ACTIVITY 3 - SECONDARY SCHOOL ACTIVITY KIT

In an Astronomer's Shoes

School Level	Preparation Time	Duration
End of elementary[1], secondary, college,	20 minutes (For printing cards)	1 period (60 or 75 minutes) or more
Keywords: planets, sun, solar system, exoplanet, star, planetary system, galaxy, astronomical unit, light-year, night sky, constellation, conditions essential to life, life like us, communication.		

BRIEF DESCRIPTION

In this activity, students will explore known exoplanets and select one they would like to investigate further using the James Webb Space Telescope (JWST). Just like professional astronomers, who must justify why and how they want to observe a celestial object, students will craft a formal request for observing time, explaining their choice and the significance of their investigation.

LEARNING GOALS

- Model the work of astronomers and gain insight into the profession.
- Explore the diversity of exoplanets, their planetary systems, and their unique characteristics.
- Consider the planetary conditions that support the development or survival of life as we know it.
- Develop familiarity with the local night sky and the apparent motion of celestial objects.

MATERIAL

- *Observing Time Request* – print one for each learner or team (see pages below).
- *(Optional)* A computer or tablet for each student or team to consult online references and databases.
- *Exoplanet Cards* – printed and laminated if desired (PDF). A set can be shared among a group or multiple groups.

  If printing the cards is not possible, consider these alternative sources for exoplanet data:
  - Interactive web tool: *Eyes on exoplanets* (site link, compatible with mobile devices). We created this tutorial video (~7 min) to help you learn it (YouTube).
  - Exoplanet catalogs: NASA (site link), the *Open Exoplanet Catalog* (site link) or Exoplanet (available on the Apple Store).

[1] This activity was designed for the secondary school level, but we believe it can be easily adapted for primary schools (from about 10 years old) by simplifying the expectations and concepts covered in class.

- Online encyclopedias: Wikipedia's *List of Potentially Habitable Exoplanets* and other related sources.

MULTIMEDIA AND WEB TOOLS

- Interactive web tool *Stellarium Web* (website, also available on mobile devices). A short tutorial (YouTube) is available to familiarize yourself or students with its use. Another tutorial shows how to know when a constellation is visible (YouTube).
- (optional) *Glossary* (Google Doc)
- (optional) Presentations: Our Solar System (Google Slides), Exoplanets (Google Slides), How do we find exoplanets? (Google Slides), Life... Here and Beyond! (Google Slides).
- (optional) The Canadian Space Agency's official James Webb Space Telescope page (site link), which includes a large list of videos about this telescope (site link).
- (optional) ExoBites video series (English CC), especially those related to the work of astronomers:
  - ExoBite 5 — Telescopes of the Future (YouTube)
  - ExoBite 6 — The Modern Astronomer (YouTube)

  As well as those related to exoplanets:
  - ExoBite 1 — An Exoplanet Zoo (YouTube)
  - ExoBite 2 — Earth 2.0 (YouTube)
  - ExoBite 3 — Alien Life (YouTube)

Quebec School Curriculum

Competencies from the Science and Technology curriculum

- Make the most of your scientific and technological knowledge (Skill 2);
- Communicate using the languages used in science and technology (Competency 3).

Progression of Learning in Science and Technology

- Compare certain characteristics of the planets in the solar system (ST 1 & 2, Earth and Space, C2a);
- Define the astronomical unit as a unit of length corresponding to the average distance from the Earth to the Sun and the light year as a unit of length corresponding to the distance travelled by light in one Earth year (ST 3, Earth and space, C3a i and ii);
- Compare the relative distances of various celestial bodies (e.g. stars, nebulae, galaxies) (ST 3, Earth and Space, C3a iii);
- Describe the conditions that favour the development or maintenance of life (e.g. presence of an atmosphere, water, a source of energy) (ST 3, Earth and space, C3b).

Digital Competency Framework

- Exploiting the potential of digital technology for learning;
- Digital collaboration and communication.

Note: The curriculum guideline connections provided here are specific to Québec, but they can serve as a valuable resource for teachers across Canada and beyond. Educational standards and objectives often share commonalities nationwide, especially in Grades 6 and 9. We hope these guidelines can inspire and assist educators outside of Québec in incorporating these activities into their own classrooms, enhancing lesson plans and engaging students in STEM in meaningful and relevant ways, regardless of their location.

INTRODUCTION

To learn more about galaxies, stars, and planets, astronomers need to study them with telescopes both on the ground and in space. One of the most powerful telescopes humanity has created is the James Webb Space Telescope (JWST), designed by scientists and engineers from all over the world, including Canada. To obtain observations of celestial objects (images, spectra, etc.) with this telescope, astronomers must submit requests for observing time.

