the Sun’s position in the sky changes throughout the day, so does the _______ of shadow.

3. The _______ is the part on which the shadow of the gnomon is cast.

5. The upright part of a sundial is called the _______.

6. If the object is on the ground, the _______ always starts at the place where the objects touches the ground.

7. The Sun, object, and the end of the shadow are always in a _______ line.

12. A disadvantage of sundials is that they are big and _______, making them difficult to move.
CROSSWORD PUZZLE

angled  direction  face  gnomon
heavy   length    novelty  obelisks
shadow  stone     straight  outdoors
sundials sunny    timepieces
Lesson Eight

Concept: Making a Sundial

Resources/Materials: Mini Textbook, pages 19 and 20
Worksheets #6C.8a and C.8b (on Manila tag, student copies)
Worksheet #6c.8c (student copies)

Introduction: Explain that the Ancient Egyptian and the Chinese use the fact that shadows have different lengths at different time of the day to make a type of clock called a sundial. Today we will make a sundial and then tomorrow we will try it out.

Procedure:

1. Discuss the disadvantage of using sundials. (no good on days when it is not sunny)


3. Distribute Worksheets #6C.8a and #6C.8b (copied on Manila tag). Explain that the more precise their cutting, folding and pasting the more accurate will be their sundials.

4. Explain that the triangular piece is called the gnomon. They are to paste the semicircular piece onto a square of cardboard. Then fold the gnomon on the dotted line and then paste it onto the appropriate spot on the semicircle. (A on the gnomon must match up with A on the semicircle.)

5. Explain that it is time to calibrate or mark the gradations on the sundial:
   • Pick a spot that is exposed to the sun all day.
   • Use the same spot each day.
   • Be sure the sundial is oriented correctly (The curved part faces north; the straight part south.)
   • Be sure the gnomon is perpendicular to semicircle.
   • Use a ruler to mark the edge of the shadow.

6. Distribute Worksheet #6C.8c. Go over the directions, if necessary.

7. On the next sunny day, allow students to go out every hour on the hour to calibrate their sundials.

Assignment:

1. Read Mini Textbook, pages 17 and 18.
2. Make the sundial.
3. Do Worksheet #6C.8c.
Sundial - Gnomon
Directions: Use the words in the box to fill the blanks.

<table>
<thead>
<tr>
<th>gnomon</th>
<th>Chinese</th>
<th>Egyptians</th>
<th>rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>midday</td>
<td>sunset</td>
<td>sunrise</td>
<td>shadow</td>
</tr>
</tbody>
</table>

1. These two groups of people used sundials to tell time long long ago.

2. A sundial uses the position of a __________________________ to tell the time.

3. The upright triangular piece on a sundial is called a __________________________.

4. The length of a shadow on a sundial changes throughout the day because of the __________________________ of Earth on its axis.

5. The sundial's shadow will the longest at __________________________ and at __________________________.

6. The sundial's shadow will be the shortest at __________________________.

Examine the table below; then answer the questions.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of the Sundial's Shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00</td>
<td>80 cm</td>
</tr>
<tr>
<td>10:00</td>
<td>70 cm</td>
</tr>
<tr>
<td>11:00</td>
<td>60 cm</td>
</tr>
<tr>
<td>12:00</td>
<td>50 cm</td>
</tr>
<tr>
<td>13:00</td>
<td>40 cm</td>
</tr>
<tr>
<td>14:00</td>
<td>50 cm</td>
</tr>
<tr>
<td>15:00</td>
<td>?</td>
</tr>
</tbody>
</table>

7. The sundial's shadow's length was shortest at __________________________.

8. How long will the shadow's length be at 14:00? __________________________

9. How long will the shadow's length be at 15:00? __________________________

10. How long will the shadow's length be at 16:00? __________________________
Directions: Use the words in the box to fill the blanks.

<table>
<thead>
<tr>
<th>gnomon</th>
<th>Chinese</th>
<th>Egyptians</th>
<th>rotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>midday</td>
<td>sunset</td>
<td>sunrise</td>
<td>shadow</td>
</tr>
</tbody>
</table>

1. These two groups of people used sundials to tell time long long ago.  
   Chinese, Egyptians

2. A sundial uses the position of a _shadow_ to tell the time.

3. The upright triangular piece on a sundial is called a _gnomon_.

4. The length of a shadow on a sundial changes throughout the day because of the _rotation_ of Earth on its axis.

5. The sundial’s shadow will the longest at _sunrise_ and at _sunset_.

6. The sundial’s shadow will be the shortest at _midday_.

Examine the table below; then answer the questions.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of the Sundial’s Shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00</td>
<td>80 cm</td>
</tr>
<tr>
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<td>40 cm</td>
</tr>
<tr>
<td>14:00</td>
<td>50 cm</td>
</tr>
<tr>
<td>15:00</td>
<td>?</td>
</tr>
</tbody>
</table>

7. The sundial’s shadow’s length was shortest at _12:00_.

8. How long will the shadow’s length be at 14:00? _60 cm_

9. How long will the shadow’s length be at 15:00? _70 cm_

10. How long will the shadow’s length be at 16:00? _80 cm_
Lesson Nine

Concept: Amount and Intensity of Light: The Sun’s Angle

Resources/Materials: Mini Textbook, pages 21 and 22
flashlight
globe
larger sheet of black construction paper
chalk
Worksheet #6C.9 (transparency or copied onto chart paper)

Introduction: By using a globe, show students the equator and the northern and southern hemispheres. Note that the Earth is tilted and rotates on its axis once every 24 hours – this is one day. Review also that the Earth takes 365¼ days to revolve around the Sun once. This is one year.

Ask “Why is it hotter in the summer and colder in the winter?”

Procedure:

1. Continue the discussion by asking students to describe each of the seasons in terms of amount of sunlight (the length of a day), temperatures, amounts of precipitation.

2. Tell students we will be investigating the reasons for these different seasons in the next couple of days.

3. Turn off the lights. Shine the flashlight on the sheet of paper at a 90° angle. Use chalk to trace the circle. Note the colour of the circle. Then shine the flashlight in the same spot, only this time slant the flashlight. Trace the oval with chalk, and note the colour of the light is less intense.

4. Point out the following observations:
   • The area of the direct sunlight is smaller than the slanted shine.
   • The direct shine is more intense in colour.
   • In the slanted shine, the intensity of the light decreases the farther you get from the flashlight.

5. Conclude that there is a direct relationship between the directness of the light and the amount of light and heat given off.

6. Explain that the Sun sometimes shines on our part of the Earth more directly than at other times. Early morning and late evening have less direct sunlight than midday. Summer has more direct sunlight than winter. Explain that this is not because the Sun has moved, it is because the Earth has changed position.

7. With the classroom lights turned off, show how the Earth’s rotating, causes the Sun to shine more directly on your community at some times of the day than at others, using the flashlight and globe. This accounts for differences in the intensity of light and heat during the course of a day.


9. Put up the chart or transparency of Worksheet #6C.9. Read the notes with students. Have them copy the notes and make diagrams in their notebooks.

Assignment:
1. Read Mini Textbook, pages 21 and 22.
2. Copy the notes from Worksheet #6C.9. Draw and label diagrams.
What is the relationship between the angle at which the Sun shines and the amount and intensity of light?

The more directly the Sun shines on any part of Earth, the lighter and hotter it is. When the Sun shines at a slant, its rays are more spread out. There is less light and it is cooler. Midday is hottest because that is when the Sun shines most directly on us.

(Draw and label a diagram of the Sun shining on your colony at midday and in early morning. Print these captions below the diagrams.)

| The Sun is high in the sky at midday. The direct Sun makes it hotter. | The Sun is lower in the early morning. The slanted rays make it cooler. |
Lesson Ten

Concept: The Reasons for the Seasons

Resources/Materials: Mini Textbook, pages 23 - 27
Worksheets #6C.10a, #6C.10b, and #6C.10c (student copies)
lamp with bare bulb globe

Introduction: Review how the angle of the Sun affects temperatures during any particular day. Explain that we have seasons for the same reason. As the Earth revolves around the Sun, the Sun shines on it more directly at some times than at others. This is the reason we have seasons.

1. Recall that direct sunlight is more intense than slanted rays.

2. Dim the lights. Place the lamp on the table. The bulb represents the Sun. About 80 cm from the bulb, place the globe so that our area faces the Sun, as in summer. Move the globe in a counterclockwise path around the Sun. Do this slowly so that you can point out the gradual change in the directness with which the Sun hits our part of the Earth. Stop at wintertime and show how the rays shining on our part of the Earth are very slanted. Note that in winter the North Pole receives very little light, while in summer it receives light almost 24 hours.


4. Use the Mini Textbook, pages 26 and 27 to further explain how the Sun’s position affects seasonal differences and also to familiarize students with the vocabulary associated with the Sun’s position at various times of the year.

5. Distribute Worksheets #6C.10a, #6C.10b, and #6C.10c. Go over the directions, if necessary.

Assignments:

1. Read Mini Textbook, pages 23 – 27.
2. Do Worksheets #6C.10a, #6C.10b, and #6C.10c.
Directions: Below is a diagram of the Earth as it travels around the Sun. Label the positions of the Earth as follows: *Summer Solstice, Winter Solstice, Autumn Equinox, Vernal Equinox.*

At what two times of the year is the Earth farthest from the Sun? __________________________

______________________________________________________________

At what two times of the year is the Earth closest to the Sun? __________________________

______________________________________________________________
**Directions:** Read the article below. Then use the information to fill in the chart on Worksheet #6C.10c.

**The Seasons**

The tilt of the Earth as it revolves around the Sun has a lot to do with the reason we have seasons. It takes the Earth 365 days or one year to make one complete orbit around the Sun. The Earth moves in a counterclockwise direction as it makes its way around the Sun. During time our part of the Earth goes through each of the seasons.

**Summer Solstice**

The Summer Solstice takes place on or about June 21 each year. It is the first day of summer. The Sun is shining directly on the Tropic of Cancer, just north of the equator. In our part of the world the Sun is about 60° above the horizon. That means that we are getting a lot of the direct rays of the Sun and that temperatures will be high for the next several weeks. The Summer Solstice is the time when the days are the longest and the nights are the shortest. After June 21, the days gradually get a little shorter and the nights a little longer. The Summer Solstice is one of two times when the Earth is farthest from the Sun.

**Autumn Equinox**

The Autumn Equinox occurs on or about September 22 each year. It marks the first day of autumn. It is at this time that the Sun is shining directly on the equator. People in our part of the world see that it is about 36° above the horizon, making it lower in the sky than in the middle of summer. This is one of the two times in the year when the Earth is closest to the Sun. As the autumn equinox approaches the temperatures gradually get cooler. The days and nights are about equal in length about this time of year.

**Winter Solstice**

December 21 is the first official day of winter, and is called the Winter Solstice. About this time the days are shortest and the nights are longest. This day is one of two days in the year when the Earth is farthest from the Sun. At this time the Sun is shining directly on the Tropic of Capricorn, which is just south of the equator. In our area you will see that the Sun is very low in the sky, only about 13° above the horizon. You will notice that the temperatures have been getting cooler since the Autumn Equinox and they will continue to get colder for the next several weeks.

**Vernal (Spring) Equinox**

As winter passes, the days gradually get longer and the night shorter until the lengths of the day and night are equal. This is the Vernal Equinox, March 21of each year. It marks the first official day of spring. After this date, the days get longer and the nights shorter. The temperatures gradually get higher too, helping plants to grow and make the countryside green. Compared to the Winter Solstice, the Sun is now higher in the sky, about 36° above the horizon.
Directions: Use the article on Worksheet #6C.10b to complete the chart below.

<table>
<thead>
<tr>
<th></th>
<th>Date</th>
<th>Begins Which Season?</th>
<th>Angle of Sun above Horizon</th>
<th>Lengths of Day and Night</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer Solstice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autumn Equinox</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter Solstic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vernal Equinox</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Directions: Below is a diagram of the Earth as it travels around the Sun. Label the positions of the Earth as follows: **Summer Solstice, Winter Solstice, Autumn Equinox, Vernal Equinox.**

At what two times of the year is the Earth farthest from the Sun? **Summer and winter solstices**

At what two times of the year is the Earth closest to the Sun? **Vernal and autumn equinoxes**
**The Seasons**

**Directions:** Use the article on Worksheet #6C.10b to complete the chart below.

<table>
<thead>
<tr>
<th>Date</th>
<th>Begins Which Season?</th>
<th>Angle of Sun above Horizon</th>
<th>Lengths of Day and Night</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summer Solstice</strong></td>
<td>June 21</td>
<td>summer</td>
<td>60°</td>
<td>longest day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>shortest night</td>
<td></td>
</tr>
<tr>
<td><strong>Autumn Equinox</strong></td>
<td>September 22</td>
<td>autumn</td>
<td>36°</td>
<td>equal day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and night</td>
<td></td>
</tr>
<tr>
<td><strong>Winter Solstice</strong></td>
<td>December 21</td>
<td>winter</td>
<td>13°</td>
<td>shortest day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>longest night</td>
<td></td>
</tr>
<tr>
<td><strong>Vernal Equinox</strong></td>
<td>March 21</td>
<td>spring</td>
<td>36°</td>
<td>equal day</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and night</td>
<td></td>
</tr>
</tbody>
</table>
Lesson Eleven

Concept: Review of the Seasons

Resources/Materials: Worksheets #6C.11a, #6C.11b, and #6C.11c (student copies) lamp with bare bulb globe

Introduction: Start the lesson with an oral review:

- How long does it take the Earth to rotate once on its axis? (1 day or 24 hours)
- How long does it take the Earth to revolve once around the Sun? (1 year or 365 ¼ days)
- What is the name of the path the Earth takes around the Sun? (orbit)
- What is the shape of Earth’s orbit around the Sun? (ellipse)
- What is the time of year when the day is longest and the night shortest? (Summer Solstice)
- What are two times of the year when lengths of days and nights are equal? (Autumnal and Vernal Equinox)
- Why is it that the Sun’s rays shine more directly on our part of the Earth during summer compared to the winter? (Earth is tilted.)

Explain that today, we will review the reasons for the seasons.

Procedure:

1. Use the lamp, globe, and any of the transparencies of the Worksheets from Lesson Ten to review the causes of the seasons. Be sure to emphasize two factors:
   - The tilt of the Earth causes the angle at which the Sun hits our part of the Earth to be more direct in summer than in winter. This affects the temperatures.
   - The tilt of the Earth causes the number of daylight hour to vary during the year. In summer, the Sun “rises” in the northeast and “sets” in the northwest; it stays light for more than 16 hours a day. In winter, the number of daylight hours is only about 8 hours or less. Because the Sun shines longer on us in summer, it has greater opportunity to warm the air and land and temperatures are higher.

   For the Teacher
   The Summer Solstice is the longest day of the year, but it is not necessarily the hottest. This is because the atmosphere around the Earth acts like an insulator and retains heat. On June 21st we receive the maximum amount of sunlight. As the Sun proceeds southward, the amount of sunlight we get grows less, but the amount of heat we are losing into space is still less than the amount we receive. Therefore, we have a net gain in heat and the temperature goes up. This opposite in true in winter.

2. Distribute Worksheets #6C.11a, #6C.11b, and #6C.11c. Go over the directions, if necessary.

Assignment:

Do Worksheets #6C.11a, #6C.11b, and #6C.11c.
Directions: Do these questions that have to do with the seasons.

1. Suzanne calculated the average amount of daylight there was in Alberta for each month. She summarized her findings in the table below. Make a bar graph showing the information.

<table>
<thead>
<tr>
<th>Month</th>
<th>Average Amount of Daylight (hr)</th>
<th>Month</th>
<th>Average Amount of Daylight (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>17</td>
<td>January</td>
<td>7</td>
</tr>
<tr>
<td>August</td>
<td>14</td>
<td>February</td>
<td>9</td>
</tr>
<tr>
<td>September</td>
<td>12</td>
<td>March</td>
<td>12</td>
</tr>
<tr>
<td>October</td>
<td>9</td>
<td>April</td>
<td>14</td>
</tr>
<tr>
<td>November</td>
<td>7</td>
<td>May</td>
<td>17</td>
</tr>
<tr>
<td>December</td>
<td>6</td>
<td>June</td>
<td>19</td>
</tr>
</tbody>
</table>

(Title)

Worksheet #6C.11a
2. Examine the graph below. It shows the average amount of daylight in the Province of Alberta. Then answer the questions.

![Bar graph showing average amount of daylight by month]

a. During what season are the days the shortest? ________________________________

b. During what season are the nights the longest? ________________________________

c. During which seasons are the days the longest and nights the shortest?
   - winter and summer
   - winter and fall
   - summer and spring
   - summer and winter

3. Look at the diagrams. Which one shows the apparent path of the Sun in the middle of December?

a. ![Diagram a]

b. ![Diagram b]

c. ![Diagram c]

d. ![Diagram d]
4. The diagram and table show how the length of the day changes from season to season. Examine them and then answer the questions.

<table>
<thead>
<tr>
<th>Hours of light for different positions of Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
</tr>
<tr>
<td>13</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>13</td>
</tr>
</tbody>
</table>

a. Write the hours of daylight for each time of year.

<table>
<thead>
<tr>
<th>Time of Year</th>
<th>Hours of Daylight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Winter</td>
<td></td>
</tr>
<tr>
<td>Late Winter</td>
<td></td>
</tr>
<tr>
<td>Mid Spring</td>
<td></td>
</tr>
<tr>
<td>Early Summer</td>
<td></td>
</tr>
<tr>
<td>Late Summer</td>
<td></td>
</tr>
<tr>
<td>Mid Fall</td>
<td></td>
</tr>
</tbody>
</table>

b. The longest day of the year has 16 hours of light. From the information above, you can infer that the amount of light in early spring would be
   - 16 hours
   - 14 hours
   - 12 hours
   - 10 hours

c. About how many hours of daylight will there be in the late fall?
   - 9 hours
   - 14 hours
   - 12 hours
   - 11 hours
**Directions:** Do these questions that have to do with the seasons.

1. Suzanne calculated the average amount of daylight there was in Alberta for each month. She summarized her findings in the table below. Make a bar graph showing the information.

<table>
<thead>
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<td>June</td>
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</tr>
</tbody>
</table>

![Bar Graph](image)
2. Examine the graph below. It shows the average amount of daylight in the Province of Alberta. Then answer the questions.

   ![Bar Graph with Days of Daylight](image)

   **Average amount of daylight (hr)**

   ![Months](chart)

   a. During what season are the days the shortest? **winter**

   b. During what season are the nights the longest? **winter**

   c. During which seasons are the days the longest and nights the shortest?

   - winter and summer
   - winter and fall
   - summer and spring
   - summer and winter

3. Look at the diagrams. Which one shows the apparent path of the Sun in the middle of December?

   ![Diagram A](image)

   ![Diagram B](image)

   ![Diagram C](image)

   ![Diagram D](image)
4. The diagram and table show how the length of the day changes from season to season. Examine them and then answer the questions.

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<tr>
<td>13</td>
</tr>
</tbody>
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a. Write the hours of daylight for each time of year.

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</tr>
<tr>
<td>Mid Spring</td>
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</tr>
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<td>Late Summer</td>
<td>13</td>
</tr>
<tr>
<td>Mid Fall</td>
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</tr>
</tbody>
</table>

b. The longest day of the year has 16 hours of light. From the information above, you can infer that the amount of light in early spring would be
   - 16 hours
   - 14 hours
   - 12 hours
   - 10 hours

c. About how many hours of daylight will there be in the late fall?
   - 9 hours
   - 14 hours
   - 12 hours
   - 11 hours
Lesson Twelve

Concept: Sky Science, Part I Review

Resources/Materials: Oral Review (Worksheets #6C.12a and #6C.12b – teacher copy)
Sky Science, Part I Review Sheets (student copies)

Introduction: Explain that first section of the unit called “Sky Science” is now complete and it is time to prepare for a test.

Procedure:

1. If you have the time, use the outline on Worksheet #6C.12 to conduct an oral review of this part of the unit.


3. Check the Review Sheets as a class, if possible.

Assignment:

Do the Sky Science, Part I Review Sheets.
A. Sources Versus Reflectors of Light

- Moon (R)
- asteroid (R)
- stars (S)
- comet (R)
- Earth (R)
- meteor (S)
- Jupiter (R)
- Sun (S)

B. Basic Facts

1. number of planets in the solar system (8)
2. Earth’s natural satellite (Moon)
3. galaxy (cluster of stars)
4. constellation (group of stars that forms a pattern)
5. meteoroid (small solid body from outer space)
6. meteor (meteoroid that has entered the Earth’s atmosphere)
7. meteorite (meteoroid that has reached the Earth’s surface)
8. Milky Way (galaxy of which our Sun is part)
9. one day (time it takes for a planet to rotate once; on Earth this is 24 hours)
10. one year (time it takes for a planet to orbit the Sun once; on Earth this is 365¼ days)
11. celestial body (any body in space)
12. smallest planet (Mercury)
13. largest planet (Jupiter)
14. orbit (path on which a planet travels around the Sun; Earth’s is elliptical in shape)
15. star map (shows location of the start)
16. summer constellation (can only be seen during the summer)
C. **Seasons**

1. Direct sunlight versus slanted rays (direct rays are more intense – provide more light and heat)

2. Why shadow length changes throughout the day (Earth is tilted and rotates – Sun hits any particular location at a slant during the first and last parts of the day. Midday – shines most directly)

3. Why there are seasons (Earth is tilted and also revolves around Sun. During summer Sun shines most directly on our part of the Earth. During winter Sun is low in the sky, shining at a greater angle)

4. Summer solstice (June 21). Earth is farthest from Sun. Days are longest, nights shortest.

5. Winter solstice (December 21). Earth is farthest from Sun. Nights are longest, days shortest.

6. Vernal equinox (March 21). Earth is closest to Sun. Day and night are equal in length.

7. Autumn equinox (September 21). Earth is closest to Sun. Day and night equal.

D. **The Sun**

1. Safety rules for viewing (do not look directly at Sun. Use a projection device or #14 welding goggles.

2. What we get from the Sun. (light and heat. No living thing can survive without Sun)

3. What account for the Sun’s brightness? (thermonuclear reactions)

4. What is the Sun made of? (gases)

E. **Stars**

1. Why constellations appear to change position during the year (has to do with Earth revolving around the Sun)

2. The Milky Way (spiral galaxy, of which our Sun is a part)

3. Ursa Major and Ursa Minor (two easily recognizable constellations; also known as Big Dipper and Little Dipper)
1. Write **source** if the celestial body is a source of light. Write **reflects** if the celestial body reflects light.

   Sun  Venus
   Earth  comet
   Moon  asteroid
   star  Polaris
   constellation  Jupiter

2. Match the words with their meanings.

<table>
<thead>
<tr>
<th>meteorite</th>
<th>Sun</th>
<th>Moon</th>
<th>constellation</th>
<th>orbit</th>
</tr>
</thead>
<tbody>
<tr>
<td>galaxy</td>
<td>Milky Way</td>
<td>Ursa Major</td>
<td>meteoroid</td>
<td>year</td>
</tr>
<tr>
<td>day</td>
<td>solar system</td>
<td>Jupiter</td>
<td>Mercury</td>
<td>meteor</td>
</tr>
</tbody>
</table>

| a small solid body found in outer space |
| the smallest planet |
| a group of stars that form a pattern |
| a cluster of stars |
| the star closest to Earth |
| the path on which a planet travels around the Sun |
| a natural satellite of Earth |
| the largest planet |
| our sun is part of this galaxy |
| the time it takes the Earth to rotate on its axis one time |
| the time it takes the Earth to revolve around the Sun one time |
| a meteoroid that enters Earth’s atmosphere |
| a meteor that lands on the Earth’s surface |
the Sun, the planets and their moons, and other smaller celestial bodies

a constellation also known as the Big Dipper

Use the following information to answer questions 3 and 4.

At 10:00 P.M., you notice the constellation of the Big Dipper and the star Polaris. When you wake up at midnight, you notice that the Big Dipper appears to have moved.

3. The reason the Big Dipper appears to have moved is that

a. the stars randomly change their positions.
b. the Moon’s gravity causes the stars to change their positions.
c. Earth tilts closer to the Sun as it rotates during the night.
d. Earth rotates on its axis as it revolves around the Sun.

4. At 2:00 a.m., the position of the Big Dipper would be

a. 

b. 

c. 

d. 
5. In the morning, you would observe the Sun rising in the 
   a. north.
   b. east.
   c. south.
   d. west.

6. The constellation Orion is called a *winter constellation* because 
   a. winter is the only time when it is visible.
   b. it reminds people of a winter scene.
   c. it reflects sunlight during the winter.
   d. it is closer to the Sun in winter.

7. What is a star map?

8. Why do the constellations appear to change positions in the night sky as the seasons change?

9. What two things from the Sun do living things on Earth need to survive?
   a. 
   b. 

10. What accounts for the Sun’s brightness?
11. What is the Sun made of?

12. What is a solar wind?

13. Answer true or false.

- _______ A sundial was a device used to tell time in ancient Egypt and China.
- _______ The Sun is part of a galaxy called *The Milky Way*.
- _______ The Moon reflects light from the Sun.
- _______ Shadows are long in the morning and gradually get shorter until the Sun sets.
- _______ Most meteors land on the Earth’s surface.
- _______ The Sun strikes the Earth at a 60° angle in early summer.
- _______ When it is summer in Canada, it is winter in Australia.
- _______ At the North Pole it is daylight 24 hours a day during the winter solstice.
- _______ The angle of the Sun above the horizon changes from season to season partly because of the fact that the Sun is revolving around the Earth.
14. An observation that can be based on the data in Suzanne’s graph is that in Alberta
   a. shadows are longer in the winter than in the summer.
   b. shadows are shorter in the winter than in the summer.
   c. there are more hours of daylight in the fall and winter than in the spring and summer.
   d. there are more hours of daylight in the spring and summer than in the fall and winter.

15. From the graph you can infer that there are about 12 hours of daylight during the
   a. summer solstice.
   b. winter solstice.
   c. vernal equinox.
   d. entire year.

16. It is warmer during the summer than in the winter because
   a. the Sun is higher up in the sky during the summer.
   b. the Sun is lower in the sky during the summer.
   c. the Sun’s rays are more slanted during the summer.
   d. there are more hours of sunlight during the winter.
17. Shadows are shortest when

- the Sun is just coming up.
- the sun is just setting.
- it is mid-morning.
- the Sun is highest in the sky.

*Use the following information to answer questions 18 and 19.*

Natalie also has a graph that she constructed to show how the length of a shadow changes throughout a sunny day.

**Shadow Length During the Day**

<table>
<thead>
<tr>
<th>Time of day</th>
<th>Shadow length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00 A.M.</td>
<td>140</td>
</tr>
<tr>
<td>11:00 A.M.</td>
<td>160</td>
</tr>
<tr>
<td>12:00 P.M.</td>
<td>120</td>
</tr>
<tr>
<td>1:00 P.M.</td>
<td>140</td>
</tr>
<tr>
<td>2:00 P.M.</td>
<td>180</td>
</tr>
<tr>
<td>3:00 P.M.</td>
<td>180</td>
</tr>
</tbody>
</table>

18. Natalie predicted the length of the shadow at 3:00 p.m. would be

- a. 140 mm.
- b. 160 mm.
- c. 170 mm.
- d. 180 mm.

19. Natalie predicted the length of the shadow at 9:00 a.m. would be

- a. 140 mm.
- b. 160 mm.
- c. 170 mm.
- d. 180 mm.
For her display, Suzanne measured and recorded the shadows that were produced by a shadow stick on a particular day.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of Shadow</th>
<th>Time of Day</th>
<th>Length of Shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30 A.M.</td>
<td>470 cm</td>
<td>12:30 P.M.</td>
<td>76 cm</td>
</tr>
<tr>
<td>8:00 A.M.</td>
<td>300 cm</td>
<td>1:00 P.M.</td>
<td>70 cm</td>
</tr>
<tr>
<td>8:30 A.M.</td>
<td>240 cm</td>
<td>1:30 P.M.</td>
<td>54 cm</td>
</tr>
<tr>
<td>9:00 A.M.</td>
<td>204 cm</td>
<td>2:00 P.M.</td>
<td>34 cm</td>
</tr>
<tr>
<td>9:30 A.M.</td>
<td>142 cm</td>
<td>2:30 P.M.</td>
<td>69 cm</td>
</tr>
<tr>
<td>10:00 A.M.</td>
<td>135 cm</td>
<td>3:30 P.M.</td>
<td>90 cm</td>
</tr>
<tr>
<td>11:00 A.M.</td>
<td>102 cm</td>
<td>4:30 P.M.</td>
<td>160 cm</td>
</tr>
<tr>
<td>11:30 A.M.</td>
<td>84 cm</td>
<td>6:00 P.M.</td>
<td>293 cm</td>
</tr>
<tr>
<td>12:00 P.M.</td>
<td>80 cm</td>
<td>7:30 P.M.</td>
<td>360 cm</td>
</tr>
</tbody>
</table>

20. According to the table, at what time was the Sun highest in the sky? ____________

21. You can infer that the shadow was so long at 7:30 A.M. because ________________

22. Which of the following graphs illustrates the data in the chart?

a. ![Graph A](image)

b. ![Graph B](image)

c. ![Graph C](image)

d. ![Graph D](image)
23. Use the information in the table below. Make a line graph showing this data. Be sure to include a title and to label the x-axis and the y-axis.

**Shadow Length**

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Shadow Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 A.M.</td>
<td>500</td>
</tr>
<tr>
<td>10:00 A.M.</td>
<td>400</td>
</tr>
<tr>
<td>11:00 A.M.</td>
<td>250</td>
</tr>
<tr>
<td>12:00 Noon</td>
<td>150</td>
</tr>
<tr>
<td>1:00 P.M.</td>
<td>250</td>
</tr>
<tr>
<td>2:00 P.M.</td>
<td>400</td>
</tr>
</tbody>
</table>

Use the information below to answer question 24.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of the Sundial’s Shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00</td>
<td>80 cm</td>
</tr>
<tr>
<td>10:00</td>
<td>70 cm</td>
</tr>
<tr>
<td>11:00</td>
<td>50 cm</td>
</tr>
<tr>
<td>12:00</td>
<td>40 cm</td>
</tr>
<tr>
<td>13:00</td>
<td>50 cm</td>
</tr>
<tr>
<td>14:00</td>
<td>?</td>
</tr>
<tr>
<td>15:00</td>
<td>?</td>
</tr>
</tbody>
</table>

24. Predict the length of the shadow cast by the sundial at 15:00. ______________________
25. Match each time of the year with the date. (Draw lines.)

- Vernal equinox: March 21
- Winter solstice: June 21
- Autumn equinox: December 21
- Summer solstice: September 21

26. On the diagram below label each of the times and dates used in question 25.
1. Write **source** if the celestial body is a source of light. Write **reflects** if the celestial body reflects light.

- **source** Sun
- **reflects** Venus
- **reflects** Earth
- **reflects** comet
- **reflects** Moon
- **reflects** asteroid
- **source** star
- **source** Polaris
- **source** constellation
- **reflects** Jupiter

2. Match the words with their meanings.

<table>
<thead>
<tr>
<th>meteorite</th>
<th>Sun</th>
<th>Moon</th>
<th>constellation</th>
<th>orbit</th>
</tr>
</thead>
<tbody>
<tr>
<td>galaxy</td>
<td>Milky Way</td>
<td>Ursa Major</td>
<td></td>
<td></td>
</tr>
<tr>
<td>day</td>
<td>solar system</td>
<td>Jupiter</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **meteoroid** a small solid body found in outer space
- **Mercury** the smallest planet
- **constellation** a group of stars that form a pattern
- **galaxy** a cluster of stars
- **Sun** the star closest to Earth
- **orbit** the path on which a planet travels around the Sun
- **Moon** a natural satellite of Earth
- **Jupiter** the largest planet
- **The Milky Way** our sun is part of this galaxy
- **day** the time it takes the Earth to rotate on its axis one time
- **year** the time it takes the Earth to revolve around the Sun one time
- **meteor** a meteoroid that enters Earth’s atmosphere
- **meteorite** a meteor that lands on the Earth’s surface
solar system the Sun, the planets and their moons, and other smaller celestial bodies

Ursa Major a constellation also known as the Big Dipper

Use the following information to answer questions 3 and 4.

At 10:00 P.M., you notice the constellation of the Big Dipper and the star Polaris. When you wake up at midnight, you notice that the Big Dipper appears to have moved.

3. The reason the Big Dipper appears to have moved is that

a. the stars randomly change their positions.
b. the Moon's gravity causes the stars to change their positions.
c. Earth tilts closer to the Sun as it rotates during the night.
d. Earth rotates on its axis as it revolves around the Sun.

4. At 2:00 a.m., the position of the Big Dipper would be

(a) (b) (c) (d)
5. In the morning, you would observe the Sun rising in the
   a. north.
   b. east.
   c. south.
   d. west.

6. The constellation Orion is called a *winter constellation* because
   a. winter is the only time when it is visible.
   b. it reminds people of a winter scene.
   c. it reflects sunlight during the winter.
   d. it is closer to the Sun in winter.

7. What is a star map?
   
   map showing locations of the stars

8. Why do the constellations appear to change positions in the night sky as the seasons change?
   
   Earth revolves around Sun

9. What two things from the Sun do living things on Earth need to survive?
   a. heat
   b. light

10. What accounts for the Sun’s brightness?
    
    thermonuclear reactions (fusion)
11. What is the Sun made of?

\[ \text{gases} \rightarrow \frac{3}{4} \text{hydrogen} \frac{1}{4} \text{helium} \]

70 other elements make up about 2%.

12. What is a solar wind?

Continuous flow of gases from Sun.

13. Answer **true** or **false**.

- **T** A sundial was a device used to tell time in ancient Egypt and China.
- **T** The Sun is part of a galaxy called *The Milky Way*.
- **T** The Moon reflects light from the Sun.
- **F** Shadows are long in the morning and gradually get shorter until the Sun sets.
- **F** Most meteors land on the Earth’s surface.
- **T** The Sun strikes the Earth at a 60° angle in early summer.
- **T** When it is summer in Canada, it is winter in Australia.
- **F** At the North Pole it is daylight 24 hours a day during the winter solstice.
- **F** The angle of the Sun above the horizon changes from season to season partly because of the fact that the Sun is revolving around the Earth.
14. An observation that can be based on the data in Suzanne’s graph is that in Alberta
   a. shadows are longer in the winter than in the summer.
   b. shadows are shorter in the winter than in the summer.
   c. there are more hours of daylight in the fall and winter than in the spring and summer.
   d. there are more hours of daylight in the spring and summer than in the fall and winter.

15. From the graph you can infer that there are about 12 hours of daylight during the
   a. summer solstice.
   b. winter solstice.
   c. vernal equinox.
   d. entire year.

16. It is warmer during the summer than in the winter because
   a. the Sun is higher up in the sky during the summer.
   b. the Sun is lower in the sky during the summer.
   c. the Sun’s rays are more slanted during the summer.
   d. there are more hours of sunlight during the winter.
17. Shadows are shortest when
   a. the Sun is just coming up.
   b. the sun is just setting.
   c. it is mid-morning.
   d. the Sun is highest in the sky.

Use the following information to answer questions 18 and 19.

Natalie also has a graph that she constructed to show how the length of a shadow changes throughout a sunny day.

![Shadow Length During the Day graph]

18. Natalie predicted the length of the shadow at 3:00 p.m. would be
   a. 140 mm.
   b. 160 mm.
   c. 170 mm.
   d. 180 mm.

19. Natalie predicted the length of the shadow at 9:00 a.m. would be
   a. 140 mm.
   b. 160 mm.
   c. 170 mm.
   d. 180 mm.
For her display, Suzanne measured and recorded the shadows that were produced by a shadow stick on a particular day.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of Shadow</th>
<th>Time of Day</th>
<th>Length of Shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30 A.M.</td>
<td>470 cm</td>
<td>12:30 P.M.</td>
<td>76 cm</td>
</tr>
<tr>
<td>8:00 A.M.</td>
<td>300 cm</td>
<td>1:00 P.M.</td>
<td>70 cm</td>
</tr>
<tr>
<td>8:30 A.M.</td>
<td>240 cm</td>
<td>1:30 P.M.</td>
<td>54 cm</td>
</tr>
<tr>
<td>9:00 A.M.</td>
<td>204 cm</td>
<td>2:00 P.M.</td>
<td>34 cm</td>
</tr>
<tr>
<td>9:30 A.M.</td>
<td>142 cm</td>
<td>2:30 P.M.</td>
<td>69 cm</td>
</tr>
<tr>
<td>10:00 A.M.</td>
<td>135 cm</td>
<td>3:30 P.M.</td>
<td>90 cm</td>
</tr>
<tr>
<td>11:00 A.M.</td>
<td>102 cm</td>
<td>4:30 P.M.</td>
<td>160 cm</td>
</tr>
<tr>
<td>11:30 A.M.</td>
<td>84 cm</td>
<td>6:00 P.M.</td>
<td>293 cm</td>
</tr>
<tr>
<td>12:00 P.M.</td>
<td>80 cm</td>
<td>7:30 P.M.</td>
<td>360 cm</td>
</tr>
</tbody>
</table>

20. According to the table, at what time was the Sun highest in the sky? **2:00 P.M.**

21. You can infer that the shadow was so long at 7:30 A.M. because **Sun’s rays shining at greatest slant**

22. Which of the following graphs illustrates the data in the chart?

   a. [Graph a]
   b. [Graph b]
   c. [Graph c]
   d. [Graph d]
23. Use the information in the table below. Make a line graph showing this data. Be sure to include a **title** and to label the **x-axis** and the **y-axis**.

