FarFarOut!

Flowers of the Sky

Volume 3, Issue 1 March 2024

STARSociety
South Texas Astronomical Society

Editorial

"What are you? From where did you come? I have never seen anything like you." The Creator Raven looked at Man and was... surprised to find that this strange new being was so much like himself.

The Eskimos asked some very interesting questions, as evident in this excerpt of one of their creation myths. I like asking questions about life in the universe as well. We often talk about searching for 'aliens' or intelligent life out there, but what about plants, fungi, and other ecosystems? How does plant life on Earth differ to what could be out there? Also, why are plants green, and more importantly, why don't we see many green things out there in the universe? It appears that life is very special, and green is intimately connected with the only example of life that we know. As a child, I asked questions such as these, and I wondered what life on other worlds would be like. I was just as interested in the possible plant and fungal life as I was in walking (and maybe talking) beings. As I got older, I realized that the color of the Sun played a role in the color of chlorophyll, the chemical responsible for the conversion of light into energy for the life of plants (and also responsible for their green color). Maybe plants, on other worlds orbiting other stars of different colors, would exhibit different colors as well. Maybe the combination of a unique star, atmosphere, and other particularities of the environment would add up to some interesting biomes and lifeforms. I encourage you to come up with your own unique configurations and see where your imagination takes you.

In this issue of FFO, we present to you the constellations and stories of the spring night sky, including why bears have stumpy tails, and a modest, yet beautiful... cup! We introduce to you a new column, recollections of a wannabe astronaut, a treasure trove of space exploration knowledge. We also introduce our first fantasy piece, one that explores distant memories and the magic of the Chalchiutli Forest. We delve into the complexities of creating settlements on the Moon, and explore the history of searching for the presence of life on Mars. Finally, we drop a few puns, talk about seasonal sky events, and leave a collection of fun activities and art for the kids.

Wishing you clear skies,

Richard Camuccio
Editor-in-Chief

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STARSociety

South Texas Astronomical Society

Want to get involved with the South Texas Astronomical Society? STARS is now hosting a Monthly Meetup every first Monday of the month at the Southmost Public Library in Brownsville, open to all who are interested in becoming a part of the Rio Grande Valley's growing community of space exploration enthusiasts! Other recurring programs to expect this year include:

- **Astronomy at the Park**, a public star party at the UTRGV Cristina Torres Memorial Observatory
- **NASA ASTRO CAMP**, a hands-on STEM program for young explorers and families (previously Space, Science, & STARS)
- **STARS on Tap**, space science presentations and trivia hosted at local bars
- **Cup o' Cosmos**, informal astrophysics discussions at Angelita's Casa de Cafe

To stay up-to-date with these and other upcoming events, please visit starsocietyrgv.org/events!

The *South Texas Astronomical Society (STARS)* is a nonprofit organization connecting the Rio Grande Valley community to space and science.

Our Mission is to ignite curiosity in the RGV through space science education, outreach programs, and by serving as a liaison between community members and space organizations and resources.

Our Vision is that STARS nurtures the innate human desire for exploration and discovery by fostering connections to science and the cosmos across the RGV.

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Carol's Corner of the Cosmos

Carol Lutsinger

MARCH officially welcomes spring on the 19th, thanks to February having 29 days this year. Do you feel spring-y now? Time to put away those dark winter shoes and pull out the white, right? Oh, does that bring back memories! Nowadays we wear whatever color we want any time of the year and no one thinks twice about it. Fashions change; planets visible in the sky change, but seasonally the constellations repeat regularly year after year. Over thousands of years their shapes have changed, and will continue to change, but we won't be around to see that so don't think about it today. Instead, become familiar with our versions of them.

Have you seen the Big Dipper asterism standing straight up to the northeast? The two stars at the front of the bowl are called the Pointer Stars because they point directly toward Polaris, the North Star, down about halfway to the horizon. Many thousands of years from now this will no longer be the shape of these stars as seen from our planet, and another star will be the north star. Alkaid, the star at the end of the handle, is moving down and to the right; Dubhe, the star at the top of the bowl, is also. However, the rest of the stars are moving together up and to the left.

And if you are wondering what the difference is between an asterism and a constellation, simply put, the asterism is a secondary discerned pattern of stars within the parameters of the mathematical designation of the area enclosing a constellation, such as the stars that comprise the Big Dipper asterism within the Ursa Major region.

Astronomers have been hypothesizing this change in appearance of star patterns because of the colors seen through a spectroscopic study which indicates by color whether stars are either "red-shifted" or "blue-shifted". Stars and galaxies that are moving away from us are said to be "red-shifted", while those moving toward us are "blue-shifted", as explained by the laws of physics. For those middle school and high school students who are reading this, I encourage you to sign up for all the math and science courses possible. Major universities expect you to have already had these classes and you will be far more ready for the rigorous courses if you take them while still in high school! Your choices of higher education sites will be far greater.

APRIL 8th of course brings us another incredible opportunity to enjoy a solar eclipse. If you have not purchased safe viewing solar eclipse glasses, hurry! The path of totality crosses Texas from the Dallas area to Eagle Pass. We here in the RGV will be experiencing the partial eclipse. As 'ordinary' as our star is to us, it is always an interesting astronomical object to explore.

Have you noticed where the Sun appears above the horizon now? Our daylight hours are extending and will continue to do so until the summer solstice. This motion of the Sun along the horizon is a fascinating phenomenon to observe – at least it is if one is *slightly* excited about astronomy. I hope you are observing the solar motion along the horizon as you are driving east or west, as this is a basic tenet of the horizon-based astronomy of ancient Amerind cultures. East/west streets are a perfect place to observe the daily motion of our star. You may want to make up stories to share with your family about why the Sun follows this pattern as did the ancient societies. The local libraries are wonderful sources for stories about the workings of the universe as explained by early cultures.

About ten P.M. Leo the Lion may be found rising in the SE. Leo is located very close to the point in the sky where the imaginary line of the ecliptic passes. The ecliptic is the Sun's (and Moon's and planets') apparent path through the heavens. You may notice a change in this path as we are now enjoying spring. The Sun is higher in the sky at noon, although it is not at the zenith; that only happens at the equator. Most of the time we tend to take our star for granted. But think about this: at an average 93 million miles away, it is in exactly the right place for us, and all other living things on our planet, to survive quite nicely. As an "average" star, it is a main sequence star, and is expected to burn steadily for billions of years. Pretty special to us Earthlings!

At nightfall if you go out and stand with your right shoulder toward where the Sun rose in the morning and your left shoulder where the Sun set in the evening, then your nose will be pointing north – unless you have turned your head! Lift your gaze to stare straight into the Big Dipper asterism emptying into the Little Dipper. At this time of the year the Milky Way galaxy plane is flat along the horizon and Earth is standing straight up and down in it. Great weather for stargazing, but not many stars or constellations to see!

The front stars in the bowl of the Big Dipper are the "pointers" that lead directly to the North Star, Polaris. This constellation is so easy to see we almost see it instinctively and recognize it instantaneously. All the major stars are named in this constellation. Beginning with the handle star there is blue-white Alkaid, which is the farthest away of the group at 210 light years distance. Mizar and Alcor are a pair of stars that come next; early civilizations sometimes called this pair the horse and rider. Next in is Alioth, the nearest star at 70 light years. There are five stars that are an actual cluster, all being nearly the same distance from Earth, 80 light years. These are Mizar and Alcor, along with three of the bowl stars, Megrez, Phecda, and Merak. The final bowl star is called Dubhe and it is just beyond the cluster at 105 light years. This orange giant star is quite different from the others in the asterism.

In case you are interested, Dubhe means "bear" and Merak means "loin of the bear", which is understandable that they would be so named by ancient Arabic astronomers who were familiar with mythology referring to bears.

Although the stars do move, these are moving together and they maintain their proper motion in relation to one another throughout many thousand years. Of course, over hundreds of thousands of years there is a major change!

Ursa Major encompasses the Big Dipper and is home to many galaxies, including M81 and M82. M81 is about seven million light years away, and is a great example of a spiral galaxy. M82 is a puzzle and a strong source of radio energy.

In MAY, check the northeastern skies this week for golden Arcturus, blue-white Spica, and the constellation Corvus. Can't see them? Remember the mnemonic clue – *"Follow the arc [of the Big Dipper handle] to Arcturus, spike to Spica, and carry on to Corvus."* The Chicago World's Fair in 1933 used the light from Arcturus to light the opening events of the Fair. Light was focused through a telescope to a photocell which triggered the switches that turned on the lights, the type of photocell that turns on water faucets automatically.

Have you noticed the changing position of the Big Dipper over the past several weeks? This marks the passing of the seasons for us just as it did for ancient civilizations. It is possible to judge the time of night as well, so don't try to miss curfew if the sky is clear with the excuse, "I didn't know it was so late."

Stars to enjoy in the west within ten minutes of sunset this week include golden Capella in the constellation Auriga, the Charioteer, and Procyon, the brightest star in Canis Minor. Turning right to the north will show the Big Dipper high in the sky, pouring its contents into the Little Dipper, surrounded by the drifting stars of Draco, the Dragon.

If you think the name Draco sounds familiar, aside from it being a character in the Harry Potter books, it is also the name of the cargo ship from Elon Musk's company that is being used by NASA to deliver crew and cargo to the International Space Station. For a schedule of ISS flyovers in your night sky, there are apps for all cell phones and NASA has a website that will send emails or texts alerting interested persons the opportunities to see the star-like ISS crossing overhead [1].

Until next issue, DO let some stars get in your eyes and KLU! ★

References

[1] B. Keeter and J. Keaton, *Sighting Opportunities*, Spot The Station: International Space Station, NASA (2023)
https://spotthestation.nasa.gov/home.cfm

Biography

Carol Lutsinger is the founder of the South Texas Astronomical Society. She spent 40 years as a teacher, serving students from Pre-K through college. Carol attributes her astronomy enthusiasm in part to her experience in the American Astronomical Society's AASTRA program from 1994-96, and her space excitement from serving as a Solar System Educator, and later Ambassador, for the NASA/JPL program. She has been writing the Stargazer newspaper column since 1998, which is carried in the Brownsville Herald and the Valley Morning Star. Retired from formal education since 2020, she still makes every opportunity to share meteorites which she carries in her purse and to ask folks in parking lots if they know what that point of light is.

Crater (or ***Krater***)

"The Cup"

This constellation is a ceramic cup. It was commonly used in ancient Greece for mixing wine and water.

The Recollections of a Wannabe Astronaut

Stephen J. Camuccio

As I approached my 70th successful circuit around the Sun, I remembered what one of my grandchildren asked me. "What did you want to be when you grew up?" I said an Astronaut! Which was followed by "Why?" It brought me back to May 5, 1961 — the day I fell in love with the space program.

I was six years old and was oblivious to what was going on in the world other than I knew the President was John F. Kennedy. My father said to me that morning, "I want you to watch the rocket launch today. An American is going into space. It is history." My mother had the black and white TV on, and at 9:34 am on a bright and sunny day, Alan B. Shepard lifted off the pad and into history. This historic flight lasted 15 minutes, but left an impression on me for a lifetime.

I was hooked! I drove my parents crazy with the countdown, saying "10, 9, 8, 7, 6, 5, 4, 3, 2, 1, Liftoff!" constantly. My memory of that small rocket with one man on board was one of wonder. The world of science fiction was now real. The next flight was another sub-orbital flight that I also watched. Then the big event. Putting an American in orbit. The Russians had already achieved this, but as a red-blooded American, ours would be the first "Free" man in orbit.

This flight was delayed numerous times and I would hear the news from my room on the TV in the living room. The reporter kept mentioning that "John Glenn" would have to wait again. It was confusing because my next door neighbor was named John Glenn. My father explained. When the flight did occur, it was even more impressive. I was in school and we were in the auditorium watching the three orbit flight on TVs that were wheeled in. There was a moment when NASA thought the heat shield was loose and Glenn may not survive re-entry. The teachers asked that we say a prayer for our astronaut and the rest is history.

I never missed a launch through the Mercury, Gemini, and Apollo programs. I've collected books, magazines, newspapers, video, and audio of the missions. I've made scale models of all the spacecraft. I hope to bring to you my recollections, impressions, and technical knowledge from what I've amassed.

If you're wondering why I did not become an astronaut. That's a story for another time. ★

Biography

Stephen J. Camuccio hails from Philadelphia, PA (Go Eagles!). He attended Community College of Philadelphia and Drexel University, and received an associate degree in mechanical engineering. Stephen worked in careers spanning several domains, including restaurants, insurance, and automobile sales (the latter starting with Saturn cars, named after the Saturn V Moon rocket, not the planet). He is currently retired... sort of. His hobbies include building scale models of spacecraft, amateur astronomy, and deep sea fishing. Stephen is married, a father of four, and a grandfather of eight.

Forgotten Factors: The Complexities of Creating a Lunar Settlement


Lizzie Flores & Raul Marquez

When you picture a Moon civilization, what do you envision? Bubbles of facilities connected through trails to rovers like *The Martian*? Maybe an ISS-esque station orbiting with scheduled trips to the surface? Ideas like these are fun to explore, but a complete analysis of what exactly defines a civilization reveals that this is much more complex than you're probably thinking of. What materials can be used to create the facilities? What levels of government are needed to run another body in space, and how do international considerations affect this? Do you really have to rely on poop to grow crops? Our group of students at the Science Academy of South Texas sought to answer these questions and more in April of 2023 at the Cities In Space competition in Austin, Texas. We presented an in-depth, 20-page paper and Revit model of a settlement we created to a panel of scientists and engineers and were awarded first place for our efforts. For those interested, the paper in its entirety with references is linked at the end of this piece, but for now, here is a condensed version of just about everything a bunch of high school seniors could research with the help of our school library.

1. Architecture, Energy, and Support

Creating structures on the Moon requires much foresight into the many issues posed by its surface and atmospheric conditions. Days on the Moon are stretched around 30 days and temperature gradients can range from -150 degrees Celsius to 150 degrees Celsius due to the lack of atmosphere, and the lack of a magnetic field and ozone layer does not prevent gamma radiation and meteorites from breaking into the surface of the Moon. In addition to the environmental struggles posed, colonies require an astronomical amount of resources to maintain order, ranging from food growth, healthcare accessibility, adaptive resourcing, and many other factors. A colony should not only be able to exist on the Moon, but thrive in a facility that is located and built to provide for all needs possible.

1.1. Location

Satellites, such as the Lunar Reconnaissance Orbiter, have taken many photos of the lunar surface and mapped out the optimal locations for habitation and the start of lunar operations. Although future investigation may indicate more optimal conditions for colonization, our conceptual lunar base will be built upon a crater, after considerations from energy consumption and travel. Our chosen location, the Shackleton Crater, receives a lot of sunlight throughout the year that is ideal for providing Earth-like conditions and stimulating endorphin production.

