National Aeronautics and Space Administration

Let's Discover New Frontiers!

Educator Guide

Goal: This activity is designed to introduce audiences to exploration aspects associated with NASA missions that have collected samples from other objects in our Solar System and returned those samples to Earth as part of NASA's Discovery and New Frontiers exploration programs.

Objectives: Audiences will:

1. Gain awareness of three NASA sample return missions.
2. Identify five aspects associated with each mission including: 1) Target Solar System Object, 2) Mission Spacecraft, 3) Sample Collector, 4) Collected Samples, and 5) Did You Know? which includes an important and interesting piece of information related to the exploration mission.
3. Design their own sample return mission (time permitting).

Audience Level: Can be used with general audiences ranging from kids through adults. [Note: Classroom Teachers may consider using this activity as part of a science night or science day set of activities with students divided into multiple groups (in a single classroom) or as an individual activity station.]

Time Requirements: ~15+ minutes to facilitate at an activity station. [This is a minimum amount of time for participants to complete the game board activity. It does not include designing their own sample return mission.] Additional time is encouraged to discuss and share information about each mission and to engage audiences with additional resources associated with these missions (see Activity Procedure Parts 3A & 3B).

Materials:

- *Let's Discover New Frontiers!* game board [26" X 38" poster]: 1 per group of ~4 participants
- *Mission Cards*: 3 cards per mission category [15 total cards]: 1 set per group of ~4 participants. [**NOTE**: Print document double sided and flip on the short side. Once printed, fold and cut each page in half so you have cards with the image on the front and associated information on the inside when you open the card.]
- *Mission Category Title Cards* (optional as a top/title card for each *Mission Card* category) Mission categories/title cards include:
  - Target Solar System Object
  - Mission Spacecraft
  - Sample Collector
  - Collected Samples
  - Did You Know?
- *Mission Design* Handout: 1 per participant; 1 per pair; or 1 per group of ~4 participants
- Colored pencils or crayons (optional)

Useful Websites for Additional Background Knowledge:

- NASA Discovery Program: https://science.nasa.gov/about-us/smd-programs/discovery

- NASA New Frontiers Program: https://science.nasa.gov/about-us/smd-programs/new-frontiers
- Solar System Exploration and NASA Science: https://solarsystem.nasa.gov/
- NASA Astromaterials Acquisition and Curation Office: https://curator.jsc.nasa.gov/

Introduction and Background

NASA exploration missions advance the scientific understanding of our Solar System in extraordinary ways. Once a solar system body has been initially observed and is found to be scientifically interesting enough, it becomes a candidate for robotic exploration missions. The progression of robotic exploration generally begins with a flyby mission. If the data and observations obtained increases the target body's scientific interest, exploration may continue with an orbiter mission, a lander and/or rover mission and sometimes progresses to a sample return mission in which samples are collected and returned to Earth. Samples returned to Earth as part of these sample return missions are extraordinary assets that enable scientists to conduct laboratory research which helps ground truth (support and validate) remotely sensed data obtained by robotic spacecraft. All extraterrestrial samples collected and returned to Earth as part of NASA missions (past, present, and future) are curated at specialized facilities at the NASA Johnson Space Center (JSC) in Houston, TX.

This activity focuses on three NASA Discovery and New Frontiers Sample Return Missions (Stardust, Genesis, and OSIRIS-REx). Discovery and New Frontiers missions are classes of missions that are part of NASA's solar system exploration portfolio. NASA Discovery missions are missions designed to complement NASA's larger planetary science explorations. These missions are generally smaller, require fewer resources and have shorter development times than other exploration missions. NASA New Frontiers missions tackle larger and more specific solar system exploration goals identified by the scientific community.

Stardust, a NASA Discovery Mission, was the first space mission dedicated to studying a comet and the first mission to return solid extraterrestrial samples to Earth since the final Apollo mission in 1972. The spacecraft launched on February 7, 1999 and collected interstellar dust as well as cometary dust particles during a close encounter with comet Wild 2. The return capsule returned to Earth on January 15, 2006. Samples are curated at NASA JSC.