**Shadow Length**

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Shadow Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:00 A.M.</td>
<td>500</td>
</tr>
<tr>
<td>10:00 A.M.</td>
<td>400</td>
</tr>
<tr>
<td>11:00 A.M.</td>
<td>250</td>
</tr>
<tr>
<td>12:00 Noon</td>
<td>150</td>
</tr>
<tr>
<td>1:00 P.M.</td>
<td>250</td>
</tr>
<tr>
<td>2:00 P.M.</td>
<td>400</td>
</tr>
</tbody>
</table>

**Use the information below to answer question 24.**

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of the Sundial’s Shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00</td>
<td>80 cm</td>
</tr>
<tr>
<td>10:00</td>
<td>70 cm</td>
</tr>
<tr>
<td>11:00</td>
<td>50 cm</td>
</tr>
<tr>
<td>12:00</td>
<td>40 cm</td>
</tr>
<tr>
<td>13:00</td>
<td>50 cm</td>
</tr>
<tr>
<td>14:00</td>
<td>?</td>
</tr>
<tr>
<td>15:00</td>
<td>?</td>
</tr>
</tbody>
</table>

24. Predict the length of the shadow cast by the sundial at 15:00. **80 cm**
25. Match each time of the year with the date. (Draw lines.)

- vernal equinox → March 21
- winter solstice → June 21
- autumn equinox → December 21
- summer solstice → September 21

26. On the diagram below label each of the times and dates used in question 25.
Lesson Thirteen

Concept: Sky Science, Part I Test

Resources/Materials: Sky Science, Part I Test (student copies)
1. Write the words in the box in the correct places in the chart.

<table>
<thead>
<tr>
<th>Moon stars</th>
<th>moons</th>
<th>planets</th>
<th>Earth</th>
<th>Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>asteroid</td>
<td></td>
<td>comet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sources of Light</th>
<th>Reflectors of Light</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Answer **true** or **false**.

- _______ The Sun is a star.
- _______ There are ten planets in our solar system.
- _______ A group of stars clustered together is called a meteorite.
- _______ The Moon is a natural satellite of Earth.
- _______ It takes 365 days for Earth to spin on its axis once.
- _______ It takes 365 days for Earth to revolve around the Sun one time.
- _______ Our Sun is part of a galaxy called *The Milky Way*.
- _______ Meteoroids are small solid bodies from outer space.
- _______ Most meteors land on the Earth’s surface.
- _______ The Moon is a source of light.
3. Write the letters of the words and phrases beside their meanings.

<table>
<thead>
<tr>
<th>a. constellation</th>
<th>b. orbit</th>
<th>c. meteorite</th>
</tr>
</thead>
<tbody>
<tr>
<td>d. celestial body</td>
<td>e. galaxy</td>
<td>f. year</td>
</tr>
<tr>
<td>g. day</td>
<td>h. meteor</td>
<td>i. Jupiter</td>
</tr>
<tr>
<td>j. Mercury</td>
<td>k. satellite</td>
<td>l. solar system</td>
</tr>
</tbody>
</table>

_____ the path a planet travels around the Sun
_____ the Sun and its eight planets, their moons, and several other bodies
_____ a group of stars that appear to form a pattern
_____ the largest planet
_____ the amount of time it takes for Earth the rotate once on its axis
_____ the smallest planet
_____ a cluster of stars
_____ a meteoroid that has entered Earth’s atmosphere
_____ the time it takes for a planet to travel around the Sun one time
_____ a meteor that has reached Earth’s surface
_____ a body found in space
_____ a body that revolves around another

4. You know that Venus is visible in the night sky because it

a. reflects light.
b. refracts light.
c. emits light.
d. produces light.

5. The Sun is part of a galaxy known as

a. Ursa Minor.
b. the solar system.
c. the Milky Way.
d. aurora borealis.
A 10:00 P.M. you notice that the constellation of the Big Dipper and the star Polaris. When you wake up at midnight, you notice that the Big Dipper appears to have moved.

6. The reason that the Big Dipper appears to have moved is that the
   a. stars randomly change their positions.
   b. Moon's gravity causes the stars to change their positions.
   c. Earth tilts closer to the Sun as it revolves during the night.
   d. Earth rotates on its axis as it revolves around the Sun.

7. At 2:00 A.M., the position of the Big Dipper would be
   a.  
   b.  
   c.  
   d.  

Use the following information to answer question 8.

Jacob displayed a drawing of the constellation Orion.

8. Orion is called a “winter constellation” because

   a. winter is the time of year when it is closest to the North Star.
   b. it is at its lowest position in the sky during the winter.
   c. winter is the only time when it is visible.
   d. it reflects sunlight during the winter.

9. What is a star map?

   ________________________________
   ________________________________

10. In your own words explain why the constellations appear to change positions in the night sky as the seasons change.

   ________________________________
   ________________________________
   ________________________________
   ________________________________
   ________________________________
   ________________________________


Jason points out the Big Dipper. He explains that the position of the Big Dipper changes throughout the year. Its position at midnight in the June night sky is shown below.

11. Which of the following diagrams illustrates the position of the Big Dipper at midnight in the December night sky?

a. 

b. 

c. 

d. 
12. Why do living things on Earth need the Sun?

_____________________________________________________________

_____________________________________________________________

13. What accounts for the Sun’s brightness?

_____________________________________________________________

_____________________________________________________________

14. What is the Sun made of?

_____________________________________________________________

_____________________________________________________________

15. What is a solar wind?

_____________________________________________________________

_____________________________________________________________

16. Why is it dangerous to look directly at the Sun with the naked eye?

_____________________________________________________________

_____________________________________________________________

17. The length of a shadow changes throughout the day because of the:

a. movement of the Sun.
b. rotation of the Earth on its axis.
c. revolution of the Earth around the Sun.
d. tilt of the Earth on its axis.
Use the following information to answer question 18.

**Shadow Length During the Day**

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of Shadow (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00 A.M.</td>
<td>177</td>
</tr>
<tr>
<td>11:20 A.M.</td>
<td>164</td>
</tr>
<tr>
<td>11:40 A.M.</td>
<td>154</td>
</tr>
<tr>
<td>12:00 Noon</td>
<td>146</td>
</tr>
<tr>
<td>12:20 P.M.</td>
<td>141</td>
</tr>
<tr>
<td>12:40 P.M.</td>
<td>138</td>
</tr>
<tr>
<td>1:00 P.M.</td>
<td>137</td>
</tr>
<tr>
<td>1:20 P.M.</td>
<td>138</td>
</tr>
<tr>
<td>1:40 P.M.</td>
<td>140</td>
</tr>
<tr>
<td>2:00 P.M.</td>
<td>145</td>
</tr>
<tr>
<td>2:20 P.M.</td>
<td>152</td>
</tr>
<tr>
<td>2:40 P.M</td>
<td>161</td>
</tr>
</tbody>
</table>

18. Use the information in the table above to make a line graph. Be sure to give you graph a title and to label both the x-axis and the y-axis.

(Title)
Throughout the day, Natalie had measured the length of her shadow and made the following graph.

19. Natalie observed that she cast the shortest shadow at noon. She concluded that the reason for this was that the

a. season is winter.
b. Sun is lower in the sky.
c. Sun is high in the sky.
d. sky is cloudy.

20. Henri made the following chart and explained that the length of a shadow cast by a sundial changes during the day.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of the Sundial's Shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00</td>
<td>80 cm</td>
</tr>
<tr>
<td>10:00</td>
<td>70 cm</td>
</tr>
<tr>
<td>11:00</td>
<td>50 cm</td>
</tr>
<tr>
<td>12:00</td>
<td>40 cm</td>
</tr>
<tr>
<td>13:00</td>
<td>50 cm</td>
</tr>
<tr>
<td>14:00</td>
<td>?</td>
</tr>
<tr>
<td>15:00</td>
<td>?</td>
</tr>
</tbody>
</table>

Look at the table above. Predict the length of the shadow at 16:00. _____________________________
Use the following information to answer question 21.

Suzanne is preparing the following graph about the average amount of daylight in Alberta.

21. An observation that can be based on the data in Suzanne’s graph is that
   a. shadows are longer in the winter than in the summer.
   b. shadows are shorter in the winter than in the summer.
   c. there are more hours of daylight in the fall and winter than in the spring and summer.
   d. there are more hours of daylight in the spring and summer than in the fall and winter.

Use the following information to answer question 22.

<table>
<thead>
<tr>
<th>Time</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of Sunrise</td>
<td>5:29 A.M.</td>
<td>5:26 A.M.</td>
<td>5:23 A.M.</td>
<td>5:20 A.M.</td>
</tr>
<tr>
<td>Time of Sunset</td>
<td>10:17 P.M.</td>
<td>10:20 P.M.</td>
<td>10:23 P.M.</td>
<td>10:26 P.M.</td>
</tr>
</tbody>
</table>

22. From the display, you can infer that these times were recorded in the month of
   a. March.
   b. June.
   c. August.
   d. September.
23. The angle of the Sun above the horizon changes from season to season partly because of the fact that

a. Earth is tilted on its axis.
b. Earth is rotating on its axis.
c. the Sun is revolving on its axis.
d. the Sun is revolving around the Sun.

Use the following information to answer questions 24 and 25.

Natalie used information from her *Sky Science* book to make a chart and a drawing that would help her explain to Peter how the length of the day changes from season to season.

<table>
<thead>
<tr>
<th>Hours of light for different positions of Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
</tr>
<tr>
<td>13</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>13</td>
</tr>
</tbody>
</table>

24. Natalie explained that if the longest day of summer has 16 hours of light, then the amount of light in early winter would be

a. 16 hours.
b. 8 hours.
c. 12 hours.
d. 10 hours.

25. The amount of light in early fall would be

a. 16 hours.
b. 8 hours.
c. 12 hours.
d. 10 hours.
Use the information below to answer question 26.

The diagrams below illustrate the apparent path of the Sun in the daytime sky in Alberta at four different times of the year. The angle above the horizon that is noted in each diagram represents the approximate angle of the Sun at its highest point in the sky for that time of year.

26. Which of the diagrams shows the apparent path of the Sun in the middle of June?

   a. a  
   b. b  
   c. c  
   d. d

27. Label the diagram with these words: vernal equinox, autumn equinox, summer solstice, winter solstice.
1. Write the words in the box in the correct places in the chart.

<table>
<thead>
<tr>
<th>Moon stars</th>
<th>moons asteroid</th>
<th>planets comet</th>
<th>Earth Sun</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Sources of Light</th>
<th>Reflectors of Light</th>
</tr>
</thead>
<tbody>
<tr>
<td>stars Sun</td>
<td>Moon moons planets Earth asteroid comet</td>
</tr>
</tbody>
</table>

2. Answer true or false.

- T The Sun is a star.
- F There are ten planets in our solar system.
- F A group of stars clustered together is called a meteorite.
- T The Moon is a natural satellite of Earth.
- F It takes 365 days for Earth to spin on its axis once.
- T It takes 365 days for Earth to revolve around the Sun one time.
- T Our Sun is part of a galaxy called The Milky Way.
- T Meteoroids are small solid bodies from outer space.
- F Most meteors land on the Earth’s surface.
- F The Moon is a source of light.
3. Write the letters of the words and phrases beside their meanings.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. constellation</td>
<td>b. orbit</td>
<td>c. meteorite</td>
</tr>
<tr>
<td>d. celestial body</td>
<td>e. galaxy</td>
<td>f. year</td>
</tr>
<tr>
<td>g. day</td>
<td>h. meteor</td>
<td>i. Jupiter</td>
</tr>
<tr>
<td>j. Mercury</td>
<td>k. satellite</td>
<td>l. solar system</td>
</tr>
</tbody>
</table>

b. the path a planet travels around the Sun

l. the Sun and its eight planets, their moons, and several other bodies

q. a group of stars that appear to form a pattern

i. the largest planet

g. the amount of time it takes for Earth to rotate once on its axis

j. the smallest planet

c. a cluster of stars

h. a meteoroid that has entered Earth’s atmosphere

f. the time it takes for a planet to travel around the Sun one time

c. a meteor that has reached Earth’s surface

d. a body found in space

k. a body that revolves around another

4. You know that Venus is visible in the night sky because it

   a. reflects light.
   b. refracts light.
   c. emits light.
   d. produces light.

5. The Sun is part of a galaxy known as

   a. Ursa Minor.
   b. the solar system.
   c. the Milky Way.
   d. aurora borealis.
A 10:00 P.M. you notice that the constellation of the Big Dipper and the star Polaris. When you wake up at midnight, you notice that the Big Dipper appears to have moved.

6. The reason that the Big Dipper appears to have moved is that the
   a. stars randomly change their positions.
   b. Moon’s gravity causes the stars to change their positions.
   c. Earth tilts closer to the Sun as it revolves during the night.
   d. Earth rotates on its axis as it revolves around the Sun.

7. At 2:00 A.M., the position of the Big Dipper would be
   a. 
   b. 
   c. 
   d. 
Use the following information to answer question 8.

Jacob displayed a drawing of the constellation Orion.

8. Orion is called a “winter constellation” because
   a. winter is the time of year when it is closest to the North Star.
   b. it is at its lowest position in the sky during the winter.
   c. winter is the only time when it is visible.
   d. it reflects sunlight during the winter.

9. What is a star map?

   show locations of stars

10. In your own words explain why the constellations appear to change positions in the night sky as the seasons change.

   Earth revolves around Sun
Jason points out the Big Dipper. He explains that the position of the Big Dipper changes throughout the year. Its position at midnight in the June night sky is shown below.

11. Which of the following diagrams illustrates the position of the Big Dipper at midnight in the December night sky?

a. 

b. 

c. 

d. 

12. Why do living things on Earth need the Sun?

light
heat

13. What accounts for the Sun’s brightness?

thermonuclear reactions (fusion)

14. What is the Sun made of?

gases (mostly hydrogen and helium)

15. What is a solar wind?

continuous flow of gases from Sun

16. Why is it dangerous to look directly at the Sun with the naked eye?

ultraviolet rays can burn retina

17. The length of a shadow changes throughout the day because of the

a. movement of the Sun.
   b. rotation of the Earth on its axis.
   c. revolution of the Earth around the Sun.
   d. tilt of the Earth on its axis.
18. Use the information in the table above to make a line graph. Be sure to give you graph a title and to label both the x-axis and the y-axis.
19. Natalie observed that she cast the shortest shadow at noon. She concluded that the reason for this was that the

a. season is winter.
b. Sun is lower in the sky.
c. Sun is high in the sky.
d. sky is cloudy.

20. Henri made the following chart and explained that the length of a shadow cast by a sundial changes during the day.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Length of the Sundial's Shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:00</td>
<td>80 cm</td>
</tr>
<tr>
<td>10:00</td>
<td>70 cm</td>
</tr>
<tr>
<td>11:00</td>
<td>50 cm</td>
</tr>
<tr>
<td>12:00</td>
<td>40 cm</td>
</tr>
<tr>
<td>13:00</td>
<td>50 cm</td>
</tr>
<tr>
<td>14:00</td>
<td>?</td>
</tr>
<tr>
<td>15:00</td>
<td>?</td>
</tr>
</tbody>
</table>

Look at the table above. Predict the length of the shadow at 16:00. **about 90 cm**
Use the following information to answer question 21.

Suzanne is preparing the following graph about the average amount of daylight in Alberta.

21. An observation that can be based on the data in Suzanne's graph is that

a. shadows are longer in the winter than in the summer.
b. shadows are shorter in the winter than in the summer.
c. there are more hours of daylight in the fall and winter than in the spring and summer.
d. there are more hours of daylight in the spring and summer than in the fall and winter.

Use the following information to answer question 22.

<table>
<thead>
<tr>
<th>Times for Sunrise and Sunset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>Time of Sunrise</td>
</tr>
<tr>
<td>Time of Sunset</td>
</tr>
</tbody>
</table>

22. From the display, you can infer that these times were recorded in the month of

a. March.
b. June.
c. August.
d. September.
23. The angle of the Sun above the horizon changes from season to season partly because of the fact that

a. Earth is tilted on its axis.
b. Earth is rotating on its axis.
c. the Sun is revolving on its axis.
d. the Sun is revolving around the Sun.

*Use the following information to answer questions 24 and 25.*

Natalie used information from her *Sky Science* book to make a chart and a drawing that would help her explain to Peter how the length of the day changes from season to season.

<table>
<thead>
<tr>
<th>Hours of light for different positions of Earth</th>
<th>Early summer</th>
<th>Mid spring</th>
<th>Late spring</th>
<th>Late summer</th>
<th>Early fall</th>
<th>Mid fall</th>
<th>Late winter</th>
<th>Early winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>Early winter</td>
<td>Late winter</td>
<td>Early winter</td>
<td>Early winter</td>
<td>Late fall</td>
<td>Fall</td>
<td>Late winter</td>
<td>Early winter</td>
</tr>
<tr>
<td>13</td>
<td>Early summer</td>
<td>Mid spring</td>
<td>Late spring</td>
<td>Late summer</td>
<td>Early fall</td>
<td>Mid fall</td>
<td>Late winter</td>
<td>Early winter</td>
</tr>
<tr>
<td>11</td>
<td>Early summer</td>
<td>Mid spring</td>
<td>Late spring</td>
<td>Late summer</td>
<td>Early fall</td>
<td>Mid fall</td>
<td>Late winter</td>
<td>Early winter</td>
</tr>
<tr>
<td>8</td>
<td>Early summer</td>
<td>Mid spring</td>
<td>Late spring</td>
<td>Late summer</td>
<td>Early fall</td>
<td>Mid fall</td>
<td>Late winter</td>
<td>Early winter</td>
</tr>
<tr>
<td>11</td>
<td>Early summer</td>
<td>Mid spring</td>
<td>Late spring</td>
<td>Late summer</td>
<td>Early fall</td>
<td>Mid fall</td>
<td>Late winter</td>
<td>Early winter</td>
</tr>
<tr>
<td>13</td>
<td>Early summer</td>
<td>Mid spring</td>
<td>Late spring</td>
<td>Late summer</td>
<td>Early fall</td>
<td>Mid fall</td>
<td>Late winter</td>
<td>Early winter</td>
</tr>
</tbody>
</table>

24. Natalie explained that if the longest day of summer has 16 hours of light, then the amount of light in early winter would be

a. 16 hours.
b. 8 hours.
c. 12 hours.
d. 10 hours.

25. The amount of light in early fall would be

a. 16 hours.
b. 8 hours.
c. 12 hours.
d. 10 hours.
26. Which of the diagrams shows the apparent path of the Sun in the middle of June?

   a. a  
   b. b  
   c. c  
   d. d

27. Label the diagram with these words: *vernal equinox, autumn equinox, summer solstice, winter solstice.*
About Part II

Part II of Sky Science deals with the Moon, the moons of other planets, and the Earth’s fellow solar system planets. They learn more about the phases of the Moon and how it influences Earth’s ocean tides. Students do research on the moons of various other planets and write paragraphs to summarize their findings. They also learn more about the similarities and differences among the planets by reading articles about them.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Concept</th>
<th>Mini Textbook Pages</th>
<th>Hands On?</th>
<th>Non Hands On Option?</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>General Fact About the Moon</td>
<td>28 – 30</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>Phases of the Moon, Part I</td>
<td>31 – 34</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>16</td>
<td>Phases of the Moon, Part II</td>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>The Solar System</td>
<td>35 – 37</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>Facts About the Planets</td>
<td>38 – 46</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>19</td>
<td>Period of Rotation and Period of Revolution</td>
<td>47 - 48</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>20</td>
<td>Sizes of Planets</td>
<td>36 and 47</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>21</td>
<td>Moons</td>
<td>49 – 54</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>22</td>
<td>Technologies Used to Gather Information About the Universe</td>
<td>55</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>23</td>
<td>The Place of the Solar System in the Universe</td>
<td>56 – 57</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>24</td>
<td>Sky Science – Part II Review</td>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>25</td>
<td>Sky Science – Part II Test</td>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Lesson Fourteen

Concept: General Facts About the Moon.

Resources/Materials: Mini Textbook, pages 28 – 30
Worksheet #6C.13 (student copies)
cantaloupe (or ball of similar size) ping pong ball
globe felt marker (water-based)

Introduction: Review that the Earth is a natural satellite of the Sun because it revolves around the Sun. The Earth rotates on its axis as it revolves around the sun. Similarly, the Moon is a natural satellite of the Earth. Tell students some general facts about the Moon:

- Revolves around the Earth about once every 27 1/3 days
- One rotation takes about a month.
- We always see the same side of the Moon.

Explain that today’s lesson is about finding out more facts about the moon.

Procedure:

1. *How big is the Moon compared to the Earth?* Hold up a ping pong ball and a cantaloupe. The ping pong ball represents the Moon, while the cantaloupe represents the Earth. Place the ping pong ball about 4.5 m from the cantaloupe to give students an idea of the comparative distance between the Earth and the Moon.

2. *How do we know the Moon rotates on its axis?* Place the globe on a table in the middle of the room. Pretend the cantaloupe is now the Moon. Use the marker to make a large dot on the side of the Moon facing the Earth. Walk around the globe holding the cantaloupe, ensuring that the dot is always facing the Earth. Note how the Moon is actually rotating slowly as it encircles the globe.

3. *Why can we sometimes see more of the Moon than at other times?* It all has to do with the positions of the Earth and the Moon relative to the Sun at any particular time. A small object like the Moon can block out the Sun. Have students hold up their thumb so that they block out the globe. We say that your thumb eclipses the globe. The Moon reflects the Sun’s light. At any given time, half the Moon is lit and the other half is in darkness. Sometimes we can see whole lit side and at other times on the dark side is facing Earth.

4. Explain that there are many fascinating facts about the Moon. Students will read about them and then answer some questions.

5. Have students turn to *Mini Textbook*, page 28. Have them read page 28 – 30 independently, if at all possible.

6. Distribute Worksheet #6C.13. Go over the directions, if possible.

Assignments:

2. Do Worksheet #6C.13.
Directions: Read *Mini Textbook*, pages 28 – 30. Then answer each of the following questions. Write a paragraph or two to answer each.

1. How strong is the Moon’s gravity?

2. Why does a full moon light up the sky?

3. What is meant by saying that the Moon is waxing or waning?

4. What is the connection between the Moon and the ocean tides?

5. What is an eclipse of the sun?

6. What is an eclipse of the moon?
Directions: Read Mini Textbook, pages 28 – 30. Then answer each of the following questions. Write a paragraph or two to answer each.

1. How strong is the Moon’s gravity? The main ideas are \( \frac{1}{6} \) that of Earth’s.

2. Why does a full moon light up the sky? From Earth we can see all of the side of the Moon on which Sun is shining.

3. What is meant by saying that the Moon is waxing or waning? Part of the Moon we can see is increasing or decreasing.

4. What is the connection between the Moon and the ocean tides? Moon’s gravitational pull causes ocean levels to rise.

5. What is an eclipse of the sun? Moon is between Sun and Earth.

6. What is an eclipse of the moon? Earth is between Moon and Sun.
Lesson Fifteen

Concept: Phases of the Moon, Part I

Resources/Materials: Mini Textbook, pages 31 – 34
- Worksheet #6C.15a (transparency, student copies)
- Worksheets #6C.15b and #6C.15c (transparencies or copied onto charts)
- softball
- beach ball
- lamp with bare bulb
- tape

Introduction: Discuss how the Moon seems to have different shapes depending on the time of year. Explain that the Moon’s shape does not change; it is spherical and appears round. Review that half the Moon is always lit and half is always in darkness. Sometimes we see all of the lit side; at other times, part of the lit side; and at still other times, none of the lit side. The changes in what we can see are called the phases of the moon. Explain the terms waxing (increasing in size) and waning (decreasing in size). We use these terms to describe the fact that as the nights go by, the part of the Moon that we can see increases and the decreases.

Procedure:

1. Demonstrate how the Moon revolves (and rotates) around the Earth. NOTE: The same side of the Moon always faces the Earth.

2. Darken the room, if possible. Use the bare bulb and lamp to represent the Sun. Have a student hold the beach ball to represent the Earth and the soft ball to represent the Moon. Have the “Moon” revolve around the Earth in a counterclockwise manner, ensuring that the same side always faces the Earth. Note the shape of the lit part of the Moon from the perspective of the Earth.

3. Explain that we use the term phases of the moon to describe the lit parts of the Moon that we can see as the nights go by.

   New Moon: (appears black) The Moon is between the Sun and the Earth. During the new moon phase the side of the Moon in shadow faces the Earth.
   Waxing Crescent (small backwards C) The “Moon” moves 1/8 of a revolution around the Earth, counterclockwise.
   First Quarter (half of the Moon is bright) The “Moon” moves another 1/8 of a revolution. NOTE: It is called the First Quarter because the Moon has travelled one-quarter of its orbit around Earth.
   Waxing Gibbous: (more than half or three-quarters of the Moon can be seen). “Moon” moves another 1/8 revolution.
   Full Moon: (entire Moon is lit) Earth is between Moon and Sun.
   Waning Gibbous: Moon seems to decrease in size to about three quarters.
   Last Quarter: (thin sliver shape of a C)

4. To help students understand what the various phases of the Moon look like, have them turn to Mini Textbook, pages 31 – 34. If at all possible, guide the reading of the pages.

5. Put up the transparency of Worksheet #6C.15a and give students each a copy. Using the transparency to guide them, have students colour in yellow the parts of the Moon that are lit in each phase.

(continued)
6. Put up the transparencies or charts of Worksheets #6C.15b and #6C.15c. Have them copy the notes into their notebooks. After the notes about each phase, have them draw and colour an illustration of the phase.

Assignments:

2. Colour in the phases of the Moon on Worksheet #6C.15a.
3. Copy the notes from Worksheets #6C.15b and #6C.15c. Draw and colour phases.
The Phases of the Moon

Directions: Draw, colour, and label the phases of the Moon.
The Phases of the Moon

The moon appears to have different shapes at different times. These are called the phases of the moon. When the portion of the Moon that we see appears to be lit is increasing, we say that it is **waxing**. When the portion of the Moon that we see appears to be decreasing, we say it is **waning**.

The phases of the moon are:

1. **New Moon** – Moon appears all black.
   (Put illustration here.)

2. **Waxing Crescent** – thin backwards C
   (Put illustration here.)
3. **First Quarter** – half of Moon is bright
   (Put illustration here.)

4. **Waxing Gibbous** – three-quarters of Moon is bright
   (Put illustration here.)

5. **Full Moon** – entire Moon is bright
   (Put illustration here.)

6. **Waning Gibbous** – other three-quarters of Moon is bright
   (Put illustration here.)

7. **Last Quarter** – other half of Moon is bright
   (Put illustration here.)

8. **Waning Crescent** – thin C is bright
   (Put illustration here.)
Directions: Draw, colour, and label the phases of the Moon.
Lesson Sixteen

NOTE: Do this lesson only if you think your students need more work on the Phases of the Moon.

Concept: Phases of the Moon, Part II

Resources/Materials: Worksheet #6C.16 b and #6C.16d (teacher copy)
Worksheet #6C.16a (transparency and student copies)
Worksheet #6C.16c, #6C.16e, and #6C.16f (student copies)
dark blue or black construction paper

Introduction: Review the term phases of the moon. Remember “phases” means “stages”. Tell students that today we will review information about the phases.

Procedure:

1. Distribute Worksheet #6C.16a and put up the transparency. With students draw in the phases correctly. Have students use a yellow crayon to colour in the lit part of the Moon in the different phases.

2. Distribute Worksheets #6C.16c and a sheet of construction paper. Tell students to colour the various moon phases, cut out the squares, and paste them in the correct order on the construction paper to make a display of the Phases of the Moon. They should write the title at the top of the sheet and label each of the pictures of the phases.

3. Distribute Worksheet #6C.16e and #6C.16f. Go over the directions, if necessary.

Assignments:

1. Draw in and colour correctly the phases of the Moon on Worksheet #6C.16a.
2. Make a display of the phases of the moon using Worksheet #6C.16c and a sheet of construction paper. Make a title and label each phase.
3. Do Worksheets #6C.16e and #6C.16f.
Directions: For each phase of the moon colour the part that is lit yellow and the part that is in shadow black.

MOON ROTATING AROUND THE EARTH

Light from the sun
Phases of the Moon

Directions: Colour the lit parts yellow. Cut out each square. Paste the squares in order to show the phases of the Moon. Label each phase.
Phases of the Moon – Answer Key

WAXING CRESCENT

1ST QUARTER

WAXING GIBBOUS

FULL MOON

WANING GIBBOUS

LAST QUARTER

WANING CRESCENT

NEW MOON
1. Examine the diagram below. Then do the questions.

   ![Diagram of the phases of the Moon]

   a. Label each of the phases of the Moon.

   b. True or false? Half the Moon is always lit? _____

   c. True or false? The portion of the Moon that we see decreases, then increases? _____

2. Examine the diagram below. Then answer the questions.

   ![Diagram of the phases of the Moon]

   a. When viewed from Earth, what phase of the Moon would be at position P?

      ________________

   b. When viewed from Earth, what phase of the Moon would be at position T?

      ________________
3. Bradley wants to show his classmates what he has learned about the phases of the Moon. He uses a volleyball to represent the Moon, the campfire to represent the Sun, and himself to represent the Earth. Look at the drawing below; then answer the questions.

Position X

a. Bradley is showing that the Moon revolves around the Earth in a _________________ direction.

b. When you hold the ball in position X, it is like the phase of the moon called the ________________.

c. Because the Moon revolves around the Earth, the Moon is referred to as a ________________ of Earth.
1. Examine the diagram below. Then do the questions.

a. Label each of the phases of the Moon.

b. True or false? Half the Moon is always lit? __true__

c. True or false? The portion of the Moon that we see decreases, then increases? __false__

2. Examine the diagram below. Then answer the questions.

a. When viewed from Earth, what phase of the Moon would be at position P?

   __full moon__

b. When viewed from Earth, what phase of the Moon would be at position T?

   __last quarter__
3. Bradley wants to show his classmates what he has learned about the phases of the Moon. He uses a volleyball to represent the Moon, the campfire to represent the Sun, and himself to represent the Earth. Look at the drawing below; then answer the questions.

Position X

a. Bradley is showing that the Moon revolves around the Earth in a __counterclockwise__ direction.

b. When you hold the ball in position X, it is like the phase of the moon called the __new moon__.

c. Because the Moon revolves around the Earth, the Moon is referred to as a __satellite__ of Earth.
Lesson Seventeen

Concept: The Solar System

Resources/Materials: Mini Textbook, pages 35 – 37
Worksheets #6C.17a, #6C.17b, and #6C.17c (student copies)
Dark blue or black roll paper (1.9 m)

Introduction: Write the term solar system on the board. Explain that the word solar means sun. Our solar system consists of the Sun, its eight planets and their moons and other celestial bodies like dwarf planets and asteroids. Note these ideas:
- The planets revolve in a counterclockwise direction around the Sun.
- The planets are of different sizes and travel at slightly different speeds. Some take longer to make a complete revolution. Because one revolution is one year, their years are of different lengths.
- The planets spin on their axes at different rates. One complete rotation is one day. The different planets have days of differing lengths.

Procedure:


2. With students make some notes about the solar system, such as:

   The Solar System
   
   The solar system is made up of the planets and their moons, dwarf planets, asteroids, and comets. The eight planets outwards from the Sun are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.

   Then have students copy the distance chart from Mini Textbook, page 35 into their notebooks.

3. Distribute Worksheets #6C.17a, #6C.17b, and #6C.17c. Have students follow the directions from Worksheet #6C.17a to make a Distance Scale Chart of the Solar System.

Assignment:

1. Copy notes from board; then copy distance chart from Mini Textbook, page 35.
2. Make a Distance Scale Chart of the Solar System, using Worksheets #6C.17a, #6C.17b, and #6C.17c.
1. Cut a piece of dark blue or black roll paper that is exactly 1.9 m in length.

2. Cut the paper in half lengthwise. Join the two pieces together with clear tape so that you now have a paper that is 3.8 m long.

3. Draw a line exactly across the centre of your paper going across (horizontally).

4. From the left-hand side of the paper, mark 60 cm from the edge.

5. Cut out the Sun and paste it so that it is halfway between the edge of the paper and the 60 cm mark.

6. You now have 3.2 m left for the planets. You are to use the chart below to help you know where to place each of the planets and how far apart they should be. (Be sure they are in the correct order.) The sketch below illustrates how to lay out the circles. The distances on the sketch are not to scale, but you must paste our planets so that their distances from the Sun are to scale.

<table>
<thead>
<tr>
<th>PLANET</th>
<th>Actual Distance in Millions of Kilometres from the Sun</th>
<th>Scaled Distance from the Sun in cm (1 cm = 20 000 km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>0</td>
<td>2.9</td>
</tr>
<tr>
<td>Mercury</td>
<td>58</td>
<td>5.4</td>
</tr>
<tr>
<td>Venus</td>
<td>108</td>
<td>7.5</td>
</tr>
<tr>
<td>Earth</td>
<td>150</td>
<td>11.5</td>
</tr>
<tr>
<td>Mars</td>
<td>230</td>
<td>38.9</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778</td>
<td>71.4</td>
</tr>
<tr>
<td>Saturn</td>
<td>1427</td>
<td>143.5</td>
</tr>
<tr>
<td>Uranus</td>
<td>2870</td>
<td>224.8</td>
</tr>
<tr>
<td>Neptune</td>
<td>4497</td>
<td></td>
</tr>
</tbody>
</table>

Sun [60cm]          Planets [3m]

(The above sketch illustrates how to lay out the circles. The distances are not to scale and all planets are not included.)
Sun
Lesson Eighteen

Concept: Facts About the Planets

Resources/Materials: Mini Textbook, pages 38 – 46
Worksheet #6C.18 (four copies per student)

NOTE: Mini Textbook, pages 39 – 46 are taken from World Book Discovery Encyclopedia. This set of reference books is highly recommended. If you have a set, have students use it in place of the Mini Textbook pages to get information about the individual planets.

Introduction: Review that the solar system includes eight planets that revolve around the Sun. Discuss that the planets are all similar in that they rotate on their axes and revolve around the Sun. In this lesson, students will get a chance to see how the planets are different.

Procedure:

1. Explain that the time it takes a planet to make one completer rotation on its axis is called its period of rotation, and the time it takes a planet to revolve once around the Sun is called its period of revolution. Students will learn more about these two concepts in the next lesson.

2. Tell students they will be doing research on each of the eight planets. This may take two or three days.

3. Have students turn to Mini Textbook, page 38. Go over the table; then guide the section entitled “Two Kinds of Planets”.

4. Explain that the information students will need to do their research on the individual planets is on Mini Textbook, pages 38 – 46.

5. Distribute four copies each of Worksheet #6C.18 to each student. Tell them to complete one chart for each planet.

   NOTE: As an alternative, if lack of time is a concern, you may want to have students research only four (more or fewer) planets.

6. OPTIONAL. Have students make a display featuring one of the planets.

Assignments:

1. Research the planets using the information on Mini Textbook, pages 38 – 46 (or have them use World Book Discovery Encyclopedia). They can use copies of Worksheet #6C.18 to record their findings.

