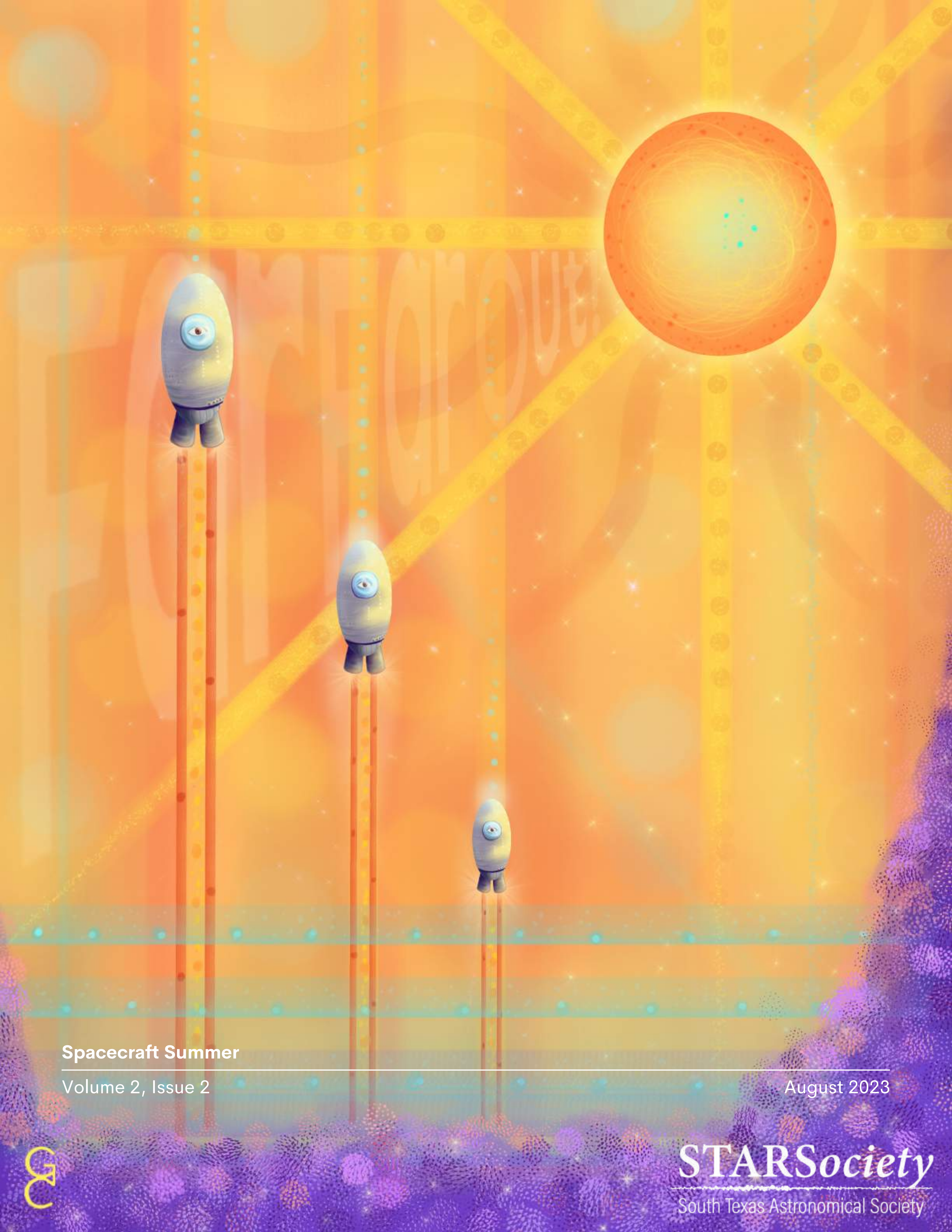


Spacecraft Summer

Volume 2, Issue 2 August 2023

STARSociety
South Texas Astronomical Society

Editorial

Rocket summer. The words passed among the people in the open, airing houses. Rocket summer. The warm desert air changing the frost patterns on the windows, erasing the art work. The skis and sleds suddenly useless. The snow, falling from the cold sky upon the town, turned to a hot rain before it touched the ground. Rocket summer. People leaned from their dripping porches and watched the reddening sky. The rocket lay on the launching field, blowing out pink clouds of fire and oven heat. The rocket stood in the cold winter morning, making summer with every breath of its mighty exhausts. The rocket made climates, and summer lay for a brief moment upon the land...

