DISCOVER THE UNIVERSE

LOOKING UP!

Activity guide for teachers

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DUNLAP INSTITUTE
for ASTRONOMY & ASTROPHYSICS

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INTRODUCTION

When was the last time you looked up at the sky?

For many of us, this simple little action is done very rarely, yet many interesting celestial objects and phenomena are easily accessible. We therefore propose to explore the sky with students using simple and fun activities.

Astronomy is mainly an observational science. The first astronomers looked up at the sky and wondered about our place in the Universe. Several celestial objects and phenomena they observed are related to basic astronomy concepts found in school curriculum and are easily accessible to the naked eye. We therefore invite all students, young and old, to look up at the sky and discover that half of the world that remains too often forgotten.

SIMPLE, ACCESSIBLE AND ADAPTABLE ACTIVITIES

This guide offers simple and accessible activities which allow a first introduction to the night sky. Students have probably already noticed several celestial objects and phenomena presented here. The difference with this module is that students are encouraged to take notes in order to analyze the regularity of events and cycles in the sky. Encourage your students to be real scientists through these two essential steps: observing and taking notes for further analysis.

Note that most of the activities can easily be adapted to students of different levels, from primary to university level. The level of information provided to the students and the worksheets can be changed while the object of observation remains the same.

PARENTAL INVOLVEMENT

Some activities can be done during the day at school while others have to be done in the evening at home. For younger students, parental collaboration will be necessary to ensure the safety of the kids. We include a sample letter to be sent to parents before starting an observation activity at home.

REDISCOVERING THE SKY

The goal of this guide is primarily to reconnect students with the sky, especially at night. Our everyday life makes us forget the beauty of the sky and all the phenomena that can be observed easily, even more so when we live in cities. We hope to inspire students to look up for a few minutes and discover the splendour of the universe.

LIST OF ACTIVITIES

ACTIVITY 1

IN THE SKY, I CAN SEE...

Grades :	Level of preparation :	Student groupings:	Length :	Location of activity :
K-4	**easy**	**individual or small groups**	**20-30 minutes**	**in class**

BRIEF DESCRIPTION

This short activity allows students to reflect on what is visible in the sky during the day and at night. As a team, they complete the activity sheet by drawing or writing what they can see in the night sky and in the daytime sky. A class discussion is encouraged at the end.

LEARNING GOALS

- Identify what is visible in the sky with the naked eye.
- Name familiar celestial objects and phenomena.
- Notice differences between the night sky and the day sky.

MATERIALS

- 1 activity sheet for each child
- crayons (if children draw on the worksheet)

INTRODUCTION

In most children's books, images of the daytime sky show the Sun while night sky images show us the Moon and stars. But is that all that is visible? Are there no other objects or phenomena that we can see?
This simple activity will allow students to reflect on the visible objects and phenomena in the sky and they will discover that many things are visible when we take the time to look up.

PREPARATION

Print the worksheet so that every student has one.

METHOD

Distribute the activity sheets and have students work in small groups to identify visible objects and phenomena in the sky, during the day and at night. Have them find as many as possible. Depending on the age of the children, they can either draw or write a list.

After 10-15 minutes, come back in a large group and start a class discussion on what students have written or drawn. The list will probably be very long! If students did not list the Moon themselves, it may be worthwhile to make them realize that it is also visible during the day.

ADDITIONAL INFORMATION

Several objects and phenomena are visible to the naked eye in the sky. We just need to think about looking up to be able to see them!

Here we present a list of astronomical phenomena visible at night and during the day. Note that students may also mention things which are not astronomical in nature, such as airplanes, rainbow sky, clouds, birds, lightning ....

BY NIGHT

- **Stars**: It is possible to see thousands of stars in a very dark sky, away from light pollution. However, this number drops to only a few dozen in cities because of artificial lights.
- **Moon**: The Moon is the easiest object to observe in the night sky. Different phases can be observed during a 30-day cycle. It is also possible to observe lunar eclipses during the night, but these are rare.
- **Planets**: Five planets are visible to the naked eye: Mercury, Venus, Mars, Jupiter and Saturn. Without an instrument such as a telescope, they simply look like stars. Some, like Venus, Mars and Jupiter, can become quite bright and it becomes easier to identify them amongst the background stars.
- **Shooting stars or meteors**: Shooting stars are not stars, but space dust particles falling through the Earth's atmosphere at high speed. The heat created when they pass through the atmosphere leaves a trail of light we can observe.
- **Milky Way**: Under a very dark sky, away from city lights, it's possible to see a whitish band across the sky. This is the disk of our galaxy, where there are so many stars that the light from all of them combines to form this white band.
- **Northern lights**: This phenomenon is rare in southern Canada, but can be seen more often as we get closer to the North Pole. People living in northern Canada, such as the territories, are very well situated to observe them. The northern lights, or aurora borealis, are created by the interaction of particles from the Sun with our atmosphere.

- **Artificial satellites**: When watching the night sky for a few minutes, many bright dots can be seen moving from one horizon to the other in a few minutes. They are artificial satellites orbiting the Earth. If a bright dot has rapidly flashing lights or lights of different colours, it is a plane and not a satellite.

BY DAY

- **Sun**: The Sun, our star, dominates the daytime sky. It's interesting to mention to students that the Sun is a star like the others we see at night. It's simply much closer to us. So in reality, it's appropriate to say that we can see stars during the day and at night!
- **Moon**: Most people are surprised to realize that the Moon is visible in daylight! In fact, it is visible in the day almost as often as at night, but it is more difficult to notice because of the brightness of the sky. It's also possible to observe solar eclipses during the day, but these are very rare.
- Other objects and astronomical phenomena can be observed during the day, but they are extremely rare, bright objects, such as a small asteroid entering the atmosphere and causing a very bright meteor. Some experienced observers can also detect planets and satellites in the daytime by knowing exactly where to look.

Name: _____

IN THE SKY, I CAN SEE...

Draw or write everything you can see in the sky during **the day**.

Draw or write everything you can see in the sky **at night**.

THE MOON

The Moon is the easiest object to observe in the sky as it is bright and completely safe to observe, unlike the Sun. It's possible to observe the Moon in urban and rural areas, regardless of the amount of light pollution. Moreover, as it continually changes shape and location in the sky, it's a perfect target to begin our observation and analysis of the world around us.

In the next three activities, we will guide you to encourage your students to observe the Moon and record their observations. The ultimate goal is the same for each activity: note your observations in order to make connections and ultimately understand the phenomenon of the phases of the Moon.

For children under 10 years, we recommend simply observing the phases of the Moon and learning to identify the main ones (crescent moon, quarter moon, gibbous moon, and full moon) without focusing on the explanation of the phenomenon. Their ability to visualize abstract concepts in three dimensions is not yet developed enough.

For older students, observation may serve as an introduction to an explanation and modelling of the cycle of the phases of the Moon.

Ideally, observation of the Moon should last at least one lunar cycle which is roughly 30 days, as described in activity 2. If you prefer, you can also emphasize a part of the lunar cycle such as in activitiy 3 (Evening Moon) and activity 4 (Daytime Moon). Since it is done during the daytime, activity 4 can easily be done during school hours.

Follow this link for a short video on the phases of the Moon: http://youtu.be/iF8k9ibNKo8

ACTIVITY 2

MOON OBSERVATION JOURNAL

Grades :	Level of preparation:	Student groupings:	Length:	Location of activity:
4 and higher	**easy**	**individual**	**5 minutes each time, total length of one month**	**at home**

BRIEF DESCRIPTION

Students observe the Moon as often as possible during a lunar cycle (30 days) and record their observations in a Moon observation log.

LEARNING GOALS

- Observe the Moon in the sky.
- Explain the changes in the appearance and position of the Moon during its cycle.
- Identify the different phases of the Moon.

MATERIALS

- Student worksheet and observation journal

INTRODUCTION

The cycle of the phases of the Moon lasts almost 30 days (29.5 days exactly). This is the time between two consecutive full moons. Throughout the cycle, it's possible to observe the Moon in its various phases: crescent moon, quarter moon, gibbous moon and full moon. Although most students have already seen the Moon in its various phases, few of them have taken the time to analyze changes from day to day. This is why it is interesting to note your observations.

PREPARATION

Print the student worksheet and extra copies of the Moon observation journal. We recommend distributing two copies of the journal to each student at the beginning of the month, then keeping several extra copies in the classroom or available online.

METHOD

- Explain to students that they will observe the Moon as often as possible in the coming month. It will obviously be impossible to record observations every single day, especially because of the weather. This is fine; it is not necessary to make observations on all days to show the cycle of phases of the Moon. The idea is to get students to look to the sky at different times of the day to find the Moon.