1.2. Construction Materials

In order to construct each compound, a material must be light in weight, readily available on the Moon, provide protection from gamma radiation, and maintain fluid pressure. A material such as concrete can use lunar regolith as an aggregate, as it contains high calcium content. Scientists have already examined the properties of "lunarcrete" and found not only does it contain the previously aforementioned properties, but it provides additional resistance to temperature gradients and can become airtight with the use of an epoxy. In order to produce concrete on the Moon itself, water can be extracted from the ice present in the Shackleton Crater. Lunarcrete also has high tensile strength useful in construction and has the durability to protect our base from small-scale meteorites that cross the

Moon.

1.3. Oxygen

The decrease in atmospheric pressure on the Moon relative to Earth would have detrimental effects on civilians' health with unprotected exposure; this extreme change nearly makes an uninhabitable space for a colony to settle. However, we planned for a concrete shell around the colony, as well as a fluid recycling system, to allow for an oxygen generation system that generates hydrogen as a byproduct; this is executed through a process called electrolysis. Another method that is easily accessible on the Moon is extraction of oxygen from the Moon's soil. This method utilizes a form of electrolysis called "molten salt electrolysis", where both hydrogen and oxygen stabilize the pressure, effectively making it comparable to atmospheric pressure on earth, given our controlled environment.

1.4. Architecture

When designing the building, the first thing that was taken into consideration was the shape of the building. The building is in the shape of squares, as they are universally easy to fit into each other with little issue. The main hub for civilians are the residential halls, planters, and public areas. Residential halls are styled after college dormitories, with private bedrooms but open living spaces, and public facilities such as libraries and community halls to provide variety in activity with ready accessibility. It is important to create semi-private yet public areas within cities to promote a sense of community, which is why these facilities are mixed. Subunits connect between these for travel. They are designed to be as low and confining as possible not only to maximize space, but to be sealed at moments notice in case of an emergency breach. In our city, all transportation has been relegated to foot traffic to promote exercise and mitigate pollution issues. The standardized grid systems provide additional benefits in that the structures are easily replicable and easy to join to the rest of the structure.

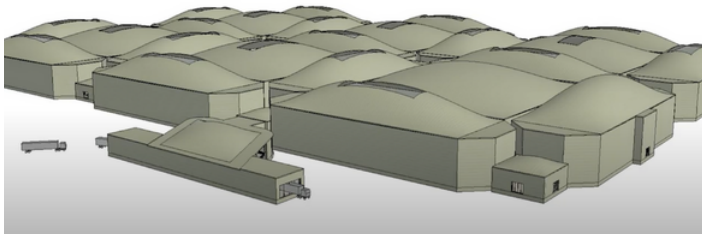

Figure 1. Our Revit design of Abeona. Not pictured here are the outer facilities, solar panels, and surrounding crater.

It was important to the designers to place as many residential units as close to the parks and community centers as possible. It was also important to try and move residents away from possible noxious uses, such as storage units and agricultural centers. These noxious uses can create disturbances for any passerby. These facilities were concentrated and separated from the rest of the residential halls to minimize a decrease in quality of life. Additionally, the public warehouse, which will store all materials and food for the colony, and the primary medical center are positioned as close to the transport hub as possible to be easily accessible for situations such as storing materials immediately when they are shipped in and taking in patients from emergency situations.

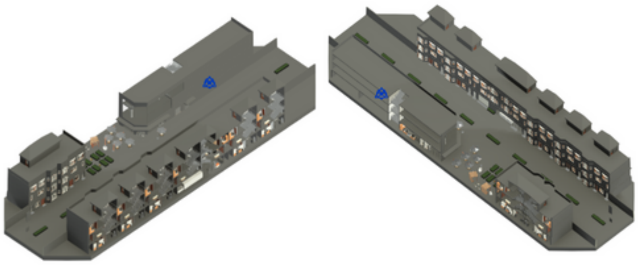

Figure 2. Revit Interior of Residential Unit. Living facilities are stacked in three stories, with public facilities close by and greenery along walking paths

1.5. Energy Placements

Accounting for utilities, the process of electrolysis, and climate control utilizing the water recycling system, ECLSS, Abeona's colony requires a total of 12,885 kWh per day for absolute necessities. Given this statistic, Abeona requires 1,611 solar panels, each being 2 kW, to function properly. Collectively, the solar panels take up slightly less than five acres; this is the planned size of our building dedicated to farming, making it the most adequate contender for placement. The space required for every solar panel accounts for the spacing needed between each individual solar panel, as they have contraction periods throughout the day. This additional spacing allows for more efficient energy conversion, ensuring energy is retained. Energy for a high functioning lunar colony is a primary concern, however, another integral aspect of the colony is reaping the benefits of lunar transit for allocation to Earth. There are a plethora of valuable resources on the Moon that are otherwise unavailable to collect efficiently on Earth, such as the mining of rocket fuel from lunar ice. This process of converting lunar ice to hydrogen and oxygen can be done through electrolysis. The liquefaction of hydrogen to create rocket fuel takes only 0.419 kWh/kg, as it involves a low temperature environment with proper insulative properties that are possible within Shackleton Crater.

1.6. Cost and Construction

Each hexagonal compound constructed requires around 720,000 cubic feet of concrete, and, when multiplied by the 17 buildings and converted to cubic yards, it is approximated to 450,000 cubic yards in total. Since each cubic yard of concrete is two tons, the total weight of concrete is 900,000 tons of concrete. According to Cement-Plants.com, an Earth concrete factory costs $20,000 per ton of concrete, thus bringing the cost to create the concrete to $17.4 billion dollars. Our buildings are around 1000 square feet per square building and 4000 square feet for square compounds when multiplied the amount of each they equate to around total 17,000 square feet and 24,000 square feet for the six hexagonal buildings. In comparison, Amazon fulfillment centers are constructed in two years and require 800,000 square feet in size; therefore, the minimum time to create these buildings will be around two years. However, transportation of workers, living conditions, and complications with construction will expand our operations further than a stadium or warehouse, so this timespan is highly tentative.

1.7. Human Support

Due to the overwhelming changes in circadian rhythms, exposure to unfamiliar environments, and overall lack of entertainment will lead to adverse health side effects. Abeona has established therapeutic institutions to help people transition and alleviate any internal dilemmas they may have. This, along with Abeona's entertainment center, will be the methods for treatment of mental health.

2. Anthropology & Economics

Living on Abeona should not bar its inhabitants from experiencing the typical life of someone on Earth; maintaining a society that not only preserves the cultural experience of the United States but provides the resources for it to evolve into its own subculture was vital in determining our layout of the compound and designing its multiple features.

2.1. Government & Politics

Abeona will operate under a commission form of municipal government, in which the main factions of operation in the compound will have a representative that decides on their functions and interactions with other aspects of the compound. The first generation of people to arrive on the Moon will have a federally pre-determined representative for each faction for two years, after which they will be able to re-elect incumbents or vote in new ones every two years afterward. Only citizens of Abeona will be able to vote in these elections. Since the colony is assumed to be U.S. sanctioned, it will follow the rules and procedures of the U.S. Constitution and other federal laws and regulations.

2.2. Culture

Creating an environment that emulates life on Earth, but allows for the cultivation of a culture that is unique and exclusive to the Moon, is vital in gathering enough people to give up their lives at home and travel to parts unknown. The compound of Abeona was created around the idea of building a community, with the residential sectors of the compound containing several public establishments such as recreation centers, religious buildings, and working centers that will preserve a growing civilization in Abeona. In doing so, the residences will feel more like neighborhoods rather than a compound. Small recreational centers will be provided to allow for small gatherings and other events to be held for celebrations or other occasions. As for religious buildings, Abeona is abiding by the United States Constitution's First Amendment of allowing its residents to practice religious freedom in designated buildings. Libraries and work centers will be similar to that of a typical city public library where a range of activities can be done. Other amenities and services will be provided in each neighborhood, such as medical centers and groceries that can be used daily. The middle "squares" that are created inside the compound will primarily consist of two facilities: the innermost squares will contain the only school of the colony, and the outermost squares will contain grassy areas for public use.

2.3. Domestic Economy: Education

The three primary levels of education will be provided in Abeona, with an elementary school, middle school, and high school being connected in a

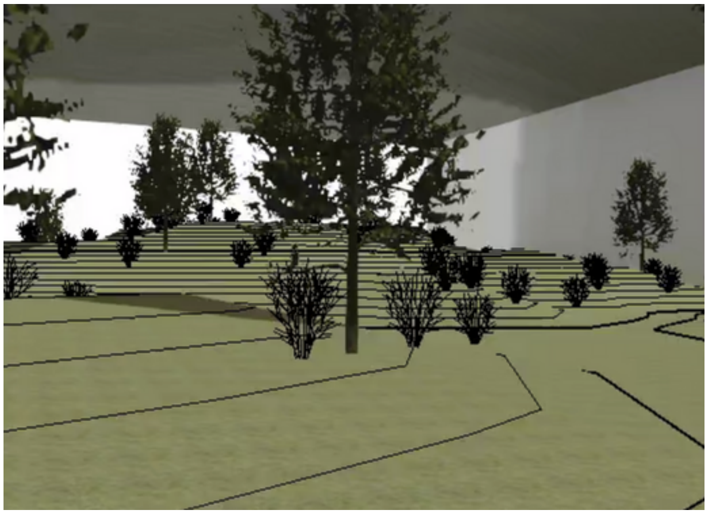

Figure 3. Revit rendering of the middle greenery areas that are enclosed by each outer residential sector. Weekly events, recreational amenities, and seating areas encourage residents to interact with greenery for improved psychology.

central square of the colony. One floor will be designated per level, with elementary on the first and high school on the third. Elementary and middle school courses will follow the standard of course requirements set in the United States, with core classes and electives making up their curriculum. High school students will have STEM-focused classes along with electives to prepare them for contributing to Abeona, with biosciences, engineering, and software development being major courses that are available to the students. Classrooms will hold a maximum of 25 students to prioritize safety, and daycare centers will be provided for families that seek daytime watching or early education for their toddlers and infants.

2.4. Resources & Trade: Foreign Economy

In order to secure funding for the operations aboard, the colony must be economically sustainable and independent or else operations aboard the Moon from private contractors or national space agencies will cease production. Luckily, the Moon has many viable forms of economic output in the large abundance of rare minerals, materials, and use of space for earth operations. Rocket fuel production will most likely be the largest export from the Moon base, with minerals and soil following.

3. Energy: Self Replicating Solar Factory

Currently, the climate problem on Earth is the biggest problem threatening human life. Solutions involving solar panels have been used to relieve fossil fuel usage; however, it is limited to the amount of area on Earth, day cycles, weather, and cost. Space solar power has been proposed to harness solar energy from the unblocked region of space and antennae the energy toward earth. Reflectors would concentrate the solar energy onto the solar panels and magnify the solar energy needs; the primary limiting factor of this project is the overall cost. However, self-replicating technology may solve this problem, but they require direct elemental composition, uniform composition, and ease of mining. These solar panels must have the ability to unfold and fold and be launched into geostationary Earth orbit by a mass driver. The components must also be able to arrange themselves to maximize the reflection and concentration of the Sun as they orbit Earth's surface and participate in refueling missions to the Moon. Either microwave transmission or lasers will solve any energy shortage problems as a form of cheap, efficient fuel. This power will be extremely cheap being able to a kWh at $0.00040 compared to $0.0951 of coal combustion. This can be an efficient economical solution to the energy crisis on Earth.

4. Food, Water, and Distribution/Storage

With extreme atmospheric conditions and a lack of food resources for animals, consistently and sustainably providing meats and other types of food is not viable. Due to this, inhabitants of Abeona will primarily have a plant-based diet. Maintaining agriculture requires large amounts of food and water, as well as viable storage, to support proper growth for human consumption.

4.1. Agriculture

Considering the environment and availability of nutrients on the Moon, hydroponics will be used to optimally cultivate herbs rather than using lunar soil for conventional farming. Hydroponics is a farming technique that uses water-based nutrient solutions. This method lays plants above the water, providing the plants' roots direct access to the water and nutrients, without the need for soil. This direct access allows plants to redirect their energy from searching for nutrients in soil into solely maturation. With direct access to nutrients, hydroponics is far more optimal for growing herbs compared to conventional farming methods, resulting in a 30-50% faster growth rate. Furthermore, using lunar soil and tilling does not allow for proper plant growth because lunar soil lacks essential nutrients such as nitrogen and contains several toxic metal elements for plants such as aluminum. However, lunar soil will still be utilized in the process of hydroponics. Despite lunar soil containing various toxic elements, it still consists of beneficial elements for plants such as iron and calcium. By extracting these from lunar soil, farmers can add these elements to the water strips in hydroponic farming to further boost herb growth.

Each person needs approximately five pounds of food daily, resulting in a required minimum of 912.5 tons of food annually. However, more of the food provided to the colony will be greens and herbs because they provide more vitamins needed in people's diets. As a result of the greater proportion of greens needed, hydroponics will be used more in comparison to aquaponics. On average, hydroponic farms have an output of 250 tons per acre and aquaponic farms have an output of 100 tons per acre. Using these proportions, on Abeona, hydroponics will supply 66.67% or two-thirds of foods through greens while aquaponics will provide 33.33% or one-third of foods through fruits. As a result, approximately 5-5.5 acres will be needed to build hydroponic and aquaponic farms to fit all dietary needs. To supply light, the rooms will use artificial direct sunlight via LEDs and redirected sunlight as a supplementary source. For other conditions such as pressurization, rooms will have adjustable pressure to accommodate certain types of fruits and vegetables.

4.2. Water Recycling

Water is an important tool for not only human survival but functionality for various aspects such as farming and forming lunarcrete. Transporting and importing water from the Earth to the Moon through supply ships is extremely expensive in the long term due to the weight of water. As such, to initially gather a supply of water, the colony will have to extract water from the ice craters present at the Moon. Because this colony is built in close proximity to the Shackleton Crater, finding a source of ice water will not be difficult as the crater has plentiful deposits of ice water. To extract the water, a viable method would be to use beamed microwaves. The microwaves can sublimate the ice water directly into a gas and capture a near 99% of the extracted water. Furthermore, using beamed microwaves eliminates the need for the colony workers to drill or mine into the ice water deposits. This not only reduces the need for more work and energy, but removes the possibility of dust interference. After using beamed microwaves to have an initial source of water, the colony will use a closed system of water recycling to ideally continually use the same supply of water for daily needs. This system first starts when people in Abeona use facilities that have running water such as a shower, sink, or a restroom. This water is then sent to a water processing unit where it is cleaned and filtered, allowing it to be reused for the same or different purpose. As another source, urine collected over time from people can also be recycled through a water processing unit. After being properly filtered, the clean water is equally transported to a water containment unit. Water containment units would be located on every large residential unit. From there, water can be freely used by the residents, regulated but as needed. Ultimately, the water generated from ice craters and urine will ideally be able to continually be recycled and reused throughout the colony.