From the master himself, Bradbury takes us from the Rocket Summer of January 1999 to the Million-Year Picnic of October 2026. In a creative burst from his typewriter, he took us from the surface of Earth to the surface of Mars. And here, in late summer 2023, we stand at a precipice, a sea of stars and a field of rockets, aligned and ready to launch us into our next phase of human exploration. What next steps should we take? Perhaps the Moon, or perhaps an asteroid, or perhaps a world beyond. I live near the first spaceport in the world, watching it actively grow in pursuit of sending humans to Mars. Maybe the Rocket Summer will be here in South Texas, where instead of melting the winter snow, it will just be welcomed by the heat seen nearly all year.

In this summer edition of FFO, we bring to you several fantastic articles on humanity's future in the cosmos. We will learn about the chemical signs of life in the universe, and the possibility of pharmaceuticals designed for life and travel in space. We will discuss the morality of traveling to other worlds, and the science of interstellar travel beyond our solar neighborhood. Carol will tell us summer night stories and a tale of a little spacecraft that, indeed, did. From our artists, we seek to understand our fixation on rockets and their deafening beauty. We will be privy to many interesting troves involving the likes of nautical roses, oracles of eight, starships aplenty, and an ancient, yet familiar, water monster. I'm also happy to introduce our Space Rangers section, composed of many artistic contributors, a coloring page, and word search.

Wishing you clear skies,

Richard Camuccio
Editor-in-Chief

Contents

Carol's Corner of the Cosmos

Carol Lutsinger

Summer is a wonderful time for star gazing - hot days, cooler evenings, and fewer rain clouds obscuring the gems of the night sky. Occasionally you will even have opportunities to follow the International Space Station pass overhead. Impress the neighborhood sidewalk athletes with the information that they may enjoy the view of a swiftly-moving point of light which is sunlight reflecting off the football field-size of the International Space Station which is home to a mixed-nations crew of seven astronauts who have been living and working 250 miles above earth since November of 2000. The amazing success of the ISS has provided food for thought as well as work and conveniences we earth-bound folks take for granted now. Although international relations are definitely strained between the USA and Russia, the astronauts carry on their cooperation in spite of government "leadership". https://spotthestation.nasa.gov/ is a link to get alerts on your phone or via email to know exactly when to see the ISS passing over our valley homes.

High overhead the kite-shaped constellation Boötes will circle for several more months. The right triangle of Coma Berenices circles with it. And the Messier 3 is between them. M3 was the first Messier object discovered by French astronomer Charles Messier. It is a globular cluster in the constellation Canes Venatici in 1764. He thought it was a nebula until 1784 later William Herschel discovered it to be thousands of stars instead; most recent observations believe there are more than 500,000 stars in the group. Most of them are variable stars which are a study in themselves.

Variable stars are intriguing and the major astronomer who uncovered their secrets was Henrietta Leavitt who worked for peanuts at the Harvard Observatory in the latter part of the 19th and early part of the 20th centuries. Her story is a fascinating one, as the secrets of those variable stars. Might be some good summer reading. For students Look Up Henrietta by Robert Burleigh is recommended. For adults The Glass Universe by Dava Sobel is one I have read twice and recommend heartily.

Facing west towards sunset the last views of Leo the Lion will sink beneath the horizon led by the Y of Cancer the Crab. Cancer harbors three Messier Objects, the Beehive cluster and M95 and 96. The last two are multiple galaxies that can only be seen with a dark site and good telescope, but the Beehive cluster is manageable with binoculars usually. It truly is a beehive of more than a thousand stars seemingly attempting to enter their hive.

An hour after the sun sets, look for golden Arcturus gleaming high overhead. In the NE, look for Vega, (VEE-ga) the brightest star in the constellation Lyra, the Harp. Compare the colors of these two beauties. As the Earth rotates on its axis throughout the night, other stars of the summertime appear in the eastern sky. By midnight, all three stars of the Summer Triangle asterism, which is the three brightest stars from three different constellations, Lyra, the harp, Cygnus the swan, and Altair in the eagle will be visible if light pollution or clouds are not an issue. Lyra resembles a slightly bent trapezoid with a handle or a tail. The brightest star in it is Vega.

To locate the others, imagine a large triangle, with Vega at the apex, Deneb to the left vertex, and Altair to the right. Deneb is the brightest star in the constellation called the Northern Cross, or the Swan, Cygnus. This arrangement of stars does look like a cross. With an active imagination it can also appear to be a swan with its graceful neck outstretched towards the center of the triangle, and its strong wings spreading out on either side of the body. Deneb marks the tail. The swan's head is marked by an exquisite pairing of stars named Albireo, a match of a 3rd magnitude yellow star and a 5th magnitude blue star, considered by many to be the most beautiful double-star in the sky. Deneb itself is a massive supergiant star pumping energy/light equal to 60,000 suns. Cygnus is located in the Milky Way, and if your summer travel takes you to the Alpine area and the McDonald Observatory, be sure to look at those velvety really dark skies and enjoy the sights. This massive grouping spreads across the E-NE sky and spans 3/4 of the sky from horizon to the zenith. And it is all ours to enjoy.