- Review the instructions on the worksheet with your students to make sure they understand the assignment.

- Throughout the month, especially during the cloudless days, remind students to observe the sky to find the Moon.

- At the end of the month, ask students to answer the questions on their activity sheet and review them with the class.

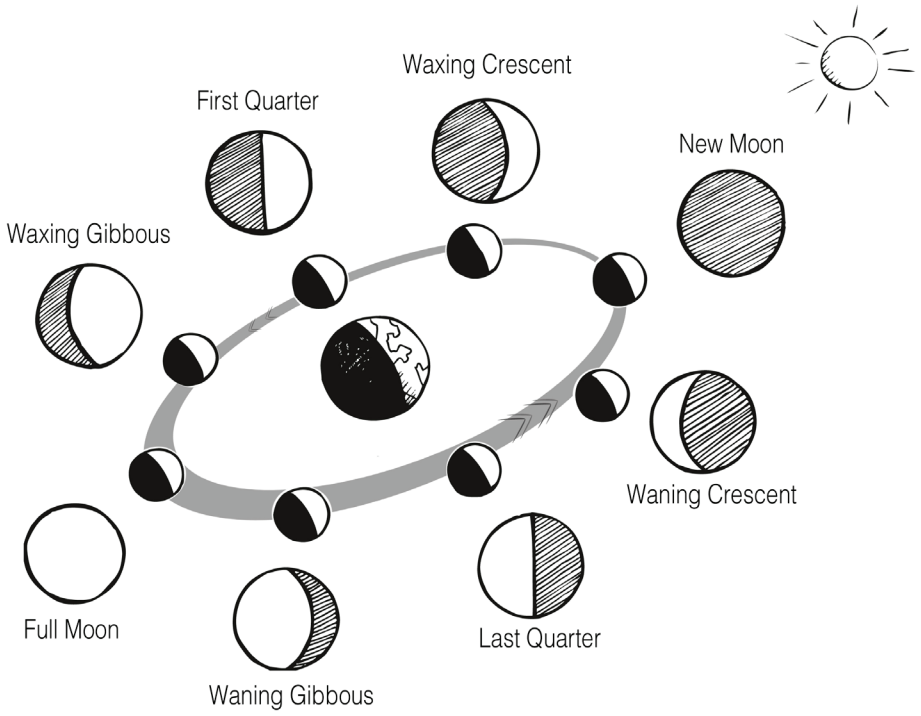


Figure 1. Schematic diagram, not to scale, showing the position of the Moon for the main phases.

ADDITIONAL INFORMATION

For a visual explanation of the phases of the Moon, please watch the accompanying video: http://youtu.be/iF8k9ibNKo8**.**

To understand the cycle of phases of the Moon, we must first understand some basic concepts.

- The Moon does not shine by itself. We see it because it reflects sunlight.
- The Moon is always half-lit: one half is facing the Sun (it's daytime on the Moon in this half) and the other half gets no sun (where it is night on the Moon).
- The Moon orbits the Earth with an orbital period (time to complete a full revolution) is about a month.
- During this month, the illuminated fraction that is visible from Earth varies. Sometimes the half we see is the fully illuminated half: this is what we call a full moon. Conversely, we call it "new moon" when we face the unlit portion of the Moon.
- Between these two extreme phases, we find the crescent moon, the quarter moon and the gibbous moon (between a quarter and full moon).

Moreover, the Moon is not always visible in the same place in the sky. Its position varies throughout the day, as the Earth rotates on its axis, and also during the month, as the Moon orbits the Earth.

Name: _____

MOON OBSERVATION

In the coming month, we invite you to discover the Moon! Observe it as often as possible and record your observations in this journal. For each observation, draw the Moon as you see it in the sky. Don't forget to include the horizon in your drawing to properly represent the height and the tilt of the Moon. Also note also if you see anything special like a bright star near the moon or a moon halo.

Remember to look up regularly and don't forget that the Moon is often visible in the daytime.

At the end of the month, answer the following questions:

How has the Moon changed during the month? Describe the changes you have observed.

_____

_____

_____

_____

Can you predict what the Moon would have looked like on days you didn't get to see it?

_____

_____

_____

_____

Did you always observe the Moon at the same time? Have you noticed a difference in the times when the Moon was visible?

_____

_____

_____

_____

On each of your observations, write the name of the phase: crescent, quarter, gibbous or full moon.

MOON OBSERVATION JOURNAL

Date: _____

Time: _____

Location: _____

Weather and sky conditions: _____

_____

Date: _____

Time: _____

Location: _____

Weather and sky conditions: _____

_____

Date: _____

Time: _____

Location: _____

Weather and sky conditions: _____

_____

Date: _____

Time: _____

Location: _____

Weather and sky conditions: _____

_____

ACTIVITY 3

EVENING MOON

Grades :	Level of preparation:	Student groupings:	Length:	Location of activity:
4 and higher	**easy**	**individual**	**5 minutes each time, total length of two weeks**	**at home**

BRIEF DESCRIPTION

In this activity, students observe the Moon when it is visible in the early evening, just after sunset. This observation period lasts about 14 days and allows observers to see the evolution from a thin crescent moon to full moon. In addition, the motion of the Moon in the sky during this period is easily observed.

LEARNING GOALS

- Observe the Moon in the sky.
- Describe the changes in the appearance and position of the Moon in the sky.
- Identify the different phases of the Moon.

MATERIALS

- Activity sheet

INTRODUCTION

The best time to easily observe the moon begins a few days after the new moon. The crescent Moon is visible in the evening when looking west. Over the next days, it is possible to observe the growing crescent become a quarter moon, a gibbous moon, and then a full moon. At the same time, the Moon moves from west to east if we observe it at the same time each day. For younger students, just after sunset is a good time to observe the Moon because it is easy to find in the sky. For older students, this observation provides insight into the movement of the Moon around the Earth.

For a visual explanation of the phases of the Moon, please watch the accompanying video: http://youtu.be/iF8k9ibNKo8**.**

PREPARATION

- Plan the observation period by finding the date of the next new moon. Most calendars have this information, but it is also possible to find it by searching online. The *Rio Tinto Alcan Planetarium* in Montreal offers a lunar calendar on their website: http://espacepourlavie.ca/en/phases-moon
- Print the activity sheet so that everyone has a copy.

METHOD

- Explain to students that they will observe the Moon as often as possible in the next two weeks. It will obviously be impossible to record observations every single day, especially because of the weather. This is fine; it is not necessary to make observations on all days to see the changes in the appearance and position of the Moon.
- Review the instructions on the worksheet with your students to make sure they understand.
- On cloudless days over the next two weeks, make sure to remind students to observe the Moon in the evening.

Here are some ideas for discussion with students:

- How has the Moon changed from night to night? Was it always in the same place in the sky?
- After some observations, have students predict and draw where the Moon will be the next day.

ADDITIONAL INFORMATION

The Moon rises on average 50 minutes later every day and moves eastward from night to night if we observe at the same time (see Figure 2). A few days after the new moon, we can see a crescent moon on the western horizon. From night to night, the crescent thickens and becomes a quarter moon a week after new moon. The quarter moon is directly south at sunset. In the following days, we see a gibbous moon towards the southeast and finally, about 2 weeks after new moon, we see the full moon rise in the east at the same time as the Sun sets in the west.

These observations show the motion of the Moon in our sky as the Moon orbits around the Earth. Throughout the lunar cycle, the Moon changes phases but also the time at which it is visible in the sky.