4.3. Food Distribution

In order for people to have equal distribution of food throughout Abeona, food distribution centers will be located on each street, where food will be stored and shelved for people to take as needed. The centers will be continuously restocked in order to ensure people have adequate food supplies. The selection of foods available will aim to accommodate the dietary needs and restrictions of a Moon colony. For example, due to muscle atrophy formed from the microgravity conditions on the Moon, people on Abeona will have to eat more protein in their diet. As such, there will be more abundance of protein-rich foods like beans. Storage in these distribution centers will utilize ceramic containers; they are an ideal method of storage because they not only excel at preserving fresh food, but they are completely sustainable. When people want a certain grocery or food, they would take the ceramic container itself to their home. After they are finished with the foods, they would later return the container back to the distribution center for reuse. Recycling these containers produces no waste for storing and transporting food. This freedom and individuality for the people to choose what foods they want to eat and make allows for a greater diversity and palatability of the food consumed. People can make any food with the available foods on Abeona, effectively eliminating menu fatigue, which occurs when people view food as less palatable and tasteful because of food monotony.

4.4. Storage

The method of storage for food should not only be energy efficient but be able to retain the food's nutritional value. Typically in lunar travel, food would be stored through various means such as thermostabilization, freeze drying, and irradiation. Despite being able to store food for a relatively long period of time, these methods are not efficient at retaining many of foods' nutrients. Furthermore, these storage methods decrease the food's versatility resulting in menu fatigue. Abeona's availability of electricity will allow for fridges and freezers to be adopted to adequately store most foods without the danger of losing their nutritional value and palatability. These facilities would also be placed in a separate complex near by the main one to lessen noise pollution and maintain supply safety.

This, of course, is not a thorough, peer-reviewed research paper. Our ideas may have limitations we were not able to recognize, and there may be inconsistencies in our methodologies. After the competition, we aimed for this paper to be an organic piece of research that can be used as inspiration for more expansive ideas. Whatever the case, if there are any comments, questions, or criticisms, please feel free to contact us. What would science be without mistake and collaboration, after all? ★

References

Our original, 20-page essay with references presented to the judging panel:
https://drive.google.com/file/d/1ppQDBiYpWqxY_wSl_wywoVJIsLrV8qoe/view?usp=sharing

Our accompanying summary video:
https://youtu.be/bU5Dbs43I6o?si=e_JwGa_O0RmnFFuz

Biographies

Lizzie Flores is a sophomore undergraduate Physics and Astronomy student at the University of Texas Rio Grande Valley and a Dean's Excellence Research Fellow of the College of Sciences. They currently research under Dr. Mario Diaz in topics regarding observational astronomy and photometry. Their other research interests include supercluster formation, black hole evolution, and cosmology.

Raul Marquez is a junior undergraduate Mathematics and Physics student at the University of Texas Rio Grande Valley and treasurer of the UTRGV Math Society. He is currently mentored by Dr. Debanjana Kundu in topics regarding L-functions. His other research interests include number theory, elliptic curves, and combinations.

Life on Mars

Richard Pomeroy

Mars, the Bringer of War

Gustav Holst included it in his suite, David Bowie sang about it, H. G. Wells wrote about it, Percival Lowell thought he'd found it, conspiracy theorists see it in every rock and shadow, Matt Damon became it, and NASA has been looking for it for over 50 years.

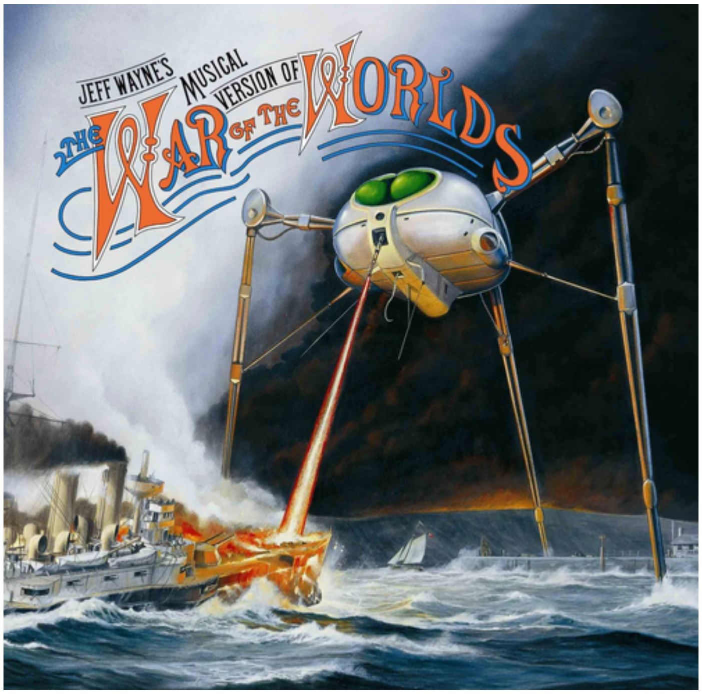

Figure 1. "The chances of anything coming from Mars, were a million-to-one they said..." Credit: Peter Goodfellow/Jeff Wayne/CBS.

The potential for life on Mars, what form it might take, and whether it is intelligent (and benign) has inspired the creative works of generations of musicians, artists, and writers alike, and the list goes on. Numerous versions of H. G. Wells' *War of the Worlds* have been produced, seemingly one for each new generation including the infamous 1938 Orson Welles radio broadcast, Jeff Wayne's 1978 album (Fig. 1), and Tom Cruise's 2005 film.

Other perspectives on Martian life have been proffered by Ray Bradbury's *Martian Chronicles*, Edgar Rice-Burroughs' *John Carter*, Jack Nicholson in *Mars Attacks*, and even Arnold Schwarzenegger's *Total Recall*, based on a Philip K. Dick short story, suggesting that life has in some way been possible on Mars in the past and might also be possible in the not too distant future.

The ancient Romans, Greeks, and Babylonians had no space missions or even telescopes to improve their view of Mars, but their perceptions were such that they could discern the red hue of the Martian sphere and they naturally associated the red planet with their gods of war: 'Mars', the Roman god of war; 'Nergal', the Babylonian god of fire, war, and destruction; the Greeks named it the 'star of Ares' after their god of war.

Schiaparelli's Canali

Although Mars is a bright planet and has been known since antiquity (1), it was only in the late 17th century that Dutch astronomer Christiaan Huygens trained his telescope on Mars and noticed the changing polar ice caps, due to Mars' axial tilt, occurring through the almost two (Earth) years it takes Mars to complete one orbit. At 24 hours and 37 minutes, the martian day was also noted to be comparable to a terrestrial day, and these similarities to Earth's life-supporting environment led to much speculation that Mars may be inhabited.

By the early 19th century, many astronomers believed that Mars (and interestingly, the other planets as well) may be inhabited. In the late 19th century when larger telescopes were being built, the Italian astronomer Giovanni Schiaparelli spent much time studying the red planet, and had sufficient resolution to be able to draw maps of the surface (see Fig. 2).

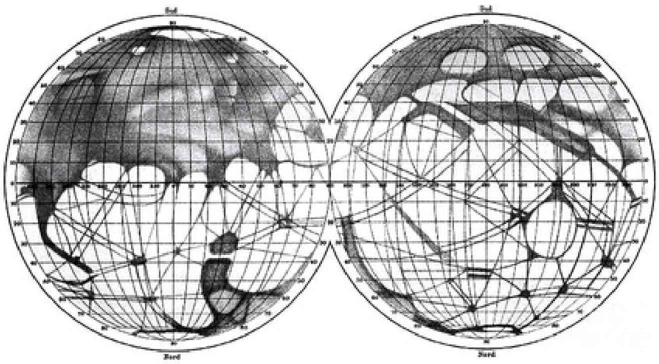

Figure 2. Giovanni Schiaparelli's map of Mars, from his observations in the late 19th Century, showing his 'canali'. Credit: From NASA Special Publication 337.

The maps that Schiaparelli drew included features which he referred to as 'channels' or in his native Italian 'canali'. In one of the most famous linguistic misinterpretations in history, this was translated by the English speaking world as 'canals', which in the late Victorian era, was far more suggestive of an industrialized and intelligent society than a cautious Schiaparelli had ever intended. The 'life on Mars' frenzy had begun.

In 1894, during the growth of speculation into the existence of martian life, the American astronomer Percival Lowell (Fig. 3) hypothesized the 'canals' were attempts by struggling Martians to route water from melting polar regions to arid settlements at lower latitudes. Lowell founded an observatory in Flagstaff, Arizona, in part to pursue this belief, and published many books on the subject over the following years [1, 2, 3]. Lowell faced much opposition to his hypothesis, and the views of Schiaparelli's and Lowell's 'canals' are suspected to have been either an optical illusion or some other form of error in perception. To his credit, Lowell also spent much time observing Venus, and the Lowell observatory can also boast to be the site of the discovery of Pluto by Clyde Tombaugh in 1930 [4].

In 1898, while Lowell was developing his hypothesis, H. G. Wells published his 'War of the Worlds'. The story is an allegory, critiquing colonialism, imperialism, and reflecting the political instability of the era, just over a decade before the outbreak of the First World War. However, Wells uses the contemporary notion of life on Mars to represent a technologically superior civilization overpowering a primitive species.

Figure 3. Percival Lowell observing in 1914, from the 24" Clark refracting telescope at the Lowell Observatory he founded in Flagstaff, Arizona. Credit: Lowell Observatory Archives.

Although largely discredited by the 1930s, it is surprising to realize that the view of channels and associated 'vegetation' existing on Mars persisted until the Mariner 4 flyby in 1964. In fact, Lowell's argument was so compelling, maps showing the canal features, such as those drawn by Vesto Slipher at the Lowell Observatory, and published by the United States Air Force as late as 1962, were used in preparation for the Mariner missions in the mid-1960s [5].

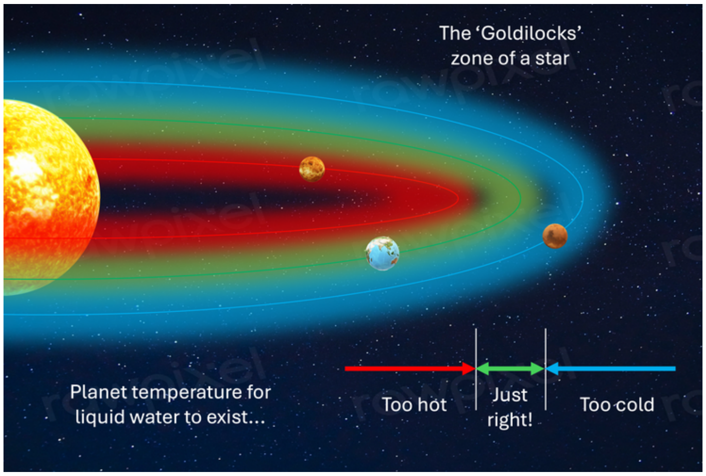

Figure 4. The Goldilocks zone. The orbital range for a planet where liquid water can exist. Credit: Author.

The Kitchen of Life

With the dawn of the space age, the time was right for science fiction to evolve into science fact as the drive to search for extraterrestrial life on our doorstep became even stronger. As Mars had captured the imagination of scientists and the public alike, our nearest viable neighbor (2) was an obvious first step for robotic exploration.

There are a number of key ingredients thought to be necessary (but not sufficient) to support the development of even simple forms of life, and these have been instructive in the search for life within our Solar System by driving the focus of much scientific effort. These ingredients for life are [6]

Liquid water – The presence of liquid water is considered fundamental to life and is required for many reasons (for example, as a medium in which to carry out basic chemistry, for the exchange of chemicals, movement of nutrients, removal of waste products, and heat exchange for temperature regulation). The main reasons water is such a unique medium is the large range of temperature for its liquid phase, its density when frozen, its high surface tension, and its heat capacity. No other common molecule has all of these properties. To achieve the liquid water phase, it was thought in the past that this meant a planet being in the Goldilocks zone of a host star to gain the benefit of its radiated energy – i.e., not too hot, not too cold, but just right (Fig. 4). However, this view is only a starting point, as other factors, such as the greenhouse effect, albedo (reflectivity) of a planet's surface or atmosphere, and alternative energy sources (see below) all need to be considered.

Rocky surface – Although we believe life needs water to thrive, the presence of a substrate upon which to build, feed, or lay the unprotected seeds of future generations also seems to be highly beneficial. Even for simple organisms, the stability afforded by 'making a home' in a fixed location, be that an underwater volcanic vent, or a rocky seashore experiencing diurnal tides, provides significant advantages not necessarily offered to those subject to the vagaries of atmospheric or ocean currents.

Energy source – Energy in some form is essential to be able to perform sustainable chemistry, and initial searches were conducted on the basis of a host star's Goldilocks zone (see Fig. 4). However, since the NASA/JPL Pioneer and Voyager missions in the 1970s, astrobiologists realized that alternative energy sources, such as tidal deformation due to orbital resonance, formation of radioisotope decay in a planetary core, and even volcanism, might provide alternative sources of thermal energy for planets, or more likely moons around planets, outside the Goldilocks zone of a host star.

Atmosphere - While it is not required for life, an atmosphere provides a medium for the exchange of gases and heat across an entire planet. It can provide a significant insulating blanket to raise the temperature of a planet on the outer reaches of a Goldilocks zone (a little greenhouse gas is a good thing!). Also, and more significantly, an atmosphere will protect a planet from outside influences, such as small meteorites, cosmic rays, and harmful radiation from a planet's star, all of which are burnt up or absorbed by a thick enough atmosphere. This is a salient point when we consider Mars and its viability to support life.

Organic compounds - The above items list the kitchen in which life can potentially form but, excluding esoteric, Star-Trek-esque, energy-based lifeforms, we would also need materials from which life could be built. The only form of life of which we are currently aware is based around carbon, otherwise referred to as organic compounds. Although based on carbon molecules, other elements such as hydrogen, oxygen, and nitrogen are also essential, with trace elements such as phosphorous and sulfur also being highly beneficial.

The availability of these key ingredients define a criteria which allow us to prioritize those regions with a higher probability for supporting life, either now or in the past, and also to discount less favorable environments (such as Venus) at a stroke. The need for liquid water became, and still is, the most important of these criteria, to such an extent that the phrase 'follow the water' became a cliché used by planetary astrobiologists when summarizing their decision making processes.