2. OPTIONAL. Make a display featuring one of the planets.
<table>
<thead>
<tr>
<th>PLANET:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description of Planet’s Surface:</strong></td>
<td><strong>Terrestrial or Gaseous?</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Distance from Sun:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Diameter:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Period Rotation:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Period of Revolution:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Number of Moons:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Weather:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Picture of Planet’s Surface:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Other Information:</strong> __________________</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLANET:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description of Planet’s Surface:</strong></td>
<td><strong>Terrestrial or Gaseous?</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Distance from Sun:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Diameter:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Period Rotation:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Period of Revolution:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Number of Moons:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Weather:</strong> __________________</td>
</tr>
<tr>
<td></td>
<td><strong>Picture of Planet’s Surface:</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Other Information:</strong> __________________</td>
</tr>
</tbody>
</table>
### PLANET: MERCURY

**Description of Planet’s Surface:**
- covered by thin layer of minerals
- wide flat areas, steep cliffs, many deep craters

**Terrestrial or Gaseous?**  Terrestrial

<table>
<thead>
<tr>
<th>Distance from Sun</th>
<th>57,900,000 km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>4,880 km</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period Rotation</th>
<th>59 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period of Revolution</td>
<td>88 days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Moons</th>
<th>0</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Weather</th>
<th>dry, very hot; but also extremely cold</th>
</tr>
</thead>
</table>

**Other Information:**


### PLANET: VENUS

**Description of Planet’s Surface:**
- looks bright
- mountains and volcanoes
- covered with thick clouds of sulfuric acid

**Terrestrial or Gaseous?**  Terrestrial

<table>
<thead>
<tr>
<th>Distance from Sun</th>
<th>108,200,000 km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>12,100 km</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Period Rotation</th>
<th>243 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period of Revolution</td>
<td>224.7 days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Moons</th>
<th>0</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Weather</th>
<th>very hot 460°C; short seasons; very little fluctuations in temperature/wind</th>
</tr>
</thead>
</table>

**Other Information:**


### PLANET: EARTH

<table>
<thead>
<tr>
<th>Description of Planet’s Surface:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• covered with water, rock, soil</td>
</tr>
<tr>
<td>• partly covered with clouds</td>
</tr>
<tr>
<td>• surrounded by atmosphere</td>
</tr>
<tr>
<td>• not perfectly spherical (flattened at poles)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Terrestrial or Gaseous?</th>
<th>Terrestrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from Sun</td>
<td>149,600,000 km</td>
</tr>
<tr>
<td>Diameter</td>
<td>12,756 km</td>
</tr>
<tr>
<td>Period Rotation</td>
<td>24 hours</td>
</tr>
<tr>
<td>Period of Revolution</td>
<td>365 days</td>
</tr>
<tr>
<td>Number of Moons</td>
<td>1</td>
</tr>
<tr>
<td>Weather</td>
<td>just right for supporting living thing; 4 seasons in most areas; 1 season at poles and equator</td>
</tr>
<tr>
<td>Other Information</td>
<td></td>
</tr>
</tbody>
</table>

### PLANET: MARS

<table>
<thead>
<tr>
<th>Description of Planet’s Surface:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• covered with rocks and craters</td>
</tr>
<tr>
<td>• red</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Terrestrial or Gaseous?</th>
<th>Terrestrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from Sun</td>
<td>229,900,000 km</td>
</tr>
<tr>
<td>Diameter</td>
<td>6,787 km</td>
</tr>
<tr>
<td>Period Rotation</td>
<td>24 hours</td>
</tr>
<tr>
<td>Period of Revolution</td>
<td>687 days</td>
</tr>
<tr>
<td>Number of Moons</td>
<td>2</td>
</tr>
<tr>
<td>Weather</td>
<td>very cold (below 0°C); dust storms; winter and summer vary greatly</td>
</tr>
<tr>
<td>Other Information</td>
<td></td>
</tr>
</tbody>
</table>

Worksheet #6C.18
<table>
<thead>
<tr>
<th>PLANET: JUPITER</th>
<th>Terrestrial or Gaseous?</th>
<th>Gaseous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of Planet’s Surface:</td>
<td>Distance from Sun:</td>
<td>778,300,000 km</td>
</tr>
<tr>
<td>• bright</td>
<td>Diameter:</td>
<td>143,200 km</td>
</tr>
<tr>
<td>• giant ball of gas and liquid</td>
<td>Period Rotation:</td>
<td>10 hours</td>
</tr>
<tr>
<td>• thick red, brown, yellow, and white clouds</td>
<td>Period of Revolution:</td>
<td>12 years</td>
</tr>
<tr>
<td>• dark and light coloured areas</td>
<td>Number of Moons:</td>
<td>63</td>
</tr>
<tr>
<td>• has Great Red Spot</td>
<td>Weather:</td>
<td>temperatures vary greatly, depending on location; can have high winds; no seasons</td>
</tr>
<tr>
<td>• three thin rings</td>
<td>Other Information:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PLANET: SATURN</th>
<th>Terrestrial or Gaseous?</th>
<th>Gaseous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of Planet’s Surface:</td>
<td>Distance from Sun:</td>
<td>1,427,000,000 km</td>
</tr>
<tr>
<td>• seven thin flat rings</td>
<td>Diameter:</td>
<td>120,000 km</td>
</tr>
<tr>
<td>• each ring made of ringlet of small pieces of ice</td>
<td>Period Rotation:</td>
<td>11 hours</td>
</tr>
<tr>
<td></td>
<td>Period of Revolution:</td>
<td>29 years</td>
</tr>
<tr>
<td></td>
<td>Number of Moons:</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Weather:</td>
<td>seasons last 7 years; uneven temperatures</td>
</tr>
</tbody>
</table>

| Picture of Planet’s Surface: | Other Information: | |
|-------------------------------|-------------------|
### PLANET: URANUS

**Description of Planet’s Surface:**
- giant ball of gas and liquid
- blue-green clouds of methane gas

**Terrestrial or Gaseous?** Gaseous

**Distance from Sun:** 2,871,000,000 km

**Diameter:** 51,800 km

**Period Rotation:** 17 hours

**Period of Revolution:** 84 years

**Number of Moons:** 27

**Weather:** seasons last 21 years;

very cold

**Other Information:**


### PLANET: NEPTUNE

**Description of Planet’s Surface:**
- bright blue clouds
- made up mostly of gases, water, and minerals

**Terrestrial or Gaseous?** Gaseous

**Distance from Sun:** 4,497,000,000 km

**Diameter:** 49,528 km

**Period Rotation:** 16 hours

**Period of Revolution:** 165 years

**Number of Moons:** 13

**Weather:** very little seasonal variation;

seasons can last 40 years; windy

**Other Information:**


Worksheet #6C.18
Lesson Nineteen

**Concept:** Period of Rotation and Period of Revolution

**Resources/Materials:** Mini Textbook, pages 47 and 48
- Worksheet #6C.19a (transparency and student copies)
- Workshops #6C.19b and #6C.19c (student copies)

**Introduction:** Review that it takes 24 hours for the Earth to rotate once on its axis. This is **one day**. It takes 365½ days for the Earth to revolve around the Sun one time. This is **one year**. What about the other planets?

**Procedure:**

1. Explain that for any planet one “day” is the length of time it takes for that planet to rotate once. One “year” is the length of time it takes that planet to revolve around the Sun once. For example, if it takes a particular planet 16 hours to rotate once, then that planet’s day is 16 hours in length. Similarly, if it take a planet 3 of our years to revolve around the Sun once, then that planet’s year is equivalent to 3 of ours.


3. Referring to the table on *Mini Textbook*, page 48, ask interpretive questions such as “Which planet has a year that is approximately twice as long as a year on Uranus?”

4. With students makes notes on rotation and revolution. Have them copy the tables from *Mini Textbook*, page 47 after the appropriate sections. OR Put up transparency or chart from Worksheet #6C.19a for students to copy.

   **Example:**  
   
   **Rotation**  
   Each planet rotates on its axis. The length of time it takes for a planet to rotate once is the length of that planet’s day.  
   
   (copy table from Mini Textbook, page 47)

   **Revolution**  
   Each planet revolves around the Sun on an orbit. The length of time it takes for a planet to make one complete revolution is the length of that planet’s year.  
   
   (paste chart from Mini Textbook, page 47)

5. Tell students they will now have the chance to do some work on rotation and revolution of the planets. Distribute Worksets #6C.19b and #6C.19c.

**Assignments:**

1. Copy notes from board or from Worksheet #6C.19a.
2. Do Worksets #6C.19b and #6C.19c.
Rotation
Each planet rotates on its axis. The length of time it takes for a planet to rotate once is the length of that planet’s day.
(Copy table from Mini Textbook, page 47.)

Revolution
Each planet revolves around the Sun on an orbit. The length of time it takes for a planet to make one complete revolution is the length of that planet’s year.
(Copy table from Mini Textbook, page 47.)
The Planets: Distance from the Sun, Rotation, and Revolution

1. Look at the table below. It compares Saturn and Earth.

<table>
<thead>
<tr>
<th></th>
<th>Saturn</th>
<th>Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum distance from Sun</td>
<td>1,507</td>
<td>152</td>
</tr>
<tr>
<td>(millions of km)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter (km)</td>
<td>120,000</td>
<td>12,756</td>
</tr>
<tr>
<td>Average Surface Temperature</td>
<td>-180°C</td>
<td>22°C</td>
</tr>
<tr>
<td>Day length (Earth units)</td>
<td>10 hr</td>
<td>24 hr</td>
</tr>
<tr>
<td>Year length (Earth units)</td>
<td>30 years</td>
<td>1 year</td>
</tr>
<tr>
<td>Number of moons</td>
<td>18</td>
<td>1</td>
</tr>
</tbody>
</table>

a. Which planet is larger? 

b. Which planet has the shorter orbit around the Sun? 

c. Which planet takes longer to rotate on its axis? 

2. Examine the table comparing several of the planets. Answer the questions.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Distance from the Sun (million kilometres)</th>
<th>Time for Planet to Circle the Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58</td>
<td>88 days</td>
</tr>
<tr>
<td>Venus</td>
<td>108</td>
<td>225 days</td>
</tr>
<tr>
<td>Earth</td>
<td>150</td>
<td>1 year</td>
</tr>
<tr>
<td>Jupiter</td>
<td>780</td>
<td>12 years</td>
</tr>
<tr>
<td>Uranus</td>
<td>2,870</td>
<td>84 years</td>
</tr>
<tr>
<td>Neptune</td>
<td>4,500</td>
<td>165 years</td>
</tr>
</tbody>
</table>

a. What conclusion can you draw from the information in the chart?

- The smaller the planet, the shorter its year.
- The larger the planet, the shorter its year.
- The farther a planet is from the Sun, the longer its year.
- The closer a planet is from the Sun, the longer its year.

b. You can hypothesize that the planet Saturn, 1,430 kilometres from the Sun, would circle the Sun about once every

- 100 days.
- 10 years.
- 30 years.
- 100 years.
3. Here is a table summarizing some facts about the planets. Examine the table and then answer the questions.

### The Solar System

<table>
<thead>
<tr>
<th>Planet</th>
<th>Maximum distance from Sun (millions)</th>
<th>Diameter</th>
<th>Average Surface Temperature</th>
<th>Day Length (Earth units)</th>
<th>Year Length (Earth units)</th>
<th><em>Number of Moons</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>69.7 km</td>
<td>4 880 km</td>
<td>350°C day -170°C night</td>
<td>58.0 days</td>
<td>88 days</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>109.0 km</td>
<td>12 100 km</td>
<td>480°C</td>
<td>243.0 days</td>
<td>225 days</td>
<td>0</td>
</tr>
<tr>
<td>Earth</td>
<td>152.1 km</td>
<td>12 756 km</td>
<td>22°C</td>
<td>1.0 day</td>
<td>365 days</td>
<td>1</td>
</tr>
<tr>
<td>Mars</td>
<td>249.1 km</td>
<td>6 787 km</td>
<td>-23°C</td>
<td>1.0 day</td>
<td>687 days</td>
<td>2</td>
</tr>
<tr>
<td>Jupiter</td>
<td>815.7 km</td>
<td>142 800 km</td>
<td>-150°C</td>
<td>10.0 hours</td>
<td>12 years</td>
<td>63</td>
</tr>
<tr>
<td>Saturn</td>
<td>1 507.0 km</td>
<td>120 000 km</td>
<td>-180°C</td>
<td>10.0 hours</td>
<td>30 years</td>
<td>61</td>
</tr>
<tr>
<td>Uranus</td>
<td>3 004.0 km</td>
<td>51 800 km</td>
<td>-210°C</td>
<td>16.0 hours</td>
<td>84 years</td>
<td>27</td>
</tr>
<tr>
<td>Neptune</td>
<td>4 537.0 km</td>
<td>49 500 km</td>
<td>-220°C</td>
<td>6.4 days</td>
<td>165 years</td>
<td>13</td>
</tr>
</tbody>
</table>

*Number of moons as of March 2010*

a. Which two pairs of planets take about the same amount of time to rotate once on their axes? 

b. Which two planets have the same number of natural satellites? 

c. Which planet takes about half the time it takes Neptune to revolve once around the Sun? 

d. From looking at the table, you can conclude that the farther a planet is from the Sun, the 
   - greater the overall size of the planet. 
   - greater the number of moons the planet has. 
   - longer the planet’s year. 
   - faster the speed at which the planet rotates on its axis. 

e. Which four planets receive the most intense heat from the Sun?
The Planets: Distance from the Sun, Rotation, and Revolution

1. Look at the table below. It compares Saturn and Earth.

<table>
<thead>
<tr>
<th></th>
<th>Saturn</th>
<th>Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum distance from Sun (millions of km)</td>
<td>1 507</td>
<td>152</td>
</tr>
<tr>
<td>Diameter (km)</td>
<td>120 000</td>
<td>12 756</td>
</tr>
<tr>
<td>Average Surface Temperature</td>
<td>−180°C</td>
<td>22°C</td>
</tr>
<tr>
<td>Day length (Earth units)</td>
<td>10 hr</td>
<td>24 hr</td>
</tr>
<tr>
<td>Year length (Earth units)</td>
<td>30 years</td>
<td>1 year</td>
</tr>
<tr>
<td>Number of moons</td>
<td>18</td>
<td>1</td>
</tr>
</tbody>
</table>

a. Which planet is larger? **Saturn**

b. Which planet has the shorter orbit around the Sun? **Earth**

c. Which planet takes longer to rotate on its axis? **Earth**

2. Examine the table comparing several of the planets. Answer the questions.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Distance from the Sun (million kilometres)</th>
<th>Time for Planet to Circle the Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58</td>
<td>88 days</td>
</tr>
<tr>
<td>Venus</td>
<td>108</td>
<td>225 days</td>
</tr>
<tr>
<td>Earth</td>
<td>150</td>
<td>1 year</td>
</tr>
<tr>
<td>Jupiter</td>
<td>780</td>
<td>12 years</td>
</tr>
<tr>
<td>Uranus</td>
<td>2870</td>
<td>84 years</td>
</tr>
<tr>
<td>Neptune</td>
<td>4500</td>
<td>165 years</td>
</tr>
</tbody>
</table>

a. What conclusion can you draw from the information in the chart?

- The smaller the planet, the shorter its year.
- The larger the planet, the shorter its year.
- The farther a planet is from the Sun, the longer its year.
- The closer a planet is from the Sun, the longer its year.

b. You can hypothesize that the planet Saturn, 1 430 kilometres from the Sun, would circle the Sun about once every

- 100 days.
- 10 years.
- 30 years.  
- 100 years.

Worksheet #6C.19b
3. Here is a table summarizing some facts about the planets. Examine the table and then answer the questions.

### The Solar System

<table>
<thead>
<tr>
<th>Planet</th>
<th>Maximum distance from Sun (millions)</th>
<th>Diameter</th>
<th>Average Surface Temperature</th>
<th>Day Length (Earth units)</th>
<th>Year Length (Earth units)</th>
<th><em>Number of Moons</em></th>
</tr>
</thead>
</table>
| Mercury | 69.7 km                             | 4 880 km | 350°C day 
-170°C night          | 58.0 days                           | 88 days                                  | 0                      |
| Venus  | 109.0 km                            | 12 100 km| 480°C                       | 243.0 days                           | 225 days                                   | 0                      |
| Earth  | 152.1 km                            | 12 756 km| 22°C                        | 1.0 day                                | 365 days                                  | 1                      |
| Mars   | 249.1 km                            | 6 787 km | -23°C                       | 1.0 day                                | 687 days                                  | 2                      |
| Jupiter | 815.7 km                            | 142 800 km| -150°C                     | 10.0 hours                              | 12 years                                  | 63                    |
| Saturn | 1 507.0 km                          | 120 000 km| -180°C                     | 10.0 hours                              | 30 years                                  | 61                    |
| Uranus | 3 004.0 km                          | 51 800 km| -210°C                     | 16.0 hours                              | 84 years                                  | 27                   |
| Neptune| 4 537.0 km                          | 49 500 km| -220°C                     | 6.4 days                                | 165 years                                  | 13                   |

*Number of moons as of March 2010*

a. Which two pairs of planets take about the same amount of time to rotate once on their axes?

   **Earth and Mars; Jupiter and Saturn**

b. Which two planets have the same number of natural satellites?

   **Mercury and Venus**

c. Which planet takes about half the time it takes Neptune to revolve once around the Sun?

   **Uranus**

d. From looking at the table, you can conclude that the farther a planet is from the Sun, the
   - greater the overall size of the planet.
   - greater the number of moons the planet has.
   - longer the planet’s year.
   - faster the speed at which the planet rotates on its axis.

e. Which four planets receive the most intense heat from the Sun? **Mercury, Venus, Earth, Mars**
Lesson Twenty

Concept: Size of Planets

Resources/Materials: Mini Textbook, pages 36 and 47
Worksheet #6C.20a and #6C.20b (student copies)

For each student or group of two or three:
Large sheet of blue or black construction paper (the larger the better)
Sheet of circles to represent Sun and planets (students can make their own)
Coloured crayons

Introduction: Tell students that not all planets are the same size. One way to measure their different sizes is to look at their diameters. Tell students that today they will be examining the diameters of the planets and then making a picture of the solar system.

Procedure:

1. Then refer students to the “Size of Planets” table on Mini Textbook, page 47. If necessary, go over how the table is set up.

2. With students make up some brief notes on the size of the planets. Have students copy the table from Mini Textbook, page 47 after the notes. Example:

The Size of Planets
Not all the planets are the same size. In order from smallest to largest the planets are Mercury, Mars, Venus, Earth, Neptune, Uranus, Saturn, and Jupiter.

(paste table from Mini Textbook, page 47)

3. Refer students to Mini Textbook, page 36. Then tell students to make a picture of the solar system on a large sheet of construction paper, using the worksheet as a guide. Explain that they are to make circles to represent the Sun and planets. The largest circle should be the Sun and the next smallest Jupiter, and then Saturn, and so forth. The size of the circles should be proportionate. Advise students to label the Sun and each planet and draw in the planets’ orbits.

4. Once finished, students can get practice interpreting information about planet size on Worksheets #6C.20a and #6C.20b.

Assignments:

1. Make a picture of the solar system.
2. Do Worksheets #6C.20a and #6C.20b.
1. Write the names of the planets in order from smallest to largest.

__________________________________________________________________________

__________________________________________________________________________

2. Following is a table showing the sizes of some of the terrestrial planets. Make a bar graph showing this information.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Diameter (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>4 880</td>
</tr>
<tr>
<td>Venus</td>
<td>12 100</td>
</tr>
<tr>
<td>Earth</td>
<td>12 756</td>
</tr>
<tr>
<td>Mars</td>
<td>6 787</td>
</tr>
</tbody>
</table>

(Title)

Diameter (km)

Name of Planet

Mercury  Venus  Earth  Mars
3. Examine the table below; then answer the questions by circling true or false.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Approximate Distance from the Sun (Earth units)</th>
<th>Length of Day</th>
<th>Length of Year (Earth Units)</th>
<th>Diameter (km)</th>
<th>Number of Moons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58.0 km</td>
<td>58.0 days</td>
<td>88 days</td>
<td>4 878 km</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>108.0 km</td>
<td>243.0 days</td>
<td>225 days</td>
<td>12 104 km</td>
<td>0</td>
</tr>
<tr>
<td>Earth</td>
<td>152.0 km</td>
<td>1.0 day</td>
<td>365 days</td>
<td>12 756 km</td>
<td>1</td>
</tr>
<tr>
<td>Mars</td>
<td>228.0 km</td>
<td>1.0 day</td>
<td>687 days</td>
<td>6 787 km</td>
<td>2</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778.0 km</td>
<td>10.0 days</td>
<td>12 years</td>
<td>142 800 km</td>
<td>63</td>
</tr>
<tr>
<td>Saturn</td>
<td>1 507.0 km</td>
<td>10.0 hours</td>
<td>30 years</td>
<td>120 000 km</td>
<td>61</td>
</tr>
<tr>
<td>Uranus</td>
<td>2 871.0 km</td>
<td>16.0 hours</td>
<td>84 years</td>
<td>51 118 km</td>
<td>27</td>
</tr>
<tr>
<td>Neptune</td>
<td>5 913.0 km</td>
<td>18.0 hours</td>
<td>248 years</td>
<td>49 528 km</td>
<td>13</td>
</tr>
</tbody>
</table>

d. The larger the planet, the more slowly it rotates. True False

c. The farther from the Sun, the less time it takes to revolve around the Sun. True False

d. The larger the planet, the more satellites it has. True False

e. Which of the following bar graphs correctly shows information from the table? (Circle it.)

[Bar graphs showing diameter of planets]
1. Write the names of the planets in order from smallest to largest.

Mercury, Mars, Venus, Earth, Neptune, Uranus, Saturn, Jupiter

2. Following is a table showing the sizes of some of the terrestrial planets. Make a bar graph showing this information.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Diameter (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>4 880</td>
</tr>
<tr>
<td>Venus</td>
<td>12 100</td>
</tr>
<tr>
<td>Earth</td>
<td>12 756</td>
</tr>
<tr>
<td>Mars</td>
<td>6 787</td>
</tr>
</tbody>
</table>

**Size of Planets**

```
16 000
14 000
12 000
10 000
8 000
6 000
4 000
2 000

Diameter (km)
```

```
Mercury Venus Earth Mars
```

Name of Planet
3. Examine the table below; then answer the questions by circling true or false.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Approximate Distance from the Sun (millions)</th>
<th>Length of Day (Earth units)</th>
<th>Length of Year (Earth Units)</th>
<th>Diameter</th>
<th>Number of Moons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58.0 km</td>
<td>58.0 days</td>
<td>88 days</td>
<td>4 878 km</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>108.0 km</td>
<td>243.0 days</td>
<td>225 days</td>
<td>12 104 km</td>
<td>0</td>
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<td>687 days</td>
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<td>5 913.0 km</td>
<td>18.0 hours</td>
<td>248 years</td>
<td>49 528 km</td>
<td>13</td>
</tr>
</tbody>
</table>

a. The larger the planet, the more slowly it rotates.  True  
   False

b. The larger the planet, the longer it takes to revolve around the Sun.  True  
   False

c. The farther from the Sun, the less time it takes to revolve around the Sun.  True  
   False

d. The larger the planet, the more satellites it has.  True  
   False

e. Which of the following bar graphs correctly shows information from the table? (Circle it.)

![Bar Graphs]

Worksheet #6C.20b
Lesson Twenty-one

Concept: Moons

Resources/Materials: Mini Textbook, pages 49 – 54
Worksheet #6C.21a (student copies)
Worksheet #6C.21b (optional, student copies)

*NOTE: Mini Textbook, pages 50 – 54 contain articles about some of the planets’ moons. If you have a set of encyclopedias or other reference materials, it may be preferable for students to use them instead of the Mini Textbook articles.

Introduction: Review that the natural satellites of the planets are its moons. Not all planets have moons; some have many; still others only a few. Tell students that today they will be finding out more about some of the planets. Note: The number of moons each planet has keeps changing, as new ones are discovered and verified. This seems to be an on going occurrence. For this reason, charts and tables about the number of moons each planet has can vary.

Procedure:


2. With students make up a few notes on moons. For example:

   Moons
   A moon is a natural satellite of a planet. This means that it revolves around a planet. Some planets have many moons, while others have none.

   (copy the table from Mini Textbook, page 49 here.)

3. Tell students that they will now do some research on some of the moons. Distribute Worksheet #6C.21a and go over it with students. Tell students they are to find and organize information about the moons mentioned on the worksheet.

   Note: There are many ways you can organize this activity. Some things to think about:
   * You can have each student research each of the moons or you can assign students to research a particular moon(s) and share what they know by making a presentation or display
   * Decide how you want students to record their information: point-form notes; a graphic organizer of some kind

4. OPTIONAL. Have students compare any two moons on Worksheet #6C.21b.

Assignments:

1. Research the planets’ moons.
2. OPTIONAL. Do Worksheet #6C.21b.
Directions: Read the sentences below. Then research to find information on the moons that are written in bold face type.

1. MARS: Has two moons named Phobos and Deimos.

2. JUPITER: Has 63 moons, four of which are so big they can be seen with binoculars: Io, Ganymede, Europa, and Callisto.

3. URANUS: Has 27 moons, but only the biggest five can be seen from Earth. One of these is called Miranda.

4. NEPTUNE: Has 13 moons. Several of these were discovered by the spacecraft Voyager. Its largest moon is Triton.

5. SATURN: Has 61 moons, the largest of which is Titan.

6. MERCURY and VENUS: Have no moons.
Satellites – Venn Diagram
Lesson Twenty-two

Concept: Technologies Used to Gather Information About the Universe

Resources/Materials: Mini Textbook, page 55
Paper off roll about 3 m long X 0.5 m wide

Introduction: Ask “How do you think scientists, called astronomers, have found out so much about the universe? Today we will look at some of the things that have gone on.

Procedure:

1. Tell students that not all information that scientists have gathered have turned out to be true. “Why do you think this is?” (probably lack of technology and information)

2. Tell students they will read about some of the developments in astronomy over the years.

3. Have students turn to Mini Textbook, page 55. Explain that this page summarizes some of the major events that have taken place in humans’ search for more knowledge about the universe. Explain that the information can be used to create a timeline.

4. Have students read the page and in their notebooks, writing the important dates and events.

5. Distribute the long paper off the roll. Have students make a line across the middle of the paper to make a time line. Explain that they should write the events from the worksheet on the time line.

Assignment:

Read the information on Mini Textbook. Then draw a line across the centre of the roll paper, and write events in the order they happened.
Lesson Twenty-three

Concept: The Place of the Solar System in the Universe

Resources/Materials: Mini Textbook, pages 56 and 57
Worksheet #6C.23 (student copies)

Introduction: Discuss the huge size of the solar system. However, it is but a minute part of a galaxy called the Milky Way. The Milky Way, like all galaxies, has a spiral shape.

Procedure:

1. Tell students that a galaxy is a spiral island of stars in space. There are about 30 galaxies nearby in the universe.


3. Then refer students to Mini Textbook, page 57. Point out the solar system. Show students that the Milky Way has three spiral arms that rotate around the centre, called the nucleus. Our solar system is located at the outer edge of one of the arms called the Orion Arm.

4. Our solar system is 30 000 light years away from the nucleus. (A light year is about 9.7 trillion kilometres – the distance that light travels in a year.) It takes the Sun 225 000 000 years to make the long voyage around the nucleus, pulling the Earth and the rest of the solar system with it as it goes.

5. Astronomers believe that the galaxies are moving away from us and each other. The universe is immense and make up of billions of galaxies, all swirling in motion.

6. Distribute Worksheet #6C.23. Tell students they are to filling in the missing information. Then they are to cut the sheet apart and paste them into their notebooks starting with the smallest and ending with the largest.

Assignment:

Do Worksheet #6C.23.
**Where Are We in the Universe?**

**Directions:** In your notebook, write the heading *Where Are We in the Universe?*. Then cut apart the rectangles. Paste them into your notebook, starting with the smallest and ending with the largest.

<table>
<thead>
<tr>
<th>Universe</th>
<th>Milky Way</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td></td>
</tr>
</tbody>
</table>

Write the name of your colony in this space.

<table>
<thead>
<tr>
<th>North America</th>
<th>Solar System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orion Arm</td>
<td>Alberta</td>
</tr>
</tbody>
</table>

Write your name in this space. Write the name of your county or municipal district here.

<table>
<thead>
<tr>
<th>Earth</th>
<th>Local Group of Galaxies</th>
</tr>
</thead>
</table>

Worksheet #6C.23
Lesson Twenty-four

Concept: Sky Science, Part II: Review

Resources/Materials: Sky Science, Part II: Review Sheets (student copies)

Introduction: Explain that the second half of Sky Science is now coming to an end, and that it is time to prepare for a test.

Procedure:

1. Briefly go over the main topics covered in Part II of Sky Science.
   - General facts about the moon
   - Phases of the Moon
   - The Solar System
   - Facts About the Planets
   - Days and Years
   - The Moons of Other Planets

2. Distribute Sky Science, Part II Review Sheets. Have students complete them.

3. Check the review sheets as a class, if possible.

Assignment:

Do the Sky Science, Part II Review Sheets.
1. Define each of these terms.
   a. solar system
   b. orbit
   c. waxing
   d. waning
   e. period of rotation
   f. period of revolution

2. Write the names of the planets in order, beginning with the one closest to the Sun.

3. Four planets, Mercury, Venus, Earth, and Mars, have the most intense light and heat. Why do you think this is?
4. One or two words in each of the following statements are incorrect. Cross them out and write the correct words above them.

a. The Earth has five natural satellites.

b. All of planets are made of gases.

c. "The shape of Earth’s orbit around the Sun is a circle."

d. The Sun causes the ocean tides on Earth.

e. A quarter of the Moon is always in darkness and a quarter is always lit.

f. Venus is a planet that has many rings around it.

g. It takes the Earth 365 days to make one rotation on its axis.

h. Mercury is the planet farthest from the Sun.

i. Uranus is the largest planet in the solar system.

j. Man has been studying the Universe for just a few years.

5. On the diagram below label and colour the phases of the Moon.

6. Explain why we always see the same side of the Moon.
Examine the diagram below. Then answer questions 7 and 8.

7. The Moon travels around the Earth in
   a. a clockwise direction.
   b. a counterclockwise direction.
   c. a square.
   d. both a clockwise and a counterclockwise direction.

8. Which of the following show the correct phases of the Moon?
   a. A is the waxing crescent and E is the waning crescent.
   b. H is the new moon and G is the waning crescent.
   c. C is the waning gibbous and F is the last quarter.
   d. D is the full moon and B is the waxing crescent.
Use the following information to answer questions 9 and 10.

Jack wanted to demonstrate the phases of the Moon. He used a ball and a campfire. Jack’s position represented the Earth.

9. Starting with the new moon phase, as the Moon revolves around the Earth, the portion of the Moon that we see

   a. disappears.
   b. remains the same.
   c. increases then decreases.
   d. decreases then increases.

10. During the new moon phase

    a. the portion of the Moon we see appears fully lit.
    b. the portion of the Moon we see appears partially lit.
    c. the portion of the Moon we see is fully in shadow.
    d. the portion of the Moon we see is sunny.
Examine the table below. Then answer questions 11 and 12.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Distance from the Sun (million kilometres)</th>
<th>Time for Planet to Circle the Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58</td>
<td>88 days</td>
</tr>
<tr>
<td>Venus</td>
<td>108</td>
<td>225 days</td>
</tr>
<tr>
<td>Earth</td>
<td>150</td>
<td>1 year</td>
</tr>
<tr>
<td>Jupiter</td>
<td>780</td>
<td>12 years</td>
</tr>
<tr>
<td>Uranus</td>
<td>2,870</td>
<td>84 years</td>
</tr>
<tr>
<td>Jupiter</td>
<td>4,500</td>
<td>165 years</td>
</tr>
</tbody>
</table>

11. Mars is 228 million kilometres from the Sun. You can hypothesize from the information in the table that Mars would circle the Sun once every

a. 200 days.
b. 51 years.
c. 687 days.
d. 754 years.

12. From the information in the table you can conclude that

a. the closer a planet is to the Sun, the longer it takes to make one revolution around the Sun.
b. the farther a planet is from the Sun, the longer it takes to make one revolution around the Sun.
c. the farther a planet is from the Sun, the less time it takes to make one revolution around the Sun.
d. the closer a planet is to the Sun, the longer it takes to rotate once on its axis.

Use the following information to answer questions 13 and 14.

Bob did a project to show how different-sized craters can be made by dropping rocks of different sizes from the same height into a pan containing 10 cm of flour.

13. The manipulated or independent variable in this project would be

a. amount of flour used.
b. size of rocks.
c. size of the crater created in the flour.
d. height from which the rocks are dropped.
14. Two of the constant variables in this investigation are the
   a. amount of flour used and the size of the rocks.
   b. depth of flour in the pan and the height from which the rocks are dropped.
   c. height from which the rocks are dropped and the size of the rocks.
   d. size of the pan and the size of the craters created.

*Use the following information to answer questions 15 – 17.*

<table>
<thead>
<tr>
<th>Planet</th>
<th>Approximate Distance from the Sun (million)</th>
<th>Length of Day (Earth units)</th>
<th>Length of Year (Earth Units)</th>
<th>Diameter</th>
<th>Number of Moons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58.0 km</td>
<td>58.0 days</td>
<td>88 days</td>
<td>4 878 km</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>108.0 km</td>
<td>243.0 days</td>
<td>225 days</td>
<td>12 104 km</td>
<td>0</td>
</tr>
<tr>
<td>Earth</td>
<td>152.0 km</td>
<td>1.0 day</td>
<td>365 days</td>
<td>12 756 km</td>
<td>1</td>
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<td>Mars</td>
<td>228.0 km</td>
<td>1.0 day</td>
<td>687 days</td>
<td>6 787 km</td>
<td>2</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778.0 km</td>
<td>10.0 hours</td>
<td>12 years</td>
<td>142 800 km</td>
<td>63</td>
</tr>
<tr>
<td>Saturn</td>
<td>1 507.0 km</td>
<td>10.0 hours</td>
<td>30 years</td>
<td>120 000 km</td>
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<td>Uranus</td>
<td>2 871.0 km</td>
<td>16.0 hours</td>
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<td>Neptune</td>
<td>5 913.0 km</td>
<td>18.0 hours</td>
<td>248 years</td>
<td>49 528 km</td>
<td>13</td>
</tr>
</tbody>
</table>

15. Two planets that have the same number of natural satellites are
   a. Earth and Mars.
   b. Mercury and Saturn.
   c. Mercury and Venus.
   d. Neptune and Saturn.

16. You can conclude that the farther a planet is from the Sun, the
   a. greater the overall size of the planet.
   b. greater the number of moons the planet has.
   c. longer it takes the planet to revolve around the Sun.
   d. faster the speed at which the planet rotates on its axis.

17. Two of the planets rotate on their axes at about the same speed. Which two are they?
   a. Jupiter and Saturn
   b. Venus and Mercury
   c. Neptune and Uranus
   d. Mars and Earth
Use the information in the table to answer questions 18 and 19.

<table>
<thead>
<tr>
<th></th>
<th>Saturn</th>
<th>Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum distance from Sun (millions of km)</td>
<td>1,507</td>
<td>152</td>
</tr>
<tr>
<td>Diameter (km)</td>
<td>120,000</td>
<td>12,756</td>
</tr>
<tr>
<td>Average surface temperature</td>
<td>-180°C</td>
<td>22°C</td>
</tr>
<tr>
<td>Day length (Earth units)</td>
<td>10 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td>Year length (Earth units)</td>
<td>30 years</td>
<td>1 year</td>
</tr>
<tr>
<td>Number of moons</td>
<td>18</td>
<td>1</td>
</tr>
</tbody>
</table>

18. When comparing Saturn with Earth, Saturn has a

a. shorter orbit around the Sun.
   b. longer period of rotation.
   c. smaller number of natural satellites.
   d. greater diameter.

19. From the table you can tell that Saturn's diameter is about

a. 1000 times greater than Earth's diameter.
   b. 100 times greater than Earth's diameter.
   c. 10 times greater than Earth's diameter.
   d. one-tenth as great as Earth's diameter.

20. Which of the following are correctly listed in order from largest to smallest?

a. universe, galaxy, solar system, Sun
   b. Sun, universe, galaxy, solar system
   c. solar system, universe, Sun, galaxy
   d. sun, solar system, galaxy, universe
1. Define each of these terms.

   a. solar system **Sun and its planets and their moons, asteroids, and comets**

   b. orbit **path a planet takes as it travels around Sun**

   c. waxing **increasing in size**

   d. waning **decreasing in size**

   e. period of rotation **length of time it takes a planet to turn once on its axis**

   f. period of revolution **length of time it takes a planet to travel once around the Sun**

2. Write the names of the planets in order, beginning with the one closest to the Sun.

   Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune

3. Four planets, Mercury, Venus, Earth, and Mars, have the most intense light and heat. Why do you think this is?

   closest to the Sun
4. One or two words in each of the following statements are incorrect. Cross them out and write the correct words above them.

a. The Earth has five natural satellites.

b. All of planets are made of gases.

c. The shape of Earth's orbit around the Sun is a circle.

d. The Sun causes the ocean tides on Earth.

e. A quarter of the Moon is always in darkness and a quarter is always lit.

f. Venus is a planet that has many rings around it. (Jupiter, Uranus, Neptune also have rings)

g. It takes the Earth 365 days to make one revolution around the Sun on its axis.

h. Mercury is the planet closest to the Sun.

i. Uranus is the largest planet in the solar system.

j. Man has been studying the Universe for just a few years.

5. On the diagram below label and colour the phases of the Moon.

6. Explain why we always see the same side of the Moon.

It takes same amount of time to rotate once on its axis as it does to revolve once around the Earth.
7. The Moon travels around the Earth in
   a. a clockwise direction.
   b. a counterclockwise direction.
   c. a square.
   d. both a clockwise and a counterclockwise direction.

8. Which of the following show the correct phases of the Moon?
   a. A is the waxing crescent and E is the waning crescent.
   b. H is the new moon and G is the waning crescent.
   c. C is the waning gibbous and F is the last quarter.
   d. D is the full moon and B is the waxing crescent.
9. Starting with the new moon phase, as the Moon revolves around the Earth, the portion of the Moon that we see

   a. disappears.
   b. remains the same.
   c. increases then decreases.
   d. decreases then increases.

10. During the new moon phase

   a. the portion of the Moon we see appears fully lit.
   b. the portion of the Moon we see appears partially lit.
   c. the portion of the Moon we see is fully in shadow.
   d. the portion of the Moon we see is sunny.
Examine the table below. Then answer questions 11 and 12.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Distance from the Sun (million kilometres)</th>
<th>Time for Planet to Circle the Sun</th>
</tr>
</thead>
<tbody>
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<td>88 days</td>
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<tr>
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<tr>
<td>Earth</td>
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</table>

11. Mars is 228 million kilometres from the Sun. You can hypothesize from the information in the table that Mars would circle the Sun once every

a. 200 days.
b. 51 years.
c. 687 days.
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12. From the information in the table you can conclude that

a. the closer a planet is to the Sun, the longer it takes to make one revolution around the Sun.
   b. the farther a planet is from the Sun, the longer it takes to make one revolution around the Sun.
   c. the farther a planet is from the Sun, the less time it takes to make one revolution around the Sun.
   d. the closer a planet is to the Sun, the longer it takes to rotate once on its axis.

Use the following information to answer questions 13 and 14.

Bob did a project to show how different-sized craters can be made by dropping rocks of different sizes from the same height into a pan containing 10 cm of flour.

13. The manipulated or independent variable in this project would be

a. amount of flour used.
b. size of rocks.
c. size of the crater created in the flour.
d. height from which the rocks are dropped.
14. Two of the constant variables in this investigation are the
   a. amount of flour used and the size of the rocks.
   b. depth of flour in the pan and the height from which the rocks are dropped.
   c. height from which the rocks are dropped and the size of the rocks.
   d. size of the pan and the size of the craters created.