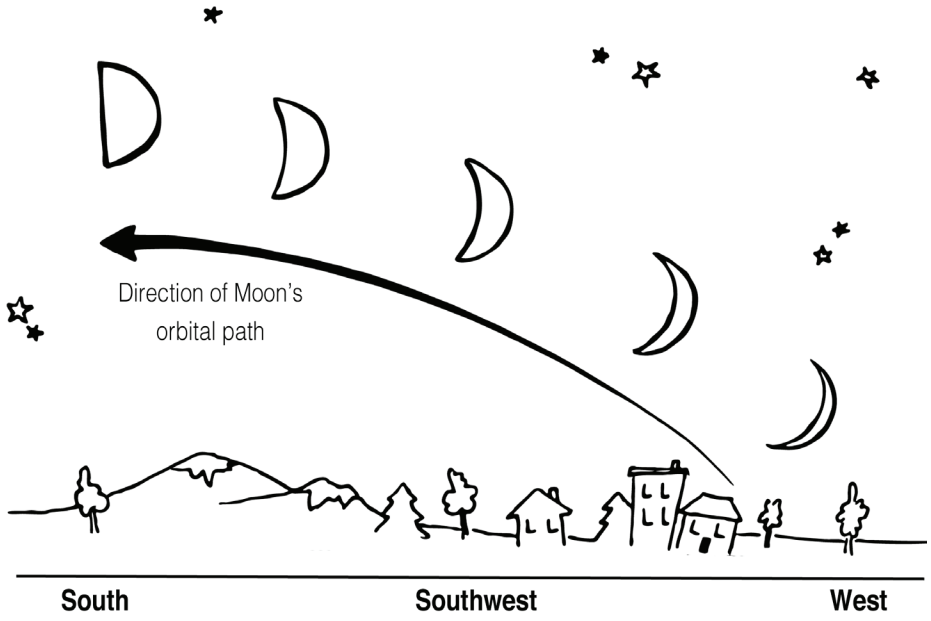


Figure 2. Change in the position and phase of the Moon a few nights after new moon.

If you would like more details about the motion of the Moon around the Earth and how that affects our view, including the fact that it rises 50 minutes later every day, have a look at this explanatory video which includes basic mathematical concepts: http://www.showme.com/sh/?h=BamO0lU.

Name: _____

EVENING MOON

Begin your observations a few days after new moon. Look west after sunset; you should be able to see a thin crescent moon. Draw it in the box below and add some landmarks such as trees or houses. **Make sure you always observe from exactly the same spot** so you can place the Moon on your drawing as it appears in the sky compared to the landmarks you included. Try to observe the Moon as often as possible during the next two weeks and draw each of your observations.

What do you notice?

_____

_____

_____

_____

ACTIVITY 4

DAYTIME MOON

Grades :	Level of preparation:	Student groupings:	Length:	Location of activity:
4 and higher	**intermediate**	**small groups**	**30-45 minutes**	**at school**

BRIEF DESCRIPTION

In this activity, students observe the Moon in the daytime and recreate its phase with a small ball.

LEARNING GOALS

- Observe the Moon in the sky.
- Model the phase of the Moon visible in the sky.

MATERIALS

- Several light-coloured balls (ideally one ball for each group of 3-4 students)
- Notebook
- Pencils

INTRODUCTION

Few people realize that the Moon may be visible in the daytime. This activity allows students to observe the Moon in daylight and to recreate the Moon phase on a ball. Holding a small ball under the real Moon allows the ball to be lit by sunlight in the same way as the Moon. This makes it possible for students to realize that the "missing" part of the Moon is still there, but it's hiding in the shadow. In addition, by analyzing the system in three dimensions, it's possible to understand the alignment of the Earth, Moon and Sun to recreate this phase.

For a visual explanation of the phases of the Moon, please watch the accompanying video: http://youtu.be/iF8k9ibNKo8**.**

PREPARATION

- Find or buy the balls. White Styrofoam balls available in dollar stores are ideal for this activity as they show a good contrast between the lit and unlit parts.
- Plan your observation for a time when the Moon will be visible in the sky. Here are the two most interesting options:
    - During the week **before full moon**, the Moon will be visible i**n the eastern sky in the afternoon.**
    - During the week **after full moon**, the Moon will be visible **in the western sky in the morning**.
- Most calendars have information about the phases of the Moon, but it is also possible to find it by searching online. The *Rio Tinto Alcan Planetarium* in Montreal offers a lunar calendar on their website: http://espacepourlavie.ca/en/phases-moon
- On the day of the activity, make sure the sky is clear enough to see the Sun and Moon.

METHOD

- Go outside with your students and have them form small groups. Make sure they bring something to write on and a pencil.
- Distribute a ball to each group and ask them to figure out how to place the ball in order to see the same pattern of light and shadow as on the real Moon. The trick is to hold the ball just under the real Moon in the sky, as in Figure 3.

FIgure 3. Modelling the phase of the Moon in daylight with a ball

Start a **discussion with your students by asking them these questions** (answers are provided in italics):

- What happens to the missing part of the Moon? *It is simply not lit and therefore does not appear in the sky. The Moon is always a sphere.*

- Identify the part of the ball and the Moon where it is daytime *(facing the Sun)* and where it is dark *(unlit part)*.

- View your model from above and draw your ball, the Sun and yourself. Then try to see the alignment of the three bodies in space: the Moon, the Sun and the Earth. *Both alignments are shown in Figure 4. It shows that the angle in a) is the same as the angle b).*

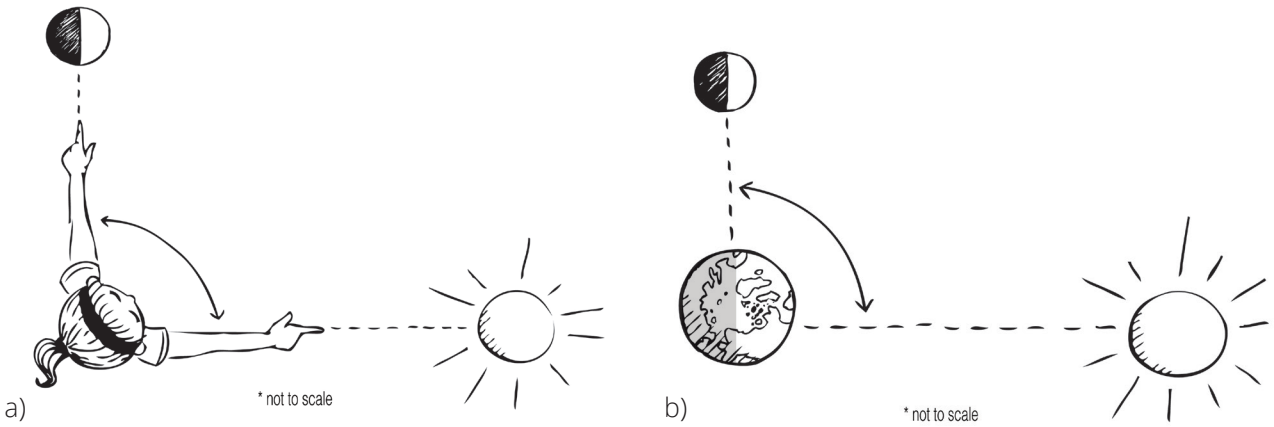
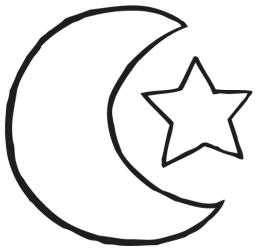


Figure 4. The angle formed by our arms pointing at the Sun and Moon in the sky is the same as the angle between the Sun, Earth and Moon with the Earth at the centre. In this case, we see that a quarter moon is formed when this angle is 90°. NOTE: the drawings are absolutely not to scale. They only serve to show the alignment and not distances. In fact, the Sun should be much farther to the right to light the Moon that way.

- Bonus Question: The symbol of a crescent moon and a star is very popular around the world and can be found on the flag of several countries. Is this configuration possible? *No, because the dark portion of the Moon is still present (the Moon is always a sphere) so it is impossible to see the stars through it. The stars are much farther away from us than the Moon. To view this alignment would require the unlit portion of the Moon to be transparent, which is impossible.*



THE SUN

The Sun is the first celestial object that children learn about. Although visible every cloudless day, its observation is not as simple as with the Moon and requires important safety precautions. **It's dangerous to observe the Sun directly and we should avoid encouraging students to do so**.

Fortunately, there are indirect observations that allow us to observe the apparent movement of the Sun in the sky. In Activity 5, we observe changes in our shadow to understand the motion of the Sun over the course of a day. In Activity 6, students record the position of the Sun at sunset for a few weeks to notice the change in its position relative to the horizon.

The **apparent motion of the Sun** in the sky is actually created by the movements of the Earth:

- **The Earth rotates once on its axis over a period of 24 hours.** This is called the rotation of the Earth. From our perspective, because we do not feel the Earth move, we see the Sun moving from east to west every day.
- **The Earth goes around the Sun over a period of 365 days**. This is called the revolution of the Earth or its orbital motion. The combination of this movement and tilt of the Earth relative to its orbital plane creates a variation in the height of the Sun throughout the year. This phenomenon is the cause of the seasons.

ACTIVITY 5

HOW LONG IS MY SHADOW?

Grades :	Level of preparation:	Student groupings:	Length:	Location of activity:
4 and higher	**intermediate**	**small groups**	**30 minutes, plus 15 minutes per observation**	**at school**

BRIEF DESCRIPTION

In this activity, students use the length of their shadow to understand the apparent movement of the Sun in the sky. They must take measurements at different times of the day to notice the differences.