The Mariners

Back in the 1960s, while there was much focus on the Apollo missions to the Moon, NASA and JPL were also finding their feet with robotic missions exploring the planets of the Solar System. The technology of the era was extraordinarily rudimentary, and getting to orbit is hard, much less getting to another planet and sending back viable scientific data. Nevertheless, the motivation to finally answer the question of life on Mars was compelling.

Some of our first tentative steps, dipping our toes into the cosmic ocean, were the Mariner missions. At the end of 1962, Mariner 2 became the first spacecraft to successfully fly by another planet [7] when it made its closest approach to Venus (21,660 miles) on December 14, 1962. It did not take images, but sent back temperature and atmospheric structure data, revealing the hellish nature of Venus.

Figure 5. The first closeup image of another world taken by Mariner 4 on its flyby of Mars in 1965. The stream of digital data returned was 'hand-colored'. Credit: NASA/JPL-Caltech.

Mariner 4 was designed to perform a similar feat on its visit to Mars, but was the first to include imaging equipment [8]. On July 15, 1965 Mariner 4 sent back the first closeup images of Mars (Fig. 5). There were no canals. There was no vegetation. There were no signs of life. As the spacecraft flew behind Mars, the refraction of its radio transmissions was measured, allowing planetary scientists to measure the minimal pressure. There was little atmosphere. The speculation of centuries had been replaced with hard evidence, and once again, there was the distinct possibility we were alone, at least in the Solar System.

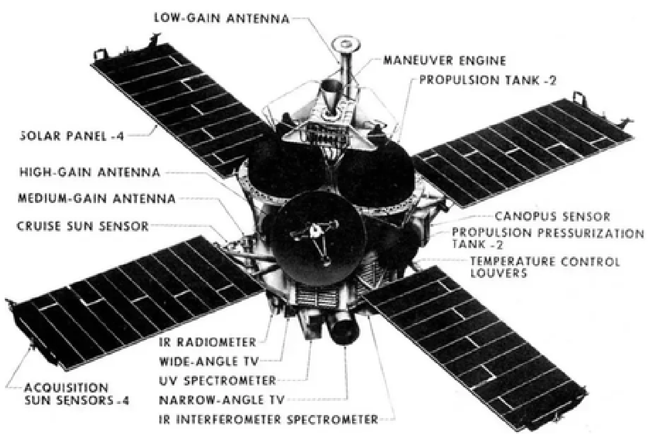

Figure 6. Mariner 9, based on the earlier spacecraft, but with larger propellant tanks to allow slowing and orbital capture at Mars. Credit: NASA/JPL-Caltech.

Mariner 5 journeyed back to Venus in 1967, and the twin missions of Mariner 6 and 7 were launched to Mars in 1969. After a failure with Mariner 8, the first orbital insertion of a mission to another planet was successful, when Mariner 9 became the first artificial satellite around Mars on November 14, 1971 [9]. The primary purpose of this mission was to provide detailed imagery, a map, of the martian globe. Mars does not give up her secrets lightly though, and as fate would have it, a global dust storm rendered little detail in the majority of the imagery for the first seven weeks after the spacecraft arrived at Mars. However, at the beginning of January 1972, the dust storm had subsided, and images coming back revealed the rich Martian landscape, with over 20 volcanoes including Olympus Mons, the largest in the Solar System, an immense system of canyons named Valles Marineris, and a great system of parallel *rilles*, or valleys and trenches, stretching over 1,000 miles across Mare Sirenum. The images didn't depict that of a geologically inactive planet, and gave tantalizing hints that liquid water may have existed on Mars at some point in the past. However, the detail possible from an orbiter was insufficient, and the evidence was inconclusive. To investigate further, closer inspection would be required, and plans were already being drawn up for the next step in the search for life on Mars.

The Viking Landers

If getting a spacecraft to orbit a planet is difficult, touching down safely on its surface with a car sized package of sensitive laboratory experiment is orders of magnitude more complicated, and yet the possibilities afforded by a successful outcome are a great motivation.

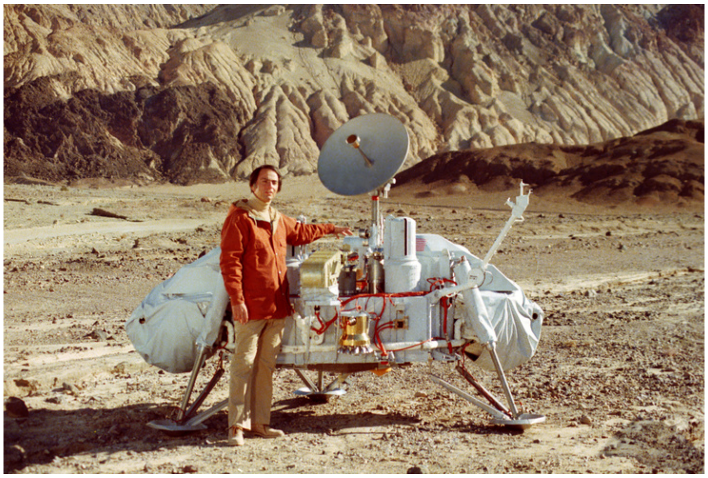

Figure 7. Astronomer Carl Sagan, an advocate and promoter of the Viking and subsequent planetary exploration missions, shown with a mock-up of the Viking Landers in Death Valley, California. Credit: NASA/JPL.

In 1975, the twin Viking 1 and 2 orbiter/lander pairings were launched from Cape Canaveral, taking over a year to reach Mars. On July 20 and September

3, 1976, respectively, Viking 1 and 2 became the first US missions to land on the surface of Mars (Fig. 7), using a combination of parachute and terminal descent engines (retro-rockets) to slow the lander.

As well as imaging equipment, the Viking landers included a set of three biological experiments designed to 'test the soil' for traces of biological life, either extant or extinct [10]. The three experiments consisted of

- **Gas Exchange Experiment (GE)** - Soil from the surface was mixed with a soup of organic nutrients from Earth, and tested for the products of respiration.
- **Pyrolitic Release Experiment (PR)** - Gases from Earth (carbon dioxide and carbon monoxide) were mixed with the Martian soil and heated to test if the carbon would be incorporated into the soil.
- **Labeled Release Experiment (LR)** - Martian soil was mixed with organic nutrients and tested for the presence of metabolism and respiration.

Excitingly, all three experiments led to positive results, but when the samples were heated, the GE and PR results remained positive [6]. This suggested the gases measured were of chemical origin rather than biological products, but the LR experiment gave results that would be expected if biological origins were responsible for the gases. A fourth experiment, the gas-chromatograph mass spectrometer (GCMS), found no evidence of organic compounds in the soil. The tantalizing promise of these experiments did not materialize, as the results from them were inconclusive and ambiguous, and the debate over their interpretation rages on to this day [11].

Although the results from the biological experiments were disappointing, the Viking landers provided the best view of the environment on Mars, and they survived on the surface for many years. The orbiters also outlived their expected lifetimes, providing the best imagery, terrain mapping, and atmospheric analysis to add to our view of the Red Planet.

Landing on Mars had proved to be achievable, but it would be 20 years before the next US foray to the Red Planet.

Figure 8. The Red Planet lives up to its name. One of the first pictures from the surface of Mars, taken by Viking 1 in 1976, showing a Martian sunset. Credit: NASA.

Traveling Laboratories

One of the advantages of the Viking landers was their 'simplicity'. Merely reaching the surface was a triumph, but having achieved that objective they were forever fixed in their location, and they had a limited range of soil they could reach with their probing arms. The frustration for planetary scientists, astrobiologists, and geologists alike, when presented with images of terrain and rocks they would never be able to investigate further, must have been palpable. Plans were already afoot for the next generation of robotic explorers though, with the next step requiring the mobility of rovers [12].

By 1996, technology had improved immensely, and the teams at NASA/JPL successfully landed a small rover on the surface using a combination of airbags and a petal leaf design to protect the rover on its final descent to the surface. The Mars Pathfinder / Sojourner Rover was designed to be a low-cost technology demonstrator, but the diminutive little rover survived for nearly three months and obtained the accolade of being the first automated, wheeled rover to be used on any other planet, and served as a testbed for many future missions.

Figure 9. Close-up of the Sojourner rover, exploring a boulder named 'Yogi', taken by the Pathfinder lander. Credit: NASA.

Spirit and Opportunity

Some nine years later, two small rovers were launched toward the Red Planet, successfully landing on the surface early in 2004. The twin Mars Exploration Rovers, named Spirit and Opportunity, bounced 27 and 26 times, respectively, using Pathfinder's airbag technology, to bring them to halt in the final few hundred feet of their 300 million mile journey to the Red Planet.

These rovers were designed as geology platforms, and their primary missions were to search for signs of water, predominantly geological evidence of past bodies of water, or streams and flows of water. The rovers were sent to opposite sides of the planet to explore areas which were thought to have been subjected to standing or flowing liquid water in the past. Upon arrival, panoramic cameras allowed scientists on Earth to select targets of geological interest, and the rovers could then be instructed to drive to those targets to explore them in detail.

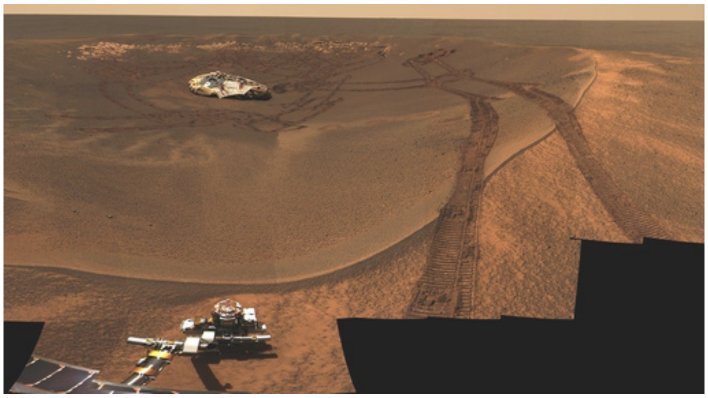

Figure 10. Mars Exploration Rover Opportunity's landing site inside the "Eagle Crater". The empty lander can be seen after the rover left the crater. Credit: NASA/JPL.

The Spirit and Opportunity rovers found conclusive evidence for water on Mars in the past. This suggests the Red Planet might at some point in its history have been able to support microbial life. While clearly not the H. G. Wells vision of superior Martians, this reality is equally as enthralling. Craters which were explored by Opportunity, named Eagle and Endurance, showed evidence of lakes which had formed in between dunes in the past, and which evaporated to form sulfate-rich sands. The sands were reworked by water and wind, solidified into rock, and soaked by groundwater [13].

Spirit's travels to the Columbia Hills showed a variety of rocks indicating that early Mars was characterized by impacts, explosive volcanism, and subsurface water. Bright patches of soil also turned out to be extremely salty and affected by evaporation of water in the past. At Home Plate, in the Columbia Hills, Spirit also discovered finely layered sedimentary rocks which were considered geologically compelling evidence for past water.

Both rovers exceeded their expected mission lifetime with Spirit lasting until March 2010, and the Opportunity mission ending in February 2019, after over 14 years of science.

Curiosity

Having proved both the viability and the value of this type of 'mobile' science platform, the next step was to send a mobile, automated laboratory which was even more capable. The Mars Exploration Rovers were 1.6 meters (5.2 feet) long and 1.5 meters (4.9 feet) tall and weighed in at 174 kilograms (384 pounds). The Mars Science Laboratory (MSL), named Curiosity (see Fig. 11), is the size of a medium sized family car, being twice as long (three meters or 10 feet) and five times as heavy as the Mars Exploration Rovers.

Figure 11. A selfie, taken by Curiosity in Gale crater on Oct. 31, 2012. Mount Sharp, a 3-mile high sedimentary mountain, rises to the right of the image. Credit: NASA/JPL-Caltech/Malin Space Science Systems.

Curiosity landed in Gale crater on the surface of Mars on August 6, 2012 and is still operating to date. Being so much larger than the Mars Exploration Rovers, a new technique was required to land the rover on the surface, and a combination of aerobraking, parachutes, and a hovering rocket crane with a lowering tether were all used to get the MSL safely to the surface, a completely automated process referred to as the 'seven-minutes of terror'. The primary objective for Curiosity was to extend the previous analysis of water on Mars, by investigating whether environmental conditions had ever been favorable for microbial life to exist.

In its many solitary years traversing the surface of Mars, Curiosity has provided the evidence to support some startling discoveries. The rover has found signs that water flowed in the past, and it has been estimated to have flowed for many thousands of years at a time. Scientists have suggested this means parts of Mars were habitable billions of years ago. By using an onboard drill to explore the rock and soil structure, Curiosity has also found many of the chemical building blocks of life, including (and significantly) carbon, nitrogen, oxygen, hydrogen, sulfur, and phosphorous. The fine gray powder (Fig. 12) extracted from the rocks had clay minerals which form in an aqueous environment, such as lakes.

Figure 12. Curiosity's tools include a drill to obtain subsurface samples. Credit: NASA/JPL-Caltech/MSSS.

Curiosity has also made controversial measurements. Methane, an organic molecule predominantly associated with biological processes on Earth, has been sporadically detected on the surface by Curiosity. While there are possible chemical and geological explanations for the source of the gas, the possibilities are nonetheless exciting. However, these surface detections have not been simultaneously corroborated by orbiters (such as the Trace Gas Orbiter, part of the ESA ExoMars mission [14]), leading to continued debate over the still undetermined source of both the methane and the discrepancy.

Perseverance

Curiosity's main mission was never to directly detect signs of life. Perhaps scientists have learned to be particularly cautious when it comes to finding evidence for life on Mars, due to the Viking experience. As Carl Sagan said, "Extraordinary claims require extraordinary evidence." NASA's latest rover, Perseverance (Fig. 13), takes the next step by building on the foundational work of previous missions, by searching for signs of past microbial life itself.

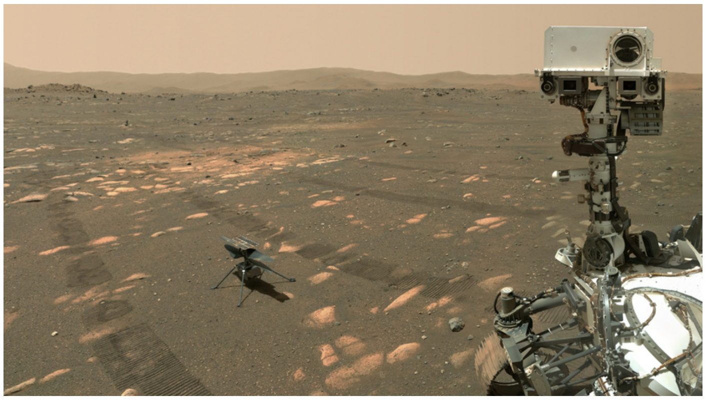

Figure 13. A selfie of Perseverance and his companion, the tiny helicopter Ingenuity. Credit: NASA/JPL.