Genesis, a NASA Discovery mission, was a mission designed to send a spacecraft to collect and return material from the Sun (solar wind samples). The spacecraft launched on August 8, 2001 and orbited a unique point called a Lagrange point (L1) between the Earth and the Sun for 884 days collecting solar wind. The return capsule returned to Earth on September 8, 2004. Upon return to Earth, the Genesis sample return capsule had a hard landing as the parachute did not deploy. Despite the hard landing, the samples were recovered and are still valuable assets useful for scientific study. Samples are curated at NASA JSC.

OSIRIS-REx, a NASA New Frontiers mission, was the first United States led mission designed to bring samples from an asteroid back to Earth. OSIRIS-REx is an acronym that stands for **O**rigins, **S**pectral **I**nterpretation, **R**esource **I**dentification, **S**ecurity-**R**egolith **Ex**plorer. The spacecraft launched on September 8, 2016 and officially arrived at asteroid Bennu on December 3, 2018. After conducting remote sensing observations of Bennu, the spacecraft will collect samples (summer of 2020) and will return to Earth in September 2023. Samples will be curated at NASA JSC.

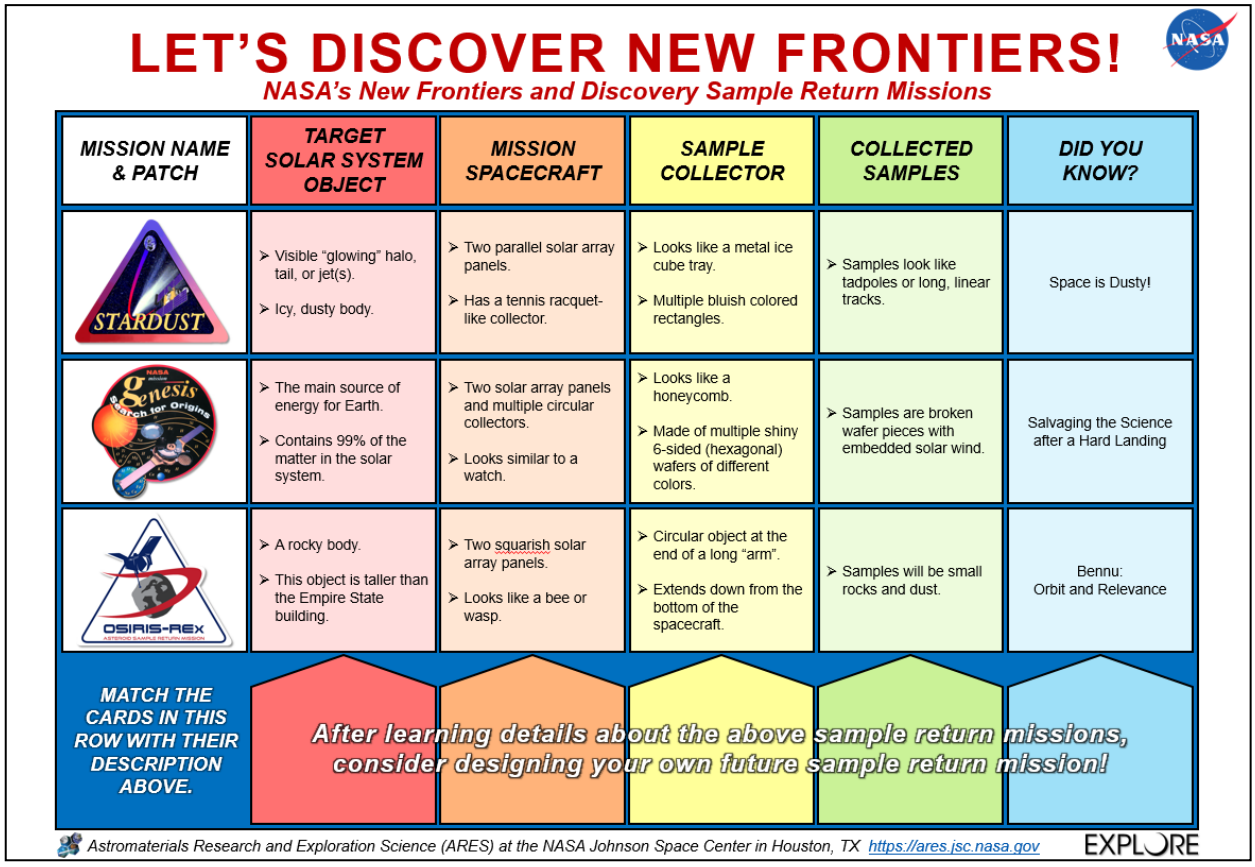
ACTIVITY PROCEDURE

This activity procedure is provided as a suggested guide and can be modified to meet your specific needs.

PART 1: ACTIVITY INTRODUCTION

Materials needed:

- *Let's Discover New Frontiers!* game board (1 per group of ~4 participants)



LET'S DISCOVER NEW FRONTIERS!

NASA's New Frontiers and Discovery Sample Return Missions

MISSION NAME & PATCH	TARGET SOLAR SYSTEM OBJECT	MISSION SPACECRAFT	SAMPLE COLLECTOR	COLLECTED SAMPLES	DID YOU KNOW?
STARDUST	➢ Visible "glowing" halo, tail, or jet(s). ➢ Icy, dusty body.	➢ Two parallel solar array panels. ➢ Has a tennis racquet-like collector.	➢ Looks like a metal ice cube tray. ➢ Multiple bluish colored rectangles.	➢ Samples look like tadpoles or long, linear tracks.	Space is Dusty!