This process is competitive: many astronomers want to use the same telescopes, and the number of requests always exceeds the number of observation hours available. For example, the James Webb Space Telescope received four times as many requests as hours available in its first call for proposals and eight times in the second call! Astronomers therefore need to convince a committee of their peers (often referred to as a "time allocation committee", or TAC for short) that the observations they request are worth making (more than those of others!) by justifying what they want to do and why, and by providing all relevant information.

In this activity, learners will simulate this real-world process in a simple and fun way! They will be asked to choose an exoplanet they'd like to observe, justify their choice (for example, because it's likely to support life as we know it), and provide details of the observation (date, position in the sky). These technical details will help learners familiarize themselves with the night sky and its apparent movement throughout the year (i.e. why we don't see the same stars in winter as in summer).

PREPARATION

- Print the *Request for observation time* pages in black and white, double-sided for each learner or team of learners.
- Print the *Exoplanet Cards*, ideally in colour and on cardstock, cut them out and laminate them (optional). A series of cards can be shared between a few learners or groups of learners. These cards can be used from year to year, shared within a school and used for other purposes. If it's not possible to print the cards, other options are available in the materials section.
- Make sure you have access to computers or tablets connected to the Internet, so you can consult tools such as "Eyes on Exoplanets", online encyclopedias, and Stellarium Web. Ideally, each learner should have his or her own device. However, the online components of this activity can also be carried out in small groups.

STEPS

Part 1: Review & Introduction to the Activity

- If necessary, review certain terms (planet, star, exoplanet, planetary system, galaxy, etc.) and basic concepts (rotation, revolution, orbital period, astronomical unit, light-year). The *Glossary* document and/or the presentations listed in the materials section may facilitate this.
- Watch one or more ExoBites videos to introduce JWST and the astronomy profession (ExoBites 5 and 6 are particularly relevant to this activity), as well as exoplanets (ExoBites 1, 2 and 3 are also relevant).
- If desired, give a more detailed presentation of JWST, using the Canadian Space Agency's website or a video (see materials section). Explain that in order to observe with humanity's most powerful telescopes (like JWST), astronomers must fill out an application for observing time. A committee of other astronomers then reviews the applications and selects the best ones for allocating observing time on the telescope.
- Make sure learners are familiar with the conditions that foster the development of life or support life, if the emphasis is on this topic.
- Explain that today they will step into the role of an astronomer who wants to study exoplanets. They must choose an exoplanet and fill out an observing time request, justifying why this exoplanet should be studied with the James Webb Space Telescope.

Part 2: Completing the Request for Observing Time Form

Alone or in teams, learners follow the steps below to complete their Request for Observation Time:

1. **Select a Target for Observation**

   Use the *Exoplanet Cards* or an alternative to select an exoplanet.

   > **Note:** This activity naturally focuses on exoplanets that could potentially support life. Learners can use what they know about conditions favourable to life to justify their choice.

2. **Justify Your Choice**

   Using the information provided on the card and additional online resources, students will explain why their chosen exoplanet is a strong candidate for study with the James Webb Space Telescope (JWST).

   > **Note** : If the focus is on potentially habitable exoplanets, students can ask themselves::
   > - Is this exoplanet rocky?
   > - Is it located in the habitable zone—the right distance from its star to potentially have liquid water?

- What other factors might indicate conditions suitable for life? (e.g., presence of an atmosphere, a moon to stabilize its orbit, a magnetic field to shield it from harmful radiation, etc.)

3. **Determining the Observation Requirements**
   When filling out a request for observing time, astronomers must indicate when (i.e. date, time) observations can be made. Learners can determine where their target is in the sky by finding out which constellation it's in (either via Stellarium or by searching the web) and when this constellation is visible in the night sky (using Stellarium or other similar apps)[2].
   A short tutorial to help with this step is available (YouTube).

Part 3 (Optional): Peer Evaluation of Observing Time Requests

To make the activity even more authentic, students can evaluate each other's Observing Time Requests, just like real astronomers do!

- In small groups (3–5 students), participants will read and assess multiple requests written by their peers.
- As a group, they will select the most compelling request(s) and explain their reasoning to the class.
- This mirrors how astronomers work—real Time Allocation Committees (TACs) review all proposals and decide which ones get valuable telescope time!

Tip: If doing this step, encourage students to use a fictitious name on their application, keeping the process anonymous—just like real JWST proposals.

ADDITIONAL ACTIVITIES

- Complete *Activity #4 - Where are the aliens?* (Google Doc) to spark discussion on the possibility of intelligent life elsewhere in the Universe.
- Watch any remaining *ExoBites* videos (YouTube, with English subtitles) and use the *Viewing Guide* (Google Doc).
- **Watch the video series:** *Exoplanets and Us* (YouTube, with English subtitles).
- Check the *Frequently Asked Questions* (Google Doc) or invite students to explore it if they're curious to learn more!