After its dramatic descent to the Jezero crater, via the tethering rocket-sky-crane, similar to that which delivered Curiosity, Perseverance made a number of surprising discoveries, including igneous rocks associated with volcanic episodes. The story of how the crater has evolved over time has been pieced together. The basin has witnessed flowing lava, potentially on more than one occasion, both of which occurred after the crater was created. Also, there has been at least one lake that lasted many tens of thousands of years, flowing rivers that created a delta consisting of mud and sand, and flooding heavy enough to transport rocks from some distance away. After several months traversing the crater, the rover had made its way to the mouth of an ancient river delta, identified from orbit, and found a very different environment. Deltas are indicative of long-term standing bodies of water, and so could have been environments to support microbial life. Sand and silt are deposited where a river joins a body of standing water, and get layered into sedimentary material, so any trapped biological matter gets buried very quickly. This is good for preserving the organic matter. Perseverance has turned up simple carbon-bearing materials, the organic molecules which are the building blocks of life mentioned earlier, in every sample it has tested.

With all its instruments, Perseverance is sending back masses of data for scientists on Earth, but the final trick up its sleeve is storing capsules of material gathered, and plans are being prepared for future missions to retrieve these and return them to Earth where they can be analyzed in well-equipped terrestrial laboratories.

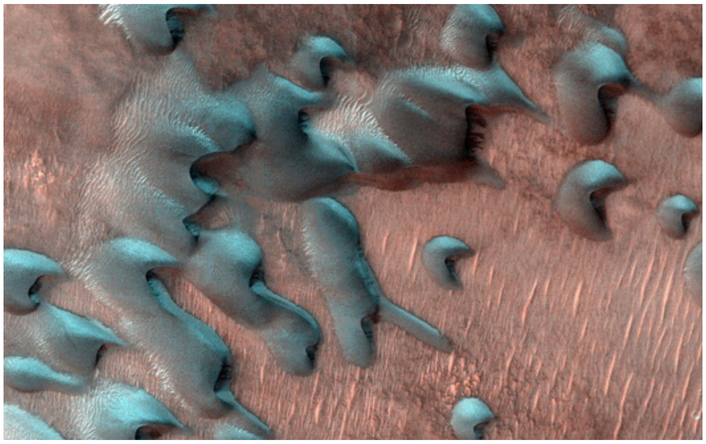

Figure 14. Water ice and carbon-dioxide ice frost, covering sand dunes, as viewed by the HiRISE camera aboard the Mars Reconnaissance Orbiter (MRO). Credit: NASA/JPL-Caltech/University of Arizona.

Fiction or Fact?

The picture we have of life on Mars is very different now compared to our perceptions from 60 years ago, when Mariner 4 was approaching the Red Planet with cameras for the first time. Our view of life on Mars, and in the Solar System in general, has changed considerably from the speculative views of the Victorian era, such as those proffered by H. G. Wells and Jules Verne.

However, the view we have now is a dramatic one, of a Martian history full of the same volatility as befell the Earth during its adolescence. We know there were episodes of volcanism and flowing lava. We also know there was much water, both standing and flowing, as evidenced by the geology explored by the brave robot emissaries we have sent to the Red Planet. We are aware of carbon compounds and simple organic materials buried in the Martian soil, and while there is still no conclusive evidence of life in Martian history, we have evidence to show there have been periods in the past where the right environment existed.

Mars, on the outer limit of the Sun's Goldilocks zone, has also suffered an early demise because of its diminutive size. Measurements of the magnetic field of Mars from orbit show it to be pitifully lacking, in comparison to its strength in the past. Measured from Martian meteorites, Mars once had a magnetic field which produced a protective magnetosphere, similar to that of Earth's. Mars is much smaller than the Earth though, and at only half Earth's radius, cooled a lot faster after its formation. After radiating away its internal energy, causing its core to cool, the magnetic field producing planetary dynamo was shut down. With no protective magnetosphere, Mars' life giving atmosphere was subject to the full ablative force of the solar wind, and it was only a matter of time before the gases disappeared into the void.

While a thick atmosphere on Mars is but a distant memory, the rovers have on numerous occasions seen evidence of 'weather' in the atmosphere that remains, including dust devils traversing the panorama, and dust storms are not uncommon. The winds in the thin atmosphere have had many years to work on the terrain, and features such as sand dunes have been sculpted. Other features subjected to long-term wind erosion have also been observed from orbit above the planet. Circling many miles above, the rover's communication companions have the opportunity to view the variability of seasons on Mars, and have seen dunes and craters covered in frost in the harsh Martian winter (Fig. 14), before it sublimates into the atmosphere with the rising spring temperatures.

Astonishingly, the Mars Reconnaissance Orbiter (MRO) was thought to have observed flowing water on Mars, streaming down finger-like slopes from late-spring to summer. However, since the observations in 2011 [15] and 2015 [16], further analysis suggested that the flows are drier than previously estimated, and likely those of sand, albeit containing hydrated salts [17]. These features, many thousands of which have been observed, are collectively referred to as 'recurring slope lineae' or RSL. They have been identified on more than 50 rocky-slope areas, from the equator to about halfway to the poles. The controversy over the interpretation of scientific data in respect of Mars continues to this day, and it would not be beyond comprehension to look back at this period in one hundred years' time, with eyes similar to us looking back to the period when Lowell and Schiaparelli were investigating the origins of their 'canali'.

Mars Colonization

Although it may be many years in the future, the first tentative steps, as Elon Musk describes it, for humans to become a "multi-planetary species" are being taken. SpaceX's Starship program, currently being developed in Boca Chica, South Texas, has a focus on developing a "fully and rapidly" reusable launch platform. The cost benefits of this re-usability are significant, and ultimately may make spaceflight and space travel as accessible as jet airliners did for air travel in the 1950s and 60s. However, the long-term goal this reduction in cost of mass-to-orbit will facilitate is a focus on getting humans to Mars within the next decade, as is to establish a permanent (and sustainable) colony there by the mid-21st century (Fig. 15).

Figure 15. SpaceX's Starship is focused on the goal of getting to Mars and establishing a permanent colony. Credit: SpaceX.

Nobody is under the impression that this feat will be easy, and Musk is well known for setting aggressive timescales for his projects. Others have noted there are significant challenges to solve before that day arrives, and some have even decried Musk's ambition as downright dangerous. However, it is conceivable with the progress of current developments on both NASA's Artemis program and SpaceX's Starship project, we will see humans on the Moon again in the next few years. With the Moon as a stepping stone, this will open the door for travel to Mars, and ultimately colonization.

Throughout history, there has been much speculation about the existence of life on the Red Planet, from the Greeks and Romans looking up at the blood red planet, to the perceptions of Schiaparelli and Lowell, and the stories of invaders penned by Wells and others. Sixty years ago, the scientific community took over the mantle of analysis with the exploration and findings of planetary scientists, geologists, and astrobiologists coming together to paint a more detailed picture of the remote world.

Despite all our efforts though, we are still unable to say conclusively whether life has ever existed on Mars. However, if Elon Musk, SpaceX, and NASA have their way, that may change in the future, and it may transpire then, that to find Martian life, all we will have to do is simply look in the mirror. ★

Notes

(1) See *Celestial Motions*, FFO 8.

(2) Although Venus is on average closer to Earth, its hostile environment (high temperature, high pressure, acid atmosphere, and lack of water) are not considered conducive to life!

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Biography
Richard Pomeroy, from the United Kingdom, originally trained as an Electronics Engineer, but spent many years both managing teams and developing application software for industries as diverse as defense, telecoms and finance, most recently as associate director of information systems for the European Bank for Reconstruction and Development. He changed career five years ago, following a lifetime passion for the stars, having completed a bachelors degree in astronomy, and a masters in astrophysics. He is currently an assistant instructor and Physics and Astronomy PhD student at the University of Texas, Rio Grande Valley.

Chapter 1: Breaking the Static

Renata Perez

Memories are often portrayed as a cinematic film reel — they play one after the other, creating a coherent visual of the highlights and lowlights of your life — but mine are coated in a layer of static, interrupted anytime I feel I might finally get to make sense of the past.

"Close your eyes," my therapist would say.

"When I tell you to open them, follow the blue dot moving on the screen."

I would obediently do as instructed. My eyes would trace the path of the ricocheting ball on her office screen as her voice prompted me to think of my mother.

My mother's almond eyes and brown skin would flash across my mind. *Static*.

I'd see her hand cupping my face. *Static*.

I'd hear laughter echoing through the room. *Static*.

I'd see a spaceship on the TV screen. *Static*. *More static*.

A casket swallowed by the dirt. *Static*. *Static*. *Static*.

Static wrapped itself around my vision. Tears would stream down my face. My lungs would twist and turn and wrap around themselves like vines. My body was broken, but I couldn't comprehend why.

I knew my mother was dead. Her body was never in that casket — only pictures were held inside that wooden box — but she'd be gone for too many years. Naturally, that was the only logical answer.

Everyone tells me she's dead. *Everyone*. But that's all they tell me. The only words I hear about her are Oneira virus and death. And the older I grow, the more this static gnaws at my brain.

This is what I know:

I know she was part of *The Project*. I know she studied the same virus that made her disappear. I know she was among the first humans to travel to Tlalocánthe. I know she spent most of her time in the forest, studying the carriers of this virus. But that is all I know.

That is *all* I know about my own mother, because I can't remember.

The moment I turned eighteen, I traveled to the mouth of the Chalchiutli Forest. Her bumble bee lips met my rugged cheeks. I was invited to her never-ending mazes.

Her trees greeted me, dancing to the rhythm of the wind, and bodies of water ran through her arteries and veins, desperate for a taste of all the landscapes pumping through her heart.

In this realm, the boundaries between the elements are blurred. All I felt was the natural world wrapping its arms around me. I leaned into its comforting embrace.

When I came to this planet, I'd never imagined I could visit the magic of Chalchiutli. I never knew you could walk beside flowers that bloom under the moonlight or bathe in different shades of neon. I couldn't comprehend how such a place treated me like one of her own. *Is this why my mother was so* *eager to study this place?*

Thirst brought me to one of the forest's streams. I filled my flask and thought of all the things people told me as I told them about my trip. From the first moment humans were allowed to travel from Earth to Tlalocánthe, I always said desire was embroidered on my skin.

I refused to forget my mother.

I drank some of Chalchihuitli's water and sat under a tree, thinking of all the times people would go back to Earth and talk about how this forest made you face things. For some people, it was their toughest memories. For others, like my mother, it led to their deaths.

I thought of this as a sudden wave of slumber slithered through me, and I surrendered to its strength. I peacefully slept — for how long I couldn't tell — when a creature with luminescent scales crawled on my sleeping body and sank its teeth into my flesh.

The stinging oozing from my chest woke me, but I could not move any of my joints. I could see the creature spreading its wings and fluttering them, creating distance between us. I desperately needed to scream, but all I could do was look. The creature hovered over my wound, and began spinning a clear liquid from my open flesh.

It mimicked a ball of water. Light shone through it like a projector screen, and moments of my life reflected on its surface. My mother's almond eyes and brown skin were shown, and she is telling me she loves me. She cups my cheek and tells me how proud she is of me for winning first place at the Spelling Bee. We are at the park, and we are both on swings.

"¿Estas lista?" she asks, a daring spark brightening her eyes.

"Are *you* ready, old lady?" A version of me I don't recognize mockingly retorts.

"¿A quien le dices viejita? I'm more ready than you'll ever be," she says through a mischievous smile.

She counts down from three to one, and we are both up in the air, falling to the ground shortly after. Laughter radiates from both of us.

The image rapidly shifts. My father's hand holds me tight against his leg. A TV mentions my mother's name as one of the people on the spaceship about to ascend.

"Todo va estar bien, Alí," my father reassures me.

But that doesn't stop my stomach from feeling like it's carrying an angry colony of ants. I watch the spaceship ascend, but the memory transitions to a funeral service. I am on a podium, but the moment I try to open my mouth, I choke on my pain. I collapsed on my knees. The only thing I knew how to do at that moment was weep. There are people around me, my father being one of them. The moment cuts to my father holding me once more as we watch a casket being lowered. Tears silently stream down his face as he sees the love of his life for the last time.

My eyes are puffy. They can't bear the thought of suffering once more.

"Te amo, mami," I inaudibly murmured.

These all play somewhat scattered. But these moments are given back to me. And I want more. The pain in my chest evolves into a deeply nauseating hunger, so desperate for more. But as I feel my eyes beg this creature to feed me, the ball gently dissolves, releasing the woven memories back into the cosmic tapestry.

The creature flies away, becoming a distant glimmer in the moonlit shadows. My body is drained of all its energy. Everything in me is fighting not to surrender to this deep exhaustion. To find the creature. But I can't resist. My eyes begin getting heavy, and I am carried into the arms of sleep. ★

Biography

Renata Perez is a multimedia creative with a passion for sparking conversations and empowering others to use their voice. They were born and raised in the Rio Grande Valley, naturally inspiring their love for bicultural stories and good Mexican food, and they now make their home in Boston, MA. They are currently pursuing a B.A. in English at Boston University, and their ultimate goal is to capture stories that bring representation to those seeking to be heard. When they're not curled up behind a romance book, you can usually find them looking for their next spot to drink a cafecito.

Why the Bear Has a Stumpy Tail

A Norse Fairy Tale Retold by Carol Lee

Have you seen any drawings of the circumpolar constellations Ursa Major and Ursa Minor? These names refer to the same groups of stars we can also see on a clear night from a dark viewing site, and in English the words mean the Great Bear and the Little Bear. If you have seen any drawings of the two constellations you may have noticed that the bears have long fluffy tails, sort of like a fox's tail or a golden retriever's tail...good for wagging!

If you have seen those illustrations and wondered why the tails on the bears are long when all the photographs and drawings of bears today show a stumpy tail more like a puff of cotton, there is a folk tale from the Norse countries of ancient days that explains the reason very well.

In the long ago times in the lands of the North on cold dark winter nights this is a story the old grandfather or grandmother told to children who were not quite sleepy enough to go to bed, especially when the Sun had been just below the horizon all day, making little light to be outdoors even if it were not too cold to be outside for very long.

Sit back and enjoy the reason behind the bears and their stumpy tails.