LEARNING GOALS

- Observe how the length and direction of a shadow change during the day.
- Explain how the changes observed in the shadow depend on the apparent movement of the Sun in the sky.
- Understand the Sun's motion from east to west in the sky during the day.
- Observe the change in the height of the Sun in the sky throughout the year.
- Observe the Moon in the sky.
- Model the phase of the Moon visible in the sky.

MATERIALS

- Several long rulers or measuring tapes
- Notebook
- Pens
- Sunny day!

INTRODUCTION

Since it is dangerous to observe the Sun directly, this activity uses the changes in a shadow to determine the movement of the Sun in the sky. The shadow projected on the ground will always be in the opposite direction to the Sun. In addition, the lower the Sun in the sky, the longer the shadows. Conversely, a very high Sun in the sky will create very short shadows.

In this activity, students observe the changes in their shadow over the course of a day. These observations will allow the students to realize that the Sun starts the day low in the east, then moves up in the sky until it reaches its highest point around noon in the south and it eventually goes down in the west in the afternoon and evening. This motion is due to the rotation of the Earth on its axis, which takes 24 hours.

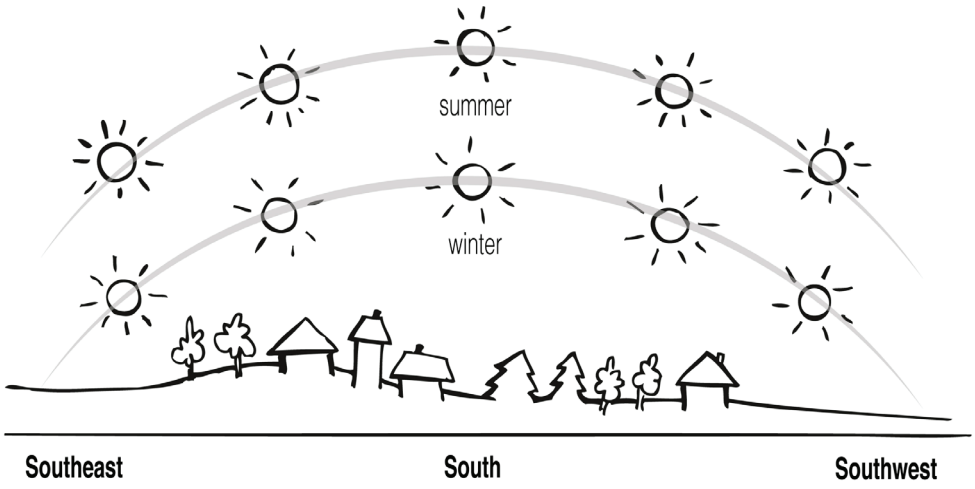


Figure 6. Apparent motion of the Sun in the sky over the course of a single day in summer and winter. In both cases, the Sun moves from east to west (left to right in this picture).

PREPARATION

- Make sure you find a place in the schoolyard where it will be possible to observe the Sun. Ideally, this spot would have a relatively clear horizon from southeast to southwest. You can do the activity yourself before doing it with students to ensure that your observing location works well.
- If you have trouble knowing the orientation (north, south, east, west), you can use a compass to find north. You can also pay attention to the position of the Sun in the sky when you arrive at school in the morning: this is east.

METHOD

- Form teams of three or four students and go outside with the rulers or measuring tapes. Each student should also have a notebook and a pencil.

- Invite students to measure their height in order to compare their shadows with their actual size. This can be done in the classroom before going outside.

- For the measurements, ask students to choose a location where their shadows will be obvious and easy to measure. Guide them in their choice to ensure they can see their shadow from the same place over several hours.

- If you want students to pay attention to the change in direction of their shadow during the day, ask them to notice their orientation by facing something obvious or using markers on the ground. They should place themselves in the exact same position and orientation every time.

- Each member of the team should take their turn to stand at the precise location. The other members of the team should then measure this person's shadow. Each student should note the time and the length of their shadow in their notebook. Students may also make a drawing of the direction of the shadow while making sure they include their reference point in the drawing, as in Figure 7.

- Repeat the measurements every hour or so to observe the changes.

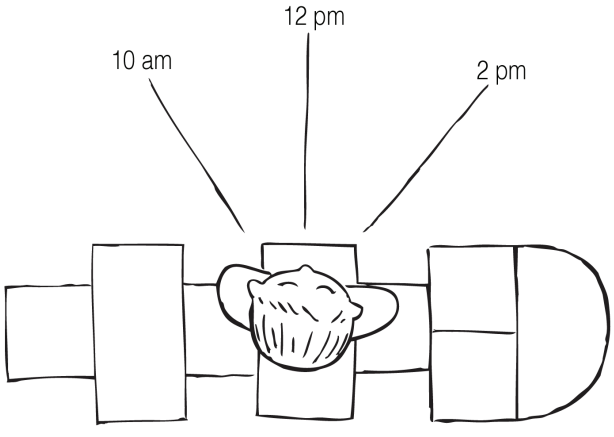


Figure 7. Direction of the shadow of the student at different times of the day.

Here are **some questions you may wish to ask your students** depending on the level of analysis and inquiry you want to reach (answers are given in italics).

- Even before finishing the steps, ask students to predict where their shadow will be at the next observation and estimate its length. They can then compare their predictions with the true measurements.

- Describe how the length of the shadow varies during the day. *The shadow shortens until noon and then lengthens in the afternoon*.

- Why does it vary this way? *The Sun is at its highest point in the sky around noon, causing the smallest shadow.*

- How has your shadow moved during the day? *From west to east (or left to right on their paper)*.
- Describe the apparent motion of the Sun during the day. *The Sun moves from the east to the south and then the west. Moreover, it is lower in the sky in the morning and afternoon and is at its highest around noon.*

- Make a graph of the length of the shadow based on the time of day.

- Is there a time when your shadow was your exact height? *This is possible when the Sun is in an elevation of 45° in the sky, but the Sun does not reach that height for several months of the year in Canada (October to April, in southern Canada)*.

TO OBSERVE VARIATIONS THROUGHOUT THE YEAR

To observe the changes at different times of the year, you can do this activity several times a year and compare the results. Changes in the length of the shadow during the year (and thus the height of the Sun in the sky) are due to the tilt of the Earth and the motion of the Earth around the sun. This tilt of the Earth and the resulting variations in the height of the Sun over the course of a year, is the cause of the seasons.

DIFFERENT OPTIONS FOR THE ACTIVITY

- Explore how sunlight enters the classroom or creates shadows in the classroom. Observe the changes during a day.
- Instead of measuring the shadows of the students, you could use an object that will always be placed at the same location. A plunger works well because it has a stable base, a long stick, and is easy to carry.

ADDITIONAL INFORMATION

Can the Sun be directly above our heads?

In Canada, the Sun never reaches the zenith, the point directly overhead. It reaches its highest point at the summer solstice around noon, but it is always several degrees off the zenith. To view the Sun directly overhead, one must be located between the two tropics, or at a latitude of less than 23.5 degrees north or south.

Does the Sun reach its highest point in the sky at noon exactly?

No, it is not always exactly at noon. When we are using daylight saving time, the Sun reaches its highest point around 1pm instead of noon. There is also a difference of a few minutes given your position in your time zone. The Sun reaches its highest point in the sky when it is directly to the south, and that time varies by a few minutes depending whether you are towards the eastern border of the time zone or western border. Other factors relating to characteristics of the orbit of the Earth also cause a slight lag between noon and the time when the Sun is directly south.

Why do we talk about the apparent motion of the Sun?

The motion of the Sun observed in this activity is the effect of the motions of the Earth. You can find more information about it on page 22. It is important to realize that children intuitively think the Sun is moving around us. This is normal because this is what we see in the sky. It was also believed by the first astronomers in history. The purpose of this activity is to become familiar with the apparent motion of the Sun in order to then explain astronomical phenomena describing this motion: rotation and revolution of the Earth as well as the tilt of the Earth's axis of rotation.

ACTIVITY 6

WHERE DOES THE SUN SET?

Grades :	Level of preparation:	Student groupings:	Length:	Location of activity:
4 and higher	**intermediate**	**individual**	**5 min each time, total length of at least one month**	**at home**

BRIEF DESCRIPTION

In this activity spanning over several weeks, students observe where the Sun sets on the horizon and record their observations.