Around the northern circle, in the NNE, look for Cepheus. This constellation looks like a crooked little house to the right of the Big Dipper. Cepheus is the king who was married to Cassiopeia, of "Clash of the Titans" fame. She will look like a letter W or M stretched out. As midnight passes, you may be able to spot her in the NNE. She enraged the sea god Neptune by ridiculing his fish-tailed daughters and was punished by being lashed to her throne and forced to circle the north star forever, sometimes under water (beneath the horizon) and other times above it, but never able to go home.

When you are wearied from the daytime heat, the cooler evening or early morning is a pleasant break and a perfect time to enjoy whatever is happening in the skies. From the riotous colors of sunlight scattered by the clouds and dust at sunrise and sunset, the presence or absence of clouds in the shades of blues, violets, lavenders, and gold skies will always have an effect on us. Make sure to enjoy them.

Summer’s progression increases the chance of seeing a meteor streak across our skies seeming to emerge from the constellations Capricornus and Aquarius. The meteors will not be very bright, but catching a "falling star" is always a special experience. I carry three meteorites in my purse most of the time and it is always fun to ask fellow diners if their children would like to hold a real meteorite and see the amazement on their faces. If you see me somewhere don't hesitate to ask to see them. I enjoy sharing them.

If you are out where there is wide-open sky to the south and little light pollution, you may be able to see the arc of the Milky Way galaxy arm that shrouds the constellations Sagittarius, Scorpius, and Ophiuchus. Sagittarius is the zodiac sign for November, but in the present era the sun is shining in front of this constellation from the end of December through most of January due to the shifting of our planet through the galaxy. Of course, the constellations have nothing at all to do with your behavior; we make those choices. The teapot asterism that forms the bow of the archer is more readily seen than the less bright stars of the entire constellation. Each of the stars have a name. The star at the top of the triangle that marks the lid is Kaus Borealis, which means northern bow, and that at the base of the spout is called Kaus Australis, which means southern bow. The tip of the spout star is El Nasi which means "point" and the star at the top of the handle is Nunki, which refers to a god of the Babylonians.

Our sun’s place in the galaxy is about two-thirds of the way from the center of the spiral we call the Milky Way. At 100,000 light years diameter, our planet is about 30,000 light years from the nucleus. Looking at the teapot we are looking directly toward the center of our galaxy.

Ancient myths called the blur of stars a heavenly river, a bridge linking heaven and earth, and a river of flowing milk. What would YOU call it? Let us know what your ideas are. Drop us an email. carolutsinger@att.net. Until next issue, DO let some stars get in YOUR eyes. ★

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.

Nunca Dejes de Ser Curioso

Ulises Jarquín

Desde que era pequeño me encantan los videojuegos. Estos han sido una parte muy importante de mi vida porque crecí con ellos y experimenté montones de diferentes y grandes historias en ellos. También, quise ser un astronauta cuando era pequeño, pero luego me gustaron las matemáticas y me interesó más la física y la astronomía.

Hace 10 meses, descubrí un juego que era de ser un astronauta, y me enamoré de él inmediatamente: mis cosas favoritas, fusionadas para crear una obra maestra. El nombre de este juego es **Outer Wilds**.

Outer Wilds es un videojuego de exploración espacial desarrollado por Annapurna Interactive. El juego trata de un astronauta extraterrestre que viaja alrededor de su sistema solar, aprendiendo sobre los diferentes planetas, sus satélites, conociendo a otros exploradores, e investigando y resolviendo los secretos de una civilización antigua que pobló su sistema solar.

Lo que me fascina de este juego es la gran cantidad de ciencia que presenta, y cómo te impulsa a aprender para poder progresar; si eres un amante del espacio, seguro te va a emocionar tanto como a mí. Outer Wilds no me enseñó nada que no supiera ya, sino que lo que ya sabía lo vi reflejado en el juego (como movimiento relativo, supernovas, leyes de Newton, etc.).