Genesis Touch for Origins	➢ The main source of energy for Earth. ➢ Contains 99% of the matter in the solar system.	➢ Two solar array panels and multiple circular collectors. ➢ Looks similar to a watch.	➢ Looks like a honeycomb. ➢ Made of multiple shiny 6-sided (hexagonal) wafers of different colors.	➢ Samples are broken wafer pieces with embedded solar wind.	Salvaging the Science after a Hard Landing
OSIRIS-REx	➢ A rocky body. ➢ This object is taller than the Empire State building.	➢ Two squarish solar array panels. ➢ Looks like a bee or wasp.	➢ Circular object at the end of a long "arm". ➢ Extends down from the bottom of the spacecraft.	➢ Samples will be small rocks and dust.	Bennu: Orbit and Relevance

MATCH THE CARDS IN THIS ROW WITH THEIR DESCRIPTION ABOVE.

After learning details about the above sample return missions, consider designing your own future sample return mission!

Astromaterials Research and Exploration Science (ARES) at the NASA Johnson Space Center in Houston, TX https://ares.jsc.nasa.gov EXPLORE

To begin, it is important to provide context to participants about solar system exploration missions and the activity. Let participants know that NASA has been exploring our Solar System for decades and as part of that exploration, some missions bring collected samples from a target solar system body back to Earth. These missions, referred to as sample return missions, are very valuable in that they allow scientists to study the collected samples with laboratory equipment which helps ground truth (support and validate) remotely sensed data obtained by robotic spacecraft. This ultimately helps scientists gain insight into the history and evolution of the target object of exploration as well as our Solar System as a whole. In this activity, participants will learn about three sample return missions (Stardust, Genesis, and OSIRIS-REx) and will explore five aspects associated with each mission. These aspects include: the target solar system object, the mission spacecraft, the sample collector, the collected samples and an interesting fact about the mission (*"Did You Know?"* category). [Point out each category of information on the game board as you provide this introduction.]