**Use the following information to answer questions 15 – 17.**

<table>
<thead>
<tr>
<th>Planet</th>
<th>Approximate Distance from the Sun (million)</th>
<th>Length of Day (Earth units)</th>
<th>Length of Year (Earth Units)</th>
<th>Diameter</th>
<th>Number of Moons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58.0 km</td>
<td>58.0 days</td>
<td>88 days</td>
<td>4 878 km</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>108.0 km</td>
<td>243.0 days</td>
<td>225 days</td>
<td>12 104 km</td>
<td>0</td>
</tr>
<tr>
<td>Earth</td>
<td>152.0 km</td>
<td>1.0 day</td>
<td>365 days</td>
<td>12 756 km</td>
<td>1</td>
</tr>
<tr>
<td>Mars</td>
<td>228.0 km</td>
<td>1.0 day</td>
<td>687 days</td>
<td>6 787 km</td>
<td>2</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778.0 km</td>
<td>10.0 hours</td>
<td>12 years</td>
<td>142 800 km</td>
<td>63</td>
</tr>
<tr>
<td>Saturn</td>
<td>1 507.0 km</td>
<td>10.0 hours</td>
<td>30 years</td>
<td>120 000 km</td>
<td>61</td>
</tr>
<tr>
<td>Uranus</td>
<td>2 871.0 km</td>
<td>16.0 hours</td>
<td>84 years</td>
<td>51 118 km</td>
<td>27</td>
</tr>
<tr>
<td>Neptune</td>
<td>5 913.0 km</td>
<td>18.0 hours</td>
<td>248 years</td>
<td>49 528 km</td>
<td>13</td>
</tr>
</tbody>
</table>

15. Two planets that have the same number of natural satellites are
   a. Earth and Mars.
   b. Mercury and Saturn.
   c. Mercury and Venus.
   d. Neptune and Saturn.

16. You can conclude that the farther a planet is from the Sun, the
   a. greater the overall size of the planet.
   b. greater the number of moons the planet has.
   c. longer it takes the planet to revolve around the Sun.
   d. faster the speed at which the planet rotates on its axis.

17. Two of the planets rotate on their axes at about the same speed. Which two are they?
   a. Jupiter and Saturn
   b. Venus and Mercury
   c. Neptune and Uranus
   d. Mars and Earth
Use the information in the table to answer questions 18 and 19.

<table>
<thead>
<tr>
<th>Saturn</th>
<th>Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum distance from Sun (millions of km)</td>
<td>1507</td>
</tr>
<tr>
<td>Diameter (km)</td>
<td>120,000</td>
</tr>
<tr>
<td>Average surface temperature</td>
<td>-180°C</td>
</tr>
<tr>
<td>Day length (Earth units)</td>
<td>10 hours</td>
</tr>
<tr>
<td>Year length (Earth units)</td>
<td>30 years</td>
</tr>
<tr>
<td>Number of moons</td>
<td>18</td>
</tr>
</tbody>
</table>

18. When comparing Saturn with Earth, Saturn has a
   a. shorter orbit around the Sun.
   b. longer period of rotation.
   c. smaller number of natural satellites.
   d. greater diameter.

19. From the table you can tell that Saturn's diameter is about
   a. 1000 times greater than Earth's diameter.
   b. 100 times greater than Earth's diameter.
   c. 10 times greater than Earth's diameter.
   d. one-tenth as great as Earth's diameter.

20. Which of the following are correctly listed in order from largest to smallest?
   a. universe, galaxy, solar system, Sun
   b. Sun, universe, galaxy, solar system
   c. solar system, universe, Sun, galaxy
   d. sun, solar system, galaxy, universe
Lesson Twenty-five

Concept: Sky Science, Part II: Test

Resources/Materials: Sky Science, Part II: Test (student copies)
1. Write the names of the planets in order, beginning with the one closest to the Sun.

2. Match the words and phrases from the box to their meanings.

<table>
<thead>
<tr>
<th>orbit</th>
<th>period of rotation</th>
<th>period of revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>satellite</td>
<td>new moon</td>
<td>full moon</td>
</tr>
<tr>
<td>waxing</td>
<td>waning</td>
<td>phase</td>
</tr>
</tbody>
</table>

____________________ the path on which a planet travels around the Sun
____________________ stage
____________________ the length of time it takes for a planet to turn once on its axis
____________________ increasing in size
____________________ time when we cannot see the Moon from Earth
____________________ the length of time it takes a planet to travel once around the Sun
____________________ decreasing in size
____________________ time when we can see all the reflected side of the Moon
____________________ a heavenly body that travels around another heavenly body

3. Answer true or false.

__________ The shape of Earth’s orbit around the Sun is a circle.

__________ The Earth has no natural satellites.

__________ The Moon causes the ocean tides.

__________ Half of the Moon is always in darkness and half it lit.
Some of the planets are actually made mostly of gases.

It takes the Earth about 365 days to rotate once on its axis.

Jupiter is the largest planet in the solar system.

All planets have moons.

Man has been studying the Universe for only the past one hundred years.

4. On the diagram below, colour in the part of each phase correctly. Then label the diagram.
5. Beginning with the new moon phase, as the Moon revolves around the Earth, the portion of the Moon that we see

a. increases then decreases.

b. decreases then increases.

c. remains the same.

d. disappears.

6. The new moon phase occurs when the portion of the Moon we see from Earth is

a. fully lit.

b. partially lit.

c. totally in shadow.

d. partially in shadow.
7. At position Q the phase of the moon would be
   a. new moon.
   b. first quarter.
   c. full moon.
   d. last quarter.

8. While looking up at the night sky, you must remember that an object that emits its own light is called
   a. a moon.
   b. a star.
   c. a planet.
   d. an asteroid.

9. Think about the difference between the forces of gravity on the Earth and on the Moon. A person who weighs 60 kilograms on Earth will weigh how much on the Moon?
   a. 360 kilograms
   b. 30 kilograms
   c. 10 kilograms
   d. 60 kilograms
Use the information below to answer questions 10 – 14.

**The Solar System**

<table>
<thead>
<tr>
<th>Planet</th>
<th>Maximum distance from Sun (millions)</th>
<th>Diameter</th>
<th>Average Surface Temperature</th>
<th>Day Length (Earth units)</th>
<th>Year Length (Earth units)</th>
<th><em>Number of Moons</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>69.7 km</td>
<td>4 880 km</td>
<td>350°C day 170°C night</td>
<td>58.0 days</td>
<td>88 days</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>109.0 km</td>
<td>12 100 km</td>
<td>480°C</td>
<td>243.0 days</td>
<td>225 days</td>
<td>0</td>
</tr>
<tr>
<td>Earth</td>
<td>152.1 km</td>
<td>12 756 km</td>
<td>22°C</td>
<td>1.0 day</td>
<td>365 days</td>
<td>1</td>
</tr>
<tr>
<td>Mars</td>
<td>249.1 km</td>
<td>6 787 km</td>
<td>-23°C</td>
<td>1.0 day</td>
<td>687 days</td>
<td>2</td>
</tr>
<tr>
<td>Jupiter</td>
<td>815.7 km</td>
<td>142 800 km</td>
<td>-150°C</td>
<td>10.0 hours</td>
<td>12 years</td>
<td>63</td>
</tr>
<tr>
<td>Saturn</td>
<td>1 507.0 km</td>
<td>120 000 km</td>
<td>-180°C</td>
<td>10.0 hours</td>
<td>30 years</td>
<td>61</td>
</tr>
<tr>
<td>Uranus</td>
<td>3 004.0 km</td>
<td>51 800 km</td>
<td>-210°C</td>
<td>16.0 hours</td>
<td>84 years</td>
<td>27</td>
</tr>
<tr>
<td>Neptune</td>
<td>4 537.0 km</td>
<td>49 500 km</td>
<td>-220°C</td>
<td>18.0 hours</td>
<td>165 years</td>
<td>13</td>
</tr>
<tr>
<td>Pluto</td>
<td>7 385.0 km</td>
<td>3 000 km</td>
<td>-230°C</td>
<td>6.4 days</td>
<td>248 years</td>
<td>1</td>
</tr>
</tbody>
</table>

*Number of moons as of March 2010*

10. The celestial body in the chart that is considered to be a dwarf planet is

a. Mercury.
b. Earth.
c. Pluto.
d. Venus.

11. The planet that has the same number of natural satellites as Mercury is

a. Venus.
b. Mars.
c. Uranus.
d. Neptune.

12. The planet that rotates most slowly on its axis is

a. Venus.
b. Mars.
c. Neptune.
d. Jupiter.
13. The planet that takes the longest to revolve around the Sun one time is

a. Neptune.
b. Mars.
c. Venus.
d. Saturn.

14. In which of the following is a group of planets correctly ordered according to how close they are to the Sun?

a. Jupiter, Uranus, Mercury, Neptune
b. Venus, Earth, Jupiter, Neptune
c. Uranus, Earth, Venus, Mars
d. Mars, Saturn, Uranus, Mercury

*Use the information in the table to answer question 15.*

<table>
<thead>
<tr>
<th>Planet</th>
<th>Distance from the Sun (million kilometres)</th>
<th>Time for Planet to Circle the Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58</td>
<td>88 days</td>
</tr>
<tr>
<td>Venus</td>
<td>108</td>
<td>225 days</td>
</tr>
<tr>
<td>Earth</td>
<td>150</td>
<td>1 year</td>
</tr>
<tr>
<td>Jupiter</td>
<td>780</td>
<td>12 years</td>
</tr>
<tr>
<td>Uranus</td>
<td>2870</td>
<td>84 years</td>
</tr>
<tr>
<td>Neptune</td>
<td>4500</td>
<td>165 years</td>
</tr>
</tbody>
</table>

15. From this information you can hypothesize that the planet Saturn, 1,420 million kilometres from the Sun, would circle the Sun about once every

a. 100 days.
b. 10 years.
c. 30 years.
d. 100 years.

16. Compared with planets far away, the four planets **closest** to the Sun have **more**

a. surface area than do the planets farther away.
b. gravity than do the planets farther away.
c. atmosphere than do the planets farther away.
d. intense sunlight than do the planets farther away.
Use the information below to answer questions 17 – 19.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Approximate Distance from the Sun (million)</th>
<th>Length of Day (Earth units)</th>
<th>Length of Year (Earth Units)</th>
<th>Diameter</th>
<th>Number of Moons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58.0 km</td>
<td>58.0 days</td>
<td>88 days</td>
<td>4 878 km</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>108.0 km</td>
<td>243.0 days</td>
<td>225 days</td>
<td>12 104 km</td>
<td>0</td>
</tr>
<tr>
<td>Earth</td>
<td>152.0 km</td>
<td>1.0 day</td>
<td>365 days</td>
<td>12 756 km</td>
<td>1</td>
</tr>
<tr>
<td>Mars</td>
<td>228.0 km</td>
<td>1.0 day</td>
<td>687 days</td>
<td>6 787 km</td>
<td>2</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778.0 km</td>
<td>10.0 hours</td>
<td>12 years</td>
<td>142 800 km</td>
<td>63</td>
</tr>
<tr>
<td>Saturn</td>
<td>1 507.0 km</td>
<td>10.0 hours</td>
<td>30 years</td>
<td>120 000 km</td>
<td>61</td>
</tr>
<tr>
<td>Uranus</td>
<td>2 871.0 km</td>
<td>16.0 hours</td>
<td>84 years</td>
<td>51 118 km</td>
<td>27</td>
</tr>
<tr>
<td>Neptune</td>
<td>5 913.0 km</td>
<td>18.0 hours</td>
<td>248 years</td>
<td>49 528 km</td>
<td>13</td>
</tr>
</tbody>
</table>

17. From the information in the table, you can conclude that the farther a planet is from the Sun, the

a. greater the overall size of the planet.

b. greater the number of moons the planet has.

c. longer it takes the planet to revolve around the Sun.

d. faster the speed at which the planet rotates on its axis.

18. One planet takes the same about of time to rotate on its axis as does another planet. The two planets are

a. Mars and Venus.

b. Earth and Mercury.

c. Jupiter and Saturn.

d. Uranus and Neptune.

19. Which of the following planets have the same number of natural satellites?

a. Earth and Saturn

b. Earth and Mars

c. Venus and Mercury

d. Venus and Mars
Use the following information to answer question 20.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Diameter (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>4 880</td>
</tr>
<tr>
<td>Venus</td>
<td>12 100</td>
</tr>
<tr>
<td>Earth</td>
<td>12 756</td>
</tr>
<tr>
<td>Mars</td>
<td>6787</td>
</tr>
</tbody>
</table>

20. Which of the following bar graphs represents the diameters of the four planets.

A.  

![Bar Graph A](image)

B.  

![Bar Graph B](image)

C.  

![Bar Graph C](image)

D.  

![Bar Graph D](image)
Use the following information to answer questions 21 and 22.

Peter wants to show how different-sized craters can be made by dropping rocks of different sizes from the same height into a pan containing 10 cm of flour.

13. The manipulated or independent variable in this project is the

a. size of the rocks.
b. height from which the rocks are dropped.
c. amount of flour used.
d. size of the crater created in the flour.

14. Two of the constant variables in this investigation are the

a. size of the pan and the size of the craters created.
b. height from which the rocks are dropped and the size of the rocks.
c. depth of the flour in the pan and the height from which the rocks are dropped.
d. amount of flour used and the size of the rocks.
1. Write the names of the planets in order, beginning with the one closest to the Sun.  

Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune

2. Match the words and phrases from the box to their meanings.

<table>
<thead>
<tr>
<th>orbit</th>
<th>period of rotation</th>
<th>period of revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>satellite</td>
<td>new moon</td>
<td>full moon</td>
</tr>
<tr>
<td>waxing</td>
<td>waning</td>
<td>phase</td>
</tr>
</tbody>
</table>

orbit: the path on which a planet travels around the Sun
phase: stage
period of rotation: the length of time it takes for a planet to turn once on its axis
waxing: increasing in size
new moon: time when we cannot see the Moon from Earth
period of revolution: the length of time it takes a planet to travel once around the Sun
waning: decreasing in size
full moon: time when we can see all the reflected side of the Moon
satellite: a heavenly body that travels around another heavenly body

3. Answer true or false.

F The shape of Earth's orbit around the Sun is a circle.
F The Earth has no natural satellites.
T The Moon causes the ocean tides.
T Half of the Moon is always in darkness and half it lit.
1. Some of the planets are actually made mostly of gases.  
2. It takes the Earth about 365 days to rotate once on its axis.
3. Jupiter is the largest planet in the solar system.
4. All planets have moons.
5. Man has been studying the Universe for only the past one hundred years.

4. On the diagram below, colour in the part of each phase correctly. Then label the diagram.
Use the following information to answer questions 5 and 6.

The diagram below can be used to explain the phases of the moon over the period of one month.

5. Beginning with the new moon phase, as the Moon revolves around the Earth, the portion of the Moon that we see
   a. increases then decreases.
   b. decreases then increases.
   c. remains the same.
   d. disappears.

6. The new moon phase occurs when the portion of the Moon we see from Earth is
   a. fully lit.
   b. partially lit.
   c. totally in shadow.
   d. partially in shadow.
7. At position Q the phase of the moon would be
   a. new moon.
   b. first quarter.
   c. full moon.
   d. last quarter.

8. While looking up at the night sky, you must remember that an object that emits its own light is called
   a. a moon.
   b. a star.
   c. a planet.
   d. an asteroid.

9. Think about the difference between the forces of gravity on the Earth and on the Moon. A person who weights 60 kilograms on Earth will weigh how much on the Moon?
   a. 360 kilograms
   b. 30 kilograms
   c. 10 kilograms
   d. 60 kilograms
### The Solar System

<table>
<thead>
<tr>
<th>Planet</th>
<th>Maximum distance from Sun (millions)</th>
<th>Diameter</th>
<th>Average Surface Temperature</th>
<th>Day Length (Earth units)</th>
<th>Year Length (Earth units)</th>
<th>*Number of Moons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>69.7 km</td>
<td>4 880 km</td>
<td>350°C day -170°C night</td>
<td>58.0 days</td>
<td>88 days</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>109.0 km</td>
<td>12 100 km</td>
<td>-480°C</td>
<td>243.0 days</td>
<td>225 days</td>
<td>0</td>
</tr>
<tr>
<td>Earth</td>
<td>152.1 km</td>
<td>12 756 km</td>
<td>22°C</td>
<td>1.0 day</td>
<td>365 days</td>
<td>1</td>
</tr>
<tr>
<td>Mars</td>
<td>249.1 km</td>
<td>6 787 km</td>
<td>-23°C</td>
<td>1.0 day</td>
<td>687 days</td>
<td>2</td>
</tr>
<tr>
<td>Jupiter</td>
<td>815.7 km</td>
<td>142 800 km</td>
<td>-150°C</td>
<td>10.0 hours</td>
<td>12 years</td>
<td>63</td>
</tr>
<tr>
<td>Saturn</td>
<td>1 507.0 km</td>
<td>120 000 km</td>
<td>-180°C</td>
<td>10.0 hours</td>
<td>30 years</td>
<td>61</td>
</tr>
<tr>
<td>Uranus</td>
<td>3 004.0 km</td>
<td>51 800 km</td>
<td>-210°C</td>
<td>16.0 hours</td>
<td>84 years</td>
<td>27</td>
</tr>
<tr>
<td>Neptune</td>
<td>4 537.0 km</td>
<td>49 500 km</td>
<td>-220°C</td>
<td>18.0 hours</td>
<td>165 years</td>
<td>13</td>
</tr>
<tr>
<td>Pluto</td>
<td>7 385.0 km</td>
<td>3 000 km</td>
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<td>6.4 days</td>
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<td>1</td>
</tr>
</tbody>
</table>

*Number of moons as of March 2010

10. The celestial body in the chart that is considered to be a dwarf planet is
   a. Mercury.
   b. Earth.
   c. Pluto.
   d. Venus.

11. The planet that has the same number of natural satellites as Mercury is
   a. Venus.
   b. Mars.
   c. Uranus.
   d. Neptune.

12. The planet that rotates most slowly on its axis is
   a. Venus.
   b. Mars.
   c. Neptune.
   d. Jupiter.
13. The planet that takes the longest to revolve around the Sun one time is
   a. Neptune
   b. Mars
   c. Venus
   d. Saturn

14. In which of the following is a group of planets correctly ordered according to how close they are to the Sun?
   a. Jupiter, Uranus, Mercury, Neptune
   b. Venus, Earth, Jupiter, Neptune
   c. Uranus, Earth, Venus, Mars
   d. Mars, Saturn, Uranus, Mercury

Use the information in the table to answer question 15.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Distance from the Sun (million kilometres)</th>
<th>Time for Planet to Circle the Sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58</td>
<td>88 days</td>
</tr>
<tr>
<td>Venus</td>
<td>108</td>
<td>225 days</td>
</tr>
<tr>
<td>Earth</td>
<td>150</td>
<td>1 year</td>
</tr>
<tr>
<td>Jupiter</td>
<td>780</td>
<td>12 years</td>
</tr>
<tr>
<td>Uranus</td>
<td>2870</td>
<td>84 years</td>
</tr>
<tr>
<td>Neptune</td>
<td>4500</td>
<td>165 years</td>
</tr>
</tbody>
</table>

15. From this information you can hypothesize that the planet Saturn, 1 420 million kilometres from the Sun, would circle the Sun about once every
   a. 100 days.
   b. 10 years.
   c. 30 years.
   d. 100 years.

16. Compared with planets far away, the four planets closest to the Sun have more
   a. surface area than do the planets farther away.
   b. gravity than do the planets farther away.
   c. atmosphere than do the planets farther away.
   d. intense sunlight than do the planets farther away.
Use the information below to answer questions 17 – 19.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Approximate Distance from the Sun (million)</th>
<th>Length of Day (Earth units)</th>
<th>Length of Year (Earth Units)</th>
<th>Diameter</th>
<th>Number of Moons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>58.0 km</td>
<td>58.0 days</td>
<td>88 days</td>
<td>4 878 km</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>108.0 km</td>
<td>243.0 days</td>
<td>225 days</td>
<td>12 104 km</td>
<td>0</td>
</tr>
<tr>
<td>Earth</td>
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<td>365 days</td>
<td>12 756 km</td>
<td>1</td>
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<td>687 days</td>
<td>6 787 km</td>
<td>2</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778.0 km</td>
<td>10.0 hours</td>
<td>12 years</td>
<td>142 800 km</td>
<td>63</td>
</tr>
<tr>
<td>Saturn</td>
<td>1 507.0 km</td>
<td>10.0 hours</td>
<td>30 years</td>
<td>120 000 km</td>
<td>61</td>
</tr>
<tr>
<td>Uranus</td>
<td>2 871.0 km</td>
<td>16.0 hours</td>
<td>84 years</td>
<td>51 118 km</td>
<td>27</td>
</tr>
<tr>
<td>Neptune</td>
<td>5 913.0 km</td>
<td>18.0 hours</td>
<td>248 years</td>
<td>49 528 km</td>
<td>13</td>
</tr>
</tbody>
</table>

17. From the information in the table, you can conclude that the farther a planet is from the Sun, the
a. greater the overall size of the planet.
b. greater the number of moons the planet has.
c. longer it takes the planet to revolve around the Sun.
d. faster the speed at which the planet rotates on its axis.

18. One planet takes the same about of time to rotate on its axis as does another planet. The two planets are
a. Mars and Venus.
b. Earth and Mercury.
c. Jupiter and Saturn.
d. Uranus and Neptune.

19. Which of the following planets have the same number of natural satellites?
   a. Earth and Saturn
   b. Earth and Mars
   c. Venus and Mercury
   d. Venus and Mars
20. Which of the following bar graphs represents the diameters of the four planets.

A. 

![Bar graph A](image1.png)

B. 

![Bar graph B](image2.png)

C. 

![Bar graph C](image3.png)

D. 

![Bar graph D](image4.png)
Use the following information to answer questions 21 and 22.

Peter wants to show how different-sized craters can be made by dropping rocks of different sizes from the same height into a pan containing 10 cm of flour.

13. The manipulated or independent variable in this project is the

   a. size of the rocks.
   b. height from which the rocks are dropped.
   c. amount of flour used.
   d. size of the crater created in the flour.

14. Two of the constant variables in this investigation are the

   a. size of the pan and the size of the craters created.
   b. height from which the rocks are dropped and the size of the rocks.
   c. depth of the flour in the pan and the height from which the rocks are dropped.
   d. amount of flour used and the size of the rocks.
Grade Six

Topic D

Evidence and Investigation
## Materials List by Lesson
Optional items are in brackets [ ].

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Materials Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>binder rings (1&quot;) or twist ties, single hole punch</td>
</tr>
<tr>
<td>2</td>
<td>tray, 10 small miscellaneous items, cloth, strips of paper</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>area of fresh snow, sand, or dirt, students’ shoes, ruler, [spray bottle]</td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>students/staff footwear</td>
</tr>
<tr>
<td>10</td>
<td>rulers, metre sticks</td>
</tr>
<tr>
<td>11</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>paper, soft leaded pencils, clear tape, damp paper towels, [ink pad]</td>
</tr>
<tr>
<td>15</td>
<td>clear tape, white powder (corn starch), soft-bristled brushes, black construction paper, beaker or smooth glass jar, damp paper towel, dry paper towel, [surgical gloves]</td>
</tr>
<tr>
<td>16</td>
<td>wax crayons, newsprint, ruler</td>
</tr>
<tr>
<td>17</td>
<td>[chromatography paper], filter paper, plastic cups or dishes, ruler, 4 different water soluble felt markers, tape</td>
</tr>
<tr>
<td>18</td>
<td>half sheets of paper</td>
</tr>
<tr>
<td>19</td>
<td>half sheets of paper</td>
</tr>
<tr>
<td>20</td>
<td>at least 4 different fabric samples, hot water, laundry soap, glass beakers or jars, tongs or tweezers, [magnifying glass], tape</td>
</tr>
<tr>
<td>21</td>
<td>at least 4 different soil samples, spoons, Styrofoam trays, [magnifying glass]</td>
</tr>
<tr>
<td>22</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** For many of the activities, you will need a set of materials for each group of students.
area of fresh snow, sand, or soil

beakers (glass) or smooth-sided jars
binder rings (1") or twist ties
brushes (soft-bristled)

[chromatography paper]
cloth (large enough to cover a tray)
corn starch
crayons (wax)

fabric samples (at least 4 different)
filter paper
footwear (students’ shoes and boots)

[gloves (surgical)]

hole punch (single-hole)

[ink pad]

[magnifying glass]
miscellaneous small objects (10)

newsprint

dpaper towels
dpencils, soft-leadased

dpens (4 different brands of felt markers, water soluble)

plastic cups (clear), or shallow plastic bowls

rulers

soil samples, at least 4 different kinds

spoons
[ spray bottle]

Styrofoam trays (meat trays from grocery store)
tape, clear
tape, masking
tray
Grade Six
Topic D
Evidence and Investigation
Mini Textbook
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Evidence and Investigation

Introduction

The role of the police is to enforce the laws of a municipality, province, or country. This helps to create a society that is fair and just. But the police cannot just go around handing out fines or arresting people without some kind of proof that a law was broken by a particular person. This proof comes in the form of evidence. Evidence is a clue or clues that helps an investigator solve a crime.

Police use photo radar to gather evidence that proves a car is speeding.

Some crimes are relatively simple to solve. If a police officer happens to be driving by as you jay walk, he or she can give you a ticket right on the spot because he witnessed you breaking the law.

In other instances, crimes are more difficult to solve. It takes a great deal of education, training, and skill on the part of police detectives to come up with the evidence necessary to determine how a crime was committed and who actually committed the crime.

Police officers work as a team when trying to solve a crime. To be effective, they must have good observation skills.

In this unit, Evidence and Investigation, you will learn about some of the ways that law enforcement workers use when investigating crimes. You will find that they are some of the same strategies that you use to solve problems in your daily life.
Part I:

Observing and Analyzing

People and Tracks

Introduction

Gathering evidence is one of the most difficult jobs that any investigator has. It not only requires that he or she have well-tuned observation skills. It is also necessary for the investigator to decide if what he or she observes is important and how it is important to solving the crime.

A good detective is a good problem solver. He or she must be able to gather evidence, make inferences about the evidence, formulate hypotheses, and synthesize (or combine) all kinds of information.

Investigative Skills

A good detective has good investigative skills. It is time to find out more about them.

Accurate Observations

A detective investigates crimes, and one of the most important traits a detective must develop is being observant. Being observant does not only mean remembering what you see. It involves gathering information using all of your senses.

An investigator must learn to use all senses when gathering information.

Studies have shown that being a good observer is not as easy as you might think. The fact is, most people are very poor observers. To test your powers of observation, examine the photograph on the next page (page 6) for about 20 seconds. (Estimate the time by counting to 20 very slowly.) Then see if you can answer the questions on page 7.
How Well Did You Observe?

Without looking back at the picture on page 6, see if you can answer these questions. The answers are at the bottom of this page. Do not be tempted to look at them before you answer the questions. If you like, cover the answers with a sheet of paper.

1. About how many people are there in the photo? (Choose from: about 6; about 12; about 20)
2. How many of the people in the photo are male?
3. From examining the shadows, from what direction is the Sun shining?
4. Of the males, how many are not wearing jackets?
5. How many people in the photo are being carried?
6. Think about the smallest girl. Would you say her apron is lighter-coloured or darker-coloured than those of the other females standing in the front of the photo?
7. How many burning barrels do you see in the photo?
8. How many John Deere tractors are there in the photo?
9. How many of those in the front row have hands in their pockets?
10. One boy has his hands on his hips. What colour are the buttons on his shirt?

How Observant Are Most People?

Research done by police departments and others interested in solving crimes has shown that people really are not very observant. Sometimes they imagine they saw or heard something that was not there at all. They are also usually poor at estimating a person’s height and weight. Even such obvious things as hair and eye colour are often difficult for people to remember.

Nonetheless, eye witnesses to crimes can provide investigators with valuable information. Investigators realize that witnesses’ observation skills and memories are not always reliable. Because of this, they rely on their questioning skills to help witnesses recall what they observed in a more accurate manner.

**ANSWERS:** 1. about 20 2. 6 3. no shadows; sun is not shining 4. 3 5. 1 6. lighter 7. 2 8. 0 9. 1 10. white
Good Questioning Techniques

An important part of investigation has to do with gathering information by questioning others. This could involve interviewing suspects or witnesses. Here are some common questioning techniques, and when (and when not) to use them.

Detectives question suspects in a room inside a police station. This helps the police decide if a suspect really did commit the crime.

Open and Closed Questions

A closed question usually receives a single word or very short factual answer. For example, “Are you thirsty?” The answer is “Yes” or “No”. “Where do you live?” The answer is generally the name of the nearest town or your colony.

Open questions receive longer answers. They usually begin with what, why, or how. An open question asks the person for his or her knowledge, opinion, or feelings. “Tell me” and “describe” can also be used in the same way as open questions. Here are some examples:

- What did you see last Friday evening?
- Tell me what happened next?
- Why did she react that way?

There are times when a closed question is the most appropriate, but investigators usually get more information when asking open questions.

Funnel Questions

This technique involves starting with general questions, and then asking for more and more detail:

Q: How many people were involved in the fight?
A: About ten.
Q: Were they kids or adults?
A: Mostly kids.
Q: What sort of ages were they?
A: About fourteen or fifteen.
Q: Were any of them wearing anything unusual or distinctive?
A: *Yes, several of them had red baseball caps on.*
Q: Can you remember is there was a logo on any of the caps?
A: *Now you come to mention it; yes, I remember seeing a big letter N.*

Funnel questions are good for finding out more information about a specific point.

**Probing Questions**

Asking probing questions is another strategy for finding out more detail. Sometimes it is as simple as asking for an example to help you understand a statement the person made. Other times you want additional information. “Where were you exactly when you say you were at home?” Probing questions are useful to help you get more information or if you suspect a person is avoiding telling you something.

**Leading Questions**

When you ask a leading question, you try to “lead” the person to your way of thinking.

- Are you saying you have never been to Green’s Shoe Store?
- If you were a thief, would you stay in the store or try to get out before someone called the police?

The type of questioning techniques an investigator uses depends on the person he or she is questioning and the type of information he or she is seeking. A good investigator knows when to use each technique. In the end, he or she wants to be able to piece together what happened by being able to answer these questions: Who? What? When? Where? Why? and How?

As part of the information-gathering process, police often question witnesses to crimes. This helps them to understand what really happened.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>crime</td>
<td>an act that breaks the law</td>
</tr>
<tr>
<td>crime scene</td>
<td>where a crime took place</td>
</tr>
<tr>
<td>investigate</td>
<td>observe or study in an organized way in order to get more information</td>
</tr>
<tr>
<td>observe</td>
<td>get information through seeing, hearing, smelling, touching, or tasting</td>
</tr>
<tr>
<td>clue</td>
<td>a bit of evidence</td>
</tr>
<tr>
<td>evidence</td>
<td>anything that provides material or information on which a conclusion can be based</td>
</tr>
<tr>
<td>mystery</td>
<td>something that cannot easily be explained</td>
</tr>
<tr>
<td>suspect</td>
<td>person whom police think may have committed a crime</td>
</tr>
<tr>
<td>witness</td>
<td>someone who sees a crime happen</td>
</tr>
<tr>
<td>forensic science</td>
<td>the science of uncovering and using clues to make inferences about how a crime happened</td>
</tr>
<tr>
<td>detective</td>
<td>person who investigates a crime</td>
</tr>
<tr>
<td>perpetrator</td>
<td>person who commits a crime</td>
</tr>
<tr>
<td>accuse</td>
<td>to blame someone for committing an illegal act</td>
</tr>
<tr>
<td>victim</td>
<td>person to whom something wrong was done</td>
</tr>
</tbody>
</table>
Predicting and Hypothesizing

Foundations of Good Investigation

1. good observation skills
2. good questioning skills
3. ability to predict and hypothesize based on evidence

So far you have learned about the importance of good observation and questioning skills. Once investigators have gathered information about a particular crime, they try to use that information to make predictions and formulate a hypothesis.

*Predicting involves making an educated guess about what will happen next.* For example, if there have been a string of incidents where thieves have broken into basement windows and expensive electronic equipment from houses in a particular community, the police might predict that it will happen again in that same community. The police would most likely warn people in the community to make sure their basement windows are locked and be on the lookout for suspicious people in the neighbourhood.

They might also predict that the thieves will try to sell the stolen goods for very low prices by advertising in the newspaper or at a second hand store. They would go through the classified ads and visit all the second hand stores, looking for evidence that someone was trying to get rid of stole electronic equipment.

Examining the crime scene is an important part of any investigation. Detectives look for clues about who committed the crime and how the crime was committed.

Being able to predict what might happen next helps police to make a plan of action. They want to be able to gather more evidence that will help them solve the crime.

When investigating a crime, a detective wants to be able to answer these questions about the crime: Who? What? When? Where? Why? and How? By gathering evidence, he or she may be able to answer some of these questions. However, he or she may not be able to answer all of them based on the evidence gathered so far. What a detective can do is formulate a hypothesis or hypotheses that fills in the missing information. *A hypothesis is an idea that tries to explain an unanswered question.* For example, the police might hypothesize that the people responsible for stealing the electronic equipment might be drug addicts who need the money from selling the equipment to buy drugs.

A skilful investigator makes hypotheses by carefully examining all the evidence gathered. He or she then tries to gather more evidence that will either prove or disprove the hypothesis.
Examining a Crime Scene

As you know, a good investigator gathers evidence in an organized and thorough manner. What kinds of things should he or she be looking for when examining a crime scene? Here is a partial list.

1. footprints
2. fingerprints
3. blood
4. tire tracks
5. animal tracks
6. clothing or cloth scraps
7. hair samples
8. notes written in pen or pencil
9. objects lying around
10. things missing
11. damage done
12. dirt or mud left at the scene
13. tools or other objects used to commit the crime

In the following story, a king in Ancient Greece had some suspicions based on a small amount of evidence. He asked a well-known scientist of the time to prove or disprove his suspicions. As you read the story, think about the process Archimedes used to solve the crime.

**The Story of Archimedes**

In Greek mythology, a story is told of how King Hiero II had a golden crown made for him by a goldsmith. The king became suspicious that the crown was not pure gold. He called on Archimedes to devise a test to discover if he had been cheated.

Archimedes thought and puzzled for many, many days. He felt that there should be some way to discover if the crown was pure gold. One day, as Archimedes stepped into his bath, he noticed that the water rose dramatically and spilled out of the tub when he sat in it. Immediately, Archimedes realized that he had the idea that he needed!

Archimedes jumped out of his bath and ran through the streets of Syracuse, shouting, "Eureka!!!! Eureka!!!!! (I've got it!)."

Archimedes had realized that a given mass will displace a predictable amount of water. All he had to do was compare an amount of pure gold equivalent to the mass of the King's crown, to the actual crown.

After performing the test, Archimedes concluded that the crown was not pure gold, but a mixture of cheaper metals. Confronted with the evidence, the goldsmith admitted that he had added silver to the gold crown. The goldsmith was suitably punished and Archimedes was handsomely rewarded.

Thus ends the "case" of Archimedes and the King's crown.
Observations, Inferences, and Hypotheses

You have learned about some of the types of evidence investigators look for when examining a crime scene. You have also learned that witnesses can also provide much valuable information. Good questioning techniques help investigators get the types of information they need to give them a more complete picture of what actually happened. However, the fact of the matter is that some witnesses are not reliable and many suspects do not tell the truth. This is when investigators must make good use of inference and hypothesis.

Inference involves drawing conclusions from facts. Inferences are not direct observations. The facts upon which inferences are made come from observations made by investigators at a crime scene as well as any information reliable eye witnesses can provide. Investigators get other information from police records, health care records, dental records, and other sources.

In some cases, investigators must wear protective clothing to ensure that they do not contaminate the crime scene. This means they must be careful not to accidentally leave any of their own fingerprints, hair, or even saliva as they examine a crime scene.

Police must do their best to arrive at a crime scene as quickly as possible. One of the main reasons for this is that they want to be able to examine it before there is a chance that any evidence can be changed or destroyed. This is especially true for outdoor crime scenes. Curious people may trample over footprints and move items without realizing how important it is to police that things are left just as they were. Wild animals could also leave tracks and carry away important pieces of evidence.

In the same way, sometimes homeowners who are victims of break and enter, are tempted to clean up before police arrive because they do not want police to think they are poor housekeepers. Police would rather homeowners leave things just as they are rather than be impressed by a spotless house.

This officer is guarding the scene of a break-and-enter. When other officers arrive, they will examine the crime scene more carefully.
Example

Let us look at an example where investigators use the information they gathered to make inferences and then make a hypothesis.

The Scenario

The family of a young man has reported him missing. His mother telephoned police to say that on Friday evening he left for a nearby park to go camping. He was supposed to be back home late the next day. When he had not arrived home by Sunday morning, the young man’s family became concerned and phoned police.

The police went to the park. They located his truck in the park parking lot. It was locked and the keys were gone. They followed the trails into the park and eventually came upon a campsite. Following is a sketch the police made of the campsite and the notes the detective took about what she observed.

- ashes from campfire warm
- backpack had the young man’s wallet inside. All credit cards were inside as well as driver’s license, and 40 dollars cash
- single set of footprints were same as those close to young man’s truck
- two sets of footprints leading to campsite left by the same people leaving campsite. Footprints leaving campsite were closer together and deeper than those going to campsite
How the Police Used the Information

From what the family told them and what they observed, the police made some inferences:

**Inferences:**
- The missing young man made the single set of footprints leading to the campsite.
- The ashes were still warm, meaning that it had not been long since the young man left the campsite.
- The young man had not been robbed.
- The young man had been drinking beer.
- Two other people came to the campsite and then left.
- The young man did not leave the campsite by walking out on his own. Most likely he was carried by the two people that came later.