LEARNING GOALS

- Observe that the Sun does not always set in the same location on the western horizon.
- Explain how the location where the Sun sets varies depending on the time of year.
- Explain how the time at which the Sun sets varies depending on the time of year.

MATERIALS

- Activity sheet
- Something rigid to write on while outside
- Pencil

INTRODUCTION

We teach children that the Sun rises in the east and sets in the west. But does the Sun always set due west exactly? To investigate, this activity encourages children to watch the sunset over several weeks or months. They will draw their observations on a map of the western horizon that they will draw the first night.

This video shows an example of the changing position of the Sun at sunrise over a full year.
https://www.youtube.com/watch?v=8FrJhFCfRW4

The images comprising that video were taken in Germany and show the changing position of sunrise. Despite the many cloudy mornings, it is easy to observe the motion of the Sun on the horizon during the year. This is the purpose of the proposed activity, but to make it simpler, we will observe sunset instead of sunrise, and only for a few weeks instead of over a full year.

PREPARATION

- **Plan the observation period.** The change in the position of the sunset will be more apparent in the weeks / month near the equinoxes of spring and fall. Around those times, the Sun will appear to move faster on the horizon from night to night. It is therefore recommended to do this activity near the autumnal equinox (September, October) or the spring equinox (February, March, April). This project works better if you extend your observations over a period of at least one month, if not longer.

- **Find the time at which the Sun sets the first night in order to guide the students.** Most weather forecast sites include the times of sunset. You can also use the Sunrise and Sunset Calculator from the National Research Council: http://www.nrc-cnrc.gc.ca/eng/services/sunrise/index.html

- Before the activity, print the activity sheet so that each student has a copy.

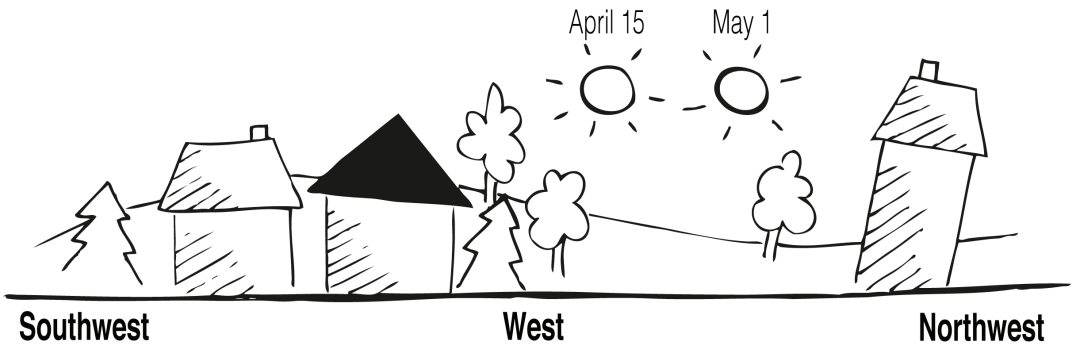


Figure 8. Map of the western horizon with two positions of the Sun at sunset. Note that it will probably be impossible to identify the cardinal points exactly.

METHOD

- Explain to the students that they will observe and note where the Sun sets in the coming weeks.

- Be careful not to stare at the Sun directly, even when it is close to the horizon. A single quick glance is enough to see its position on the horizon.

- Start by determining the place where you will make your observations. Since you will try to observe as often as possible, it's best to choose the location where you usually are around sunset. Try to find a spot with a good view of the western horizon. It's important to make the observations from the exact same spot each time.

- Observe your first sunset. You are now looking at the western horizon. Draw some objects you see on the horizon, such as houses and trees. You will use this as a map to show the changing position of the Sun each evening. Make sure to make your map large enough to include several observations of the Sun.

- For each observation, draw the Sun on your map. Remember to include the date and time.

- The weather and your daily activities may not allow you to observe sunset every day. This is normal! It isn't necessary to observe so often to notice the motion of the Sun. In fact, it would be difficult to notice the difference in position between one evening and the next. It's better to have one or two good observations each week.

Here are **some questions you may wish to ask your students**, depending on the level of analysis and inquiry you want to reach (answers are given in italics).

- Before finishing the observation period, ask students if they can predict where the Sun will set next. They can then compare their prediction with their real observation.

- What did you notice in your observations? *The sun does not always set in the same place. It moves along the western horizon. Moreover, it does not always set at the same time.*

- What direction does the Sun appear to move along the horizon? *If you observe during summer or fall, the Sun moves from right to left night after night. If you observe during winter or spring, the motion will be from left to right. To be more precise, we can give the answers based on the cardinal points (see Figure 9):*
    - *Between December 21 and March 21, the Sun moves from southwest to west (to the right).*
    - *Between March 21 and June 21, the Sun moves from west to northwest (to the right).*
    - *Between June 21 and September 22, the Sun moves from northwest to west (to the left).*
    - *Between September 22 and December 21, the Sun moves from west to southwest (to the left).*

- Can you tell if there's a time of the year when the Sun sets exactly due west? What's special about that day? *The sun sets exactly due west on the equinoxes: March 21 (approximately) for the spring or vernal equinox and September 22 (approximately) for the fall equinox. These are the times of the year when the Sun is directly above the equator and lights the southern and northern hemispheres equally.*

ALTERNATIVE:

If your students are old enough and have access to cameras, you might suggest they take a picture of the sunset instead of drawing it. Just as for the drawings, they should make sure to always take their photos from the same location. To compare the Sun's position on each picture, they could then use the pictures to draw their map. If they want a more complex project, they could assemble the pictures into a video as in the example provided in the introduction. Note: students should make sure to take pictures quickly and only at sunset to avoid damaging their camera. They should also avoid looking directly through the viewfinder if they have a camera with this option, which is not the case for cameras on smartphones.

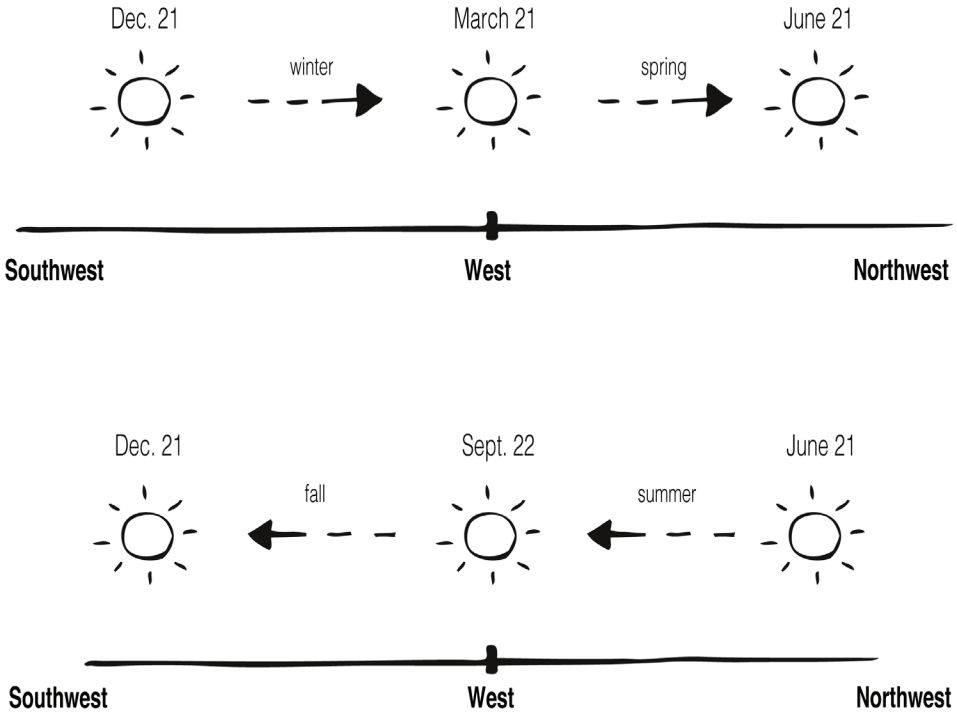


Figure 9. Position of the setting Sun on the western horizon throughout the year.

ADDITIONAL INFORMATION

Why does the Sun appear to move along the western horizon throughout the year? This apparent motion of the Sun is due to the tilt of Earth's axis of rotation. As the Earth moves around the Sun, we in the North face toward the Sun in summer and away in winter because of this tilt. This is the same phenomenon that explains why the Sun is higher in the sky at noon in summer than at noon in winter. In this activity, instead of watching the Sun at noon, we watched it at sunset. Look at Figure 6 to compare the positions of the Sun in the sky in summer and winter. Pay special attention to the western horizon. This apparent motion on the western horizon is shown in Figure 9, indicating the direction depending on the season.