PART 2: ACTIVITY SET UP AND INSTRUCTIONS

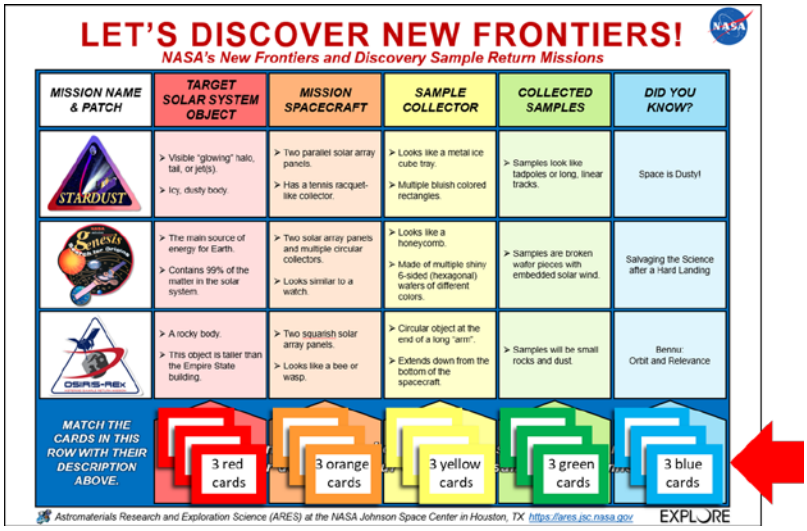
Materials needed:

- *Let's Discover New Frontiers!* game board (1 per group of ~4 participants)
- *Mission Cards*: 3 cards per mission category [15 total cards] (1 set per group of ~4 participants; *Mission Category Title Cards* are optional.)

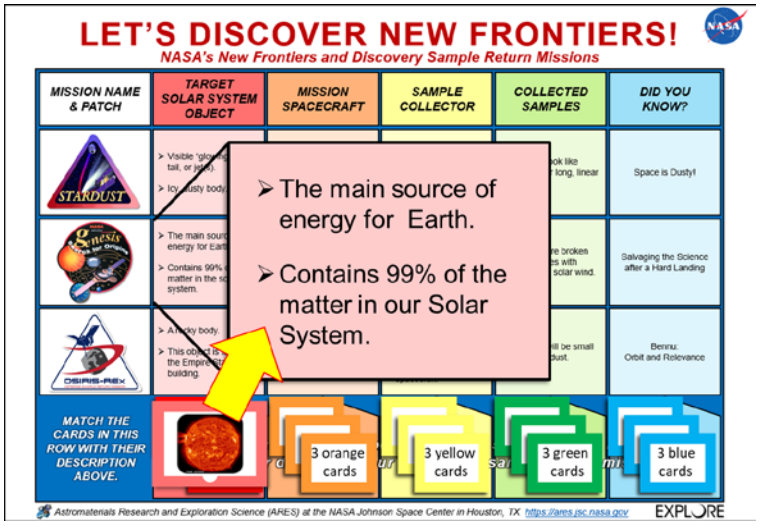
After providing context about the activity (Part 1) but before you have participants investigate the *Mission Cards*, go over the activity set up and instructions provided below so participants will have an idea of what they will do.

GOAL: Have participants: 1) Place each *Mission Card* in the square on the game board that best describes the picture on the specific card; ***and*** 2) Read the information provided on each card (depending on age level).