**Other Information:**
- Several people in the nearby city had reported that thieves had broken into their homes and stole valuable items.
- There had been several incidents of bullying at the high school.
- In the past three months two young people had gone missing, one male and one female.

Based on their direct observations and the inferences they made, the police made two different hypotheses:

**Hypothesis 1:** The young man was joined by two friends at some time. They were having so much fun and it got late. They stayed with the young man as it was getting too late to go home. They decided that he was in no shape to drive himself home. They carried him out of the campsite and drove him to one of their homes, where he would stay until he was more alert.

**Hypothesis 2:** The young man was enjoying camping so much that he decided to stay an extra night. Two strangers came upon the young man and the young man invited them to join him. After a few hours of talking, the strangers confessed they had broken into several houses in the neighbourhood and were hiding from police. The two men heard the police as they searched for the young man. They men became alarmed. They knocked the young man out and quickly carried him away.

**What Next?**

Most likely the police would follow up on both hypotheses. While doing so, they might discover which of their two hypotheses turned out to be true. On the other hand, they might find that neither of their hypotheses was true. In this case, they would look at all the evidence again and look for more clues. Then they would come up with a new hypothesis and work to see if it explained what happened.

As you can see, investigations can be complex and very difficult to carry out.
Shoeprints and Animal Tracks

Images left by the feet of humans, animals, and birds can give investigators clues about who or what has been at a crime scene. In addition, it can give them information about what actually happened. The most useful shoeprints and animal tracks are left in areas of soft dirt, areas of fresh snow, and in places where dirt is not too powdery. Shoeprints are also often found if a person has just been on a muddy area and then walked on a clean surface.

American astronaut Buzz Aldrin left his footprint on the Moon.

Shoeprints

Footprints refer to the images left by a human’s barefoot, while shoeprints refer to the images left by a human wearing some kind of footwear. However, most times we refer to footprints to mean the same thing as shoeprints.

Clues in Footprints (or shoeprints)

1. **Manufacturer.** Each shoe manufacturer has a different tread design for each style of shoe it produces.
2. **Size.** The larger the footprint, the taller the person
3. **Depth.** The deeper the footprint, the heavier the person
4. **Length of stride.** The longer the stride, the taller the person
5. **Direction.** This helps to know which way the person was walking
6. **Patterns of Footprints.** Can give us clues about whether the person was walking, running, limping, and so on. (If a person is walking, his or her stride will be longer.)
7. **Tread.** Helps investigators match a suspect to footprints left behind at a crime scene.

Investigators can determine the maker of a particular shoe by examining a shoeprint. Each manufacturer has a different tread design for each of its shoe types.
Example

Say the police found shoeprints at a crime scene. A thief broke into a house, stole a television, and left. Here is what police investigating the theft observed.

- The shoeprints came from a wooded area and to a window at the back of the house.
- The shoeprints inside the house started at the window of a back bedroom. From there they went into the living room to where the television used to be. They then went out the front door.
- From the front door the shoeprints went back into the wooded area.
- The shoeprints were 45 cm long and the stride was 1.2 m.
- The shoeprints leaving the house were deeper than those leading up to the house.
- The left shoeprint showed a long deep cut across the tread.

What Can the Investigators Infer?

- By examining the direction of the footprints, they can infer that the thief came from the wooded area and broke into the house through the rear bedroom window.
- From the bedroom, the thief went into the living room and up to the television.
- The thief picked up the television and carried it out through the front door and then back into the wooded area.
- At one time the thief had stepped on something that was sharp enough the cut the shoe tread.

What Next?

The police will most likely follow the footprints into the wooded area. They might find that they lead to someone’s house. The people living in the house then become suspects. They would look to see if the missing television is somewhere in the house. They would also look to see if any of the people in the house was tall and if anyone in the house had a shoe with a tread that matched those left at the crime scene. They would be looking for tread design and also if the left shoe had a cut across its tread. If they find a match, they most likely have found the perpetrator.

It is possible that the footprints lead to a set of tire tracks. In this case, the investigators would conclude that the thief loaded the television into a motor vehicle. This would make the case much more complicated. What steps do you think the police might take to solve this crime? What other evidence besides shoeprints could be left at the crime scene? (Hint: Look back to page 12.)

It is not often that police are able to use footprints left on a beach because waves usually wash them away.
Animal and Bird Tracks

Often investigators come across tracks made by animals and birds. It does happen that some crimes are committed by animals and birds while they are searching for food, protecting their young, or in the case of many pets, just playing. At other times, animals accompany humans who commit crimes.

Birds have a “three-toed track”. Generally, the larger the track, the larger the bird. Interpreting animal tracks takes a great deal of knowledge and skill. The types of tracks as well the patterns they leave can help an investigator determine the type of animal and the gait or speed at which it is travelling.

Generally, there are three main types:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>walkers</td>
<td>Steady alternating left, right, left right. The length of three sets of footprints in a walking gait is equivalent to the animal’s length.</td>
<td>coyote, bobcat, elk, deer, porcupine, beaver</td>
</tr>
<tr>
<td>hoppers</td>
<td>The width of the track is approximately the width of the animal. The tracks appear in spaced groupings, each containing two front and two rear footprints.</td>
<td>squirrel, mouse, snowshoe hare, cottontail rabbit</td>
</tr>
<tr>
<td>trotters</td>
<td>Left and right tracks are not obvious, and the footprints appear to be in a line. In each depression there is a diagonal set of two footprints, another set of two, another set of two, etc.</td>
<td>red fox, weasel, marten</td>
</tr>
</tbody>
</table>

Clues in Animal Tracks

1. **Size.** Larger animals have larger prints
2. **Depth.** The deeper the prints, the heavier the animal
3. **Number of Prints.** Most animals walk on four legs. Birds walk on two legs.
4. **Claws.** Animals that climb or dig have claws.
5. **Claws and Pads.** Usually indicate an animal that catches and eats other animals
6. **Patterns.** Indicate whether the animal is a hopper, a walker or a trotter.

Archaeologists have uncovered dinosaur footprints. These fossils provide many clues about the type and size of dinosaur that lived in a particular area. They also offer clues about whether they ate plants or animals.
Making Inferences

By examining animal tracks, an investigator can make inferences about the animal that left the tracks. For example, if the prints show claw marks, the investigator infers that the animal can either climb, dig, or both. If the prints show the animal has pads, he or she might infer it belongs to the dog or bear family. The investigator can also infer that the animal is not a polar bear because polar bears do not live in the area. He or should would have to decide which type of animal with those types of tracks would most likely have left them.

These prints indicate that the animal that left them is carnivorous; that is, it eats meat.

Inferring Rates of Speed from Animal Tracks

You learned that you can infer a human’s gait (type of walk or run) by examining footprint patterns. The same goes for animal tracks. Generally, sets of prints that are farther apart indicate the animal was travelling faster than set of prints that are closer together. A change in the print pattern indicates a change in the animal’s gait.

Different types of animals leave different track patterns for each type of gait. Following are examples of some animals and their gaits.

The Walk

When an animal starts to walk or move slowly, it begins by moving both of the legs on one side of its body before moving the legs on the other side. Usually it begins by moving one of its hind legs followed by the front legs on the same side. About the time these two legs have completed their movement, the legs on the other side of the body will move in a similar fashion.

The Trot

As an animal starts to increase its speed, it will shift to a trot. This is a “diagonal” foot movement, meaning that as the left-hind leg starts to move forward, the right-front leg will move forward at the same time and same distance, followed by the right-hind leg and left-front legs. When you see this gait in the ground, you may observe the two right tracks together on one side and the two left tracks together on the other side.
The Lope

When an animal lopes, it is travelling at a slow gallop. When it lopes, there is an increase in the distance between each set of four tracks. The space between the sets of tracks generally increases with speed. There are two types of lopes:

1. The front track is followed by a hind track, followed by the other front and then the other hind. Notice that these will always alternate. It will show in the dirt as 1-2-3-4---1-2-3-4---

2. The other type of lope is called a 3 X 4 lope. It will show in the dirt as 1-2/3-4... The first track will always be a front foot and the last one will always be a hind foot. What makes this particular lope different from the other is the position of the middle two tracks, which will either be side-by-side or partially overlapping.

The Gallop

In the gallop you might observe an even greater space between the sets of tracks, and you will also notice that the first two tracks will always be the front feet followed by the hind feet. The hind feet may or may not be side-by-side, but they will always follow the same sequence. The distance between sets of tracks increases if the gallop speed increases.

Each species has its own preferred gait. However, almost all animals can change their gait depending on the situation.
Dichotomous Key

A dichotomous key is a chart that can be used to identify unknown organisms. The word *dichotomous* means “divided into two parts”. A dichotomous key consists of a series of groups. At each step the user is presented with two choices. As the user makes a choice about a particular characteristic of an organism, he or she is led to a new branch of the key. Eventually the user will be led to the name of the organism that they are trying to identify.

The following animals have been put into the dichotomous key on the next page, according to their tracks. If the user of the key comes across the track of one of the animals in the key, he or she can use the key to identify the animal that left the tracks.
Animal Tracks
- muskrat, rabbit, deer mouse, deer, opossum, beaver, mink, rabbit, bobcat, fox

Claws
- muskrat, fox, mink, beaver, opossum

Five Toes
- muskrat, mink, beaver, opossum

Four Toes
- fox

No Claws
- weasel, bobcat, rabbit, deer mouse, deer

Non-split
- weasel, bobcat, rabbit, deer mouse

Split
- deer

Large Space Between "Thumb" and Other Digits
- muskrat, opossum

No Large Space Between "Thumb" and Other Digits
- mink, beaver

Large Rear Foot
- muskrat

Wide Rear Foot
- opossum

Webbed Rear Foot
- beaver

Non-webbed Rear Foot
- mink

Pads on Feet
- bobcat

No Pads on Feet
- weasel, rabbit

Larger Rear Foot
- weasel

Rear Foot Not Larger
- rabbit
Police tape off crime scenes to prevent anyone from disturbing evidence.
Part II: Fingerprints and Other Evidence

Introduction

In Part I of *Evidence and Investigation* you learned about how investigators used their senses to gather information about crimes that have been committed. You learned how to use inference to predict and make hypotheses. Finally, you learned how human and animal tracks can provide detectives with clues about the details of a crime.

Part II of *Evidence and Investigation* deals with some of the other clues investigators gather and use to solve crimes.

Fingerprints

No two humans have identical fingerprints. For this reason, fingerprints found at the scene of a crime are useful evidence for investigators because they can help identify criminals. Fingerprints are the patterns that the ridges found on your fingertips form. Examine the insides of your own fingers between the tips and the first joint. You will notice that all ten are different.

When a person is arrested by police, they take his or her fingerprints. These fingerprints are scanned and kept in an electronic file. They can be shared with other police forces around the world.
Types of Fingerprints

Experts classify fingerprints according to the patterns the ridges make. There are four basic types of fingerprint patterns.

1. **Arch** – wave or hill
2. **Loop** – ridges enter one side, then form a loop, then exit on the same side it entered. This is the most common type of fingerprint.
3. **Whorl** – spiral
4. **Composite** – combination of patterns.
Examining Fingerprints

When the police identify fingerprints, the first thing they do is look at the general pattern of the print; that is, loop, whorl, arch, or composite. Once they have a matching pattern type, they look for unique features of a print to help them match a suspect to the fingerprints found at a crime scene. In order for a print to be considered “a match” they must have a number of ridge characteristics in common. The following are five *ridge characteristics* they look for in a fingerprint.

1. **Delta** – a triangular pattern. Deltas are found on most fingerprints.
2. **Bifurcation** (fork) – One ridge splits to form two ridges.
3. **Ridge Ending**. A ridge ends.
4. **Island** – A very short ridge in the print pattern is not connected to any other ridge, much like an island floating by itself.
5. **Lake** – A ridge is in the shape of a circle or oval.

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<tr>
<td>Island</td>
<td>Lake</td>
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When investigators match fingerprints using ridge characteristics, they are making observations. When they find that a large number of ridge characteristics from a fingerprint found at a crime scene are similar to that of a suspect’s, they infer that the suspect was at the crime scene and was somehow involved with the crime.
Dusting for Fingerprints

Whenever you touch something, you leave a fingerprint. This is because your fingers are slightly oily. When you open a window, pick up a glass, or move a chair, you are leaving fingerprints. The oils and perspiration from the ridges of your fingertips transfer to the surfaces they touch. The clearest fingerprints are left on very smooth surfaces.

What You Need

dusting powder  paper  soft-bristled brush  cellophane tape

Procedure

1. Identify the surface area that you want to dust for fingerprints.

2. Pour a small amount of dusting powder on a piece of paper. Use a powder whose colour contrasts with the surface colour (white powder on dark surfaces; black powder on light surfaces).

3. Shake the brush so the bristles spread apart.

4. Dip the tip of the brush in the powder, and then gently tap the brush’s handle to remove any excess powder.

5. Run the brush’s bristles lightly over the powdered surface in short and quick strokes. The powder will stick to the oil and perspiration, revealing the fingerprint.

6. Take a strip of cellophane tape and gently press it on top of the print.

7. Pull the tape away from the print in one quick and smooth motion, and apply the tape with the print to a piece of paper. (If you used white powder, apply it to dark-coloured paper. If you used black powder, apply it to light-coloured paper.)

When dusting for fingerprints, investigators must ensure that they do not leave any of their own fingerprints at the crime scene. For this reason, they wear rubber gloves.
Tire Tracks and Treads

Often wheeled vehicles, such as cars, trucks, motorcycles, and bicycles are used in crimes. They can be the way that criminals get to and from the scene of the crime. Just as shoeprints can help investigators identify perpetrators, tire tracks left by vehicles at crime scenes can give them useful clues. And like shoeprints, evidence from tire tracks is best gathered as soon after a crime has been committed as is possible. This is because as time goes on, there is an increasingly greater chance that the tracks will have been disturbed by passers-by, animals, other vehicles, and weather.

Investigators are always interested in any tire tracks present at a crime scene. There is the possibility that the tracks left will match those of a suspect’s vehicle. As part of their investigation, detectives take photographs of any tire tracks using a good quality camera.

Like shoes, tires have distinctive tread patterns. Each type of tire from each manufacturer has a particular tread design. Investigators can use this information to determine the type of tire that left a particular track.

There is a large variety of tire tread patterns. Each manufacturer has a different tread design for each of its tire types.
Examining Tire Tracks

When examining tire tracks, investigators are on the lookout for certain things. Some of these include:

1. tread design
2. tread size
3. tread wear
4. uneven wear
5. unusual markings, such as cuts across the tread
6. type of soil where the tracks were made

Knowing how a tire is wearing helps investigators match tire tracks to the tires of a suspect’s vehicle.

Tracks with large patterns usually indicate tires from vehicles used for off-roading or construction.

The tire tracks themselves are useful to detectives, but so is the soil in the area where the tracks were found. Mud from the area might stick to the tires. If that same type of mud is found on the tires of a suspect’s vehicle, it can be proof that the particular vehicle was at the crime scene, and therefore proof that the suspect was there also.

Sometimes only partial tracks are left. However, this can be enough to make the connection between a crime and a suspect.
Paper Chromatography

There are times when investigators want to be able to analyze and match pen ink samples. These ink samples might be from a note, found on clothing, and even found on furniture. Different pen manufacturers use different pigments (colours) to make their inks. (You may have noticed that some black felt pens seem to be “blacker” than others.) Chromatography is used to separate ink into its various pigments. Chromatography can help forensic scientists determine from which kind of pen an ink sample came. **Paper chromatography is used to separate an ink sample found on paper into its component colours.**

**When Is Paper Chromatography Used?**

Before examining the actual process involved in paper chromatography, let us examine some uses.

**Scenario 1**

A dog-napper broke into a house and stole the owner’s dog. The dog-napper left a note to the owner demanding a large sum of money for the dog’s return. Some neighbours saw a man carry the dog from the house to his car. They noted the license plate number and reported it to the police. The police used the license plate number to identify the vehicle’s owner and where he lived. They went to his house to question him and search the house. They found four pens that had the same colour ink as the note was written in. Paper chromatography could be used to see if the ink used to write the note was from a pen similar to one of the pens found in the suspect’s house.

**Scenario 2**

In one neighbourhood there have been several break-ins. Each time the thief left a “happy face” drawing on the kitchen table. Forensic scientists could use paper chromatography to determine if the happy faces were drawn using the same pen. They would then be fairly sure that the break-ins were being done by the same person.

**Scenario 3**

Someone had vandalized a downtown business by spraying graffiti on one of the inside walls. While investigating, police noticed that someone had dropped a small piece of paper with a telephone number on it. They contacted the telephone company who identified the person who had that telephone number and her address. They questioned the individual about whom she may have given her telephone number. She listed seven people. They eliminated five of them for one reason or another. That made the remaining two suspects. Their next step was to go to their homes, find the pens in their possession and use paper chromatography to see if there might be a match.

The pattern of separated colours by chromatography is called a chromatogram. This picture shows that different inks create different chromatograms.
Producing a Paper Chromatogram

Paper chromatography works on the idea that when a piece of paper absorbs some kind of solvent, such as water or alcohol, the pigments that make up an ink sample will separate. As the solvent travels up the paper, the various pigments will travel up the paper with the solvent, but at different rates.

Say you wanted to use paper chromatography to make a chromatogram of an ink sample. You would follow these steps.

1. Take strip of chromatography paper about 2 cm wide and 15 cm long. (You can use coffee filter paper if you do not have chromatography paper.)

2. About a centimetre from one end draw a heavy horizontal line with the pen.

3. Fill the bottom of a plastic cup with 1 or 2 cm of solvent. (Use water for water-soluble markers; alcohol for permanent markers.)

4. Fold the other end of the strip around a pencil or stirring rod and secure it with a paper clip. You want the paper strip to just barely touch the surface of the solvent. Be sure that the line does not touch the water. (See the diagram.)

5. Wait for about an hour.

6. You will notice that most of the ink has separated into colours and forms a unique pattern on the paper.
Graphology

**Graphology is the study of analyzing handwriting.** It is not considered a pure science like chemistry, biology, or physics. A person who practises graphology is called a **graphologist.** Nonetheless, graphology has proved to be useful where crime investigation is concerned.

Among other things, graphology is based on the idea that we write in a certain way out of habit. Even when we are trying to disguise our own writing, there are clues that give us away.

**When Might Graphology Be Used?**

There are several instances where graphology might be useful for crime investigators. Let us take a look at two of them.

1. **Signature Forgery.** Forgery occurs when you sign someone else’s name with the hope that those who see the signature will think that person signed his or her name. Example: Todd needed some money badly. When he was visiting his cousin George, he found one of his cousin’s blank cheques. Todd took the blank cheque and wrote a cheque to himself for a hundred dollars and signed it with his cousin’s name. This is strictly illegal and if you are caught, you would be sentenced to a jail term. A graphologist would be able to determine that George did not sign the cheque. He or she might even be able to determine who did.

2. **Notes.** A person could leave a threatening note, anonymously (without identifying him/herself). A graphologist could analyze the handwriting on the note. Then he or she would have any suspects write a few sentences and analyze those writing samples. If there are enough similarities between the handwriting on the threatening note and the handwriting of one of the suspects, there is a good chance that the suspect was the perpetrator.

**What Does the Graphologist Do?**

A well-trained and experienced graphologist knows that certain characteristics of a person’s handwriting are difficult, if not impossible, for the person to change, even when he/she is making a great deal of effort to do so. For example, a good graphologist can tell, just by examining your handwriting, the angle at which you hold your pen.

When trying to determine whether or not two handwriting samples were written by the same person, a graphologist looks for similarities between the two by examining how the letters are formed, the size and slant of writing, the pressure put on the writing instrument, and so on. Some graphologists say that a person’s handwriting gives clues about a person’s personality.

> I want to make it quite clear that I deny ever having written any of the above - it’s all an obvious forgery and in any case the answers were obtained by undue pressure, probably by the illicit use of truth serum and unscrupulously blackmailed into the bargain. I never said it, I wouldn’t say it and if you won’t print it I will sue.

---

*Everyone’s handwriting is unique.*
Indicators Used in Handwriting Analysis

Each person’s handwriting has certain characteristics. Graphologists used them to analyze a handwriting sample. Some of these characteristics are

1. **Spacing of Letters** – How much space there is between letters in a word.

2. **Slant of Letters** – Do the letters slant to the right, to the left, or are they almost straight up and down? Does the slant vary from letter to letter and word to word?

3. **Spacing of Words** – How much space is there between words?

4. **Pressure on the Page** – Does the writing appear to press so hard that the pen tip almost goes through the paper or does he or she press so lightly that it affects the darkness of the writing?

5. **Formation of Loop Letters** – (l, o, f, p, and b) What shape are the loops? roundish, skinny and long, almost non-existent?

6. **Dotting of Letters** – (i and j) Some people make their dots directly over the letter; others dot them a little ways to the right. Some people make tiny circles for dots; others omit the dots altogether.

7. **Making the Letter t** – Some people make the t with a loop. Some people make the letter short. Some people cross the letter a little to the right or the left; others miss the letter altogether when crossing. If there are two ts together, some people cross them with one long stroke. If the t is at the end of the word, some people cross with letter with the tail of the letter.

8. **Formation of Low Loop Letters** – (g, y, j, and f) Some people make the loop almost round. Some people make the low loop skinny and long. Still others make the loop large with much of the loop under the letters preceding it.

9. **How Letters Are Joined** – Most people join all letters of a word. Some make almost all letters independently, not joining them at all. Some people do not join certain letter grouping, such as -ing with the other letters of a word.

10. **Writing/Printing Combination** – Many people use a combination of writing and printing. Some people’s letters look like a cross between writing and printing.

11. **Less Common Letters** – (z, x, q, j) Often these letters are made very distinctively.

12. **Size of Letters and Words**

13. **Extraneous Marks** – Some people put extra doodles on the page, such as tiny arrows or triangles, flowers, people’s names who have nothing to do with the message.

14. **Writing Tool** – Some people prefer pen; some mechanical pencil; others roller ball
Fabric Analysis

Fabric analysis can be an important part of solving a crime. Usually it involves comparing a scrap of fabric found at a crime scene with an article of clothing owned by a suspect. Forensic scientists, who usually do fabric analysis, only need a fibre or two to match it to a piece of clothing.

Examine the photo on the right. A thief climbed through the window of a home in a small town in central Alberta. He tied up the two senior citizens who lived in the house and then robbed them of any cash they had. As he climbed through the small opening, his jacket caught on a sharp piece of metal, tearing the jacket and leaving a few fibres behind.

Police suspected that a man in his early twenties who lived in the community was responsible for the crime. When they searched his home, they discovered a jacket with a tear in the sleeve. Forensic scientists were able to match the fibres left at the crime scene with the torn jacket. This provided valuable evidence for police.

Fabric Analysis

Following are some of the characteristics of fabrics that forensic scientist would consider when analyzing fabrics.

1. **Tendency to Wrinkle.** When you bunch up the fabric into a ball and then release it, how wrinkled is it? Does it smooth out easily?

2. **Colour.**

3. **Dye Hold.** Does the dye come out of the fabric easily when soaked in soapy water?

4. **Weave.** Is the weave coarse or fine? Is the fabric knitted or woven?

5. **Texture.** Is the fabric smooth or rough?

6. **Stretchiness.** How much will the fabric stretch before it tears?

7. **Absorbancy.** To what extent does the fabric absorb or repel water?

8. **Burning.** Does the fabric burn easily?

9. **Thread.** What does a single thread look like? (hairy, smooth, even, wavy, etc.)
Soil Analysis

In forensic science, soil analysis can provide important clues about who committed a crime and where it occurred. Different soils have different characteristics. Soils differ from area to area. Even in a relatively small place like a backyard, there can be several different soil types.

When Is Soil Analysis Used?

Soil analysis is used when forensic scientists want to compare soils from two or more sources. If the soils match, investigators may be able to infer that a suspect was in the locations where the soil samples were found. Let us take a look at a couple of examples of when soil analysis might be used.

Scenario 1

A cattle rustler stole a dozen of Farmer Brown’s livestock. They noticed footprints in the mud from the pasture where the cattle were grazing, but they were not distinct enough to get a clear idea of the tread. A nearby farmer thought he saw a rancher a few kilometres away pulling a small cattle truck near Farmer Brown’s pasture. The neighbour notified police, who paid a visit to the rancher. While talking to him, they spotted a pair of muddy work boots. Analyses of the soils from the boots and from Farmer Brown’s pasture showed they came from the same location.

Scenario 2

Two girls, Sarah and Matilda, were going to be in a cycling competition. Both were favoured to win. On the eve of the competition, Sarah was alarmed to see that someone had broken the spokes on her bicycle. She called the police who did a thorough search of the area. They noticed some pieces of hardened mud on Sarah’s driveway. It did not match any of the soils around Sarah’s home. When the police questioned Sarah about who might have wanted her out of the race, Sarah mentioned Matilda. The police went to Matilda’s home and examined her car. It did not have soil that matched the soil left at Sarah’s. Then they noticed that Matilda’s sister’s car had a different type of soil stuck to the fenders. When this soil was sent in for analysis, it did match the soil found at Sarah’s. It turns out that Matilda’s sister was the perpetrator.

The fact that there are so many different soil types can be an important factor in solving crimes. Being able to match soil from one source with soil from another can show where a person has been.
What Soil Analysts Look For

Soil analysts look for many soil characteristics. Here is a list of some of them.

1. **Colour** (black, brown, grey, red, etc.) – tells what the soil is made of

2. **Texture** (soft, coarse, smooth, gritty) – wet a small amount and rub it between the fingers.

3. **Odour** (musty, woody, decaying) – tells about what kinds of organic matter are in the soil.

4. **Composition** – the presence of different materials, such as sand, black soil, clay, leaves

5. **Shape of Particles**

6. **Size of Particles** – Small particles feel smooth when rubbed between the fingers.

Forensic scientists examine soils very thoroughly, but ordinary citizens can analyze soils as well. The following chart shows the characteristics of several common kinds of soil.

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<th>Sandy Loam Description</th>
<th>Silty Loam Description</th>
<th>Loam Description</th>
<th>Clay Loam Description</th>
<th>Clay Description</th>
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<tr>
<td>Soil Cast</td>
<td>cast will not break when handled carefully</td>
<td>cast will not break when handled carefully</td>
<td>cast can be freely handled without breaking</td>
<td>cast will endure considerable handling without breaking</td>
<td>cast may be molded into many shapes without breaking</td>
</tr>
<tr>
<td>Soil Thread</td>
<td>thread is readily broken, thick and crumbly</td>
<td>thread is readily broken, thick and crumbly</td>
<td>thread can be pointed to pencil lead thickness that is readily broken</td>
<td>thread is strong and can be rolled to a pinpoint</td>
<td>thread is strong and elastic and can be rolled to a pinpoint</td>
</tr>
<tr>
<td>Soil Ribbon</td>
<td>soil will not form a ribbon</td>
<td>soil will not form a ribbon</td>
<td>soil will form a short, thick ribbon that easily breaks</td>
<td>soil will form a thin ribbon that breaks easily</td>
<td>soil will form a long, thin ribbon that does not easily break</td>
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Topic D

Evidence and Investigation

Revised Edition
Science
Grade Six

Topic D: Evidence and Investigation

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Part I of Evidence and Investigation introduces students to the vocabulary used in investigations. It also teaches students about three of the main processes used by investigators: observing, inferring, and hypothesizing. During the latter parts of Part I, students learn to use evidence gathered from examining shoe prints and animal tracks. Finally, they review how to use a dichotomous key as a tool for organizing and retrieving information.

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<td>8</td>
<td>Inferring Rates of Speed About Animal Tracks</td>
<td>19 - 20</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>Classifying Shoe Prints: Using a Dichotomous Key</td>
<td>21 - 22</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>Relating Length of Foot and Height</td>
<td>1-3</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>11</td>
<td>Evidence and Investigation – Part I Review</td>
<td>1-2</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>Evidence and Investigation – Part I Test</td>
<td>1-2</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Lesson One

Concept: Introduction

Resources/Materials: Worksheets #6D.1a and #6C.1b (student copies)  
Worksheet #6D.1c (optional, 5 copies per student)  
1” binder rings, five per student (or twist ties, if you are unable to get binder rings)  
single hole punch

Introduction: Have a student or another staff member come to the front of the class. Whisper in his or her ear that they are to leave the room and close the door. Explain that he or she will have to stay out for about 10 minutes, so they should take something to do.

Once the person has gone, distribute Worksheet #6D.1. Tell students to fill in the sheet about the person who just left. Warn students they must do this without looking at or talking to anyone.

Procedure:

1. Give students about five minutes to complete as much as they can. Then call the person back into the classroom.

2. Have students compare what they “think” they saw with what actually was.

3. Explain that the next science unit is called “Evidence and Investigation”. Evidence is clues left behind by someone. Investigation refers to finding out more about a particular situation. Evidence and investigation involve
   - making keen observations
   - finding more information
   - making inferences and drawing conclusion.

4. Explain that students will learn a lot of the techniques that the police use when they try to solve crimes.

5. Explain that students will now have the opportunity to make a “face book”. Distribute Worksheet #6C.1b. Tell students to follow the directions to make a booklet where you can make different faces with different features. Each student will also need 5 copies each of Worksheet #6D.1c.

Note: If you prefer, instead of students using Worksheet #6D.1c, they can use five sheets of unlined paper make their own face outline.

Assignment:

Make a “face book” using Worksheet #6D.1c.
**What Did You Observe?**

**Directions:** In the spaces below write down what you remember about the person. Try to make your observations as accurate as possible.

<table>
<thead>
<tr>
<th>Person’s Name</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eye</strong> (colour, shape)</td>
<td></td>
</tr>
<tr>
<td><strong>Height</strong> (approximate)</td>
<td></td>
</tr>
<tr>
<td><strong>Hair</strong> (colour, length, style)</td>
<td></td>
</tr>
<tr>
<td><strong>Clothing</strong> (style, colour, items, other things)</td>
<td></td>
</tr>
<tr>
<td><strong>Shoes</strong> (type, colour)</td>
<td></td>
</tr>
<tr>
<td><strong>Distinguishing Characteristics:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Other Observations:</strong></td>
<td></td>
</tr>
</tbody>
</table>
Directions: Make a face book to show the different characteristics of faces. Follow these directions:

1. Cut each sheet on the lines. Be as careful as you can.

2. On each of the top sections, draw in and colour different hair. Be sure each has a different colour and/or style.

3. On each of the second sections, draw in and colour different eyes and eyebrows.

4. On each of the third sections, draw in different noses.

5. On each of the fourth sections, draw in and colour different mouths and chins.

6. Stack all the top sections together. Then punch a hole in the centre of the left-hand edge. Put a binder ring or twist tie through the hole.*

7. Do the same for the other three sections.

8. Now that you have drawn and coloured your faces, you can try different combinations of hair, eyes, noses, and mouths.
Lesson Two

Concept: The Powers of Observation

Resources/Materials:

HANDS ON: tray or other larger shallow container (like the lid from a box of paper)
ten small miscellaneous objects cloth to cover tray and the objects
cloth to cover the tray and the objects
strips of paper, each with the name of a person in the school (folded)

ADVANCE PREPARATION: Lay ten objects on the tray. Cover with the cloth. Be sure the cloth covers the entire tray.

NON HANDS ON: Mini Textbook, pages 4 – 7
Worksheets #6D.2a and #6D.2b (student copies)

Introduction: Tell students that good detectives need good powers of observation. Today, they will get the chance to practise.

Procedure:

HANDS ON

1. In their notebooks, have students write the heading “Objects” and then number their pages from 1 to 10.

2. Bring out the tray of objects. Tell students you have ten different objects under the cloth. You will let them study the objects for 30 seconds. Then they are to write down the names of as many of the objects as they can remember.

3. Allow students to gather round before you uncover the tray of object.

4. Once the 30 seconds observation period is over, re-cover the objects and have students return to their desks and begin writing.

5. After two or minutes or so, uncover the objects again so students can compare their lists to the objects on the tray.

6. Discuss:
   • Strategies students used to help them remember.
   • What they would do next time.
   • Why detectives need reliable witnesses.

7. Explain to students that they will be given a strip of paper with the name of someone in the school. Without naming the person, the student must write a detailed description of him/her, and then hand it in. Keep your description to what can be observed. Students should keep the person’s name a secret.

8. Once all the paragraphs are in, read the descriptions. See if the students can guess who “the suspect is” in each case. “Were they good eyewitnesses?”

(continued)
Lesson Two (continued)

NON HANDS ON

9. Discuss the various ways that police officers try to gather evidence in their endeavours to ensure that citizens follow the rules. (photo radar, examining a crime scene, observing a crime as it happens, etc.)

10. Explain that a good detective uses his powers of observation to gather evidence. Observation involves using all five senses.

11. Explain that the everyday citizen’s powers of observations are actually quite poor. For this reason, police officers must undergo extensive training to hone their skills.


13. Have students examine the photo on Mini Textbook, page 6 as per the directions at the bottom of page 5. Then have them cover the very bottom of page 7 with a sheet of paper. Once this is done, have them try to answer the questions at the top of page 7.

14. Distribute Worksheets #6D.2a and #6D.2b. Go over the directions, if necessary.

Assignments:

1. HANDS ON. Write a description of someone in your class.

2. NON HANDS ON. Read Mini Textbook, pages 4 – 7. Then do Worksheets #6D.2a and #6D.2b.
Directions: Use Mini Textbook, pages 4 – 7 to help you with the questions.

1. What is the role of the police?

2. Define the term evidence.

3. A police detective must have certain qualities in order for him or her to do the job effectively. What are four of these qualities? Tell why each is important.

<table>
<thead>
<tr>
<th>Quality</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Why do you think witnesses to a crime are not always a reliable source of information?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
5. Each of the following is a photo of a crime scene. Examine each photo. Then write down three observations you could make if you were a police officer investigating the crime.

<table>
<thead>
<tr>
<th>Photo</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Image 1]</td>
<td></td>
</tr>
<tr>
<td>![Image 2]</td>
<td></td>
</tr>
<tr>
<td>![Image 3]</td>
<td></td>
</tr>
</tbody>
</table>
Directions: Use Mini Textbook, pages 4 – 7 to help you with the questions.

1. What is the role of the police?
   - enforce laws of a municipality, province, or country

2. Define the term evidence.
   - clue or clues that helps an investigator solve a crime

3. A police detective must have certain qualities in order for him or her to do the job effectively. What are four of these qualities? Tell why each is important.

<table>
<thead>
<tr>
<th>Quality</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>honesty</td>
<td></td>
</tr>
<tr>
<td>objective</td>
<td></td>
</tr>
<tr>
<td>analytical</td>
<td></td>
</tr>
<tr>
<td>intelligent</td>
<td></td>
</tr>
<tr>
<td>determined</td>
<td></td>
</tr>
</tbody>
</table>

   Answers may vary

4. Why do you think witnesses to a crime are not always a reliable source of information?
   - not trained to observe
   - often busy with own affairs
   - often put own interpretation on what actually happened

   Answers may vary
5. Each of the following is a photo of a crime scene. Examine each photo. Then write down three observations you could make if you were a police officer investigating the crime.

<table>
<thead>
<tr>
<th>Photo</th>
<th>Observations</th>
</tr>
</thead>
</table>
| ![Photo 1](image1.png) | Answers may vary:
1. window broken
2. merchandise in window
3. glass pieces on sidewalk in front of window |
| ![Photo 2](image2.png) | 1. driver has phone and appears to be using it
2. driver appears to be eating
3. driver appears to be drinking |
| ![Photo 3](image3.png) | 1. woman walking across street with baby in carriage
2. woman is walking between cars
3. a pedestrian is looking at something on the pavement |
Lesson Three

Concept: The Value of Good Questioning in an Investigation

Resources/Materials: Mini Textbook, pages 8 – 10
Worksheet #6D.3a and #6D.3b (one copy each, cut into strips)

Introduction: Recall that last class students learned the importance of good observation. In the discussion try to work in these vocabulary words:

- crime
- investigation
- evidence
- accuse
- detective
- clue
- criminal
- perpetrator
- mystery

Throughout the unit use these words and others related to investigation as often as possible to help students remember them.

Tell students that one of the most important skills a good detective needs is the ability to use concise questioning. Good questioning helps to narrow down the list of possibilities quickly and efficiently. To practise this, we will play a game.

Procedure:

1. Tell students that the object of the game is to figure out (not guess) who or what the teacher is thinking of. (Examples: pizza, minister, coffee, eraser)

2. Explain the rules:
   - Students will work in twos or threes.
   - Each group gets a turn to ask a question.
   - Each question that furthers the discovery of the person, place, or thing, is awarded one point.
   - Each question that does not further the investigation loses a point.
   - Each direct, incorrect guess loses a point.

3. Think of the first word. Have one group begin the “investigation” with a question. The next group then asks a question, and so on. Continue keeping score and the questioning until the mystery is solved.

4. Discuss that wild guessing is inefficient. Detectives have a better chance of catching a criminal “while the trail is hot”.


6. Distribute Worksheets #6D.3a and #6D.3b. Go over the directions, if necessary.

Assignment:

1. Read Mini Textbook, pages 8 – 10
2. Do Worksheets #6D.3a and #6D.3b.
**Directions:** Use the information on *Mini Textbook*, page 8 – 10 to help you with the questions.

1. Tell whether each of the following tells about an open question, a closed question, funnel questions, probing questions, or leading questions.