Primero quiero empezar hablando de la ciencia que está presente alrededor de todo el juego y su universo, empezando en el propio universo: a pesar de que es un sistema solar bastante pequeño comparado con los reales, las distancias en este son bastante grandes. Todos los planetas de este sistema solar se asemejan mucho a los nuestros, siendo que algunos son iguales. Para recorrer el sistema solar, tu personaje viaja en una nave la cual tiene sistemas de piloto automático, y esto le permite alinear su velocidad con la de algún otro objeto, hasta que tu nave esté "quieta", y pongo quieta entre comillas porque ahí entra el movimiento relativo, ya que tu nave nunca está quieta si alineas tu velocidad, porque te mueves conforme a aquel cuerpo celeste con el que hayas alineado tu velocidad. Y aunque no la hayas alineado, tampoco puedes quedarte quieto, porque por el momento que carga tu nave al haberte impulsado para salir de tu planeta, hará que no pare de moverse. Puedes contrarrestar esto, pero cada pequeño movimiento hace que la nave se mueva, y esto se intensifica más gracias a la gravedad que los cuerpos celestes tienen.

Hablando de los cuerpos, estos también presentan cosas muy interesantes. Voy a empezar en el orden en que vienen en el mapa del juego.

El sol es bastante grande y es el objeto con más gravedad de todos. Presenta tormentas solares las cuales se pueden apreciar a simple vista y cumple el ciclo de vida de una estrella, convirtiéndose en una gigante roja para luego morir en una supernova.

Después está el sistema binario de planetas conocido como Hourglass Twins. Este sistema binario funciona como un reloj de arena, literalmente, ya que uno de los planetas, llamado Ash Twin, está lleno de arena que es atraída hacia el otro planeta, Ember Twin, que termina por llenar unas cuevas que existen dentro de él. En Ember Twin hay un laboratorio ancestral que estudia la teletransportación mediante agujeros negros y blancos, implementando física teórica de manera muy buena dentro de la historia y el gameplay, y lo hace consiguiendo que tenga mucho sentido con el mundo del juego. También, dentro de este planeta existe una roca cuántica, algo que explicaré más tarde.

Después de Hourglass Twins está Timber Hearth, el planeta equivalente a la Tierra y del que es nativo nuestro personaje. Este se encuentra en la zona habitable del sistema solar, y en él hay sistemas de agua subterránea, y esta agua es expulsada en geiseres que causan ríos, que terminan llegando devuelta a otros geiseres, creando un ciclo del agua funcional; dentro de las cuevas de los geiseres hay muchos minerales, los cuales seguramente generan un campo electromagnético que protege al planeta de los rayos cósmicos y la radiación solar. Cuenta con una luna llamada the Atterlock, en la cual ya ha habido alunizajes anteriormente y ha sido explorada bastante. En Timber Hearth también existe un museo que funciona de observatorio, ya que es la segunda estructura más alta del planeta. Cuenta con otra roca cuántica y un telescopio en el que se hacen observaciones; gracias a ese telescopio, los personajes han descubierto que el universo se expande, que hay más de una galaxia, han replicado la foto del Campo ultraprofundo del Hubble, han estudiado la Radiación de fondo de microondas, entre muchas otras cosas... podría continuar, dando mil y un detalles del museo y el planeta, pero mejor sigamos con los demás planetas.

Más allá, un poco lejos en la zona habitable, se encuentra Brittle Hollow, un planeta que, en donde iría su núcleo, se encuentra un agujero negro, y poco a poco este planeta se va despedazando por el agujero negro. El agujero causa una inmensa gravedad, la cual, además de eventualmente tragarse el planeta, te atrae hacia su singularidad, y si te acercas mucho puedes ver cómo la luz alrededor de

este se distorsiona y cae dentro del agujero. En los polos de este planeta, al igual que en Timber Hearth, hay hielo y agua líquida, que es responsable de que la civilización antigua hubiera sido capaz de subsistir en el planeta y que hayan crecido árboles; y al igual que en Timber Hearth, este cuenta con una roca cuántica. El planeta casi no tiene edificaciones en su superficie, sólo en la parte interior; esto se debe a la inestabilidad del terreno. Brittle Hollow tiene una luna llamada Hollow's Lantern, que está hecha casi de pura lava, y es la causante de la inestabilidad de Brittle Hollow, porque los volcanes de la luna siempre están expulsando meteoros.