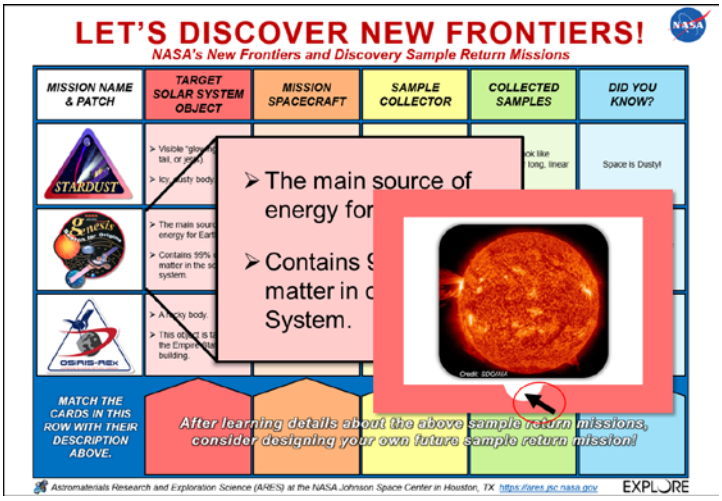
1. Place the *Mission Cards*, according to category (noted by the border color of the cards), in the bottom row of the game board. There will be 3 cards in each colored space along the bottom row. (Note: Have the cards already placed on the board if you are facilitating this at an activity station. If working with multiple groups simultaneously in a classroom-like environment have the cards organized but don't distribute them before going over the instructions. Include the *Mission Category Title Card* (optional) as the first card in each category to help participants know which cards go with which category.)



2. Let participants know they should read the information in each square on the game board and match it with the *Mission Card* picture that best fits the description. They will then place that *Mission Card* on its corresponding square on the game board. Demonstrate as necessary.



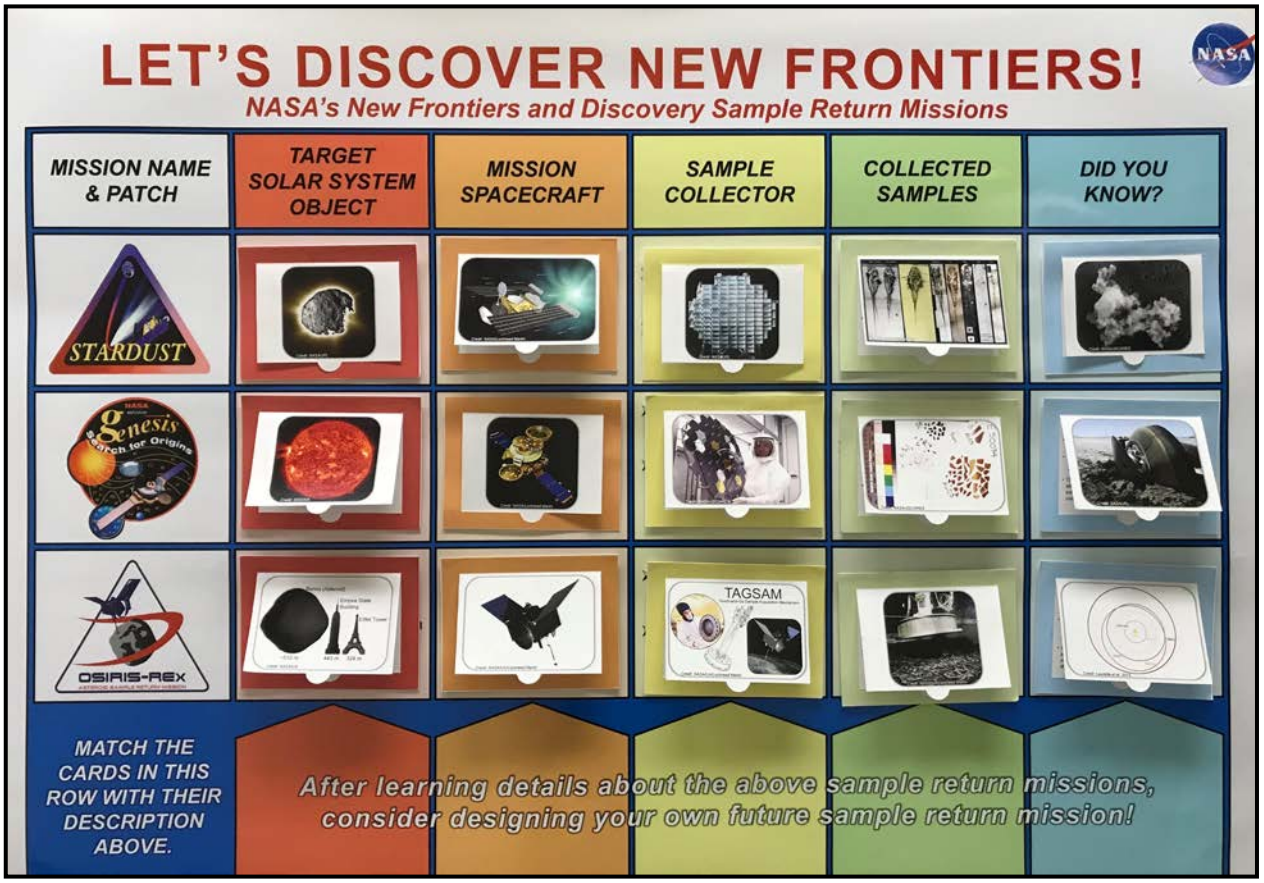
3. Encourage participants to lift the tab/open the card to read additional information.