One cold snowy day Sly Fox was taking a quick run across the piled up drifts of snow, looking for a mouse or rabbit for his dinner. He was quite eager to find something and get home to his warm den under a fallen tree. As he trotted along he chanced to sniff a really good sniff...and caught the scent of fresh fish, his favorite feast! Sly Fox quickly and quietly followed the scent with his wonderful long nose guiding him to a woodcutter's log cabin near the banks of the pond in the woods. Hanging from a tall pine tree was a stringer of beautiful fish the woodcutter had caught that morning. His wife was planning on preparing a delicious fish stew for her family's supper that night with those fish, but Sly Fox never thought about anything but tricks and he decided to grab that stringer of fish and hurry home to his den and enjoy those fish himself. So, he did; he jumped up, grabbed the stringer of fish in his mouth and, smiling all the while, off he headed for his home.

As Sly Fox was loping along, not far ahead he saw Bruin Bear who had not yet gone to hibernate, for the winter had not been terribly cold up until a few days before. Sly Fox, who had always been jealous of the long tail Bruin Bear had, decided he was going to play a trick on Bruin Bear and he called out, "Hello there, Bruin! I just caught the greatest bunch of fish for supper and am hurrying home for my hungry children. Would you like to catch some for your supper?"

Now Bruin thought that knowing how to catch fish for himself would be a great skill to have and so he replied, "Yes. Will you tell me how to catch fish for myself?"

"Gladly, Bruin. You are definitely equipped to be a fine fisherman, with your long fluffy tail. All I ever use is my tail, and yours is even more likely to catch a great fish than mine. Go to the edge of the pond and sit quite still with your tail hanging in the water. I will keep watch and tell you when a fish has your tail. Then all you must do is pull your tail full of fish out of the water and enjoy fresh fish whenever you wish."

"That sounds good to me," replied Bruin, and off he went to the pond. Carefully he sat down and hung his tail in the water and began to wait. Time passed and Bruin fell asleep while Sly Fox watched the water in the pond slowly turning into ice. When he was sure Bruin's tail was trapped tightly in the ice, Sly Fox barked loudly, "Wake up, Bruin! The woodcutter is coming to get you!"

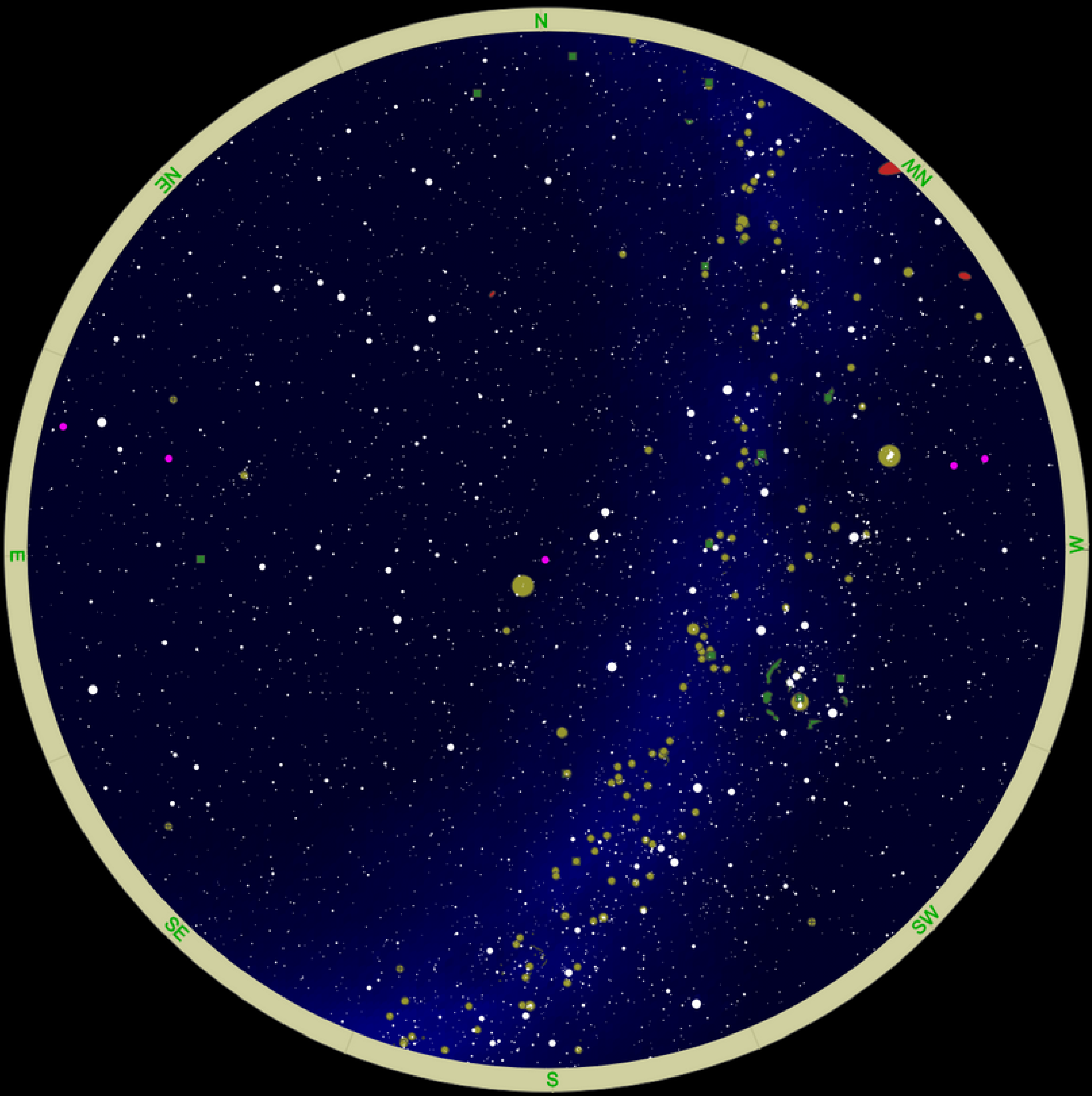
Bruin leaped up, leaving his beautiful tail behind him in the ice, and ran to safety in the woods, while Sly Fox went home laughing to himself at the way that he had tricked Bruin, who now only had a stumpy tail, where before he had a long beautiful tail that Sly Fox had been envious of. And that is the end of the story.

Although this is not a true story, jealousy and envy cause a lot of real trouble for many people. I imagine this was a cautionary tale told to children to help them not be overcome by those traits, as are most of those fairy tales and myths of old times. ★

Biography
Carol Lutsinger is the founder of the South Texas Astronomical Society. She spent 40 years as a teacher, serving students from Pre-K through college. Carol attributes her astronomy enthusiasm in part to her experience in the American Astronomical Society's AASTRA program from 1994-96, and her space excitement from serving as a Solar System Educator, and later Ambassador, for the NASA/JPL program. She has been writing the Stargazer newspaper column since 1998, which is carried in the Brownsville Herald and the Valley Morning Star. Retired from formal education since 2020, she still makes every opportunity to share meteorites which she carries in her purse and to ask folks in parking lots if they know what that point of light is.

Cosmic Coordinates

Spring 2024

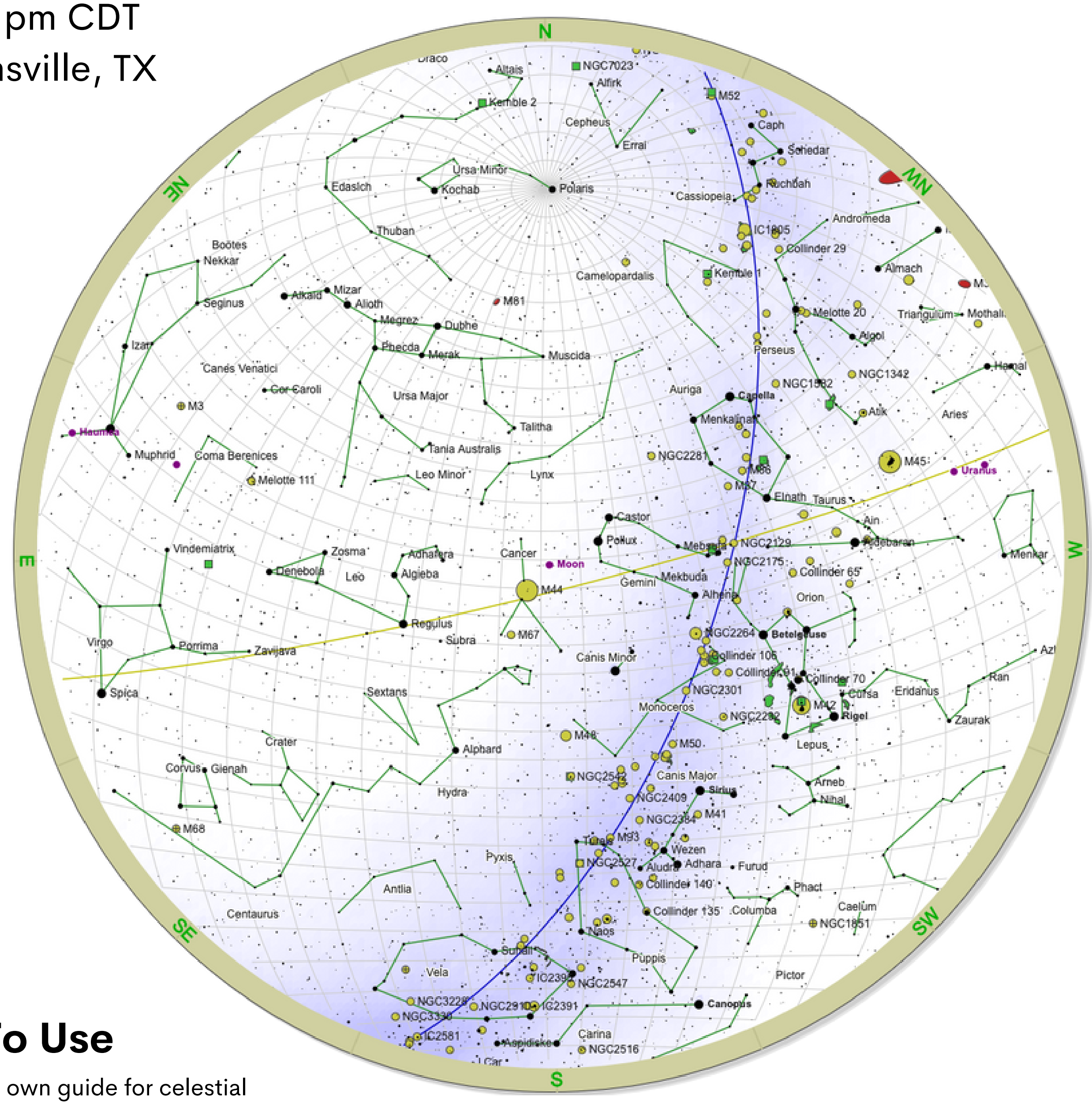


Sky Map

19 March 2024

10:00 pm CDT

Brownsville, TX



How To Use

Here is your own guide for celestial navigation: your very own sky map, allowing you to select and observe the finest of cosmic objects. If you find yourself within the Rio Grande Valley, this map will be accurate to help you along your celestial journey. Good luck, and clear skies! [Credit: Dominic Ford, In-The-Sky.org]

Sky Map Legend

The Equator · Ecliptic Plane · Galactic Plane

Galaxy · Bright nebula · Open cluster · Globular cluster

Sky Events

Spring 2024

Appulses

Mar 13, Appulse of Moon and Jupiter
Mar 14, Appulse of Moon and M45
Mar 21, Appulse of Venus and Saturn

Apr 06, Appulse of Moon and Mars
Apr 06, Appulse of Moon and Saturn
Apr 07, Appulse of Moon and Venus
Apr 10, Appulse of Saturn and Mars
Apr 11, Appulse of Moon and M45
Apr 28, Appulse of Mars and Neptune

May 03, Appulse of Moon and Saturn
May 04, Appulse of Moon and Neptune
May 04, Appulse of Moon and Mars

Apsides

Mar 17, Mercury at Perihelion
Mar 19, Venus at Aphelion

Apr 21, 12P/Pons-Brooks at Perihelion
Apr 30, Mercury at Aphelion

May 08, Mars at Perihelion
May 17, 46P/Wirtanen at Perihelion
May 20, Jupiter at Apogee

Conjunctions

Mar 07, Conjunction of Moon and Mars
Mar 08, Conjunction of Moon and Venus
Mar 13, Conjunction of Moon and Jupiter
Mar 17, Neptune at Solar Conjunction
Mar 21, Conjunction of Venus and Saturn

Apr 03, Conjunction of Venus and Neptune
Apr 05, Conjunction of Moon and Mars
Apr 06, Conjunction of Moon and Saturn
Apr 07, Conjunction of Moon and Venus
Apr 10, Conjunction of Moon and Jupiter
Apr 10, Conjunction of Saturn and Mars
Apr 11, Mercury at Inferior Solar Conjunction
Apr 14, 136199 Eris at Solar Conjunction
Apr 20, Conjunction of Jupiter and Uranus
Apr 28, Conjunction of Mars and Neptune

May 03, Conjunction of Moon and Saturn
May 04, Conjunction of Moon and Mars
May 06, Conjunction of Moon and Mercury
May 13, Uranus at Solar Conjunction
May 14, Conjunction of Mercury and Eris
May 18, Jupiter at Solar Conjunction
May 30, Conjunction of Mercury and Uranus

Dichotomies

Mar 22, Mercury at Dichotomy

May 14, Mercury at Dichotomy

Earth

Mar 19, March Equinox

Elongations

Mar 24, Mercury at Highest Evening Altitude
Mar 24, Mercury at Greatest Eastern Elongation

May 09, Mercury at Greatest Western Elongation
May 12, Mercury at Highest Morning Altitude

Moon

Mar 03, Last Quarter Moon
Mar 10, New Moon
Mar 16, First Quarter Moon
Mar 25, Full Moon

Apr 01, Last Quarter Moon
Apr 08, New Moon
Apr 15, First Quarter Moon
Apr 23, Full Moon

May 01, Last Quarter Moon
May 07, New Moon
May 15, First Quarter Moon
May 23, Full Moon
May 30, Last Quarter Moon

Occlusions

Mar 03, Lunar Occultation of Antares
Mar 16, Lunar Occultation of Elnath
Mar 25, Penumbral Lunar Eclipse
Mar 30, Lunar Occultation of Antares

Apr 06, Lunar Occultation of Saturn
Apr 07, Lunar Occultation of Venus
Apr 08, Total Solar Eclipse
Apr 12, Lunar Occultation of Elnath
Apr 26, Lunar Occultation of Antares

May 03, Lunar Occultation of Saturn
May 04, Lunar Occultation of Neptune
May 04, Lunar Occultation of Mars
May 10, Lunar Occultation of Elnath
May 23, Lunar Occultation of Antares

Oppositions

Mar 03, 3 Juno at Opposition
Mar 11, 23 Thalia at Opposition
Mar 30, 136472 Makemake at Opposition

Apr 08, 532 Herculina at Opposition
Apr 20, 136108 Haumea at Opposition

May 17, 2 Pallas at Opposition

Definitions

Appulse – the minimum apparent separation in the sky of two astronomical objects.