<table>
<thead>
<tr>
<th>Type of Question</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• asked when the police detective wants to steer a person to a certain way of thinking</td>
</tr>
<tr>
<td></td>
<td>• asked when the police officer wants to know a person’s opinion or how a person recalls an event</td>
</tr>
<tr>
<td></td>
<td>• starts out with asking a few general questions; then asking increasingly detailed questions.</td>
</tr>
<tr>
<td></td>
<td>• asked in order to get a short factual answer</td>
</tr>
<tr>
<td></td>
<td>• used when the police officer suspects a person is avoiding revealing certain information.</td>
</tr>
</tbody>
</table>

2. What kind of question(s) do you think a police detective might use if he suspected a person was not telling the truth about what happened? Tell why.

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

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__________________________________________________________________________

__________________________________________________________________________

Worksheet #6D.3a
3. Write the words beside their descriptions.

_________________________ person who commits a crime

_________________________ use your senses to gather information

_________________________ person who investigates a crime

_________________________ an act that is against the law

_________________________ person to whom something wrong was done

_________________________ something that can be used as evidence

_________________________ place where a crime happened

_________________________ the science of uncovering and using clues to make inferences about how a crime happened

_________________________ anything that provides material or information on which a conclusion can be based

_________________________ to blame someone for breaking the law

_________________________ someone who sees the law being broken

_________________________ person whom police think may have committed a crime

_________________________ something that cannot be easily explained

_________________________ to look for information in an organized way
Directions: Use the information on *Mini Textbook*, page 8 – 10 to help you with the questions.

1. Tell whether each of the following tells about an open question, a closed question, funnel questions, probing questions, or leading questions.

<table>
<thead>
<tr>
<th>Type of Question</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>leading questions</td>
<td>• asked when the police detective wants to steer a person to a certain way of thinking</td>
</tr>
<tr>
<td>open question</td>
<td>• asked when the police officer wants to know a person’s opinion or how a person recalls an event</td>
</tr>
<tr>
<td>funnel questions</td>
<td>• starts out with asking a few general questions; then asking increasingly detailed questions.</td>
</tr>
<tr>
<td>closed question</td>
<td>• asked in order to get a short factual answer</td>
</tr>
<tr>
<td>probing questions</td>
<td>• used when the police officer suspects a person is avoiding revealing certain information.</td>
</tr>
</tbody>
</table>

2. What kind of question(s) do you think a police detective might use if he suspected a person was not telling the truth about what happened? Tell why.
   Answers may vary.
   Most likely “probing questions” Detective starts out asking for seemingly obvious questions with obvious answers. Person being questioned may find some of his answers are contradictory, which the detective will most likely notice.
3. Write the words beside their descriptions.

perpetrator — person who commits a crime
observe — use your senses to gather information
detective — person who investigates a crime
crime — an act that is against the law
victim — person to whom something wrong was done
clue — something that can be used as evidence
crime scene — place where a crime happened
forensic science — the science of uncovering and using clues to make inferences about how a crime happened
evidence — anything that provides material or information on which a conclusion can be based
accuse — to blame someone for breaking the law
witness — someone who sees the law being broken
suspect — person whom police think may have committed a crime
mystery — something that cannot be easily explained
investigate — to look for information in an organized way
Lesson Four

Concept: The Importance to Prediction and Hypothesis in Investigation

Resources/Materials: Mini Textbook, pages 11 and 12
Worksheet #6D.4
several unusual gadgets (e.g., a garlic press, a collar stay, etc. – anything you think will not be readily identified by students)

Introduction: Read the story about Archimedes from the bottom of Mini Textbook, page 12. Discuss the process Archimedes used to figure out how to prove whether the crown was pure gold or not.

Procedure:

1. Tell students you will be showing the group some unusual objects. They are to hypothesize what the gadget is used for and tell why.

2. Show the objects one at a time. Have students hypothesize.

3. Conclude that good investigators must be skilled at making hypotheses based on evidence.

4. With students make notes:
   Foundations of Good Investigation
   - Good observation skills
   - Concise questioning
   - Good predictions and hypotheses based on evidence.


6. Have students copy the list of types of evidence detectives look for when examining a crime scene from Mini Textbook, page 12 (top).

7. Distribute Worksheet #6D.4. Have students read the “evidence” and make hypotheses.

Assignments:

1. Read Mini Textbook, pages 11 and 12.
2. Copy the list of the types of evidence detectives look for when examining a crime scene from the top of Mini Textbook, page 12.
3. Do Worksheet #6D.4.
Directions: Read each of the scenarios. Then predict or hypothesize about what is about to happen or why something happened. Explain your predictions and hypotheses.

1. David knew something was going on. For the past few days, every time his sisters looked at him, they giggled. When he asked what was going on, they just smiled and said, “Nothing.” He was getting annoyed. Tomorrow he was going to turn eleven, but he felt like his family was treating him as if he were three. Even his mother told him not worry about anything. What do you think is going on?

2. When Dorothy got home, she was horrified. The house was a complete mess with clothes scattered everywhere and the dresser drawers opened. This was strange because her mother was very particular about her housekeeping. The dishes had been done and put away. But the little kids’ toys were not put away. She wanted to cry out, but she didn’t want her four-year-old twin sisters to wake up. Then she heard giggling coming from behind a closed door. She opened it, and then she knew… What do you think she “knew”?

3. As Billy approached the school, he noticed that Mr. Google’s car was not in its usual parking spot outside the front door. In fact, it was no where to be seen. Was Mr. Google sick? Billy was relieved to see Mr. Google’s familiar face as he neared the classroom. How had he got to school? It was much too far for him to walk. When Billy looked more closely, he noticed that Mr. Google’s clothes were stained and his hands dirty. How do you think Mr. Google got to school?

4. Elsie was getting frustrated. Everyday when she got to school, she noticed that someone had been in her desk. Nothing was ever missing, but things were just a little different from how she had left them the day before. Elsie was determined to find out who had been in her desk. She asked her teacher for some powdered paint. Her teacher wanted to know why she wanted to paint. When Elsie explained, the teacher smiled and handed her the powder. The next morning, Elsie knew who had been in her desk. How did Elsie know?
Answers may vary. **Predict and Hypothesize**

**Directions:** Read each of the scenarios. Then predict or hypothesize about what is about to happen or why something happened. Explain your predictions and hypotheses.

1. David knew something was going on. For the past few days, every time his sisters looked at him, they giggled. When he asked what was going on, they just smiled and said, "Nothing." He was getting annoyed. Tomorrow he was going to turn eleven, but he felt like his family was treating him as if he were three. Even his mother told him not worry about anything. **What do you think is going on?**

   David's family may be planning a surprise birthday party.

2. When Dorothy got home, she was horrified. The house was a complete mess with clothes scattered everywhere and the dresser drawers opened. This was strange because her mother was very particular about her housekeeping. The dishes had been done and put away. But the little kids' toys were not put away. She wanted to cry out, but she didn't want her four-year-old twin sisters to wake up. Then she heard giggling coming from behind a closed door. She opened it, and then she knew... **What do you think she "knew"?**

   The twins woke from their naps and got into mischief by emptying the dresser drawers.

3. As Billy approached the school, he noticed that Mr. Google's car was not in its usual parking spot outside the front door. In fact, it was no where to be seen. Was Mr. Google sick? Billy was relieved to see Mr. Google's familiar face as he neared the classroom. How had he got to school? It was much too far for him to walk. When Billy looked more closely, he noticed that Mr. Google's clothes were stained and his hands dirty. **How do you think Mr. Google got to school?**

   Mr. Google has a flat tire/car trouble. He got the car going again. The colony mechanic is fixing the tire/car.

4. Elsie was getting frustrated. Everyday when she got to school, she noticed that someone had been in her desk. Nothing was ever missing, but things were just a little different from how she had left them the day before. Elsie was determined to find out who had been in her desk. She asked her teacher for some powdered paint. Her teacher wanted to know why she wanted to paint. When Elsie explained, the teacher smiled and handed her the powder. The next morning, Elsie knew who had been in her desk. **How did Elsie know?**

   Elsie dusted some of the items in her desk with the powder paint. The person's hands would then be stained with the paint.
Lesson Five

Concept: Making Observations and Inferences in a Natural Outdoor Setting

Resources/Materials:
- **HANDS ON:** Worksheet #6D.5a (optional, student copies)
- **NON HANDS ON:** Mini Textbook, pages 13 – 15
  - Worksheets #6D.5b and #6D.5c (student copies)

Introduction: Explain that when the police are called to the scene of a crime, one of their main goals is to try to figure out what happened. If there are eye witnesses, this sometimes makes the job easier. However, often times, there are none. The police must look for evidence. They do this by looking for clues. They must put all the clues together to make inferences and then a hypothesis. Part of the **forensics** is the scientific study of clues. Today we are going to be using forensics to make some inferences and hypotheses.

Procedure:
**HANDS ON**
1. Explain to students that they will be going outside and looking around the yard to look for clues of human and animal activity. Caution students to be alert and observant. They must be careful about where they step as they might accidentally tamper with evidence.
2. Remind students that observations can be made with any of the five senses. Inferences and hypotheses are **not** observed, but made on the bases of observations.
3. Distribute Worksheet #6D.5a (or have students make a similar chart in their notebooks). Go over the directions.
4. Tell students to look for any signs of human and animal activity. They should be examined with an inquiry mind:
   - Were any items left in the area recently? How do you know?
   - Have they been there for a while? How can you tell?
   - Where might the items have come from?
   - How did the items get there?
   - Who are what made any footprints or animal tracks?
   - How fast do you think the subject was moving?
   - What direction was the subject moving?
   - Is there any evidence of more than one person or animal being in the area? Did they interact?
5. Send students outside, preferably to a part of the yard where there is the greatest possibility of seeing “untampered and unspoiled clues”. Better yet, if you can accompany the students.

**NON HANDS ON**
7. Distribute Worksheets #6D.5b and #6D.5c. Go over the directions, if necessary.

Assignments:
1. **HANDS ON.** Go outside to look for evidence of recent human and animal activity. Record your observations on Worksheet #6D.5a. Then make inferences and hypotheses based on these observations.
2. **NON HANDS ON.** Read **Mini Textbook**, pages 13 – 15. Then do Worksheets #6D.5b and #6D.5c.
**Evidence of Human and Animal Activity**

**Directions:** Go outside into a natural setting in the yard. Look for evidence of any human or animal activity. Record what you observed; then make inferences and/or hypotheses about what you observed.

<table>
<thead>
<tr>
<th>My Observations</th>
<th>Inferences and Hypotheses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
Directions: Use *Mini Textbook*, pages 13 – 15 to help you with the questions.

1. Explain what each of these terms mean. (You may have to use a dictionary.)

   - observation ________________________________

   - inference ________________________________

   - hypothesis ________________________________

2. For each observation below, make one inference.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Possible Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little Matthew was crying and complaining of a tummy ache. His parents noticed candy wrappers all over his bedroom floor.</td>
<td></td>
</tr>
<tr>
<td>A grocery store had been robbed some time during the night. A back window to the store was broken.</td>
<td></td>
</tr>
<tr>
<td>Police were found a man unconscious in car that had driven off the road. An open roadmap was found lying on the steering wheel.</td>
<td></td>
</tr>
<tr>
<td>When police entered the house of a suspect, they found a cup of coffee on the kitchen table. The coffee was hot.</td>
<td></td>
</tr>
<tr>
<td>A woman reported that someone had been in her house. All the drawers and cupboards lay open, but nothing seemed to be missing.</td>
<td></td>
</tr>
</tbody>
</table>
3. Read the following scenario. Then write two different hypotheses that might explain what happened.

Maggie owned a jewellery shop that specialized in very expensive necklaces, rings, and watches. When she arrived at the store on Monday morning, she noticed that the Cartier watch that was on display on the counter was missing. The watch was always locked in a clear glass case. Maggie thought that perhaps she had forgotten to lock it, but when she tried to open the case, it was locked.

Maggie carefully looked around the rest of the store. Nothing else was missing. When the store workers showed up, they were shocked and afraid. They had all worked for Maggie for many years. Each of them had keys, but Maggie knew none of them would ever steal from her. In the end, Maggie could take comfort in the fact that all of her merchandise was insured and that she would eventually get the money to replace the watch from the insurance company.

Hypothesis 1:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Hypothesis 2:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Observations, Inferences, and Hypotheses

Directions: Use Mini Textbook, pages 13 – 15 to help you with the questions.

1. Explain what each of these terms mean. (You may have to use a dictionary.)

observation gathering information using senses

inference drawing conclusion based on facts

hypothesis explanation of what a person thinks happened based on observation and inference

2. For each observation below, make one inference.

<table>
<thead>
<tr>
<th>Observation</th>
<th>Possible Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little Matthew was crying and complaining of a tummy ache. His parents noticed candy wrappers all over his bedroom floor.</td>
<td>Matthew has tummy ache because he ate too much candy.</td>
</tr>
<tr>
<td>A grocery store had been robbed some time during the night. A back window to the store was broken.</td>
<td>Robber gained entrance to store by breaking rear window.</td>
</tr>
<tr>
<td>Police were found a man unconscious in car that had driven off the road. An open roadmap was found lying on the steering wheel.</td>
<td>Man drove off road while looking at roadmap.</td>
</tr>
<tr>
<td>When police entered the house of a suspect, they found a cup of coffee on the kitchen table. The coffee was hot.</td>
<td>Suspect just left.</td>
</tr>
<tr>
<td>A woman reported that someone had been in her house. All the drawers and cupboards lay open, but nothing seemed to be missing.</td>
<td>Intruders were not robbers, but people looking for something specific</td>
</tr>
</tbody>
</table>
3. Read the following scenario. Then write two different hypotheses that might explain what happened.

Maggie owned a jewellery shop that specialized in very expensive necklaces, rings, and watches. When she arrived at the store on Monday morning, she noticed that the Cartier watch that was on display on the counter was missing. The watch was always locked in a clear glass case. Maggie thought that perhaps she had forgotten to lock it, but when she tried to open the case, it was locked.

Maggie carefully looked around the rest of the store. Nothing else was missing. When the store workers showed up, they were shocked and afraid. They had all worked for Maggie for many years. Each of them had keys, but Maggie knew none of them would ever steal from her. In the end, Maggie could take comfort in the fact that all of her merchandise was insured and that she would eventually get the money to replace the watch from the insurance company.

**Answers will vary**

**Hypothesis 1:**

One of the staff was the thief.

**Hypothesis 2:**

Maggie herself stole the watch.
Lesson Six

Concept: Observing differences in shoe prints (shape, size, depth, stride, etc.)

Note: This activity is best done outdoors where students can make and easily observe footprints. If this is not practical, you can do much of the activity indoors in the classroom.

Resources/Materials: Mini Textbook, pages 16 and 17
Worksheets #6D.6c and #6D.6d, and #6D.6e (student copies)
HANDS ON: Worksheet #6D.6a (transparency or copied onto chart)
Worksheet #6D.6b (student copies)
11” X 17” sheet of paper per person
area of fresh soil, sand, or snow (if at all possible)
variety of shoes ruler spray bottle of water (nice to have)
NON HANDS ON:

Introduction: Explain that in a crime scene one of the first clues forensic experts look for are footprints. Ask students to speculate as to why. (Most will say they tell something about the size of feet and the tread of the shoe, helping to identify the person who made them.) Explain that size and tread are important, but they are not the only types of evidence. We will find out more today.

Procedure:
HANDS ON
1. Take students out to a prearranged sight where there is undisturbed soil, sand, or snow.
2. Have students of varying heights and weights walk naturally in the undisturbed soil. Compare length, width, and depth of prints. Relate them to the people who made them. What inferences can be made, knowing the size and depths of footprints? Tall people usually have larger footprints. Heavier people leave deeper prints.
3. Compare the types of tread, looking for any “oddities” such as a cut in the tread, a worn heel, and so on. Discuss why it is important to note such things.
4. Next compare the length of the stride. Discuss that taller people usually have a longer stride.
5. Have a student walk forward, then backward, then sideways. Note differences in the patterns left. Discuss how they can make inferences about the person’s activity by examining these patterns.
6. Have a student walk, run, skip, hop, jump, etc. Compare the differences, especially in distance between prints, the depth, and the clarity.
7. Observe some overlapping prints. Ask students how they could tell if the same person made them or whether they were made by more than one person.
8. Have two students walk side by side, then stop and have one of the people piggy back the other. Note the pattern (two sets of tracks, then one). Note the difference in depth of prints when one person is carrying the other.

Continued
Lesson Six (continued)

9. With students make notes, to be copied into notebooks (or put up the transparency or chart of Worksheet #6D.6a OR copy from Mini Textbook, page 16). Example:

   Clues in Footprints
   1. size – the larger the footprint, the taller the person
   2. depth – the deeper the footprint, the heavier the person
   3. length of stride – the longer the stride, the taller the person
   4. direction – helps us to know which way the person was walking
   5. patterns of footprints – can give clues about different gaits
   6. tread – helps us match a suspect to footprints

10. Distribute Worksheet #6D.6b. Go over the directions if necessary. You may have to allow students to go outside and “dirty” their shoes so they will make a more distinct print.

11. Distribute Worksheets #6D.6c, #6D.6d, and #6D.6e to give students practice in making inferences from footprint evidence.

NON HANDS ON


13. Have students copy the section entitled “Clues in Footprints” from Mini Textbook, page 16.

14. Distribute Worksheets #6D.6c, #6D.6d, and #6D.6e. Go over the directions, if necessary.

Assignments:

HANDS ON
1. Copy notes from board, transparency/chart of Worksheet #6D.6a OR from Mini Textbook, page 16.
2. Do Worksheet #6D.6b.
3. Do Worksheets #6D.6c, #6D.6d, and #6D.6e.

NON HANDS ON
4. Read Mini Textbook, pages 16 and 17.
5. Do Worksheets #6D.6c, #6D.6d, and #6D.6e.
Clues in Footprints

1. **size** – the larger the footprint, the taller the person
2. **depth** – the deeper the footprint, the heavier the person
3. **length of stride** – the longer the stride, the taller the person
4. **direction** – helps us to know which way the person was walking
5. **patterns of footprints** – can give clues about different gaits
6. **tread** – helps us match a suspect to footprints
Investigating Footprints

What You Need

large sheet of paper  
shoe (cannot be super clean)  
ruler

What To Do

1. Put on your shoe.

2. Carefully step on the sheet of paper, starting with your heel and ending up with your toe. Try not to twist or slide your foot.

3. Examine your shoe print.

4. Fill in the chart below.

<table>
<thead>
<tr>
<th>Length</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td></td>
</tr>
<tr>
<td>Wear on the Tread</td>
<td></td>
</tr>
<tr>
<td>Distinguishing Marks</td>
<td></td>
</tr>
</tbody>
</table>

5. In the space below make a sketch of the shoe print. Make it as accurate as you can.
Some Shoe Print Information

Directions: Below are descriptions of three shoe prints left in the snow. Use what you know to make some inferences about the people who left the prints.

1. Shoe Print One
   - 20 cm long and 9 cm wide
   - tread marks are very clear and crisp
   - shoe print was 2 cm deep

   Inferences:

2. Shoe Print Two
   - 43 cm long and 19 cm wide
   - no tread marks, but there was a heel mark
   - shoe print was 7 cm deep

   Inferences:

3. Shoe Print Three
   - 30 cm long and 18 cm wide
   - tread marks are faint
   - lines across two of the treads
   - shoe print is 12 cm deep

   Inferences
1. Examine the diagram of three different sets of footprints. List the order in which these footprints were made. Describe how you came to this conclusion.

2. Tell what you can infer from each of the following:
   a. size of footprints
   b. length of stride
   c. depth of footprints
   d. clarity of tread
3. The police were sent out to observe several different crime scenes. Read what they observed. Then tell why they might be able to infer from the observations.

<table>
<thead>
<tr>
<th>Police Observation Notes</th>
<th>What They Can Infer from their Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• footprints are large and deep</td>
<td></td>
</tr>
<tr>
<td>• footprint stride started out at 45 cm, then changed to 60 cm</td>
<td></td>
</tr>
<tr>
<td>• two sets of footprints led to a side window</td>
<td></td>
</tr>
<tr>
<td>• the same set of footprints led away from the window, but one set was deeper going away than going to the window</td>
<td></td>
</tr>
<tr>
<td>• set of shoe prints led to the house; each print was 25 cm long and 10 cm long</td>
<td></td>
</tr>
<tr>
<td>• another set of prints led away from the house; each print was 32 cm long and 13 cm wide</td>
<td></td>
</tr>
<tr>
<td>• no one was found in the house</td>
<td></td>
</tr>
<tr>
<td>• two sets of footprints found side by side</td>
<td></td>
</tr>
<tr>
<td>• changed to one set of very deep footprints</td>
<td></td>
</tr>
<tr>
<td>• one set of footprints went up to a back window</td>
<td></td>
</tr>
<tr>
<td>• same set of footprints led away from front door</td>
<td></td>
</tr>
</tbody>
</table>
Directions: Below are descriptions of three shoe prints left in the snow. Use what you know to make some inferences about the people who left the prints.

1. **Shoe Print One**
   - 20 cm long and 9 cm wide
   - tread marks are very clear and crisp
   - shoe print was 2 cm deep

   Inferences:
   - a child left the prints
   - prints are recent
   - shoes are new

2. **Shoe Print Two**
   - 43 cm long and 19 cm wide
   - no tread marks, but there was a heel mark
   - shoe print was 7 cm deep

   Inferences:
   - prints left by tall, heavy person
   - shoes may be worn or soles may be made of leather

3. **Shoe Print Three**
   - 30 cm long and 18 cm wide
   - tread marks are faint
   - lines across two of the treads
   - shoe print is 12 cm deep

   Inferences
   - person has a wide foot
   - person is heavy
   - stepped on something sharp that cut the tread
1. Examine the diagram of three different sets of footprints. List the order in which these footprints were made. Describe how you came to this conclusion.

1. black 2. white 3. grey
Some of white footprints cover black tracks.
Some of grey tracks cover white and black tracks

2. Tell what you can infer from each of the following:
   a. size of footprints longer the footprint, the taller the person
   b. length of stride longer the stride, the taller the person
   c. depth of footprints deeper the footprint, the heavier the person
   d. clarity of tread clearer the tread, the more recent it has been made
   clearer the tread, the newer the shoe

Worksheet #6D.6d
3. The police were sent out to observe several different crime scenes. Read what they observed. Then tell why they might be able to infer from the observations.

<table>
<thead>
<tr>
<th>Police Observation Notes</th>
<th>What They Can Infer from their Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• footprints are large and deep</td>
<td>• tall, heavy person</td>
</tr>
<tr>
<td>• footprint stride started out at 45 cm, then changed to 60 cm</td>
<td>• started out walking; then began to run</td>
</tr>
<tr>
<td>• two sets of footprints led to a side window</td>
<td>• two people entered house through window</td>
</tr>
<tr>
<td>• the same set of footprints led away from the window, but one set was deeper going away than going to the window</td>
<td>• one of the people left house carrying something heavy</td>
</tr>
<tr>
<td>• set of shoe prints led to the house; each print was 25 cm long and 10 cm long</td>
<td>• person went into house, put on boots, and then left the house</td>
</tr>
<tr>
<td>• another set of prints led away from the house; each print was 32 cm long and 13 cm wide</td>
<td></td>
</tr>
<tr>
<td>• no one was found in the house</td>
<td></td>
</tr>
<tr>
<td>• two sets of footprints found side by side</td>
<td>• one person began to carry the other</td>
</tr>
<tr>
<td>• changed to one set of very deep footprints</td>
<td></td>
</tr>
<tr>
<td>• one set of footprints went up to a back window</td>
<td>• person entered house through window, but left through front door</td>
</tr>
<tr>
<td>• same set of footprints led away from front door</td>
<td></td>
</tr>
</tbody>
</table>

Answers may vary
Lesson Seven

Concept: Examining Animal Tracks

Resources/Materials: Mini Textbook, pages 18 and 19 (top)
                 Worksheets #6D.7a and #6D.7b (student copies)

Introduction: Explain that when Europeans first came to North America, one of the things that impressed them most was the First Nations knowledge of nature. One of the skills they were particularly good at was “reading” animal tracks. This was because they relied on animals to provide them with much of their food, clothing, and shelter. Today and the next day we will learn more about how to “read” animal tracks.

Procedure:

1. Explain that several different factors give us clues about the type and size of the animal and the way each lives.

2. Have students turn to Mini Textbook, page 18. Guide the reading of pages 18 and 19 (top), if possible.

3. Have students copy the section entitled “Clues in Animal Tracks” from Mini Textbook, page 18 into their notebooks.

4. Write the following list on the board:
   Deer
   Mouse
   Rabbit
   Magpie
   Dog/coyote
   Opossum/raccoon

5. Distribute Worksheets #6D.7a and #6D.7b. As a class decide which animals made each of the prints. Have students write the names of the animals in the print boxes.

6. With students do “A” about coyote or dog. Then have students complete the rest independently.

   A. dog or coyote – Observations: large pads, claws, front prints slightly smaller that back prints
      Inferences: claws – climbing, digging;

Assignments:

1. Read Mini Textbook, pages 18 and 19 (top)
2. Copy notes from page 18 of Mini Textbook, page 18.
3. Do Worksheets #6D.7a and #6D.7b.

Continued
Lesson Seven (continued)

For the Teacher

Interpreting tracks is like playing detective where we carefully interpret the clues left behind. The clues are animal signs, which include tracks, droppings, claw marks, chew marks, and scenting. These signs are tangible evidence that tells us the animals were here. Each animal chooses the mode of propulsion that is most efficient for its body type. For instance, walking a great mode for conserving energy. Without stopping to rest, many of us can walk much farther than we could run. Human are a good example of walkers. Why don’t we hop, trot, or skip? Because it takes less energy to walk to a destination. It comes down to efficiency. Out in the wilderness where efficiency is essential, animals travel in three main modes: walking, hopping, and trotting.

Walkers. Examples: coyotes, bobcats, elk, deer, porcupines, beavers.
Steady alternating left, right, left, right, tells us it’s a walking gait.
Here is a simple method for determining a walker’s length from hip to shoulder. Take a series of three of the footprints in a walking track. Measure it. That would be the animal’s length.

Hoppers. Examples: squirrels, snowshoe hares, cottontail rabbits, and mice.
For these animals, it is simply more efficient to propel themselves by leaping forward, landing, and then jumping again.
The width of the track tells us the width of the animal’s hips.
The tracks appear in spaced groupings, each containing two front and two rear footprints. The rear legs appear in the rear of the grouping, because when a hopping animal is in motion, the rear feet land first, are overstepped by the rear, and then propels itself forward using its powerful hind legs.

Trotters. Examples: red fox, weasel, marten
Left and right tracks are not obvious, and the depressions in the snow appear in a line. In each depression there are a diagonal set of two footprints, another set of two, another set of two, etc.
<table>
<thead>
<tr>
<th>A.</th>
<th>Observations:</th>
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<td>Inferences:</td>
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<tr>
<th>B</th>
<th>Observations:</th>
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<tr>
<th>C</th>
<th>Observations:</th>
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<td>Inferences:</td>
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<tr>
<td></td>
<td>Observations:</td>
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</tr>
<tr>
<td><strong>D.</strong></td>
<td></td>
</tr>
<tr>
<td><img src="image1.png" alt="Footprints" /></td>
<td></td>
</tr>
<tr>
<td><strong>E.</strong></td>
<td></td>
</tr>
<tr>
<td><img src="image2.png" alt="Footprints" /></td>
<td></td>
</tr>
<tr>
<td><strong>F.</strong></td>
<td></td>
</tr>
<tr>
<td><img src="image3.png" alt="Footprints" /></td>
<td></td>
</tr>
</tbody>
</table>
A. dog/coyote

Observations:
- large pads
- claws
- four legs

Inferences:
- larger animal
- animal digs or needs claws to hold its food

B

Observations:
- two legs
- three toes

Inferences:
- bird

C

Observations:
- five toes
- medium-sized on claws
- smaller tracks
- four legs

Inferences:
- small/medium-sized animal
- good climber - claws and long "thumb"
### D.

<table>
<thead>
<tr>
<th>Observations:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>fairly large</td>
<td></td>
</tr>
<tr>
<td>four legs</td>
<td></td>
</tr>
<tr>
<td>cloven hoofs (split)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inferences:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>larger animal</td>
<td></td>
</tr>
<tr>
<td>cloven hoofs → deer family</td>
<td></td>
</tr>
</tbody>
</table>

### E.

<table>
<thead>
<tr>
<th>Observations:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>four legs</td>
<td></td>
</tr>
<tr>
<td>back feet much bigger than front</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inferences:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>back legs used for pushing off</td>
<td></td>
</tr>
<tr>
<td><em>good hopper</em></td>
<td></td>
</tr>
</tbody>
</table>

### F.

<table>
<thead>
<tr>
<th>Observations:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>tiny tracks &quot;fingers&quot;</td>
<td></td>
</tr>
<tr>
<td>four legs</td>
<td></td>
</tr>
<tr>
<td>front feet smaller than back</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inferences:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>back legs stronger than front</td>
<td></td>
</tr>
<tr>
<td>can hold food w/ front paws</td>
<td></td>
</tr>
<tr>
<td>fingers → can climb</td>
<td></td>
</tr>
</tbody>
</table>
Lesson Eight

Concept: Inferring Rates of Speed from Animal Tracks

Resources/Materials: Mini Textbook, pages 19 and 20 (optional)
Worksheet #6D.8a (transparency, student copies)
Worksheets #6D.8b and #6D.8c (student copies)

Introduction: Recall that during the last period, students had practice matching prints to animals. In today’s lesson students will try to make inferences about the animals’ gaits.

Procedure:

1. Discuss with students the different types of gaits animals may have: walking, running, hopping/jumping, trotting, etc. Note that many animals can employ more than one type of gait, their bodies are made so that it has a preferred type of gait that uses normally.

2. Tell students they will receive a sheet showing six different animals. They are to examine the tracks. From there they will be making inferences about the gaits of the animals.

3. Distribute Worksheet #6D.8a and put up a transparency of the worksheet. Note that the vertical line indicates a change in an animal’s gait. With students examine the tracks and speeds of the skunk, weasel, and mink. Have students observe how the track patterns differ for each animal. With students fill in the empty boxes: A, B, and C.

4. Distribute Worksheets #6D.8b and #6D.8c. Go over the directions, if necessary. Check in class, if possible.

5. OPTIONAL. If you would like students to read more about inferring animal gaits, have them read Mini Textbook, pages 19 and 20.

Assignment:

1. Do Worksheets #6D.8b and #6D.8c.
2. OPTIONAL. Read Mini Textbook, pages 19 and 20.
Speedy Tracks

**A.** Lynx
- Casual gait

**B.** Badger
- Walking
- Loping

**C.** Skunk
- Walking
- Easy loping

**D.** Weasel
- Jumping

**E.** Mink
- Jumping

**F.** Marten
- Jumping
**Looking at Speedy Tracks**

**Directions:** Examine the tracks left by each animal. Make observations about how the track pattern changed. Then make inferences about the animal's gait.

<table>
<thead>
<tr>
<th>Observations:</th>
<th>Inferences:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lynx:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Badger:</td>
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<td>Skunk:</td>
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Worksheet #6D.8b
<table>
<thead>
<tr>
<th>Observations:</th>
<th>Inferences:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weasel:</strong></td>
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<tr>
<td><strong>Mink:</strong></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Marten:</strong></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Speedy Tracks**

- **Lynx**
  - A. Running
  - Casual gait

- **Badger**
  - Walking
  - Loping

- **Skunk**
  - Walking
  - Loping

- **Weasel**
  - Easy loping
  - Jumping

- **Mink**
  - Jumping
  - Running

- **Hare**
  - Jumping
  - Walking

*Worksheet #6D 8a*
**Directions:** Examine the tracks left by each animal. Make observations about how the track pattern changed. Then make inferences about the animal's gait.

<table>
<thead>
<tr>
<th>Observations:</th>
<th>Inferences:</th>
</tr>
</thead>
</table>
| **Lynx:**
  - long distance between sets of tracks at first; two left feet far apart while right feet close together.
  - change to tracks close together with regular left alternating with right side prints |
  Lynx was running; then changed to walking                                       |
| **Badger:**
  - evenly spaced left/right pattern
  - change to clusters of four                                                   |
  Badger was walking; then began running                                           |
| **Skunk:**
  - evenly spaced left/right pattern
  - little distance between prints
  - change to clusters of three prints - two front and one rear                  |
  Skunk was walking; then began loping                                             |
<table>
<thead>
<tr>
<th>Observations:</th>
<th>Inferences:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weasel:</strong></td>
<td></td>
</tr>
<tr>
<td>- clusters of four prints</td>
<td>Weasel was in an easy lope; then</td>
</tr>
<tr>
<td>- change to clusters of two prints</td>
<td>began jumping</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mink:</strong></td>
<td></td>
</tr>
<tr>
<td>- clusters of two prints</td>
<td>Mink started out jumping; then</td>
</tr>
<tr>
<td>- changed to clusters of four prints</td>
<td>started running</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Martens:</strong></td>
<td></td>
</tr>
<tr>
<td>- clusters of two side-by-side print</td>
<td>Mink started out jumping; then</td>
</tr>
<tr>
<td>- change to evenly spread left/right pattern</td>
<td>began walking</td>
</tr>
</tbody>
</table>
Lesson Nine

Concept: Classifying Shoe Prints: Using a Dichotomous Key

Resources/Materials:

HANDS ON: Worksheet #6D.9a (transparency)
Worksheet #6D.9a (2 copies per student)
Worksheet #6D.9b (teacher copy)
many shoes, boots, and other footwear as you can possibly gather up from the staff and the students.

NON HANDS ON:  Mini Textbook, pages 21 and 22
Worksheet #6d.9c (student copies)

Introduction: Recall the activity where footprints were examined. Size, depth, and tread designs were examined. Today’s less involves more work with shoe prints.

Procedure:
1. Explain to students that in science we usually try to organize things into categories. This helps us to think about what we know in an organized way.
2. Explain that today students will get practice in organizing some shoes using a graphic organizer called a dichotomous key. Dichotomous means dividing into two parts.

HANDS ON
3. Have the shoes and boots put into a big pile in the middle of the room (or at the front). Tell students we want to separate the pile of shoes into two main groups. To do this, we must first decide on some criteria, like colour, function, etc. From there, each of the two groups is subdivided again.
4. Put up the transparency of Worksheet #6D.9a and distribute copies to the students. Show why this graphic organizer is called a dichotomous key. (Each category is divided into two; then subdivided again into two, etc.)
5. In the top box, students should write All Footwear. With students decide how to divide the footwear into two categories. (Examples: shoes – boots; leather – not leather)
6. If possible, as a class, complete the dichotomous key. Explain that not all boxes have to be filled. (See Worksheet #6D.9b for an example of a completed dichotomous key.)
7. Once you have led the class in making a dichotomous key, distribute a second copy of Worksheet #6D.9a. Tell students All Footwear category, using a different criterion than one done by the class. (That is, if you used shoes – boots, then they might want to use black – not black or something else.)

NON HANDS ON
8. Have students turn to Mini Textbook, page 21. Guide the reading. Then show students how the information from the chart on page 21 can be reorganized using a dichotomous chart like the one on page 22.
9. Distribute Worksheet #6D.9c. Go over the directions, if necessary.

Assignments:
1. HANDS ON. Organize a pile of footwear using the dichotomous key on Worksheet #6D.9a.
2. NON HANDS ON. Read Mini Textbook, pages 21 and 22. Do Worksheet #6D.9c.
Directions: Use the dichotomous key to organize the footwear in your classroom.
Shoe Sorting – A Example

List all shoes

Shoes without heels
- No visible treads
  - Treads cover entire sole
Shoes with heels
- Visible treads
  - Treads cover part of sole
- No visible treads
  - Treads cover entire sole
- Visible treads
  - Treads cover part of sole
Animal Tracks: Dichotomous Key

Directions: Use *Mini Textbook*, pages 21 and 22 to help you answer the questions.

1. Explain how a dichotomous key is organized.

2. Of the ten animals in the dichotomous key on page 22, how many have claws? ______
   How many do not have claws? ____________

3. Following are some descriptions of animals in the dichotomous key. Use the dichotomous key to determine the animals described.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• split hoof</td>
</tr>
<tr>
<td></td>
<td>• front foot smaller than rear</td>
</tr>
<tr>
<td></td>
<td>• four toes</td>
</tr>
<tr>
<td></td>
<td>• all digits close together</td>
</tr>
<tr>
<td></td>
<td>• webbed rear feet</td>
</tr>
<tr>
<td></td>
<td>• thumb seemed separated from other digits</td>
</tr>
<tr>
<td></td>
<td>• rear foot large</td>
</tr>
<tr>
<td></td>
<td>• four toes</td>
</tr>
<tr>
<td></td>
<td>• padded feet</td>
</tr>
<tr>
<td></td>
<td>• five toes</td>
</tr>
<tr>
<td></td>
<td>• non-webbed rear foot</td>
</tr>
<tr>
<td></td>
<td>• no claws</td>
</tr>
<tr>
<td></td>
<td>• padded feet</td>
</tr>
</tbody>
</table>
Directions: Use *Mini Textbook*, pages 21 and 22 to help you answer the questions.

1. Explain how a dichotomous key is organized.
   - large group is sorted into two groups, based on a particular trait
   - each of the two groups is further subdivided into two groups, etc.