INTERESTING NOTE:

The Sun appears to stop its apparent motion and to change direction at the summer and winter solstices (June 21 and December 21 approximately). In fact, the word "solstice" comes from the Latin "sol", meaning "Sun", and from "sistere", meaning "stop". So these are the times of the year when the Sun seems to stop for a few days before going back in the opposite direction.

Name: _____

WHERE DOES THE SUN SET?

Over the next few weeks, you will observe where the Sun sets on the horizon. You will mark your observations on an horizon map you will draw here. This project works better if the observation period lasts a month or more. **Be careful not to observe the Sun directly, even when it is low on the horizon**.

- First, you need to decide the location from which you will observe. It is important for the observations to be made from the exact same spot every time.
- When you observe a sunset, you are facing the western horizon. Draw below what you see on this horizon, such as trees or buildings. This will be the map on which you will indicate the Sun's position at each sunset. Make sure your map is large enough to draw many observations of the Sun.
- Every time you observe, draw the Sun on your map. Make sure you note the date and time.

Once you have many observations over a long period, what do you notice?

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THE STARS

When we think of astronomy, the first idea that comes to mind is the starry sky. Unfortunately, for most people today, the stars are difficult to see because artificial lights obscure the view. Light pollution greatly affects our view of the night sky by reducing the number of stars visible, from several thousand in rural areas to only a few dozen in cities. If you are curious about the effect of light pollution in your area, you can try Activity 8 - Globe at Night with your students.

But let's start with an activity to familiarize students with the main stars and constellations. It is by observing these stars that people learn to find their way in the sky and understand the motions seen during the night and the year.

ACTIVITY 7

INTRODUCTION TO THE STAR FINDER

Grades :	Level of preparation:	Student groupings:	Length:	Location of activity:
6 and higher	**intermediate**	**individual or small groups**	**60 minutes**	**at school**

BRIEF DESCRIPTION

In this activity, students cut and assemble their own star finder and learn how to use it. An activity sheet is then used to introduce them to the main stars and constellations.

LEARNING GOALS

- Use the star finder, an observational tool.
- Recognize the main stars and constellations.

MATERIALS

- Star finders printed on cardstock paper (2 sheets per student)
- Scissors
- Activity sheet

INTRODUCTION

A star finder is a chart that allows us to identify the main stars and constellations visible at a specific time. It is a basic tool for all those who are becoming interested in astronomy and observing the night sky. This cardboard version allows a first introduction. If students are interested, they can buy a plastic version ($10-20) available in most bookstores.

PREPARATION

Before the activity, print the star finders on cardstock paper, 8 ½ X 11 in. Each student should have two sheets: the sky map and the support with the times. If you do not have cardstock paper, you can print on regular paper and ask students to glue it on thin cardboard, such as file folders (used ones if possible, to reduce the use of new material).

Print the activity sheet so that each student has a copy.

METHOD

Distribute the sheets to each student and ask them to cut out the pieces following the instructions on the star finder.

Then show how to use the star finder:

- Insert the chart in the support to see the constellations in the oval hole.
- Align the time on the support with the and date on the wheel at which you want to observe the sky.
- The constellations visible in the hole represent the sky at this time. The edges of the oval represent the horizon, while its centre represents the point directly overhead, called the zenith.
- While looking at the actual sky, turn the star finder so that the direction at the bottom of the star finder coincides with the direction in which you're looking.

You can **show the following video in class to demonstrate how to use the star finder**: http://youtu.be/BgqICmDIT9c

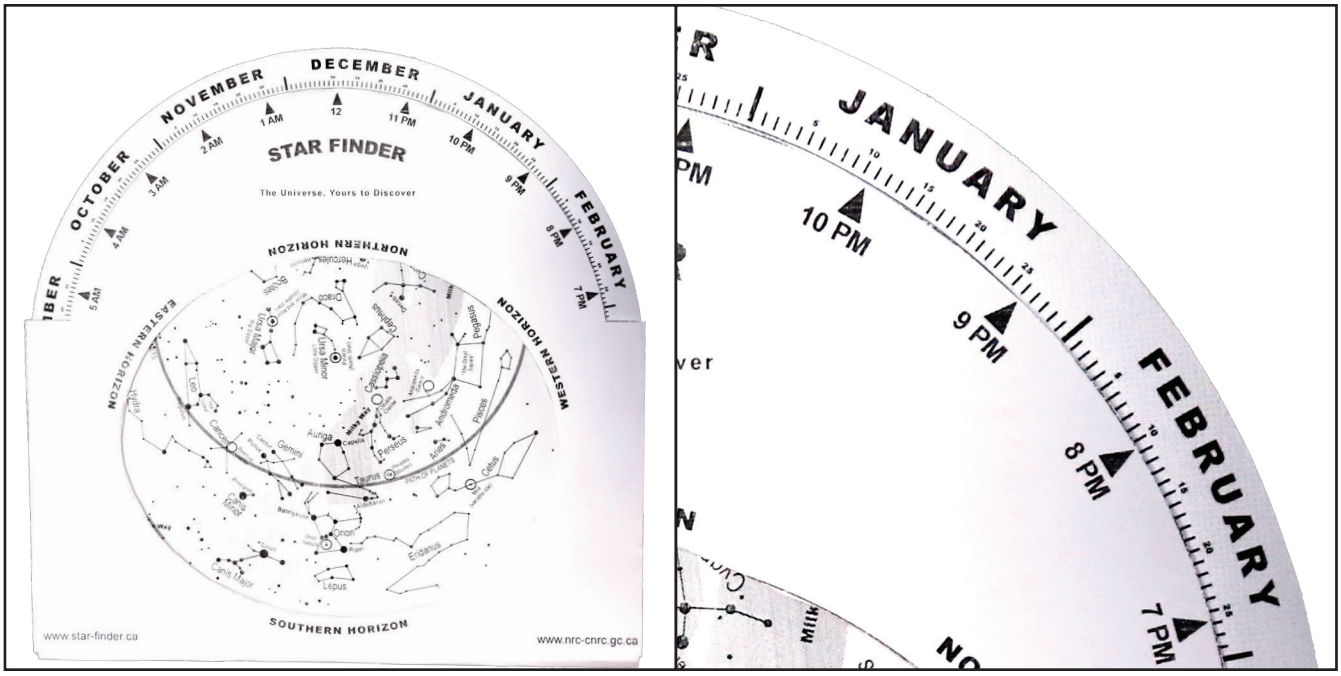


Figure 10. Star finder set to show the sky on February 10 at 8pm .

ADDITIONAL INFORMATION

The star finder presented here is associated with the website www.star-finder.ca.
There you can get more information about using the star finder and its characteristics. Here are some interesting facts about the star finder which are discussed in more detail on the website:

- The small circles represent interesting celestial objects visible to the naked eye or with a small instrument (binoculars or telescope). These objects can be interesting stars, star clusters, galaxies or nebulae. You can find more information about these objects on the website www.star-finder.ca.

- The pale grey band across the sky is the Milky Way, our galaxy. In this region of the sky, we find many more stars, which creates a whitish band. However, one must be away from light pollution to see it clearly.

- The dark circle labeled "Path of planets" shows the range of positions at which planets can be visible. This is called the ecliptic. Since the planets are always moving in the Solar system, they are not represented on the star finder. If you see a bright, unmoving star-like object in the sky which is not represented on the star finder, but is close to this band, it is probably a planet.

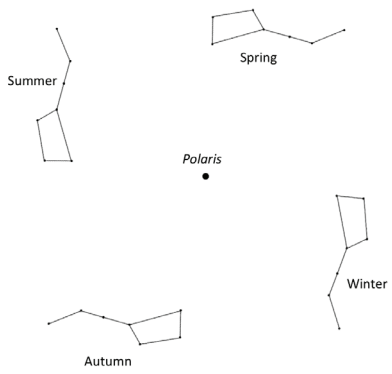
Note that **the star finder does not account for daylight saving time**. When DST is in effect, subtract an hour from the time indicated on your watch. For example, if you want to observe the sky at 9pm daylight saving time, set the star finder for 8pm.

STUDENTS' WORKSHEET ANSWER KEY

1. **Name three constellations visible in the south tonight.** To find the constellations visible in the south, simply align the date and time on the star finder and look at the major constellations above the southern horizon. We can look between the southeast and southwest. Be careful not to go beyond the centre of the oval, which is the point directly overhead.