[2] *In reality, the James Webb telescope is in space! The telescope naturally has access to a slightly different portion of the sky than we have access to here on Earth. For simplicity's sake, however, it's claimed here that the constellation is visible at the same time from the ground as it is from JWST. The video Webb's field of Regard prepared by the Space Telescope Science Institute (YouTube) provides more info on this specific topic.*

GOING FURTHER

- Create a video and vote! Encourage learners to create a video explaining why their chosen exoplanet deserves to be observed. Organize a contest where, like real scientists, they vote as a community for the most compelling exoplanet.
- Stay up to date with scientific discoveries. Invite students to explore recent exoplanet research, particularly work done by local astronomers. The *Trottier Institute for Research on Exoplanets* website is a great resource for this.
- Observe the sky firsthand. Encourage students to engage with the night sky by:
    - Watching a sunset or sunrise.
    - Spotting the Moon and noting its different phases.
    - Identifying well-known constellations like the Big Dipper or Orion.
    - Observing planets in our Solar System.
    - Using *Stellarium Web* to check what's visible in their location at different times of the year.
    - **Bonus challenge:** Adapt Challenge - Exploring the Sky... and Exoplanets! (originally designed for elementary students) for older learners to deepen their connection to the night sky.

REMOTE LEARNING OPTION

This activity can be conducted remotely. All resources are available online and can be done individually at home.

SOURCES AND INSPIRATION

This activity is taken from the Secondary School Activity Kit created as part of the Exoplanets in the Classroom project, led by the Trottier Institute for Research on Exoplanets at the Université de Montréal Faculty of Arts and Science, in collaboration with Discover the Universe, École en réseau, the Association pour l'enseignement de la science de la technologie au Québec (AESTQ) and a number of school staff, thanks in particular to funding from the NovaScience programme of the Quebec Ministère de l'Économie, de l'Innovation et de l'Énergie.

Request for Observing Time
James Webb Space Telescope

Applicant Information
Team Name:

Target Information
1. Exoplanet Name:
2. Why should the James Webb Space Telescope observe this target rather than another? Is it a good candidate for finding life beyond Earth? If so, why do you think this is the case? If not, what is interesting or special about this target? To study an exoplanet in the highest detail with a telescope like JWST, it must also be as close as possible to our Solar System.

3. What question would you like to answer with further observations of this exoplanet? Think about what's currently unknown about this planet: presence of an atmosphere, composition of the atmosphere, presence of water, presence of one or more moons, presence of a magnetic field...

Observation Information

The James Webb telescope is in space, but to get used to spotting celestial objects, let's check where and when this exoplanet is visible in the night sky from Earth.

Tip: Use Stellarium Web to answer the following questions!

4. Where in the sky (constellation or coordinates) is this exoplanet? Search for your planet's star on Stellarium Web. If the star isn't listed, do a quick web search to find out which constellation it's in. Then search for that constellation in Stellarium. You can also click on the star and note its celestial coordinates.

5. Write down your city and country. Is this exoplanet visible in the sky over your city tonight? If so, where is it located? If not, indicate a time and a place from which it will be visible.

Example

Request for Observing Time
James Webb Space Telescope

Applicant Information
Team Name: *Cassiopeia*

Target Information
1. Exoplanet Name: *Trappist-1d*
2. Why should the James Webb Space Telescope observe this target rather than another? Is it a good candidate for finding life beyond Earth? If so, why do you think this is the case? If not, what is interesting or special about this target? To study an exoplanet in the highest detail with a telescope like JWST, it must also be as close as possible to our Solar System. *This planet is an excellent candidate in the search for life as we know it! It is similar to Earth in size and mass. It's probably rocky like Earth. Its star is much smaller than our Sun (and less hot), but the planet is also much closer to its star, so it's sure to receive enough heat.* *What's more, it's relatively close to Earth (41 light-years)!*

3. What question would you like to answer with further observations of this exoplanet? Think about what's currently unknown about this planet: presence of an atmosphere, composition of the atmosphere, presence of water, presence of one or more moons, presence of a magnetic field...

I'd like to know if this exoplanet has an atmosphere like Earth's, with oxygen? I'd also like to know: does it have a moon?

Observation Information

The James Webb telescope is in space, but to get used to spotting celestial objects, let's check where and when this exoplanet is visible in the night sky from Earth.

Tip: Use Stellarium Web to answer the following questions!

4. Where in the sky (constellation or coordinates) is this exoplanet? Search for your planet's star on Stellarium Web. If the star isn't listed, do a quick web search to find out which constellation it's in. Then search for that constellation in Stellarium. You can also click on the star and note its celestial coordinates.

This planet is located around the star TRAPPIST-1, in the constellation Aquarius.

5. Write down your city and country. Is this exoplanet in the sky over your city tonight? If so, where is it located? If not, indicate a time and a place from which it will be in the sky. Although the James Webb Telescope is in space, let's simplify the situation and check where and when this exoplanet is visible in the night sky from Earth.

From Montreal (Canada), this constellation is visible on November 11, 2024, around 7 pm, in the south.