2. Of the ten animals in the dichotomous key on page 22, how many have claws? 5
   How many do not have claws? 5

3. Following are some descriptions of animals in the dichotomous key. Use the dichotomous key to determine the animals described.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>deer</td>
<td>• split hoof</td>
</tr>
<tr>
<td>weasel</td>
<td>• front foot smaller than rear</td>
</tr>
<tr>
<td></td>
<td>• four toes</td>
</tr>
<tr>
<td>beaver</td>
<td>• all digits close together</td>
</tr>
<tr>
<td></td>
<td>• webbed rear feet</td>
</tr>
<tr>
<td>muskrat</td>
<td>• thumb seemed separated from other digits</td>
</tr>
<tr>
<td></td>
<td>• rear foot large</td>
</tr>
<tr>
<td>bobcat</td>
<td>• four toes</td>
</tr>
<tr>
<td></td>
<td>• padded feet</td>
</tr>
<tr>
<td>mink</td>
<td>• five toes</td>
</tr>
<tr>
<td></td>
<td>• non-webbed rear foot</td>
</tr>
<tr>
<td>bobcat</td>
<td>• no claws</td>
</tr>
<tr>
<td></td>
<td>• padded feet</td>
</tr>
</tbody>
</table>
Lesson Ten

Concept: Relating Length of Foot to Height

Resources/Materials: Worksheet #6D.10a (optional, student copies)  
Worksheet #6D.10b (transparency, student copies)  
rulers metre sticks

Introduction: Tell students that today they will try to make inferences about the lengths of their feet.

Procedure:

1. Divide students up into as many groups as you have metre sticks.

2. Tell students they will be measuring the length of their feet and their heights; then plotting the information on a line graph.

3. In their notebooks, have students make a table to record their information (or use distribute Worksheet #6D.10a).

   Foot Length and Height

<table>
<thead>
<tr>
<th>Student</th>
<th>Length of Foot (cm)</th>
<th>Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>

4. Have students take their foot length and height measurements and record the information in the table. Then they should go around and get the measurements of their classmates.

5. Tell students to use the information to make a line graph on Worksheet #6D.10b.

6. If time, discuss the relationship they found between foot length and height.

Assignments:

1. Find the foot lengths and heights of everyone in the class.
2. Make a line graph showing the information on Worksheet #6D.10b.
**Foot Length and Height**

**Directions:** Record the foot length and height of each of the people in the class.

<table>
<thead>
<tr>
<th>Student</th>
<th>Foot Length (cm)</th>
<th>Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>
By examining the information on the graph, what is the relationship between a person's foot length and their height?
Lesson Eleven

Concept: Evidence and Investigation, Part I Review

Resources/Materials: Evidence and Investigation, Part I Review Sheets

Introduction: Explain that the first part of the unit is now coming to an end. It is time to prepare for a test.

Procedure:

1. With students briefly go over the main topics covered in the unit so far.
   
   - The powers of observation – what to look for when observing a person
   - The value of concise questioning
   - The importance of prediction and hypothesis in investigations
   - Making observations and inferences in an outdoor setting
   - Shoe prints
   - Animal tracks
   - Classifying using a dichotomous key
   - Relationship between foot length and height

2. Distribute the Evidence and Investigation, Part I Review Sheets. Have students do them independently. If at all possible, check them as a class.

Assignment:

Do the Evidence and Investigation, Part I Review Sheets.
1. Define each of these words.
   a. crime __________________________
   b. observe __________________________
   c. clue __________________________
   d. evidence __________________________
   e. mystery __________________________
   f. investigate __________________________
   g. witness __________________________
   h. forensic science __________________________

2. Tell about six characteristics to look for when observing a person.
   a. __________________________
   b. __________________________
   c. __________________________
   d. __________________________
   e. __________________________
   f. __________________________
3. What are six things to look for at a crime scene.
   a. __________________________________________
   b. __________________________________________
   c. __________________________________________
   d. __________________________________________
   e. __________________________________________
   f. __________________________________________

4. What are six things to look for when examining footprints?
   a. __________________________________________
   b. __________________________________________
   c. __________________________________________
   d. __________________________________________
   e. __________________________________________
   f. __________________________________________

5. Explain what each of the following can tell you when observing footprints.
   a. length of footprint __________________________________________
   b. depth of footprint __________________________________________
   c. length of stride __________________________________________
   d. clarity of footprint __________________________________________
   e. distinguishing marks __________________________________________
6. What can the following tell you about animal tracks?
   a. claw marks
   b. three thin long toe marks on each prints, that are made in sets of two
   c. size of animal track
   d. length of stride
   e. changes in the length of stride

7. Examine the animal tracks. Then make observations and inferences about them.

   Observations:
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________

   Inferences:
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
   ______________________________________________________________
8. Look at the observations that some police officers made about footprints. Make some inferences or hypotheses about what they observed.

<table>
<thead>
<tr>
<th>Observations</th>
<th>Inferences I Can Make</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two different sets of footprints lead part way across a field. One set keeps going in the same direction; the other goes back in the opposite direction.</td>
<td></td>
</tr>
<tr>
<td>Three different sets of footprints go to the back door of a house. One of those sets of footprints leads away from the house.</td>
<td></td>
</tr>
<tr>
<td>One set of footprints leads to the front door of a house. This same set of footprints leads away from the house along with another set of footprints.</td>
<td></td>
</tr>
</tbody>
</table>


1. Define each of these words.
   a. crime an act that breaks the law
   b. observe get information using the senses
   c. clue a hint
   d. evidence anything that provides material or information on which a conclusion can be based
   e. mystery something that cannot be easily explained
   f. investigate look for information in an organized way
   g. witness someone who sees a crime happen
   h. forensic science the science of uncovering and using clues to make inferences about how a crime happened.

2. Tell about six characteristics to look for when observing a person.
   a. eye colour
   b. height
   c. weight
   d. hair - colour, cut
   e. clothing
   f. shoes
distinguishing characteristics (e.g. scars, limp, etc)
3. What are six things to look for at a crime scene.
   a. footprints
   b. tire tracks
   c. clothing/cloth samples
   d. hair samples
   e. notes written in pen or pencil
   f. objects lying around

4. What are six things to look for when examining footprints?
   a. size
   b. depth
   c. length of stride
   d. clarity
   e. patterns of footprint
   f. tread

5. Explain what each of the following can tell you when observing footprints.
   a. length of footprint height of person
   b. depth of footprint weight of person
   c. length of stride height of person or gait
   d. clarity of footprint how recently footprint was made
   e. distinguishing marks if shoes are new/worn; if person had stepped on something sharp; if heels are worn
6. What can the following tell you about animal tracks?

a. claw marks animals the dig, climb, meat-eaters

b. three thin long toe marks on each prints, that are made in sets of two bird

c. size of animal track size of animal

d. length of stride gait

e. changes in the length of stride change in gait

7. Examine the animal tracks. Then make observations and inferences about them.

Observations:

- large prints with tracks close together, then more space between print
- small prints close together
- two sets of tracks meet
- lots of both tracks in one spot
- only large tracks leave area

Inferences:

- large animal meets up with smaller animal.
- large animal attacks smaller one and eats it.
8. Look at the observations that some police officers made about footprints. Make some inferences or hypotheses about what they observed.

<table>
<thead>
<tr>
<th>Observations</th>
<th>Inferences I Can Make</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two different sets of footprints lead part way across a field. One set keeps going in the same direction; the other goes back in the opposite direction.</td>
<td>Two people walk together. One return to where they came; other continues on.</td>
</tr>
<tr>
<td>Three different sets of footprints go to the back door of a house. One of those sets of footprints leads away from the house.</td>
<td>Three people go to a house. Two stay; one leaves.</td>
</tr>
<tr>
<td>One set of footprints leads to the front door of a house. This same set of footprints leads away from the house along with another set of footprints.</td>
<td>Person went to a house, picked up someone; both left.</td>
</tr>
</tbody>
</table>
Lesson Twelve

Concept: Evidence and Investigation, Part I Review Test.

Resources/Materials: Evidence and Investigation, Part I Test (student copies)
1. Match the words and phrases in the box with their meanings.

<table>
<thead>
<tr>
<th>a. crime</th>
<th>b. investigate</th>
<th>c. criminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>d. evidence</td>
<td>e. observe</td>
<td>f. mystery</td>
</tr>
<tr>
<td>g. clue</td>
<td>h. forensic science</td>
<td>i. witness</td>
</tr>
</tbody>
</table>

____ an act that break the law
____ a person who has broken the law
____ something that cannot be easily explained
____ a hint
____ anything that provides material or information on which a conclusion can be based
____ the science of uncovering and using clues to make inferences about how a crime happened
____ get information through seeing, hearing, smelling, touching, or feeling
____ someone who sees a crime happen

2. Pretend you saw someone rob a bank. The police have asked you to describe the robber. Tell about five characteristics of the robber you would tell the police about.

a. ______________________________________________________

b. ______________________________________________________

c. ______________________________________________________

d. ______________________________________________________

e. ______________________________________________________
3. Pretend you are a police officer. Someone broke into a store and stole a toaster, an electric mixer, and an electric drill. The thief got away before anyone could stop him. You have been called in to investigate this crime. Name five things you would do or look for to help solve the crime.

a. 

b. 

c. 

d. 

e. 

4. What can you infer by knowing each of the following about footprints?

a. length of the footprint

b. depth of the footprint

c. how distinct the footprint is

d. length of the stride

e. a change in the length of the stride

f. the way the footprints are pointing
5. It is winter and there is deep snow everywhere. You notice some footprints in the snow. You decide to take a closer look. Here is what you observed.

- The footprints are 40 cm long and 20 cm wide.
- The footprints are very deep.
- There is only about 40 cm between footprints.
- The tread is not very clear.
- There is a line that cuts across part of the tread of the left footprint.

From these observations, what are four things you could infer about the person who made the footprints.

a. 

b. 

c. 

d. 

6. Examine the following sets of animal tracks. Then tell something about the animal that made them.

a. 

b. 

7. Read about the following observations made by a crime scene investigator. Tell what inferences he or she could make.

<table>
<thead>
<tr>
<th>Observations</th>
<th>Possible Inferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>A person left long deep footprints.</td>
<td></td>
</tr>
<tr>
<td>A set of footprints leads to the front door of a house. A similar set of</td>
<td></td>
</tr>
<tr>
<td>footprints leads away from the back door of the same house.</td>
<td></td>
</tr>
<tr>
<td>Two sets of footprints go up to the side window of a house. The same two</td>
<td></td>
</tr>
<tr>
<td>sets lead away from the house, but this time one set is deeper.</td>
<td></td>
</tr>
<tr>
<td>Two sets of animal tracks appear side by side. One set is large and the</td>
<td></td>
</tr>
<tr>
<td>other small. You know from experience that they are those of cats. At one</td>
<td></td>
</tr>
<tr>
<td>point the smaller set no longer continues.</td>
<td></td>
</tr>
</tbody>
</table>
1. Match the words and phrases in the box with their meanings.

| a. crime | b. investigate | c. criminal |
| d. evidence | e. observe | f. mystery |
| g. clue | h. forensic science | i. witness |

---

_a_ an act that break the law

_c_ a person who has broken the law

_f_ something that cannot be easily explained

_g_ a hint

_d_ anything that provides material or information on which a conclusion can be based

_h_ the science of uncovering and using clues to make inferences about how a crime happened

_e_ get information through seeing, hearing, smelling, touching, or feeling

_i_ someone who sees a crime happen

---

2. Pretend you saw someone rob a bank. The police have asked you to describe the robber. Tell about five characteristics of the robber you would tell the police about.

_a. hair colour/style

_b. height

_c. weight

_d. clothing

_e. distinguishing marks/characteristics
3. Pretend you are a police officer. Someone broke into a store and stole a toaster, an electric mixer, and an electric drill. The thief got away before anyone could stop him. You have been called in to investigate this crime. Name five things you would do or look for to help solve the crime.

a. hair left behind
b. fingerprints
c. footprints inside and/or outside
d. something possibly left behind
e. clothing or torn cloth
f. possible note left behind

g. damage done
h. tire tracks

4. What can you infer by knowing each of the following about footprints?

a. length of the footprint
b. depth of the footprint
c. how distinct the footprint is

d. length of the stride

e. a change in the length of the stride

f. the way the footprints are pointing
5. It is winter and there is deep snow everywhere. You notice some footprints in the snow. You decide to take a closer look. Here is what you observed.

- The footprints are 40 cm long and 20 cm wide.
- The footprints are very deep.
- There is only about 40 cm between footprints.
- The tread is not very clear.
- There is a line that cuts across part of the tread of the left footprint.

From these observations, what are four things you could infer about the person who made the footprints.

a. tall person
b. heavy person
c. walking
d. footprints not recent

e. person stepped on something sharp

6. Examine the following sets of animal tracks. Then tell something about the animal that made them.

a.

bird

b.

four legged
animal digs or climbs
c.

started out jumping/running, then walking

7. Read about the following observations made by a crime scene investigator. Tell what inferences he or she could make.

<table>
<thead>
<tr>
<th>Observations</th>
<th>Possible Inferences</th>
</tr>
</thead>
<tbody>
<tr>
<td>A person left long deep footprints.</td>
<td>running</td>
</tr>
<tr>
<td></td>
<td>tall person (also heavy)</td>
</tr>
<tr>
<td>A set of footprints leads to the front door of a house. A similar set of</td>
<td>person entered house through front door, but left thru</td>
</tr>
<tr>
<td>footprints leads away from the back door of the same house.</td>
<td>rough back door.</td>
</tr>
<tr>
<td>Two sets of footprints go up to the side window of a house. The same two</td>
<td>two people entered house through window.</td>
</tr>
<tr>
<td>sets lead away from the house, but this time one set is deeper.</td>
<td>one person was carrying something heavy when he/she was</td>
</tr>
<tr>
<td></td>
<td>leaving</td>
</tr>
<tr>
<td>Two sets of animal tracks appear side by side. One set is large and the</td>
<td>mother and baby cat walking</td>
</tr>
<tr>
<td>other small. You know from experience that they are those of cats. At one</td>
<td>mother picked up baby and continued walking</td>
</tr>
<tr>
<td>point the smaller set no longer continues.</td>
<td></td>
</tr>
</tbody>
</table>
About Part II

In Part II of Evidence and Investigation students continue their study of techniques used by investigators when solving crimes. They learn about examining fingerprints, tire tracks, clothing and fabrics, soil samples, and paper chromatography. While they are important in investigation, this unit does not explore such methods as analyzing blood samples and DNA.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Concept</th>
<th>Mini Textbook Pages</th>
<th>Hands On?</th>
<th>Non Hands On Option?</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Examining Fingerprints</td>
<td>24 - 26</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>Making Fingerprints</td>
<td>25 - 26</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>Lifting Fingerprints</td>
<td>30 - 31</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>16</td>
<td>Examining Tire Tracks and Treads</td>
<td>28 - 29</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>17</td>
<td>Using Chromatography to Analyze Pen Colours</td>
<td>30 - 31</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>Analyzing Handwriting (Graphology)</td>
<td>32</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>19</td>
<td>Analyzing Handwriting</td>
<td>33</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>20</td>
<td>Examining the Characteristics of Fabrics</td>
<td>34</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>21</td>
<td>Examining and Determining the Characteristics of Different Types of Soil</td>
<td>25</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>22</td>
<td>Vocabulary Review</td>
<td>26</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>23</td>
<td>Evidence and Investigation – Part II Review</td>
<td>27</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>24</td>
<td>Evidence and Investigation – Part II Test</td>
<td>28</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Lesson Thirteen

Concept: Examining Fingerprints

Resources/Materials: Mini Textbook, pages 24 - 26
- Worksheet #6D.13a (transparency, student copies)
- Worksheets #6D.13b, #6D.13c and #6D.13d (student copies)

Introduction: Explain that one thing that police can do is to look for fingerprints left at a crime scene. Every person has different fingerprints.
Have students examine theirs and another person’s fingerprints.
If police have a suspect and the suspect’s fingerprints match those left at a crime scene, they can conclude that the suspect was at the scene of the crime.

Procedure:

1. Explain that forensic scientists have categorized fingerprint types into four categories.
2. Put up the transparency of Worksheet #6D.13a. With students go over the four basic fingerprint types.
4. Have students examine their own fingerprints to decide which type or types of fingerprints they have.
5. OPTIONAL. Have students make notes on
   - Types of Fingerprints (names, descriptions, sketches)
   - Ridge Characteristics (names, descriptions, sketches)
6. Distribute Worksheets #6D.13b, #6D.13c, and #6D.13d.

Assignments:

1. OPTIONAL. Make notes on the types of fingerprints and ridge characteristics. Illustrate each.
2. Do Worksheets #6D.13b, #6D.13c, and #6D.13d.
There are four basic types of fingerprint patterns.

<table>
<thead>
<tr>
<th>Loop</th>
<th>Whorl</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Fingerprint Loop" /></td>
<td><img src="image2" alt="Fingerprint Whorl" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Arch</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3" alt="Fingerprint Arch" /></td>
<td><img src="image4" alt="Fingerprint Composite" /></td>
</tr>
</tbody>
</table>

Most fingerprints have triangular-shaped patterns called *deltas*.
Directions: Examine each of the fingerprints. Then classify each as an arch, loop, whorl, or composite. In each fingerprint, circle any deltas you see in red.
Who Was the Kidnapper?

While investigating a kidnapping case, the police lifted fingerprints from the windowsill, the ransom note, and a display case. The police were holding four suspects in the case.

Windowsill:

Ransom note:

Display case:

Below is a fingerprint from each of the four suspects. Compare the above prints with those of the suspects being held in the case. Decide which one matches the closest.

Suspect 1  Suspect 2  Suspect 3  Suspect 4
Directions: Examine each of the fingerprints. Then classify each as an arch, loop, whorl, or composite. In each fingerprint, circle any deltas you see in red.
<table>
<thead>
<tr>
<th>Arch</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Fingerprint Image" /></td>
<td><img src="image2.png" alt="Fingerprint Image" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Loop</th>
<th>Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image3.png" alt="Fingerprint Image" /></td>
<td><img src="image4.png" alt="Fingerprint Image" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Arch</th>
<th>Whorl</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Fingerprint Image" /></td>
<td><img src="image6.png" alt="Fingerprint Image" /></td>
</tr>
</tbody>
</table>
Who Was the Kidnapper?

While investigating a kidnapping case, the police lifted fingerprints from the windowsill, the ransom note, and a display case. The police were holding four suspects in the case.

Windowsill:

Ransom note:

Display case:

Below is a fingerprint from each of the four suspects. Compare the above prints with those of the suspects being held in the case. Decide which one matches the closest.

Suspect 1  Suspect 2  Suspect 3  Suspect 4
Lesson Fourteen

Concept: Making Fingerprints.

NOTE: As an alternative to the activity described below, you can have students make a fingerprint set by having them gently press each finger lightly on an ink pad, and then gently pressing the inked finger gently onto the paper.

Resources/Materials: Worksheets #6D.14a (transparency, student copies)

HANDS ON: Worksheets #6D.14b and #6D.14d (student copies)
- paper
- soft-leaded pencil
- damp towels
- clear tape

NON HANDS ON: Worksheets #6D.14c and #6D.14d (student copies)

Introduction: Review the different types of fingerprint patterns. Tell students that today they will learn a procedure for making their own fingerprints.

Procedure:

1. Put up the transparency of Worksheet #6D.14a. Go over the steps for making fingerprints with students. Demonstrate how to make a fingerprint. Distribute copies of Worksheet #6D.14a.

HANDS ON
2. Pass out the paper, and damp towels. Have students practise making a fingerprint. Remind students to wipe off their fingers after making each print.
3. Once you are comfortable that students know how to make a good clear print, distribute Worksheet #6D.14b. Have them make a complete set of fingerprints.
4. Once they have completed making the fingerprints, as a class, have them tally the total number of each type of fingerprint pattern. They should then make a bar graph to show the results, using Worksheet #6D.14d.

NON HANDS ON
5. Distribute Worksheets #6D.14c and #6D.14d. Go over the directions, if necessary.

Assignments:

HANDS ON
1. Make a set of your fingerprints on Worksheet #6D.14b.
2. Graph the total number of each type of fingerprint pattern on Worksheet #6D.14d.

NON HANDS ON
3. Do Worksheets #6D.14c and #6D.14d.
Directions: Follow these steps to make your own set of fingerprints.

1. Rub a pencil lead (graphite) on a sheet of paper.
2. Rub your finger tip on the paper. Ensure that it is covered with graphite.
3. Put clear tape over your finger. Notice that the tape should be placed over the pad of your finger (not the tip).
4. Carefully pull off the tape and stick it on a sheet of paper.
<table>
<thead>
<tr>
<th></th>
<th>Thumb</th>
<th>Index</th>
<th>Middle</th>
<th>Ring</th>
<th>Pinkie</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left Hand Print</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type of Print</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Right Hand Print</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type of Print</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total number of fingerprint you have of each pattern:

- [ ] arch
- [ ] loop
- [ ] whorl
- [ ] composite
Directions: Use the information from Worksheet #6D.14a to answer the questions. You will also need to use Worksheet #6D.14d to do question number 3.

1. Examine the directions for making fingerprints on Worksheet #6D.14a. Then tell why it is important to do each of the following:

<table>
<thead>
<tr>
<th>What You Must Do</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use a soft-lead pencil instead of a pencil crayon.</td>
<td></td>
</tr>
<tr>
<td>Rub the pencil lead heavily and over a space of at least four cm.</td>
<td></td>
</tr>
<tr>
<td>Press your finger firmly on the graphite. Do not move your finger from side to side or turn it.</td>
<td></td>
</tr>
<tr>
<td>Use clear tape and not and opaque tape, such as masking tape.</td>
<td></td>
</tr>
<tr>
<td>Stick the tape with your fingerprint on it onto light-coloured paper, not black paper.</td>
<td></td>
</tr>
</tbody>
</table>

2. Why do you think it is important for police to take prints of all ten of a suspect’s fingers rather than just one?

3. There are 27 students in Tammy’s grade six class. She examined the index finger of each student’s right hand and determined the type of fingerprint each was. She found that 4 were whorls, 9 were arches, 12 were loops, and 2 were composites. Make a bar graph showing this information.
<table>
<thead>
<tr>
<th>Arch</th>
<th>Loop</th>
<th>Whorl</th>
<th>Composite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Directions: Use the information from Worksheet #6D.14a to answer the questions. You will also need to use Worksheet #6D.14d to do question number 3.

1. Examine the directions for making fingerprints on Worksheet #6D.14a. Then tell why it is important to do each of the following:

<table>
<thead>
<tr>
<th>What You Must Do</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use a soft-lead pencil instead of a pencil crayon.</td>
<td>Soft-lead pencil lead will stick to finger more easily</td>
</tr>
<tr>
<td>Rub the pencil lead heavily and over a space of at least four cm.</td>
<td>Must have enough lead to make an entire fingerprint</td>
</tr>
<tr>
<td>Press your finger firmly on the graphite. Do not move your finger from side to side or turn it.</td>
<td>Want fingerprint to be clear</td>
</tr>
<tr>
<td>Use clear tape and not and opaque tape, such as masking tape.</td>
<td>Can see through clear tape</td>
</tr>
<tr>
<td>Stick the tape with your fingerprint on it onto light-coloured paper, not black paper.</td>
<td>Print will contrast against light-coloured paper, making it easier to see</td>
</tr>
</tbody>
</table>

2. Why do you think it is important for police to take prints of all ten of a suspect’s fingers rather than just one? Answers may vary.

May only find a partial set of prints at a crime scene. Can try to match the prints found against the suspects, hoping that at least some will be the same.

3. There are 27 students in Tammy’s grade six class. She examined the index finger of each student’s right hand and determined the type of fingerprint each was. She found that 4 were whorls, 9 were arches, 12 were loops, and 2 were composites. Make a bar graph showing this information.
### Types of Fingerprints in Tammy's Class

<table>
<thead>
<tr>
<th>Type of Fingerprint</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arch</td>
<td>2</td>
</tr>
<tr>
<td>Loop</td>
<td>8</td>
</tr>
<tr>
<td>Whorl</td>
<td>4</td>
</tr>
<tr>
<td>Composite</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>
Lesson Fifteen

Concept: Lifting Fingerprints

Resources/Materials: Mini Textbook, page 27

HANDS ON: Worksheet #6D.15a (one copy per group)
- clear tape
- white powder (corn starch)
- soft-bristled brush (like a soft art paint brush)
- black construction paper
- very clear jar with smooth sides
- damp towel
- dry paper towel
- surgical gloves (for teacher)

NON HANDS ON: Worksheets #6D.15c and #6d.15d (student copies)

Introduction: Tell students that when forensic experts enter the scene of a crime, they never touch anything with their bare hands. This is because they do not want to leave any of their fingerprints anywhere. Fingerprints are EVERYWHERE: on your pencil, on the doorknob, on your books — on anything your fingers have touched. We cannot see them with the naked eye. Most fingerprints are latent, meaning they cannot be easily seen. For this reason, forensics experts use special techniques to “lift” prints from objects. The technique is called dusting. Today students will be dusting for fingerprints.

Procedure:

HANDS ON
1. Explain the following before starting on the activity:
   - When a person is arrested, he or she is fingerprinted at the police station. The fingerprints are kept on an electronic file and shared with law enforcement agencies across the globe.
   - Lifting fingerprints at the scene of a crime is only useful if that particular person’s fingerprints are already on file, or if a suspect is arrested and fingerprinted.

2. Demonstrate for students the dusting technique as described on Worksheet #6D.15a.

3. Then give each group a set of materials and a copy of Worksheet #6D.15a. Tell the students to each make and lift two or more fingerprints following the steps listed on the worksheet.

NON HANDS ON
5. Distribute Worksheets #6D.15c and #6D.15d. Go over the directions, if necessary.

Assignment:
1. HANDS ON. Follow the directions on Worksheet #6D.15 to learn how to lift fingerprints.

2. NON HANDS ON. Read Mini Textbook, page 27. Then do Worksheets #6D.15b an #6D.15c.
Directions: Follow these steps to learn how to lift fingerprints.

Materials:
clear tape
soft-bristled brush
very clean smooth glass jar
dry paper towel
white powder (like corn starch)
black construction paper
damp paper towel

1. With the dry paper towel place the glass jar in front of you. Do not touch the jar with your bare hands.

2. Rub your finger on your forehead – this makes your finger slightly oily.

3. Carefully, but firmly press that finger on the side of the jar. (Your fingerprint may not be visible yet.)

4. Use the soft-bristled brush to lightly brush the white powder over the print. Be careful not to use too much powder or brush too hard. Gently blow off the excess powder. The print should now be visible.

5. Use the clear tape to lift the print by gently pressing it onto the print and peeling it off. Place the tape on the black paper.

6. With a damp towel wipe off the fingerprint and white powder from the jar. Dry it off. Now you are ready to lift another print.
Dusting for Fingerprints

Directions: Use *Mini Textbook*, page 27 to help you answer the questions.

1. Explain why we leave fingerprints on things that we touch.

2. Why do you think the fingerprints we leave on smoother surfaces are much clearer than those we leave on rougher surfaces?

3. Examine the photo of the investigator at the bottom of page 27. Why do you think he is wearing rubber gloves?

4. A forensic scientist was dusting a crime scene for fingerprints. He found prints on many surfaces, including a window sill, a doorknob, a coffee table, and television set. She found 43 different fingerprints. How can this be? A person only has ten fingers!
5. What is the importance of each of the following when it comes to dusting for fingerprints?

<table>
<thead>
<tr>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>the colour of the dusting powder</td>
</tr>
<tr>
<td>using a soft-bristled brush</td>
</tr>
<tr>
<td>shaking the bristles so they are far apart</td>
</tr>
<tr>
<td>shaking off the excess powder from the brush</td>
</tr>
<tr>
<td>being careful to brush over the fingerprint lightly</td>
</tr>
<tr>
<td>being careful not to let the cellophane tape wrinkle or fold</td>
</tr>
<tr>
<td>ensuring that you press the tape down firmly</td>
</tr>
<tr>
<td>ensuring that you do not pull the tape down and then press it down again on the same print.</td>
</tr>
<tr>
<td>pulling the tape away in one quick motion</td>
</tr>
</tbody>
</table>
Directions: Use Mini Textbook, page 27 to help you answer the questions.

1. Explain why we leave fingerprints on things that we touch.
   Oils and perspiration from fingers transfer to things we touch.

2. Why do you think the fingerprints we leave on smoother surfaces are much clearer than those we leave on rougher surfaces?
   Fingers come into more continuous contact with smoother surfaces; whereas they only come into contact with some of a rougher surface.

3. Examine the photo of the investigator at the bottom of page 27. Why do you think he is wearing rubber gloves?
   Does not want his own fingerprints to transfer to the glass.

4. A forensic scientist was dusting a crime scene for fingerprints. He found prints on many surfaces, including a window sill, a doorknob, a coffee table, and television set. She found 43 different fingerprints. How can this be? A person only has ten fingers!
   The people who use the space also use the room, not just the perpetrator.
5. What is the importance of each of the following when it comes to dusting for fingerprints?

<table>
<thead>
<tr>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>the colour of the dusting powder</strong></td>
</tr>
<tr>
<td><strong>using a soft-bristled brush</strong></td>
</tr>
<tr>
<td><strong>shaking the bristles so they are far apart</strong></td>
</tr>
<tr>
<td><strong>shaking off the excess powder from the brush</strong></td>
</tr>
<tr>
<td><strong>being careful to brush over the fingerprint lightly</strong></td>
</tr>
<tr>
<td><strong>being careful not to let the cellophane tape wrinkle or fold</strong></td>
</tr>
<tr>
<td><strong>ensuring that you press the tape down firmly</strong></td>
</tr>
<tr>
<td><strong>ensuring that you do not pull the tape down and then press it down again on the same print.</strong></td>
</tr>
<tr>
<td><strong>pulling the tape away in one quick motion</strong></td>
</tr>
</tbody>
</table>
Lesson Sixteen

Concept: Examining Tire Tracks and Treads

Resources/Materials: Mini Textbook, pages 28 and 29
- HANDS ON: Worksheet #6D.16a and #6D.16d (student copies)
  - wax crayons
  - newsprint
  - ruler
- NON HANDS ON: Worksheets #6D.16b, #6D.16c, and #6D.16d (student copies)

Introduction: Tire tracks are also an important clue for investigators. If the tires on a suspect’s vehicle can be matched to tire tracks left at the scene of a crime, the investigators know that the suspect was at the crime scene. Tire tracks have even been left on pavement when the car has just driven through some oil. In addition, the length and direction of skid marks left on pavement can give clues as to how an automobile accident happened.

Today’s lesson is on examining tire tracks.

Procedure:

HANDS ON
1. Explain that all tires have a tread. This is its pattern. The purpose of the tread to help the vehicle grip the road.
2. Distribute Worksheet #6D.16a. Explain that students will be going outside to examine the tires of the cars in the parking area. They will each examine two different tires, preferably from two different vehicles. Go over Worksheet #6D.16a to see what information they will be looking for.
3. Have students go outside, each with a deeper and darker wax crayon and two sheets of newsprint. Have them make a rubbing of one of the tires in the parking lot. Caution them to make sure the whole width of the tread is rubbed. An even back and forth motion produces the best results. Each student should note which cars and which tires he or she took the rubbings from.
4. Hang up the rubbings on the wall with the tires from each car hanging together. As a class discuss how the treads are different: tread width, spacing depth, shape, design, special marks like cut or wear marks)
5. Distribute Worksheet #6D.16d. Go over the directions, if necessary.

NON HANDS ON
7. Distribute Worksheets #6D.16b, #6D.16c, and #6D.16d. Go over the directions, if necessary.

Assignments:
1. HANDS ON. Making rubbings of tire treads. Then do Worksheet #6D.16c.
2. NON HANDS ON. Read Mini Textbook, pages 28 and 29. Then do Worksheets #6D.16b, #6D.16c, and #6D.16d.
**Examining Tire Tracks**

**Directions:** Examine two different tires. Find the following information for each.

<table>
<thead>
<tr>
<th></th>
<th>Tire Sample 1</th>
<th>Tire Sample 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location (which vehicle, which tire)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Width of Tread</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number of Grooves</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Width of Grooves</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tread Pattern (description, sketch)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Texture:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Distinguishing Marks (worn areas, cuts, etc.)</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Worksheet #6D.16a
Directions: Use Mini Textbook, pages 28 and 29 to help you with the questions.

1. What are six things investigators look for when examining tire tracks?
   
   a. __________________________________________
   
   b. __________________________________________
   
   c. __________________________________________
   
   d. __________________________________________
   
   e. __________________________________________
   
   f. __________________________________________

2. Match the tire tread halves in the first row with the halves in the second row. Draw lines.

   [Diagram of tire treads]
3. Detective Lewis found these tire tracks at the scene of a crime.

![Tire Tracks Image]

He went to the homes of three suspects and took photos of tracks left by their vehicles. By examining their tire tracks Detective Lewis was able to conclude that one of the suspects was at the scene of the crime. Which one? _______________________

<table>
<thead>
<tr>
<th>Suspect 1</th>
<th>Suspect 2</th>
<th>Suspect 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Suspect 1 Image]</td>
<td>![Suspect 2 Image]</td>
<td>![Suspect 3 Image]</td>
</tr>
</tbody>
</table>

4. A mechanic examined a car while it was in the shop. He knew that the tire was overinflated. How did he know?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Worksheet #6D.16c
Directions: In the space below draw four tire treads. Make three of them identical to each other. Make one slightly different from the others. See if your classmates can guess which of your tire treads is different from the others.

Tire Tread #1

Tire Tread #2

Tire Tread #3

Tire Tread #4
Tire Tracks and Treads

Directions: Use Mini Textbook, pages 28 and 29 to help you with the questions.

1. What are six things investigators look for when examining tire tracks?
   
a.  tread design
   
b.  tread size
   
c.  tread wear
   
d.  uneven wear
   
e.  unusual markings
   
f.  type of soil where tracks were made

2. Match the tire tread halves in the first row with the halves in the second row. Draw lines.
3. Detective Lewis found these tire tracks at the scene of a crime.

He went to the homes of three suspects and took photos of tracks left by their vehicles. By examining their tire tracks Detective Lewis was able to conclude that one of the suspects was at the scene of the crime. Which one? **Suspect 2**

<table>
<thead>
<tr>
<th>Suspect 1</th>
<th>Suspect 2</th>
<th>Suspect 3</th>
</tr>
</thead>
</table>

4. A mechanic examined a car while it was in the shop. He knew that the tire was overinflated. How did he know?

*middle of tread is more worn than*  
sides
Lesson Seventeen

Concept: Using Chromatography to Analyze Pen Colours

Resources/Materials: Mini Textbook, pages 30 and 31
   HANDS ON: Worksheet #6D.17a (one copy per group)
   Worksheet #6D.17b (student copies)
   For each group
   4 plastic cups or dishes
   *4 strips chromatograph papers, each 2 cm X 15 cm
   4 rulers
   4 different black markers (water soluble)
   tape
   NON HANDS ON: Worksheets #6D.17c and #6D.17d (student copies)

*Actual chromatography paper works best, but filter paper or coffee filters can produce satisfactory results.

Introduction: Explain that often investigators find different kinds of ink stains on clothing, on paper, and even on furniture. They try to link an ink stain with a pen belonging to a suspect. To do this, they use a technique called paper chromatography.

Procedure:
   HANDS ON
   1. Explain to students they will analyze some felt marker ink.

   2. Distribute a copy of Worksheet #6D.17a. Go over the directions, in necessary.

   3. THE NEXT DAY. Distribute Worksheet #6D.17b. Go over the directions, if necessary.

   NON HANDS ON
   4. RECOMMENDED. Following the directions on Mini Textbook, demonstrate how you can use separate water-based ink into its component pigments.

Assignments:

   HANDS ON
   1. Do a paper chromatography activity by following the instructions on Worksheet #6D.17a.
   2. Record your results on Worksheet #6D.17b.

   NON HANDS ON
   4. Do Worksheets #6D.17c and #6D.17d.
Paper chromatography is used to separate the different colours of dynes used to make the ink in pens. Examine the diagram below.

As the water moves up the filter paper, it separates the ink into different water-soluble dyes. The different dyes move at different rates up the filter paper.

**Materials:**
- 4 strips of chromatography or filter paper, 2 cm X 15 cm
- 4 different brands of black felt markers (must be water soluble)
- 4 dishes
- 4 rulers or something similar
- 8 identical books or blocks or some other suitable items
- tape

**Procedure:**

1. Make a large dot (1 cm in diameter) about 2 cm from the end of the chromatography paper strip. Do this for each type of felt marker.

2. On the back of each strip and at the opposite from where you made the dot, write the name of the brand of marker.

3. Attach the strips to rulers with tape so that the dots end rest in the water. (See the diagram)

4. Allow the water to rise up through the chromatography papers.

5. Once the dyes have stopped moving up the papers, remove them. Allow them to dry on a piece of paper towelling or newspaper.

6. Examine the different dyes used to make the pens’ ink.
<table>
<thead>
<tr>
<th>Make of Pen</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Strip: (tape sample here)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Observations: (colours observed, patterns) |   |   |   |

Worksheet #6D.17b
**Paper Chromatography**

**Directions:** Use *Mini Textbook*, pages 30 and 31 to help you with the questions.

1. What is paper chromatography?

2. Detective Tikkonen was investigating the dognapping of a tiny puppy named Fluffy. The dognapper left a handwritten note on a table telling the owners that they would have to pay five thousand dollars if they wanted their dog back. The detective wanted to know if the person who dognapped Fluffy was the same person who dognapped a dog in the same neighbourhood just a week before. That person also left a handwritten note.

   Explain how Detective Tikkonen could use paper chromatography to find out.