Apsis – the farthest (*apoapsis*) or nearest (*periapsis*) an orbiting body gets to the primary body. Plural is *apsides*. Special terms are used for specific systems: *aphelion* and *perihelion* are used for any object with respect to the Sun; *apogee* and *perigee* are used for any object with respect to the Earth.

Conjunction – when two astronomical objects or spacecraft share the same right ascension or ecliptic longitude as observed from Earth. For superior planets, conjunction occurs when the planet passes behind the Sun (also called *solar conjunction*). For inferior planets, if the planet is passing in front of the Sun, it is called *inferior conjunction*; if behind, it is called *superior conjunction*. Solar conjunctions are the most difficult periods to view a planet with a telescope.

Dichotomy – the phase of the Moon, or an inferior planet, in which half its disk appears illuminated.

Elongation – the angular separation on the sky between a planet and the Sun with respect to the Earth. When an inferior planet is visible in the sky after sunset, it is near its *greatest eastern elongation*. When an inferior planet is visible in the sky before sunrise, it is near its *greatest western elongation*.

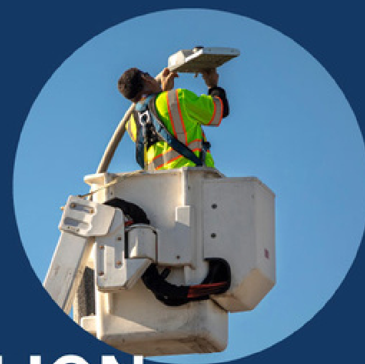
Occlusion – when one astronomical object passes in front of the other. An *occultation* is when the foreground object completely blocks the background object. A *transit* is when the background object is not fully concealed by the foreground object. An *eclipse* is any occlusion that casts a shadow onto the observer.

Opposition – when two astronomical objects are on opposite sides of the celestial sphere. Opposition only occurs for superior planets and objects. Solar opposition is the best time to view a planet with a telescope.

Retrograde – when a planet reverses its direction of motion on the sky. A planet entering retrograde motion is an apparent phenomenon caused by the relative motion between the Earth and the object (like a slower car appearing to move backward on a highway as you overtake it).

Light Pollution has SOLUTIONS

This waste can be solved with advanced lighting controls like **DIMMING** and **MOTION SENSORS**



and transitioning to **ENERGY-EFFICIENT LEDs**

which would save **$15.4 BILLION** per year in the U.S. alone

Source: U.S. Department of Energy, 2022
https://www.energy.gov/sites/default/files/2022-02/2022-ssl-rd-opportunities.pdf

International Dark-Sky Association
www.DarkSky.org

3 things YOU CAN DO

1. **Assess your home's outdoor lighting**
darksky.org/home-lighting

2. **Look for Dark-Sky Approved fixtures at your retailer**
darksky.org/fsa

3. **Join us and be part of the international movement**
darksky.org/join

This Spring 2024, we present to you...

COSMIC COMEDY

Don't space out on our jokes... you know they're absolutely stellar.

Cosmic Comedy

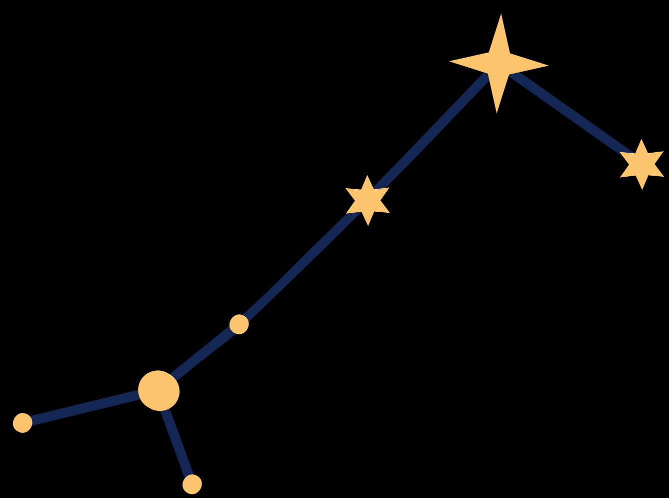
Spring 2024

A neutron walks into a bar and asks how much it costs for a drink.

The astute bartender replies, “for you, it’s no charge.”

Why didn’t the Dog Star laugh at the joke?

… because it was Sirius.



Ben Reed

"Houston, we have a problem"

Space Rangers

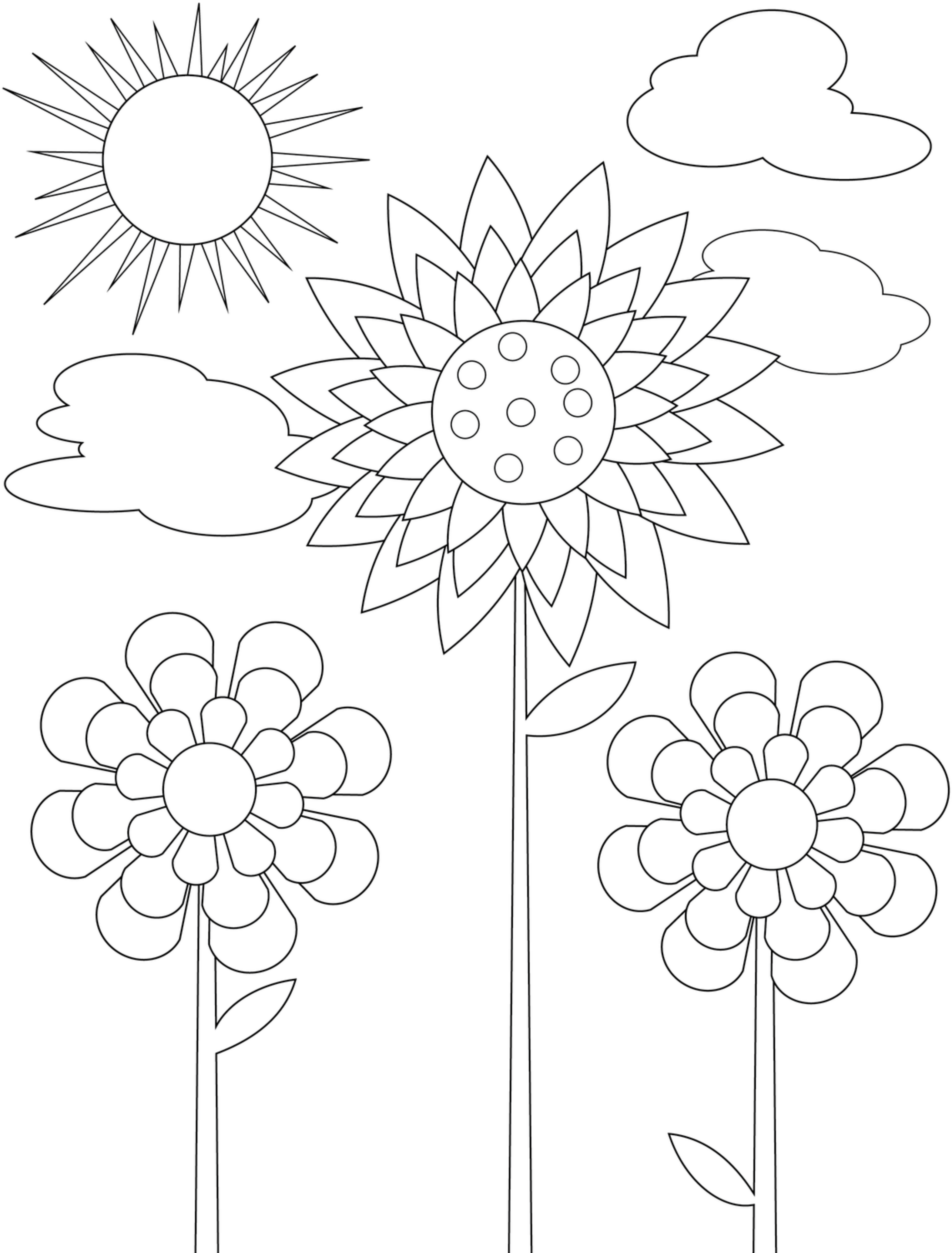
Spring 2024

🚀 Welcome Space Rangers! 🚀

Time to use your creative skills and put them to the test! We hope you enjoy our featured coloring page, word search, some fantastic eclipse artwork!

Your adventure awaits!

Table of Contents



Space Rangers

Word Scramble

1. AOTBISOOGRLY	The study of the origin, evolution, and distribution of life in the universe
2. BIGOOLY	A branch of knowledge that deals with living organisms and vital processes
3. ETRAH	The planet on which we live that is third in order from the Sun
4. OEXGYN	A chemical element with atomic number 8 that constitutes 21% of the Earth's atmosphere
5. NEIGORTN	A nonmetallic chemical element with atomic number 7, it constitutes 78% of the Earth's atmosphere
6. HGDEORYN	A nonmetallic gaseous element with atomic number 1, and it's the lightest of the elements
7. NAURTE	The external world in its entirety
8. FUNAA	The animals characteristic of a region, period, or special environment
9. ERUPOA	Jupiter's moon that has an ocean beneath its icy crust
10. GOOEGLY	A science that deals with the history of the earth and its life especially as recorded in rocks

Space Rangers

Word Scramble (Solutions)

1. ASTROBIOLOGY	The study of the origin, evolution, and distribution of life in the universe
2. BIOLOGY	A branch of knowledge that deals with living organisms and vital processes
3. EARTH	The planet on which we live that is third in order from the Sun
4. OXYGEN	A chemical element with atomic number 8 that constitutes 21% of the Earth's atmosphere
5. NITROGEN	A nonmetallic chemical element with atomic number 7, it constitutes 78% of the Earth's atmosphere
6. HYDROGEN	A nonmetallic gaseous element with atomic number 1, and it’s the lightest of the elements
7. NATURE	The external world in its entirety
8. FAUNA	The animals characteristic of a region, period, or special environment
9. EUROPA	Jupiter’s moon that has an ocean beneath its icy crust
10. GEOLOGY	A science that deals with the history of the earth and its life especially as recorded in rocks

Space Rangers

Word Search

Astrophysicists research and make new discoveries all the time! In the puzzle below, see if you can discover the terms that pertain to the search for life "out there" in space.

R	M	B	C	Z	X	V	N	L	J	G	D
N	E	G	Y	X	O	P	K	H	F	S	A
I	A	T	M	O	S	P	H	E	R	E	E
C	Y	R	E	W	Q	E	B	T	U	O	X
L	C	B	M	M	S	I	N	A	G	R	O
I	Z	X	V	N	O	L	J	G	D	A	P
M	B	I	O	M	A	R	K	E	R	S	L
A	Y	I	E	P	K	R	T	H	F	S	A
T	V	E	G	G	I	E	R	C	W	Q	N
E	Z	C	B	M	O	T	U	T	E	E	E
X	V	N	L	J	G	A	D	A	S	P	T
K	H	F	D	N	I	W	R	A	L	O	S

Space Rangers

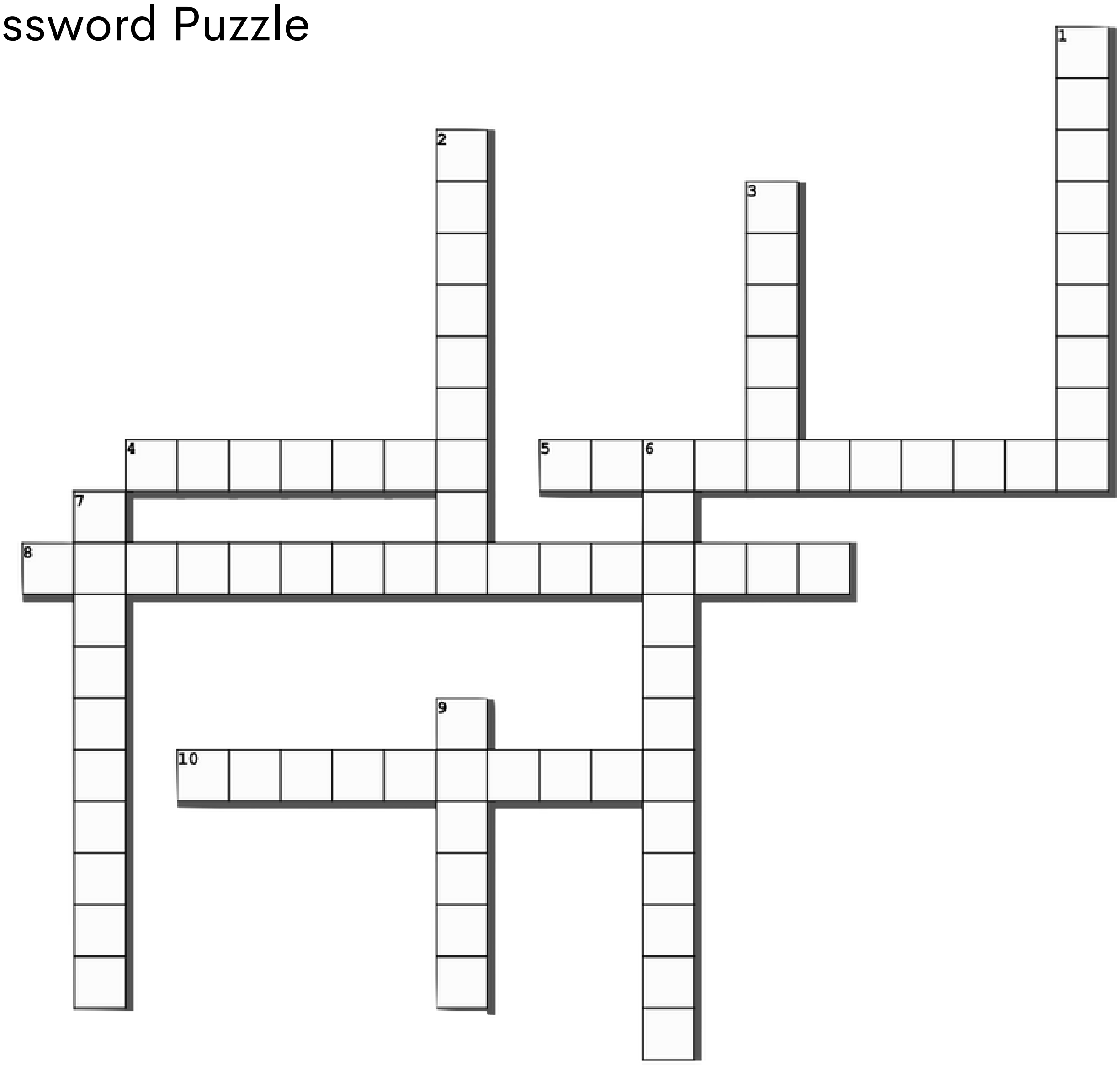
Word Search (Solutions)