2. **Name three bright stars visible in the sky tonight.** The brightest stars are represented by black dots. The bigger the dot, the brighter the star. Here are a few bright stars identified on the star finder: Sirius, Vega, Altair, Deneb, Aldebaran, Rigel, Betelgeuse, Antares, Regulus, Arcturus, and Polaris.

3. The Big Dipper is visible every night of the year, but its orientation and position change according to the season. Here is the approximate position of the Big Dipper in the evening depending on the season, as seen in this image:



4. **Name an interesting celestial object (in a small circle) visible tonight.** Several objects are visible to the eye or with a small instrument such as binoculars or a small telescope.These objects are circled on the star finder. Here are those indicated on the star finder:
    - Beehive Cluster, in the constellation Cancer
    - Orion Nebula, in the constellation Orion
    - Pleiades cluster, in the constellation Taurus
    - Mira, a variable star in the constellation Cetus
    - Double Cluster, between the constellations Perseus and Cassiopeia
    - Andromeda Galaxy, in the constellation Andromeda
    - Coathanger Cluster, between the constellations Cygnus and Aquila
    - Hercules Cluster, in the constellation Hercules
    - Polaris, in the constellation Ursa Minor
    - Mizar and Alcor in constellation Ursa Major

5. **Draw the constellation Cassiopeia. In what region of the sky is it visible tonight?** The constellation Cassiopeia looks like a W. Depending on the time of the year, it can also look like an M or be on its side. It's visible in the northern part of the sky, but its exact position varies from northeast to northwest or almost at the zenith.

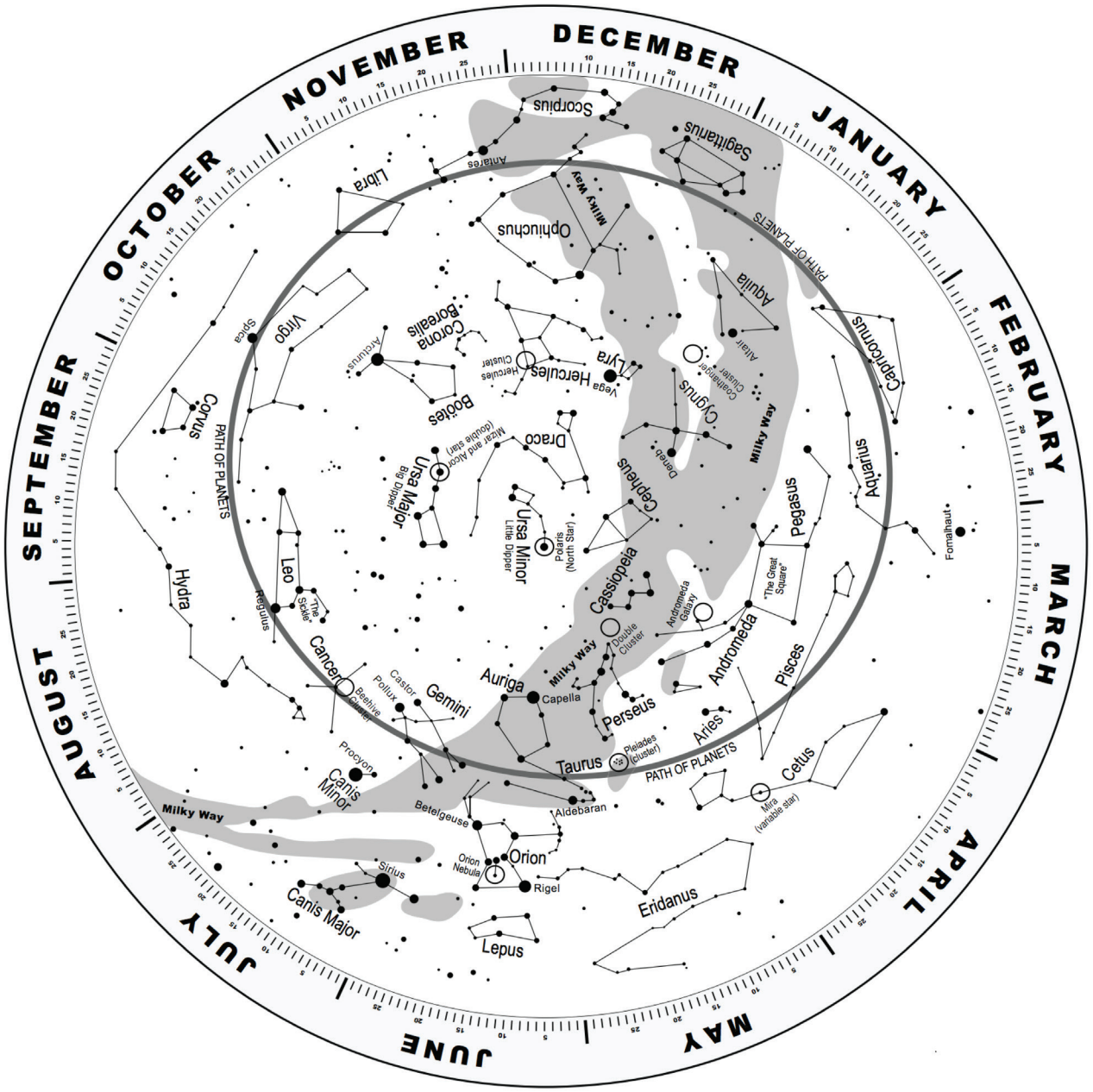
6. **Name three constellations which are in the band of the Milky Way.** These constellations are found along the grey band representing the Milky Way: Canis Minor, Canis Major, Gemini, Orion (in part), Auriga, Taurus, Perseus, Cassiopeia, Andromeda (in part), Cepheus, Cygnus, Aquila, Lyra, Ophiuchus, Sagittarius, Scorpius.

7. **Imagine we look at the sky on March 20 at 8pm. We can see the stars in the same positions at other combinations of dates and times. At what time of the night do we need to look to see the same sky as the one on March 20 at 8pm if today's date is a) January 20? b) November 20?** If you configure the star finder to show the sky on March 20 at 8pm, you may notice that other date/time combinations will show the same sky. You simply need to read off the time aligned with January 20 and you can find 12am. On November 20, you would need to look around 4am to see the same stars and constellations.

REFERENCES

This activity is based on the star finder developed by the Royal Astronomical Society of Canada with the accompanying site www.star-finder.ca.