Once you have gone over the activity set up and instructions, have participants complete the activity.

<u>Reminder</u>: The goal is to have participants: 1) Place each *Mission Card* in the square on the game board that best describes the picture on the specific card; *<u>and</u>* 2) Read the information provided on each card (depending on age level).

The image below shows the completed board with cards placed in their correct locations on the board.



PART 3A: REINFORCING PARTICIPANT KNOWLEDGE GAIN (Summary of Missions)

Materials needed:

- Completed *Let's Discover New Frontiers!* game board and *Mission Cards*.

Once participants have completed placing the *Mission Cards* on the game board, encourage them (depending on their age level) to read the information provided within each card. Quiz participants on information to reinforce and test information learned about each mission. Example questions might include: "Which mission collected and returned samples from the Sun?"; "Which collected samples are atomic in scale?"; "What is the name of the material used to capture the samples collected as part of the Stardust Mission?"; "What is the name of the asteroid being investigated as part of the OSIRIS-REx Mission?" Consider having participants create their own questions. Alternatively, consider having participants write interesting facts about the missions on post-it notes and place those post-it notes in an area for participants to share interesting facts and their knowledge gained with others.

Note: The OSIRIS-REx mission spacecraft launched in September 2016 and samples are expected to be returned to Earth in 2023. If using this activity between 2016 and 2023, discuss the current status of the mission or encourage participants to investigate this on their own. For the most up to date information on the mission go to: https://www.asteroidmission.org/.

PART 3B: ADDITIONAL ACTIVITY REINFORCEMENT RECOMMENDATIONS

A powerful addition to this activity can be to have additional display materials and/or hands-on resources available for your event participants to explore after completing and reviewing the information on the game board. This might include sharing 3D printed models of one or more of the exploration aspects associated with these missions; sharing a spacecraft model; using *NASA's Eyes on the Solar System* tool to view the journey of the spacecraft and mission; sharing an image or sample of aerogel; providing information and access to collected samples or sample catalogs; and/or sharing videos about the exploration missions. Sharing additional and engaging hands-on materials and/or resources associated with these missions helps provide an even greater appreciation and understanding of the missions. It can also help reinforce design principles and important aspects related to each mission that participants can consider when designing their own mission in Part 4 of this activity.

Optional resources and links to consider:

- NASA 3D Models and Resources: https://nasa3d.arc.nasa.gov/models
- NASA's Eyes on the Solar System: https://eyes.nasa.gov/
- Aerogel: https://stardust.jpl.nasa.gov/tech/aerogel.html
- Genesis Solar Wind Samples: https://curator.jsc.nasa.gov/genesis/index.cfm#
- Stardust Samples: https://curator.jsc.nasa.gov/stardust/index.cfm
- OSIRIS-REx Samples: Coming soon at https://curator.jsc.nasa.gov/