(1) ATMOSPHERE, (2) BIOMARKERS, (3) BIOME, (4) CLIMATE, (5) EXOPLANET, (6) ORGANISM, (7) OXYGEN, (8) SOLAR WIND, (9) SPECTROMETER, (10) WATER, (11) VEGGIE (name given to the space garden located on the International Space Station and something future scientists should eat every day)

R											
N	E	G	Y	X	O						
	A	T	M	O	S	P	H	E	R	E	E
C			E				B				X
L				M	S	I	N	A	G	R	O
I					O						P
M	B	I	O	M	A	R	K	E	R	S	L
A			E			R	T				A
T	V	E	G	G	I	E		C			N
E						T			E		E
						A				P	T
			D	N	I	W	R	A	L	O	S

Space Rangers

Crossword Puzzle



Across

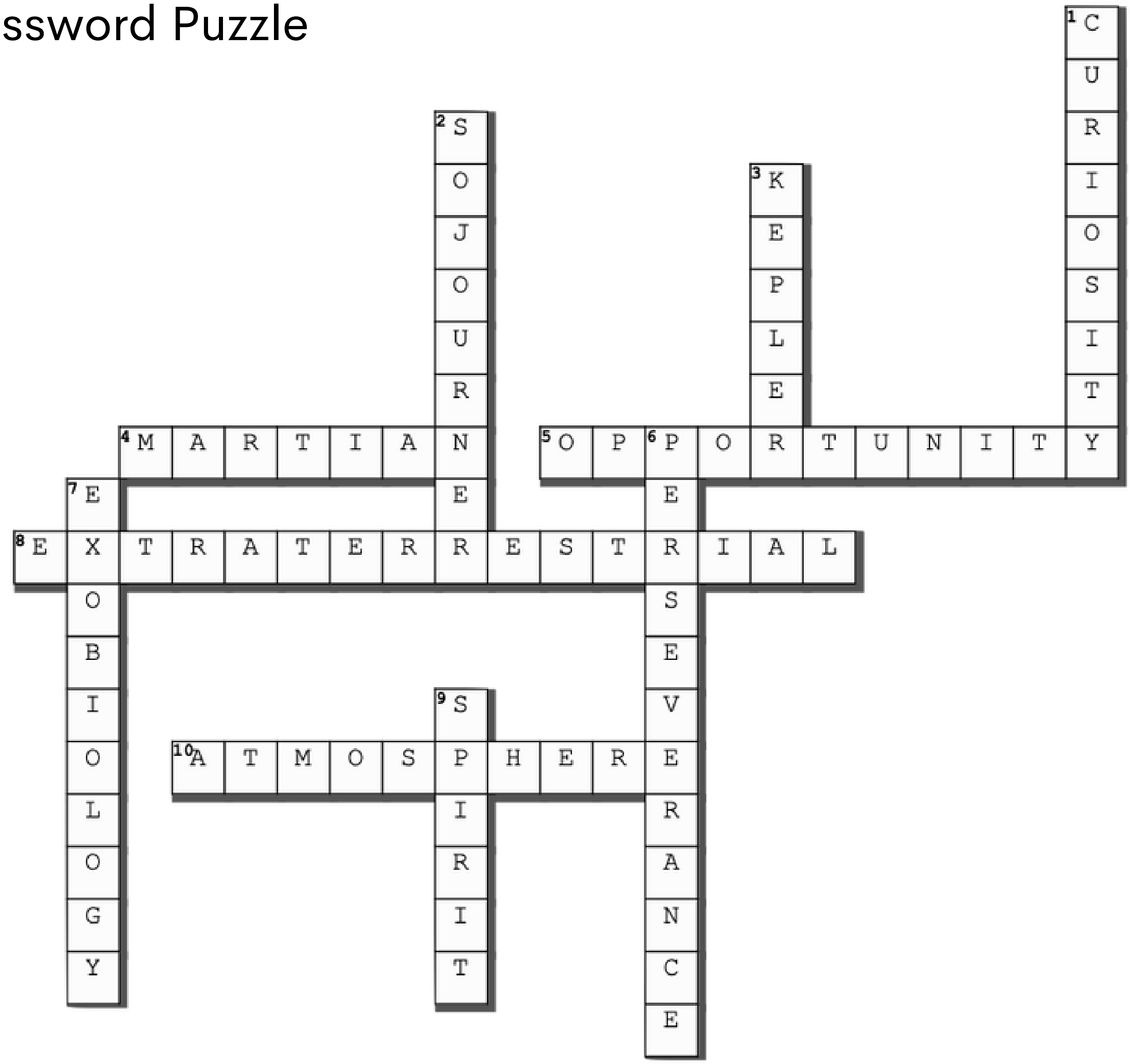
4. Relating to the planet Mars or its hypothetical inhabitants
5. Landed on Mars in 2004 and became one of the most successful and enduring interplanetary missions
8. A being from another world
10. The gaseous envelope of a celestial body

Down

1. Largest and most capable rover ever sent to Mars
2. NASA's first-ever Mars rover
3. Aspace observatory designed to identify Earth-size planets around distant stars
6. Car-sized Mars rover designed to explore the Jezero crater on Mars
7. The origin and early evolution of life, the potential of life to adapt to different environments, and life elsewhere
9. One of two rovers launched in 2003 to explore Mars and search for signs of ancient water

Space Rangers

Crossword Puzzle



Across

4. Relating to the planet Mars or its hypothetical inhabitants
5. Landed on Mars in 2004 and became one of the most successful and enduring interplanetary missions
8. A being from another world
10. The gaseous envelope of a celestial body

Down

1. Largest and most capable rover ever sent to Mars
2. NASA's first-ever Mars rover
3. Aspace observatory designed to identify Earth-size planets around distant stars
6. Car-sized Mars rover designed to explore the Jezero crater on Mars
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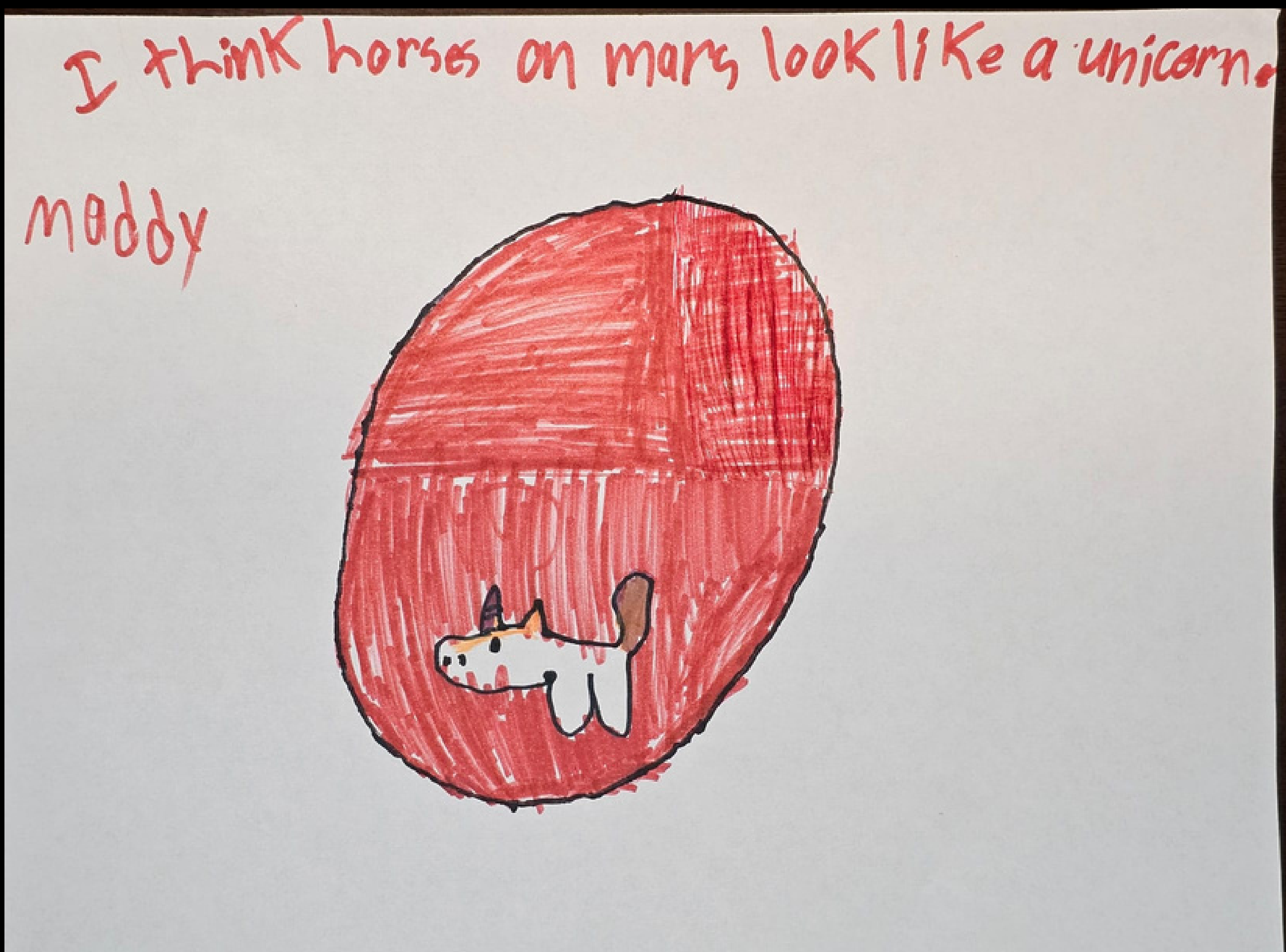
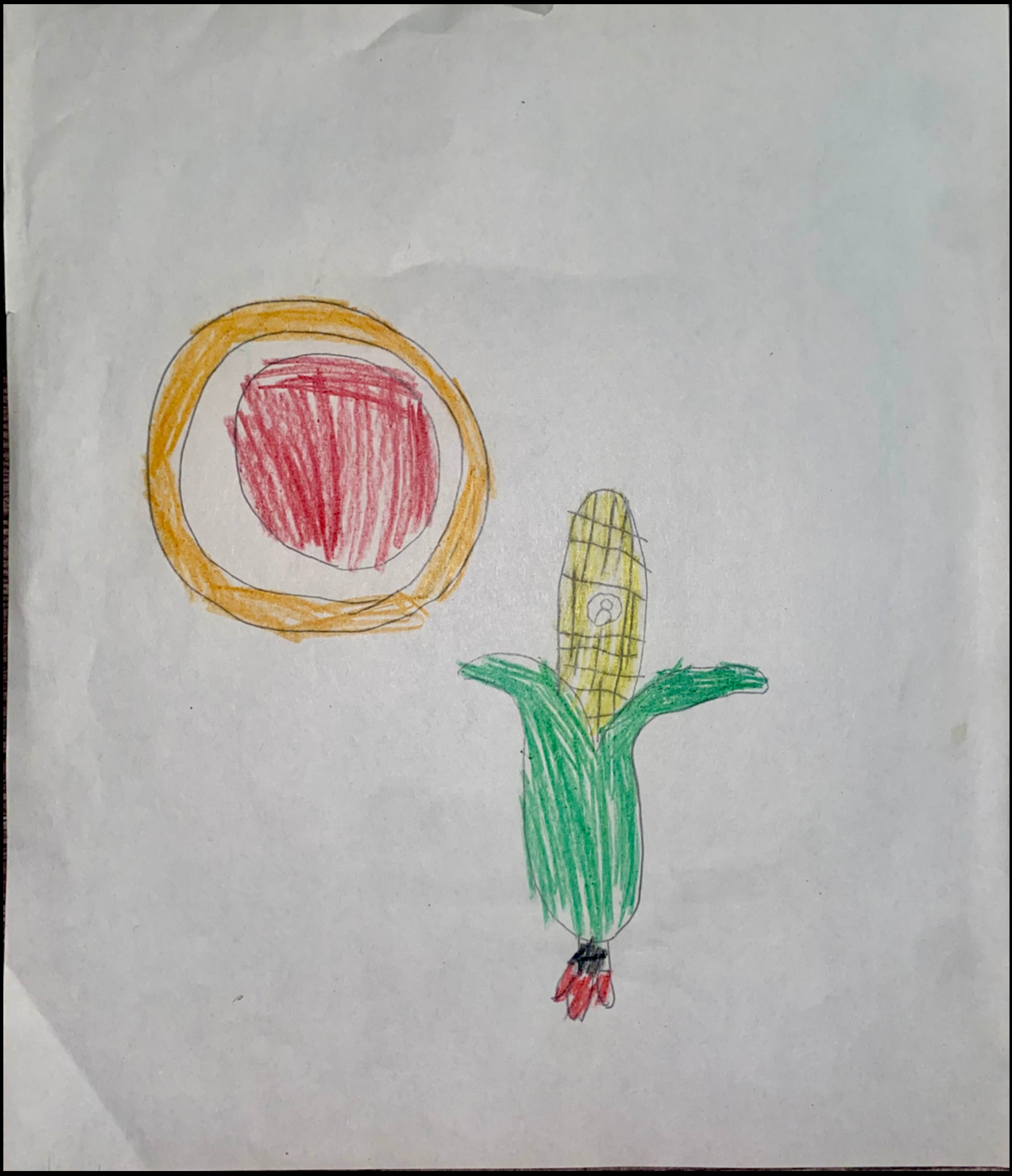


Madahlia (2nd Grade)



Ander (2nd Grade)
"Corn Rocket"

MariaJulieta (1st Grade)
"Rocket Garden"

About the Artist
MariaJulieta, affectionately known as MaJu and MJ. She is a first-grade student. Her hobbies include drawing, reading, and playing basketball. When she grows up she aspires to become a zoologist. With her compassionate heart and vibrant personality, MaJu is destined to make a positive impact on the world and help needy animals through her future endeavors.

Colophon

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Submissions

We encourage submissions from anyone interested in contributing to our magazine. Any readers with ideas for submission, including their own articles, illustrations, or other content, or any corrections or comments, please contact the Editor-in-Chief at: rcamuccio {at} gmail {dot} com

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