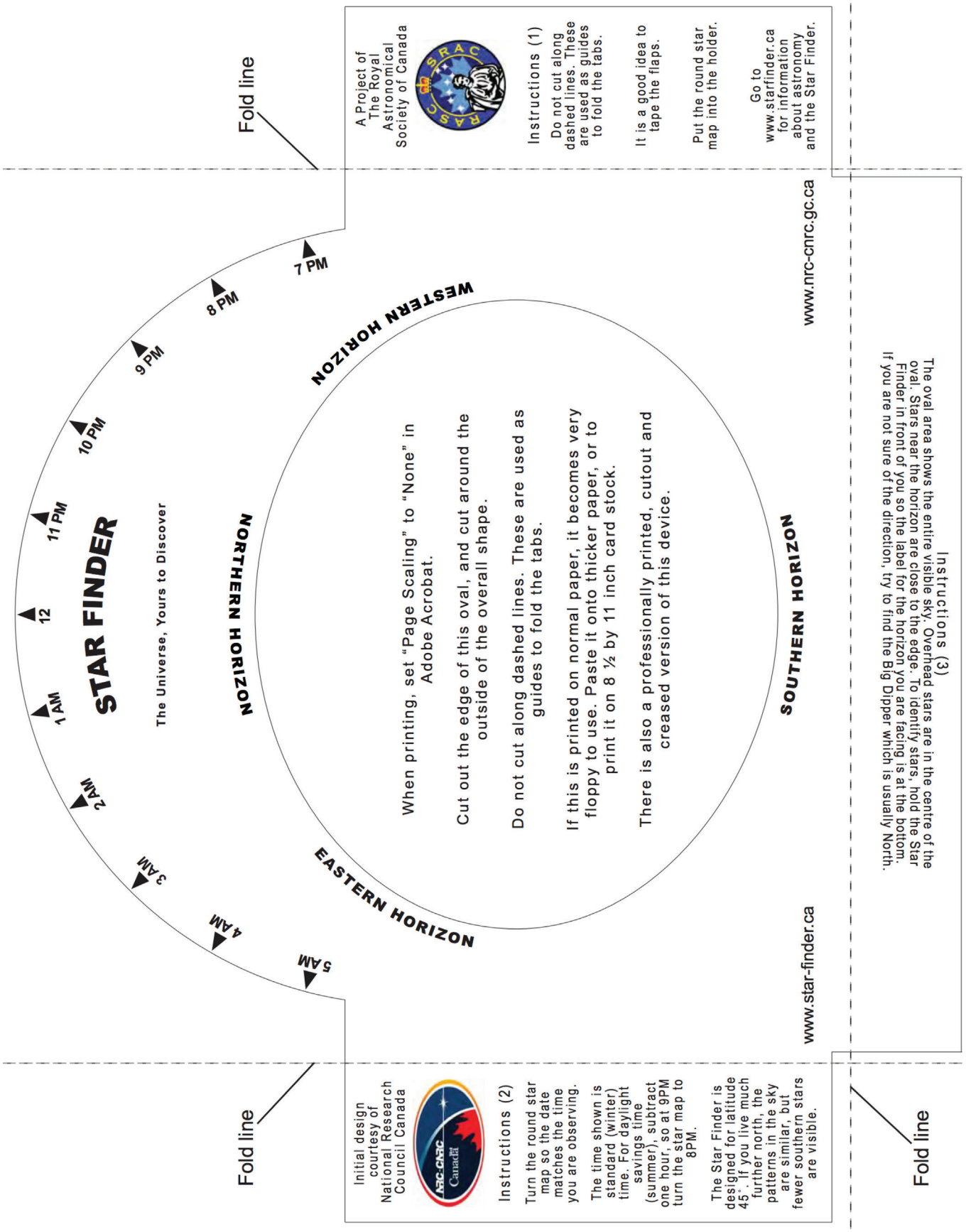
STAR FINDER - PART 1



Instructions:

- When printing, set “Page Scaling” to “None” in Adobe Acrobat.
- Carefully cut around the outside of the circle.
- The round star map fits inside the holder after the flaps are folded back.

STAR FINDER - PART 2



Name: _____

ACTIVITY WITH THE STAR FINDER

Align the star finder to see the sky tonight at 8pm and answer the following questions.

1. Name three constellations visible in the south at 8pm tonight.

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2. Name three bright stars visible in the sky at 8pm tonight.

_____

_____

3. The Big Dipper is the main part of the constellation Ursa Major. Where is this constellation tonight? If you look in this direction, draw the Big Dipper as you would see it in the sky. Now, align the star finder to show the sky 6 months from now. Where is the Big Dipper now? Draw it and compare your two drawings.

4. Name an interesting celestial object (in a small circle) visible tonight?

_____

5. Draw the constellation Cassiopeia. In what region of the sky is it visible tonight?

6. Name three constellations which are in the band of the Milky Way.

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7. At what time of the night do we need to look to see the same sky as the one on March 20 at 8pm if today's date is a) January 20? b) November 20?

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ACTIVITY 8

GLOBE AT NIGHT

Grades :	Level of preparation:	Student groupings:	Length:	Location of activity:
6 and higher	**advanced**	**individual**	**30 minutes in class, then 15 min at home**	**at school and at home**

BRIEF DESCRIPTION

Students participate in the international citizen-science campaign Globe at Night, which invites participants to measure light pollution in their area city and to share this data with scientists.

LEARNING GOALS

- Become familiar with a constellation visible in the sky at a particular time of the year.
- Knowing the effect of light pollution on the night sky.
- Participate in an international citizen-science project.

MATERIALS

- Visit www.globeatnight.org to find the necessary documents.
- It is not necessary to print the activity guides with the star charts since everything can now be done directly through their online app: https://www.globeatnight.org/webapp/

INTRODUCTION

Globe at Night is a citizen-science project which allows everyone to contribute to scientific research. The goal is to create a global map of light pollution thanks to measurements people each make in their area.

The observation itself only takes 15 minutes. Just find the constellation used as a reference for the observation period and compare your view with the provided constellation maps. The fewer stars visible in the constellation, the greater the light pollution and the lower the limiting magnitude of your site.

WHAT IS MAGNITUDE?

The magnitude is a measure of the brightness of a star, as we see in the sky. The brighter the star, the lower its magnitude. Therefore, a star with a magnitude 3 is fainter than a star with a magnitude 0. The brightest star at night, Sirius, even has a negative magnitude of -1.5. This is a somewhat strange scale that has evolved since its origins in Ancient Greece when the stars were classified into six levels, starting from Class 1 - the brightest – to class 6 - the faintest. Since then, the scale has evolved to include brighter objects with negative numbers. The human eye can see stars up to a magnitude of about 6.

The maps used indicate the limiting magnitude, or brightness, of the faintest star seen in a constellation. A sky with a limiting magnitude of 5 indicates that it is possible to see the stars with magnitude 5, which is very faint, and all stars with lower magnitudes. This site therefore offers a very black sky with little light pollution. Conversely, a sky with a limiting magnitude of 1 makes it impossible to see stars fainter than 1. This is a sky with a lot of light pollution.

PREPARATION

- Visit the Globe at Night website to determine the observation period. Several campaigns are planned throughout the year during periods without a bright evening Moon.
- Familiarize yourself with the documents related to the constellation chosen for the campaign: observation guide, online form for submitting the data

METHOD

- Introduce the project to the students and invite them to observe the proposed constellation and to enter their data in the online form. Make sure to discuss the concepts of light pollution and magnitude with them.

- To make it easier for the students to recognize the constellation in the sky, this activity could be preceded by the activity 7 on the star finder.

- During the observation period, make sure to regularly discuss the activity in the classroom and to remind them to make the observation at home in the evening. What results did they get? Are there any difficulties?

Here are **some ideas to push the activity further**:

- Explore the mythology of the constellation. Do not hesitate to research the stories associated with this constellation in different cultures, such as the ones from different Indigenous communities in Canada.

- Discuss issues related to light pollution. See "Additional Information" below for more details.

- It is also possible to analyze the data collected during the Globe at Night campaigns. Graphs and maps are available on their website: http://www.globeatnight.org/maps.php

ADDITIONAL INFORMATION.

Light pollution is a problem that affects much more than our view of the night sky. Its impacts are numerous: wasted energy and money, effects on our health, negative impacts on ecosystems, glare, and security. More and more studies are done on the subject and many Canadian researchers are world leaders in this field. Here are two good Canadian resources for more information on the subject:

- Light-Pollution Abatement from the Royal Astronomical Society of Canada: www.rasc.ca/lpa
- Mont-Megantic Dark Sky Reserve: http://ricemm.org/en

APPENDIX 1

REFERENCES AND ADDITIONAL RESOURCES

TEACHING ASTRONOMY IN GENERAL

(collection of activities to download or purchase)

- **Skyways Astronomy Handbook for Teachers**: http://www.rasc.ca/skyways-explorons-lastronomie
  Published by the Royal Astronomical Society of Canada

- **Universe In A Box**, activity kit (downloadable guide) from Universe Awareness : http://www.unawe.org/resources/universebox/

- **Universe at your Fingertips**, DVD with activities and information produced by the Astronomical Society of the Pacific: https://www.astrosociety.org/education/the-universe-at-your-fingertips-2-0/

- List of **outreach resources from the Night Sky Network**, NASA, https://nightsky.jpl.nasa.gov/download-search.cfm

THE MOON AND ITS PHASES

- Video - **Phases of the Moon** : http://youtu.be/iF8k9ibNKo8

- **Animation on the motions of the Earth and the Moon**, produced by the Centre for pedagogical development: http://cdpsciencetechno.org/cdp/UserFiles/File/previews/earth/

- **International Observe the Moon Night** - http://observethemoonnight.org/

THE SUN

- **Solar Science**, book produced by the National Science Teachers Association, https://www.nsta.org/store/product_detail.aspx?id=10.2505/9781941316078

THE STARS

- Downloable **star finder** with information: www.star-finder.ca

- Video - **How to use a star finde**r : http://youtu.be/BgqICmDIT9c

- **List of constellations**, Wikipedia , http://en.wikipedia.org/wiki/88_modern_constellations

APPENDIX 2

NOTE TO PARENTS

Copy and modify as needed.

Hello,

As part of astronomy activities covered in class, your child will need to make some observations of the sky. These observations only take 5 minutes each time, but we ask your help to make sure they do so safely.

To observe the sky, your child will have to go outside (during / after) sunset. Some observations should be repeated a few times (night after night / this month / ...) to observe the changes in the sky. It is therefore important that your child always makes his/her observations from the exact same location. We invite you to help your child find a safe place which offers a beautiful view of the sky with the horizon as clear as possible. By observing the sky with them, you may discover things which were unknown to you.

Thank you for encouraging your child in their discovery of the universe!

Teacher