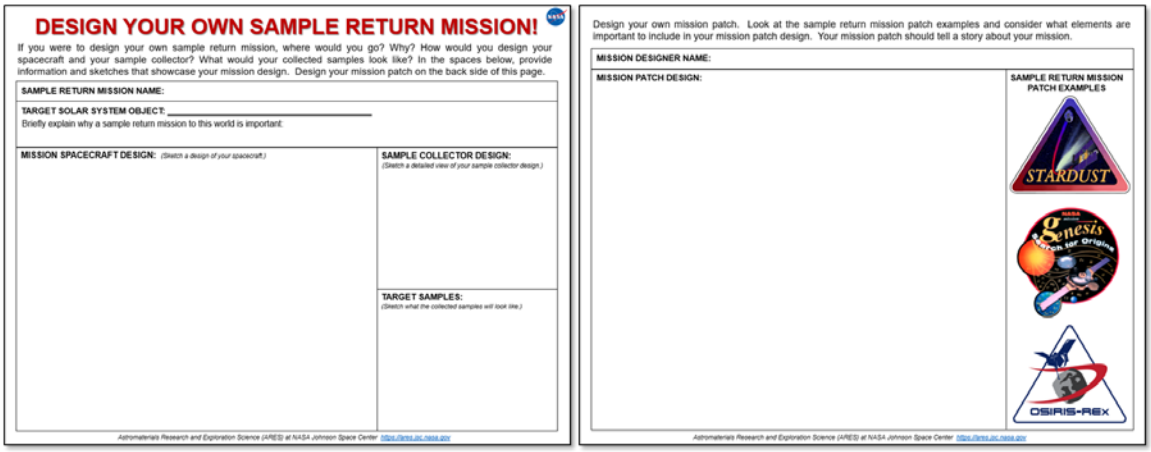
Mission related video resources:

- Genesis: https://youtu.be/K5q60jDs2Jg
- Stardust: https://nasaeclips.arc.nasa.gov/video/ourworld/our-world-stardust
- OSIRIS-REx*:* https://svs.gsfc.nasa.gov/10793

PART 4: DESIGN YOUR OWN SAMPLE RETURN MISSION

Materials needed:

- *Mission Design* handout (1 per participant; 1 per pair; or 1 per group of ~4 participants)
- Colored pencils or crayons (optional)



DESIGN YOUR OWN SAMPLE RETURN MISSION!

If you were to design your own sample return mission, where would you go? Why? How would you design your spacecraft and your sample collector? What would your collected samples look like? In the spaces below, provide information and sketches that showcase your mission design. Design your mission patch on the back side of this page.

SAMPLE RETURN MISSION NAME:

TARGET SOLAR SYSTEM OBJECT: _____

Briefly explain why a sample return mission to this world is important:

MISSION SPACECRAFT DESIGN: *(Sketch a design of your spacecraft.)*

SAMPLE COLLECTOR DESIGN: *(Sketch a detailed view of your sample collector design.)*

TARGET SAMPLES: *(Sketch what the collected samples will look like.)*

Astromaterials Research and Exploration Science (ARES) at NASA Johnson Space Center https://ares.jsc.nasa.gov

Design your own mission patch. Look at the sample return mission patch examples and consider what elements are important to include in your mission patch design. Your mission patch should tell a story about your mission.

MISSION DESIGNER NAME:

MISSION PATCH DESIGN:

SAMPLE RETURN MISSION PATCH EXAMPLES

STARDUST

Genesis Search for Origins

OSIRIS-REx

Astromaterials Research and Exploration Science (ARES) at NASA Johnson Space Center https://ares.jsc.nasa.gov

After discussing the Stardust, Genesis, and OSIRIS-REx sample return missions, discuss ideas with participants related to designing their own sample return mission. Discuss questions with participants such as: Where would they go? Why? How would they design their spacecraft and sample collector? Etc. Provide a *"Mission Design"* handout to each participant (or group of 2-4 participants or family members) and have them design their own **sample return** mission. Encourage participants to get ideas and use design principles from what they learned in the activity. Also encourage participants to think outside the box and be creative.

Depending on time and space constraints, provide the mission design handout to participants to work on or to take with them to design their mission at a later time.