3. Read about how to produce a chromatogram. In the chart below and on Worksheet #6D.17d, illustrate each step.

4. | **Step** | **Illustration** |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Take a strip of chromatography paper that is about 2 cm wide and 15 cm long.</td>
<td></td>
</tr>
</tbody>
</table>

Worksheet #6D.17c
<table>
<thead>
<tr>
<th>Step</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>About a centimetre from one end draw a heavy horizontal line with a</td>
<td></td>
</tr>
<tr>
<td>pen.</td>
<td></td>
</tr>
<tr>
<td>Fill the bottom of a plastic cup with 1 or 2 cm of water.</td>
<td></td>
</tr>
<tr>
<td>Fold the other end of the strip around a pencil or stirring rod and</td>
<td></td>
</tr>
<tr>
<td>secure it with a paper clip.</td>
<td></td>
</tr>
<tr>
<td>Set the pencil so that it rests on the cup’s rim and so that the</td>
<td></td>
</tr>
<tr>
<td>paper just barely touches the surface of the water.</td>
<td></td>
</tr>
<tr>
<td>Wait for an hour or longer.</td>
<td></td>
</tr>
<tr>
<td>You will notice that most of the ink has separated into colours and</td>
<td></td>
</tr>
<tr>
<td>forms a unique pattern on the paper.</td>
<td></td>
</tr>
</tbody>
</table>

Worksheet #6D.17d
Paper Chromatography

Directions: Use *Mini Textbook*, pages 30 and 31 to help you with the questions.

1. What is paper chromatography?
   - **separating an ink sample found on paper into its component colours**

2. Detective Tikkonen was investigating the dognapping of a tiny puppy named Fluffy. The dognapper left a handwritten note on a table telling the owners that they would have to pay five thousand dollars if they wanted their dog back. The detective wanted to know if the person who dognapped Fluffy was the same person who dognapped a dog in the same neighbourhood just a week before. That person also left a handwritten note.

   Explain how Detective Tikkonen could use paper chromatography to find out.
   - **Use paper chromatography on both ink samples to see if they are similar**

3. Read about how to produce a chromatogram. In the chart below and on Worksheet #6D.17d, illustrate each step.

4. | Step | Illustration |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Take a strip of chromatography paper that is about 2 cm wide and 15 cm long.</td>
<td></td>
</tr>
</tbody>
</table>
Lesson Eighteen

**Concept:** Analyzing Handwriting (Graphology)

**Resources/Materials:** Mini Textbook, page 32
- Workets #6D.18a and #6D.18b (student copies)
- Half sheets of plain white paper

**Introduction:** Introduce the word *forgery*. Ask when a person might be tempted to forge someone else’s handwriting. Tell them that forgery is a long-practised activity by some criminals. However, it is usually unsuccessful. Today and tomorrow we will examine why.

**Procedure:**

1. Distribute the paper to the students. Have students fold the paper in half length-wise. On the board write a two-sentence message. Have copy the sentences on the top half of their sheet.

2. Have students exchange papers with someone else. Challenge them to copy or *forge* their partner’s sentences by trying to copy their style of handwriting. They should do this at the bottom half of the sheet. Have students compare the original to their forgery.

3. Discuss:
   - Which characteristics or traits did you try to copy to make your handwriting the same as the original?
   - Which letters were difficult to copy? Why?
   - Which letters were easy to copy? Why?

4. Conclude that forgery is difficult because our handwriting is habitual and it is difficult to break writing habits. We can copy some parts of other people’s handwriting, but many parts are difficult.

5. Explain that a person who analyzes handwriting is called a *graphologist*.

6. If you like, have students read *Mini Textbook*, page 32 to find out more about graphology.

7. Distribute Worksheets #6D.18a and #6D.18b. These pages are designed to help make students more aware of their own handwriting.

**Assignment:**

1. Read *Mini Textbook*, page 32

2. Do Worksheets #6D.18a and #6D.18b.
Directions: Answer the following questions to find out more about your handwriting.

1. **T-Bar analysis:** Which of the following examples most resembles the way you cross your T's?
   
   ![Images of T-bar analysis examples]

2. **The 'i' dot:** Which of the following most resembles the way you dot your i's?
   
   ![Images of 'i' dot examples]

3. **Stems:** Which of the following best represents the way you write the stems on your lower case g's and y's?
   
   ![Images of stem examples]

4. **Breaks:** Within words, how much space do you leave between letters? Are there breaks between your letters?
   
   ![Images of breaks examples]

5. **The 'E':** Which of the following resembles most the way you write your e's?
   
   ![Images of 'E' examples]

6. **Ending stroke:** How do you finish your words? Look and see how much your ending strokes curve up and to the left.
   
   ![Images of ending stroke examples]
7. **Lead-in stroke:** Look for a soft, wavy line leading into an 'm' or 'n'.

8. **The 'M':** Is the second hump of your 'm' higher than the first?

9. **Loops:** Which of the following most resembles the loops in your 't' and 'd' letters?

10. **Slant:** Do you write on an angle? Pick the example that most matches yours.

11. **T-Bar analysis:** Examine the relative weight of your 't-bar' and select the most appropriate example.

12. **Loops:** Examine the loops in your 'm's and 'n's; which of the following most resembles yours?
Lesson Nineteen

Concept: Analyzing Handwriting

Resources/Materials: Mini Textbook, page 33
Worksheet #6D.19 (student copies)
Half sheets of paper (2 per student)

Introduction: Recall the last day’s activity where students tried to forge someone else’s handwriting. Today they will try to analyze handwriting. This is called graphology.

Procedure:

1. Distribute two sheets of paper to each person. Have students copy off the board, the sentence

   *The shy brown fox jumped quickly over the lazy dog.*

2. Have students put their names on the papers. Collect them and hang them up or lay them on a table.

3. **Warn students not to put their names on the second piece of paper.** Have them write a second message on this paper. They can either make one up or the teacher can give them one to write.

4. Gather the second sheets of paper. (If necessary, give each writing sample a number, without students knowing which student has been assigned any particular number.)

5. Redistribute the second sheets of paper, so that no student gets his/her own.

6. Challenge students to match the handwriting on the second paper with those hanging up or laying on the table.

7. Discuss:
   - Were you successful in making a match?
   - What techniques did you use?
   - What was difficult about the task?
   - Did people consistently form letters in the same way?
   - Which letters are easiest to spot differences in?
   - Which letters are more difficult?
   - Does your own handwriting always look the same?

8. Have students turn to *Mini Textbook*, page 33 to find out more about handwriting analysis indicators. If you have the time, go over what each means. **Note: Most students will not know the meaning of the word extraneous.** Have students copy the indicators into their notebooks (underlined parts only).

9. Distribute Worksheet #6D.19. Tell them to examine the writing samples in the top box; then decide which person wrote the note from the crime scene.

Assignments:
Copy the notes from *Mini Textbook*, page 33 and do Worksheet #6D.19.
Standard phrases:

1. Today is Wednesday
2. Today is Wednesday
3. Today is Wednesday
4. Today is Wednesday
5. Today is Wednesday
6. Today is Wednesday

Note from crime scene:

I went to the market and did my shopping.

<table>
<thead>
<tr>
<th>Observations:</th>
<th>Inferences:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
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1. Today is Wednesday
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Note from crime scene:

I went to the market and did my shopping.

<table>
<thead>
<tr>
<th>Observations:</th>
<th>Inferences:</th>
</tr>
</thead>
<tbody>
<tr>
<td>letter ‘v’ has no loop</td>
<td>#3 wrote the note</td>
</tr>
<tr>
<td>letter ‘s’ is printed</td>
<td></td>
</tr>
<tr>
<td>sometimes ‘e’ is tall</td>
<td></td>
</tr>
<tr>
<td>letter ‘o’ has no lead-up stroke</td>
<td></td>
</tr>
</tbody>
</table>
Lesson Twenty

Concept: Examining the Characteristics of Different Fabrics

Resources/Materials: Mini Textbook, page 34
Worksheet #6D.20a (student copies – the number of copies per student depends on the number of samples you have students analyze)

For teacher demonstration:
4 samples of fabrics
hot water
laundry soap
glass jars or beakers
tongs or tweezers

HANDS ON
For each group of students
2.5 cm X 5 cm samples of fabrics – a variety is best: some natural, some synthetic; some coarse, some fine, and so on (canvas, double knit, cotton broadcloth, denim, burlap, rayon, etc.)
sheets of white paper
tweezers (optional)
magnifying glass (optional)
tape

NON HANDS ON: Worksheets #6D.20b and #6D.20c (student copies)

Introduction: Explain that another important clue that forensics experts look for is pieces of fabric. This can even be a thread from a fabric. Sometimes criminals snag their clothing on piece of furniture, a nail, or a bush while committing the crime or trying to get away quickly. This is where fabric analysis comes in handy. Today lesson involves putting some fabrics through some tests.

Procedure:

1. With students brainstorm for some ways that we can compare fabrics. Write them on the board as they are suggested:
   - Tendency to wrinkle (bunch up the sample into a ball and then release. Smooth it out a little.)
   - Colour (be as specific as you can)
   - Does the dye come out of it? (soak in hot soapy water)
   - The weave (course, fine; knit, woven)
   - Texture (rough or smooth)
   - Stretchiness (measure the amount of stretch with a ruler)
   - Tendency to absorb or repel water (drop two or three drops of water on a fabric)
   - Does it burn readily
   - What does one thread look like? (hairy, smooth, even, wavy, etc.)

(continued)
Lesson Twenty (continued)

2. **Teacher Demonstration.** Put about 1/3 cup of hot water into each of as many jars or beakers as you have samples. Add a pinch of laundry soap to each. Stir. With tweezers or tongs soak each of the samples in the soapy water for two or three minutes. Lift out the sample. Notice if there is any colouration in the water.

**HANDS ON**

3. Give each group of students at least two different fabric samples to test. They are to examine the texture, colour, and weave. IN ADDITION, they are to test for TWO other characteristics (not flammability). Ask them to separate one thread and examine it as well. They are to record their findings on Worksheet #6D.20a.

4. OPTIONAL. Have students copy the notes from *Mini Textbook*, page 34 entitled “Fabric Analysis”.

**NON HANDS ON**


6. Have students copy the section entitled “Fabric Analysis” into their notebooks.

7. Distribute Worksheets #6D.20b and 6D.20c. Go over the directions, if necessary.

**Assignments:**

**HANDS ON**

1. OPTIONAL. Copy the notes from *Mini Textbook*, page 34.
2. Test samples of fabric and record findings on copies of Worksheet #6d.20a.

**NON HANDS ON**

3. Copy the notes from *Mini Textbook*, page 34.
4. Do Worksheets #6D.20b and #6D.20c.
Fabric Forensics

Sample of Fabric:  

Sample of Thread:  

Description of the Fabric:  

Texture: 

Colour: 

Weave: 

Unique Characteristics: 

Results of the Teacher Demonstration: 

Worksheet #6D.20a

-From Edmonton Public Schools
**Directions:** Use *Mini Textbook*, page 34 to help you with the questions.

1. Each of the following scenarios has to do with clothing or a piece of fabric found at a crime scene. After reading each, try to come up with a hypothesis about how the clothing or piece of fabric got where it did.

<table>
<thead>
<tr>
<th>What Investigators Found</th>
<th>My Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Someone broke into the Stahl’s house and took a heavy bedroom dresser. Detectives found a few threads of fabric on the bedroom doorknob.</td>
<td></td>
</tr>
<tr>
<td>Thieves broke into the high school. They did not steal anything, but they a lot of damage. Police found a small piece of ripped fabric on a bush outside one of the school windows.</td>
<td></td>
</tr>
<tr>
<td>The Walters’ live at Midrock Colony. They never lock their house. They trust everyone. One day they had just come home from a visit to the dentist. Mrs. Walters noticed a jacket lying on the back steps.</td>
<td></td>
</tr>
<tr>
<td>Two masked men mugged and then robbed a senior citizen. Police were called. After questioning the senior, they combed the area for evidence. They found a balaclava in a garbage can in a back alley.</td>
<td></td>
</tr>
</tbody>
</table>
2. Unscramble the letters to make words that go with fabric analysis.

________________________ a e e v w
________________________ a d e h r t
________________________ e i k l n r w
________________________ c l o o r u
________________________ b g i n n r u
________________________ c e e h i n r s s s t t
________________________ a a b b c n o r s y
________________________ e e r t t u x
________________________ d e y
**Directions:** Use *Mini Textbook*, page 34 to help you with the questions.

1. Each of the following scenarios has to do with clothing or a piece of fabric found at a crime scene. After reading each, try to come up with a hypothesis about how the clothing or piece of fabric got where it did.

<table>
<thead>
<tr>
<th>What Investigators Found</th>
<th>My Hypothesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Someone broke into the Stahl’s house and took a heavy bedroom dresser. Detectives found a few threads of fabric on the bedroom doorknob.</td>
<td>Perpetrator caught clothing on doorknob, tearing it.</td>
</tr>
<tr>
<td>Thieves broke into the high school. They did not steal anything, but they a lot of damage. Police found a small piece of ripped fabric on a bush outside one of the school windows.</td>
<td>Thieves caught clothing on bush</td>
</tr>
<tr>
<td>The Walters’ live at Midrock Colony. They never lock their house. They trust everyone. One day they had just come home from a visit to the dentist. Mrs. Walters noticed a jacket lying on the back steps.</td>
<td>One of the boys left jacket on the steps. It probably has nothing to do with the unlocked door</td>
</tr>
<tr>
<td>Two masked mugged and then robbed a senior citizen. Police were called. After questioning the senior, they combed the area for evidence. They found a balaclava in a garbage can in a back alley.</td>
<td>One of the men threw his balaclava into the garbage while running from crime scene.</td>
</tr>
</tbody>
</table>
2. Unscramble the letters to make words that go with fabric analysis.

weave
thread
wrinkle
colour
burning
stretchiness
absorbancy
texture
dye
Lesson Twenty-one

Concept: Examining and Determining the Characteristics of Different Types of Soil

Resources/Materials: Mini Textbook, pages 35 and 36
HANDS ON: Worksheets #6D.21a and #6D.21b (student copies)
magnifying glass soil samples
Styrofoam trays or some other shallow type of container spoons
NON HANDS ON: Worksheet #6D.21c (student copies)

Introduction: Recall that forensics experts often use footprints and tire tracks to assist them in tracking down criminals. A related clue is to look for soil samples. For example, they may find that some mud on a car matches that of mud found at the scene of a crime, or mud found on a suspect’s shoe matches that of the soil at a crime scene. So, today’s lesson is about analyzing soil.

Procedure:

1. Discuss with students what makes one soil sample different from another? Write on the board or on a chart as they are suggested:
   • Colour (black, brown, grey, red) – tells what soil is made of
   • Texture (soft, coarse, smooth, gritty) – wet a small amount and rub between fingers
   • Odour (musty, woody, decaying)
   • Composition (presence different materials such as sand, black soil, clay, leaves)
   • Shape of particles
   • Size of particles – small particles feel smooth when rubbed between fingers.

HANDS ON
2. Have each group of students take a small scoop of two soils. They are to make observations about each that would distinguish it from the others, referring to the chart or from copies of Worksheet #6D.21a, if necessary. Record the results on Worksheet #6D.21b.
3. Discuss the findings as a class.
4. Give each group several soil samples (You can include the two used in the previous part of the activity, if you like.). Have students analyze the soil samples and record their findings on Worksheet #6D.21c

NON HANDS ON
6. Have students copy the section entitled “What Soil Analysts Look For” (top of page 36).
7. Distribute Worksheet #6D.21c. Go over the directions, if necessary.

Assignments:

HANDS ON
1. Examine two soil samples. Record observations on Worksheet #6D.21a.
2. Analyze several soil samples. Record observations on Worksheet #6D.21b.

NON HANDS ON
3. Read Mini Textbook, pages 35 and 36.
5. Do Worksheet #6D.21c.
**Examining Soil Samples**

<table>
<thead>
<tr>
<th>Sample #1</th>
<th>Sample #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(tape a small sample here)</td>
<td>(tape a small sample here)</td>
</tr>
</tbody>
</table>

**Observations**

<table>
<thead>
<tr>
<th>Sample #1</th>
<th>Sample #2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>CHARACTERISTIC</td>
<td>Sample #1</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Colour</td>
<td></td>
</tr>
<tr>
<td>Texture</td>
<td></td>
</tr>
<tr>
<td>Odour</td>
<td></td>
</tr>
<tr>
<td>Composition</td>
<td></td>
</tr>
<tr>
<td>Particle Size</td>
<td></td>
</tr>
<tr>
<td>Particle Shape</td>
<td></td>
</tr>
</tbody>
</table>
Directions: Use *Mini Textbook*, pages 35 and 36 to help you with the questions.

1. Put a check mark (✓) next to all the sentences that tell how soil analysis helps forensic scientists when they are investigating a crime.

   _____ Soil differs depending on location.
   _____ Soil is not nice to look at.
   _____ Some soils are different colours than others.
   _____ Soil can stick to clothing, shoes, and tires.
   _____ Soils vary in their texture.
   _____ Gardeners depend on soil.
   _____ Some soil contains more organic matter than others.

2. Tell what kind of soil is being described.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Description</th>
</tr>
</thead>
</table>
|           | • will form a thin ribbon that breaks easily  
          | • cast can be handled quite a bit before it breaks |
|           | • thread breaks easily  
          | • breaks apart most easily of all soils  
          | • will not form ribbon |
|           | • may be molded without breaking  
          | • strong and elastic and can be rolled to a pinpoint |
|           | • can be handled freely without breaking  
          | • forms short thick ribbons that break easily |
|           | • will not form ribbons  
          | • thread breaks easily  
          | • does not break apart as easily a sandy loam |
Directions: Use *Mini Textbook*, pages 35 and 36 to help you with the questions.

1. Put a check mark (✓) next to all the sentences that tell how soil analysis helps forensic scientists when they are investigating a crime.

   ✓ Soils differ depending on location.
   
   ____ Soil is not nice to look at.
   
   ✓ Some soils are different colours than others.
   
   ✓ Soil can stick to clothing, shoes, and tires.
   
   ✓ Soils vary in their texture.
   
   ____ Gardeners depend on soil.
   
   ✓ Some soil contains more organic matter than others.

2. Tell what kind of soil is being described.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Description</th>
</tr>
</thead>
</table>
| clay loam  | • will form a thin ribbon that breaks easily  
|            | • cast can be handled quite a bit before it breaks                          |
| sandy loam | • thread breaks easily  
|            | • breaks apart most easily of all soils  
|            | • will not form ribbon                                                      |
| clay       | • may be molded without breaking  
|            | • strong and elastic and can be rolled to a pinpoint                       |
| loam       | • can be handled freely without breaking  
|            | • forms short thick ribbons that break easily                              |
| silty loam | • will not form ribbons  
|            | • thread breaks easily                                                      
|            | • does not break apart as easily a sandy loam                              |
Lesson Twenty-two

Concept: Vocabulary Review

Resources/Materials: Worksheets #6D.22 (student copies)
dictionaries

Introduction: Review that in the area of evidence and investigation, there certain words that are frequently used. Explain that today we will do a quick review.

Procedure:

1. Distribute Worksheet #6D.22. Go over the directions, if necessary.

Assignment:

Do Worksheet #6D.22.
Directions: Match the words and phrases from the box with their meanings.

<table>
<thead>
<tr>
<th>accuse</th>
<th>alibi</th>
<th>chromatography</th>
<th>client</th>
</tr>
</thead>
<tbody>
<tr>
<td>clues</td>
<td>condemn</td>
<td>crime</td>
<td>evidence</td>
</tr>
<tr>
<td>framed</td>
<td>forensic science</td>
<td>investigate</td>
<td>loops</td>
</tr>
<tr>
<td>polygraph</td>
<td>stakeout</td>
<td>stash</td>
<td>witness</td>
</tr>
</tbody>
</table>

- the person who hires a detective
- to study a crime carefully
- a person who saw a crime in progress
- the science that studies clues
- in court these facts are proof
- small oval marks in fingerprints
- a test that matches ink samples with the ink used in samples of writing
- a test that is used to tell if a witness is telling the truth
- to hide something or someone
- an excuse that tells others that a suspect was not at the scene of the crime
- to blame or charge someone with a crime
- to sentence a criminal who has been found guilty of a crime
- to watch a suspect's home or business
- a small piece of evidence
### Evidence and Investigation – Vocabulary

**Directions:** Match the words and phrases from the box with their meanings.

<table>
<thead>
<tr>
<th>accusé</th>
<th>alibi</th>
<th>chromatography</th>
<th>client</th>
<th>clues</th>
<th>condemn</th>
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<td>condemn</td>
<td>forensic science</td>
<td>evidence</td>
<td>loops</td>
</tr>
</tbody>
</table>

- **client**: the person who hires a detective
- **investigate**: to study a crime carefully
- **witness**: a person who saw a crime in progress
- **forensic science**: the science that studies clues
- **evidence**: in court these facts are proof
- **loops**: small oval marks in fingerprints (whorls)
- **chromatography**: a test that matches ink samples with the ink used in samples of writing
- **polygraph**: a test that is used to tell if a witness is telling the truth
- **stash**: to hide something or someone
- **alibi**: an excuse that tells others that a suspect was not at the scene of the crime
- **accuse**: to blame or charge someone with a crime
- **condemn**: to sentence a criminal who has been found guilty of a crime
- **stakeout**: to watch a suspect’s home or business
- **clue**: a small piece of evidence
Lesson Twenty-three

Concept: Evidence and Investigation, Part II Review

Resources/Materials: Worksheet #6D.23 (optional, student copies)
                     Evidence and Investigation, Part II Review Sheets (student copies)

Introduction: Explain that the second half of the unit on Evidence and Investigation is now almost finished. It is time to review.

Procedure:

1. OPTIONAL. Distribute Worksheet #6D.23, the Jeopardy game on 11” X17” paper. Use the sheet as you see fit. You can just have the students do the questions; make it an oral review; or have students do the questions and count up the points.

2. Distribute the Evidence and Investigation Review Sheets. Have students complete them independently. Check them in class, if possible.

Assignments:

1. OPTIONAL. Do Worksheet #6D.23.
2. Do the Evidence and Investigation, Part II Review Sheets.
1. List and describe the four basic types of fingerprints.

   a. 

   b. 

   c. 

   d. 

2. On the next page you will find the “Fingerprint Challenge”. Write the correct numbers next to the letters below.

   A. ____
   B. ____
   C. ____
   D. ____
   E. ____
   F. ____
   G. ____
   H. ____
   I. ____
   J. ____
   K. ____
   L. ____
Match the prints inside the question mark to the prints found around the border of the page.
Use the following information to answer question 3.

A police officer found this shoe print at a crime scene.

3. Which of the following shoe prints matches the shoe print found at the crime scene?
   
   a.  
   
   b.  
   
   c.  
   
   d.

4. When investigating a crime, the police found some fresh tire tracks on the dirt. So far they have no suspects. They notice that a rainstorm is on its way. What should the police do next?
   
   a. Search for a suspect and then see if his or her tire treads match the tire tracks.
   b. Measure the tire’s tracks and take a photograph of the tire tracks.
   c. Clean up the tire tracks for the homeowner.
   d. Wait until the storm passes.
Use the following information to answer question 5.

Michael learned how to perform paper chromatography in science class. He made a line with a water-soluble marker near the bottom of a piece of filter paper, then hung the paper so that just the tip touched the water. He waited for fifteen minutes to see what would happen.

5. What is Michael most likely to observe?

   a. The black ink filled the filter paper.
   b. There was no sign of any colour on the paper at all.
   c. The water would not absorb into the filter paper past the black line.
   d. The black ink separated into different colours.

6. Define these terms:

   a. graphology ________________________________

   ________________________________

   b. forgery ________________________________

   ________________________________

Use the following information to answer question 7.

Someone kidnapped Bob’s pet duck. The kidnapper left the following ransom note.

Don’t be crazy! I have your duck!

Cancel school on Friday if you ever expect to see the duck again.

(continued)
The police detective took handwriting samples from four suspects.

Suspect W  The quick brown fox jumps over the lazy black dog.

Suspect X  The quick brown fox jumps over the lazy black dog.

Suspect Y  The quick brown fox jumps over the lazy black dog.

Suspect Z  The quick brown fox jumps over the lazy black dog.

7. The ransom note was most likely written by
   a. suspect W.
   b. suspect X
   c. suspect Y.
   d. suspect Z.

8. Why is it difficult to forge someone else's handwriting?

   ____________________________________________________________
   ____________________________________________________________
   ____________________________________________________________

9. What are seven characteristics a forensic scientist would be looking for when examining a fabric sample?
   a. _______________________________________________________
   b. _______________________________________________________
   c. _______________________________________________________
   d. _______________________________________________________

                      5
e. 

f. 

g. 

Use the following information to answer question 10.

A fabric sample was found at the crime scene. Inspector Drake took fabric samples from the clothing of four suspects. He placed the data in the chart below to help identify the sample taken from the crime scene.

<table>
<thead>
<tr>
<th>Source of fabric</th>
<th>Mass per square cm</th>
<th>Length that a 10 cm sample stretches</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspect W</td>
<td>4.0 g</td>
<td>3.0 cm</td>
<td>rough</td>
</tr>
<tr>
<td>Suspect X</td>
<td>3.0 g</td>
<td>1.0 cm</td>
<td>rough</td>
</tr>
<tr>
<td>Suspect Y</td>
<td>2.0 g</td>
<td>4.0 cm</td>
<td>smooth</td>
</tr>
<tr>
<td>Suspect Z</td>
<td>1.0 g</td>
<td>2.5 cm</td>
<td>smooth</td>
</tr>
</tbody>
</table>

Fabric sample taken from the crime scene:
- mass—3.5 g per square cm
- stretches—2.5 cm
- texture—rough

10. From the data, Inspector Drake concluded that the fabric from the crime scene was **most likely** from the fabric sample taken from

a. suspect W.
b. suspect X.
c. suspect Y.
d. suspect Z.

11. What are six different qualities of soil that a forensic scientist would be looking for?

a. 

b. 

c. 

d. 

e. 

f. 
12. Pretend that a police officer took a soil sample from a suspect's boot. How would a forensic scientist use this soil sample to see if the suspect was at the scene of the crime?

13. Match these words and phrases with their meanings.

| a. client | b. polygraph | c. condemn |
| d. accuse | e. framed | f. alibi |
| g. stakeout | h. stash | i. forensic science |
| j. loops | k. evidence | l. investigate |

_____ to blame or charge someone of a crime
_____ to sentence a criminal who has been found guilty of a crime
_____ an excuse that tells others that a suspect was not at the scene of the crime
_____ to hide someone or something
_____ the person who hires a detective
_____ to watch a suspect's home or business
_____ when someone is accused falsely
_____ a test that is used to tell if a witness is telling the truth
_____ to study a crime carefully
_____ small oval marks in fingerprints
_____ the science that studies clues
_____ in court these facts are proof
1. List and describe the four basic types of fingerprints.
   
a. arch-wave or hill

b. loop-ridges enter on one side, then form a loop, then exit on the same side it entered

c. whorl-spiral

d. composite-combination of patterns

2. On the next page you will find the “Fingerprint Challenge”. Write the correct numbers next to the letters below.
   
   A. 1
   B. 7
   C. 9
   D. 11
   E. 3
   F. 10
   G. 6
   H. 2
   I. 4
   J. 12
   K. 5
   L. 8
Use the following information to answer question 3.

A police officer found this shoe print at a crime scene.

3. Which of the following shoe prints matches the shoe print found at the crime scene?

a.  

b.  

3.

c.  

d.  

4. When investigating a crime, the police found some fresh tire tracks on the dirt. So far they have no suspects. They notice that a rainstorm is on its way. What should the police do next?

a. Search for a suspect and then see if his or her tire treads match the tire tracks.
b. Measure the tire's tracks and take a photograph of the tire tracks.
c. Clean up the tire tracks for the homeowner.
d. Wait until the storm passes.
Use the following information to answer question 5.

Michael learned how to perform paper chromatography in science class. He made a line with a water-soluble marker near the bottom of a piece of filter paper, then hung the paper so that just the tip touched the water. He waited for fifteen minutes to see what would happen.

![Paper chromatography](image)

5. What is Michael most likely to observe?
   a. The black ink filled the filter paper.
   b. There was no sign of any colour on the paper at all.
   c. The water would not absorb into the filter paper past the black line.
   d. The black ink separated into different colours.

6. Define these terms:
   a. graphology science of analyzing handwriting
   b. forgery copying someone’s handwriting

Use the following information to answer question 7.

Someone kidnapped Bob’s pet duck. The kidnapper left the following ransom note.

```
Don't be crazy I have your duck!
Cancel school on Friday if you ever expect to see the duck again.
```
The police detective took handwriting samples from four suspects.

Suspect W  The quick brown fox jumps over the lazy black dog.

Suspect X  The quick brown fox jumps over the lazy black dog.

Suspect Y  The quick brown fox jumps over the lazy black dog.

Suspect Z  The quick brown fox jumps over the lazy black dog.

7. The ransom note was most likely written by
   a. suspect W.
   b. suspect X.
   c. suspect Y.
   d. suspect Z.

8. Why is it difficult to forge someone else's handwriting?
   - by habit we make certain letters a certain way
   - slant and spacing are habitual

9. What are seven characteristics a forensic scientist would be looking for when examining a fabric sample?
   a. tendency to wrinkle
   b. colour
   c. ability to hold dye
   d. appearance of weave
   - flammability
   - appearance of a single thread
   - pattern
e. texture

f. stretchiness

g. ability to hold/absorb water

Use the following information to answer question 10.

A fabric sample was found at the crime scene. Inspector Drake took fabric samples from the clothing of four suspects. He placed the data in the chart below to help identify the sample taken from the crime scene.

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<td>rough</td>
</tr>
<tr>
<td>Suspect Y</td>
<td>2.0 g</td>
<td>4.0 cm</td>
<td>smooth</td>
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<td>1.0 g</td>
<td>2.5 cm</td>
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Fabric sample taken from the crime scene:
- mass—3.5 g per square cm
- stretches—2.5 cm
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10. From the data, Inspector Drake concluded that the fabric from the crime scene was most likely from the fabric sample taken from

a. suspect W.
b. suspect X.
c. suspect Y.
d. suspect Z.

11. What are six different qualities of soil that a forensic scientist would be looking for?

a. colour
b. texture
c. odour
d. composition
e. shape of particles
f. size of particles
12. Pretend that a police officer took a soil sample from a suspect’s boot. How would a forensic scientist use this soil sample to see if the suspect was at the scene of the crime?

- analyze soils from crime scene and suspect's boot
- to see if they match

13. Match these words and phrases with their meanings.

| a. client | b. polygraph | c. condemn |
| d. accuse | e. framed | f. alibi |
| g. stakeout | h. stash | i. forensic science |
| j. loops | k. evidence | l. investigate |

_**d**_ to blame or charge someone of a crime
_**c**_ to sentence a criminal who has been found guilty of a crime
_**f**_ an excuse that tells others that a suspect was not at the scene of the crime
_**h**_ to hide someone or something
_**a**_ the person who hires a detective
_**g**_ to watch a suspect’s home or business
_**e**_ when someone is accused falsely
_**b**_ a test that is used to tell if a witness is telling the truth
_**l**_ to study a crime carefully
_**j**_ small oval marks in fingerprints
_**i**_ the science that studies clues
_**k**_ in court these facts are proof
Lesson Twenty-four

Concept: Evidence and Investigation, Part II Test

Resources/Materials: Evidence and Investigation, Part II Test (student copies)
1. Detective Jones was sent to investigate a robbery that took place on a farm just outside of town. Some expensive tools were stolen from the farmer’s shop. What are five things Detective Jones should be looking for as he investigates the crime scene?
   a. ____________________________________________
   b. ____________________________________________
   c. ____________________________________________
   d. ____________________________________________
   e. ____________________________________________

2. Detective Jones has a suspect. When he examined the soles of the suspect’s shoes, he found some soil. What are four characteristics of the soil should Detective Jones be looking for?
   a. ____________________________________________
   b. ____________________________________________
   c. ____________________________________________
   d. ____________________________________________

3. Write the name of the fingerprint type under the correct fingerprint.

\[
\begin{array}{ccc}
\text{whorl} & \text{arch} & \text{composite} \\
\hline
\text{[fingerprint]} & \text{[fingerprint]} & \text{[fingerprint]} \\
\end{array}
\]
Use the following information to answer question 4

A police detective found these two sets of fingerprints at a crime scene.

4. What can he conclude by examining the sets of fingerprints?
   
   a. The person who left them stole two different things.
   b. The fingerprints were left by two different people.
   c. The person who left them was very careless.
   d. No conclusions can be drawn.

Use the information below to answer question 5.

A police detective found a partial tire track in the mud near a crime scene. It looked like this.

He visited a local tire shop and obtained samples of four different tire tracks.

5. The partial tire track that the police officer found in the mud matches the
   
   a. Akko tire.
   b. Pyron tire.
   c. Descan tire.
   d. Fostier tire.
6. Pretend you are a forensic scientist and you are investigating a crime. You found a note written with a black felt pen. List the steps you would take to try to find out what kind of pen was used.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

In the box below draw a diagram that shows what you would do.

________________________________________________________________________

Use the following information to answer question 7.

A police officer who had been sent to investigate a home robbery, found a torn piece of cloth on a bush just outside the home where the robbery took place. He noticed that it was red and stretchy. When he got back to the police station, he noticed a grubby looking man with a torn red jacket. The police officer knew that man had to be the robber. He told his supervisor that he was sure the grubby looking man had committed the crime. After all, the cloth on the torn jacket looked just like the piece of cloth he had found on the bush. The supervisor said it was too soon to tell.
7. Why was the supervisor not convinced that the grubby looking man had committed the robbery?


Use the following information to answer question 8.

A kidnapper left a note. Here is what it said:

Are you missing something? I think I know where it is

The police investigated the kidnapping and came up with four suspects. They had each of the suspects write the same sentence. They are shown below.

<table>
<thead>
<tr>
<th>Suspect A</th>
<th>Suspect B</th>
<th>Suspect C</th>
<th>Suspect D</th>
</tr>
</thead>
<tbody>
<tr>
<td>This will be my own handwriting, but please do not copy.</td>
<td>This will be my own handwriting, but please do no-copy.</td>
<td>This will be my own handwriting, but please do not copy.</td>
<td>This will be my own handwriting, but please do not copy.</td>
</tr>
</tbody>
</table>

8. By analyzing the handwriting samples, which person most likely left the kidnapping note?

   a. Suspect A  
   b. Suspect B  
   c. Suspect C  
   d. Suspect D
9. Match the words and phrases with their meanings.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tr>
<td>j. forensic science</td>
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<td>l. loops</td>
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<td>m. polygraph</td>
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<td>o. stash</td>
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____ the person who hires a detective
____ to study a crime carefully
____ a person who saw a crime in progress
____ the science that studies clues
____ in court these facts are proof
____ small oval marks in fingerprints
____ a test that matches ink samples with the ink used in samples of writing
____ a test that is used to tell if a witness is telling the truth
____ to hide something or someone
____ an excuse that tells others that a suspect was not at the scene of the crime
____ to blame or charge someone with a crime
____ to sentence a criminal who has been found guilty of a crime
____ to watch a suspect's home or business
____ a small piece of evidence
1. Detective Jones was sent to investigate a robbery that took place on a farm just outside of town. Some expensive tools were stolen from the farmer’s shop. What are five things Detective Jones should be looking for as he investigates the crime scene?
   a. fire tracks
   b. footprints
   c. signs of break-in
   d. hair
   e. objects lying around

2. Detective Jones has a suspect. When he examined the soles of the suspect’s shoes, he found some soil. What are four characteristics of the soil should Detective Jones be looking for?
   a. texture
   b. colour
   c. odour
   d. composition

3. Write the name of the fingerprint type under the correct fingerprint.

   whorl
   arch
   loop
   composite

   [Fingerprints and labels]
Use the following information to answer question 4.

A police detective found these two sets of fingerprints at a crime scene.

4. What can he conclude by examining the sets of fingerprints?
   
   a. The person who left them stole two different things.
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   a. Akko tire.
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   c. Descan tire.
   d. Fostier tire.
6. Pretend you are a forensic scientist and you are investigating a crime. You found a note written with a black felt pen. List the steps you would take to try to find out what kind of pen was used.

- get several different brands of black felt pen
- make large dots or heavy lines with each pen on pieces of chromatography paper
- suspend paper so the tip just touches water
- wait to see how colours separate
- compare with note

In the box below draw a diagram that shows what you would do.

![Chromatography Diagram]

Use the following information to answer question 7.

A police officer who had been sent to investigate a home robbery, found a torn piece of cloth on a bush just outside the home where the robbery took place. He noticed that it was red and stretchy. When he got back to the police station, he noticed a grubby looking man with a torn red jacket. The police officer knew that man had to be the robber. He told his supervisor that he was sure the grubby looking man had committed the crime. After all, the cloth on the torn jacket looked just like the piece of cloth he had found on the bush. The supervisor said it was too soon to tell.
7. Why was the supervisor not convinced that the grubby looking man had committed the robbery?

Police officer should try to match the man's jacket and cloth piece by comparing more characteristics than just colour.

Use the following information to answer question 8.

A kidnapper left a note. Here is what it said:

Are you missing something? I think I know where it is.

The police investigated the kidnapping and came up with four suspects. They had each of the suspects write the same sentence. They are shown below.

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8. By analyzing the handwriting samples, which person most likely left the kidnapping note?

a. Suspect A  
b. Suspect B  
c. Suspect C  
d. Suspect D
9. Match the words and phrases with their meanings.

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_d_ the person who hires a detective

_k_ to study a crime carefully

_p_ a person who saw a crime in progress

_j_ the science that studies clues

_h_ in court these facts are proof

_l_ small oval marks in fingerprints

_c_ a test that matches ink samples with the ink used in samples of writing

_m_ a test that is used to tell if a witness is telling the truth

_o_ to hide something or someone

_b_ an excuse that tells others that a suspect was not at the scene of the crime

_q_ to blame or charge someone with a crime

_f_ to sentence a criminal who has been found guilty of a crime

_n_ to watch a suspect’s home or business

_e_ a small piece of evidence