El planeta más grande, y el segundo objeto con más gravedad, es Giant's Deep, un planeta oceánico y parcialmente gaseoso, que cuenta con vida en forma de medusas que tienen un cuerpo que las aísla de la electricidad, algo que les permite entrar y acercarse al núcleo del planeta, que está rodeado de un campo eléctrico. Giant's Deep, como planeta oceánico que es, tiene bastantes tormentas, causantes de tornados que giran hacia la dereche o izquierda. El planeta tiene 5 formaciones rocosas que pueden llegar a ser succionadas por algún tornado y llevadas afuera del planeta, aunque por la gran gravedad de este, las formaciones siempre vuelven al planeta. Después tenemos a the Quantum Moon, y ustedes dirán: ¿por qué es cuántica? Bueno, porque este extraño cuerpo celeste cumple con el Principio de incertidumbre de Heisenberg... más o menos. Al igual que la cuántica de la vida real, este cuerpo es muy extraño, porque cuando lo vemos ahí se queda, sin hacer nada, pero cuando lo dejamos de ver desaparece, y ya no podemos saber dónde está hasta que lo encontremos y lo volvamos a mirar. Las rocas cuánticas que he mencionado desde hace rato vienen de aquí, y cumplen sus mismas características: sabemos que están ahí, en un determinado espacio, pero no podemos saber en dónde están, a qué velocidad se mueven, a dónde van a ir, o dónde estaban; una mecánica increíble que nunca antes vista en un videojuego.

Con lo que respecta a la ciencia que existe en el mundo de Outer Wilds eso sería todo, porque los demás cuerpos, Dark Bramble y The Interlooper, ya no cuentan con tanta ciencia de verdad, si no que tienen mecánicas del juego, las cuales crean un mundo muy interesante, que hace que sea emocionante aprender más, que es de lo que quería hablar ahora.

En Dark Bramble tú estás dentro de un espacio muy raro, porque si lanzas sondas para investigar el lugar, estas serán detectadas en varios lugares al mismo tiempo. También, Drak Bramble tiene una atmosfera muy aterradora, que se intensifica más cuando te das cuenta que esos puntos brillantes que se pueden ver no son "portales", si no monstruos. Para avanzar, necesitas aprender cómo evadir a los monstruos, usar bien tus herramientas disponibles, e incluso explorar en otros planetas para saber qué puedes hacer con respecto a ello. Lo mismo pasa con otras subtramas del juego: necesitas explorar varios lugares y llenarte de conocimiento para superar el reto que tengas al frente.

En Outer Wilds, conforme avanzas en el juego, no vas desbloqueando nuevos objetos, o subes de nivel un árbol de habilidades, o consigues mejoras en algo, si no que te llevas enseñanzas las cuales te permiten avanzar. Tu nave tiene un mapa mental que registra todo lo que ves y aprendes, literalmente atando cabos los cuales te permiten desvelar los misterios del juego y que hacen que seas capaz de terminarlo, como había dicho. Ningún juego que había jugado antes progresaba de esa manera, o sea, con conocimiento; y ningún otro juego me había hecho querer seguir jugando con el fin de aprender y desvelar su gran historia.

Las mecánicas increíbles del juego, aunadas a los múltiples hechos científicos y a los secretos que el juego esconde, me hicieron casi completar el mapa mental. No todos los videojuegos impulsan al jugador a completarlo al 100%, o al menos no como Outer Wilds lo hace, y es lo que hace que ame tanto el juego.

Completarlo fue algo muy satisfactorio, porque todos los amigos que hice, todos los conocimientos que obtuve, valieron la pena para el final; resolví algo que muchos no pudieron, y esa es la mejor parte del juego.

Outer Wilds impulsó mi curiosidad a niveles muy altos, y encendió de nuevo esa chispa que me hacía querer aprender. La curiosidad es una característica muy importante en un científico, y es algo que siempre debo de tener en cuenta. Gracias a Outer Wilds estoy más seguro de lo que quiero hacer.

Finalmente, quiero volver a decir que el juego despertó de nuevo esa chispa que hizo que quisiera aprender, e hizo que me diera cuenta de lo increíble que es, no solo el juego, pero el mundo real: lleno de misterios sin resolver, cosas que aún hay que descubrir, o como dijo uno de mis científicos favoritos.

"En algún lugar, algo increíble está esperando a ser descubierto."
 - Carl Sagan

Nunca dejes de ser curioso. Muchas gracias por leer.
★

Biografía
Ulises Jarquín es junior en Saint George Prep School en Heroica Matamoros. Es voluntario para la South Texas Astronomical Society y se ha entrenado en el Cristina Torres Memorial Observatory. Sus intereses incluyen la ciencia, el espacio, y los videojuegos. Ulises aspira a convertirse en astrofísico para crear un futuro mejor para la humanidad.

On Organic Molecules in Space and What They Tell Us

Eloi Camprubí-Casas

Decades ago - much like our thoughts on the chances for liquid water beyond Earth - we thought organic molecules were a rare phenomenon in the Universe. Due to this skewed perception, the first detections of organics in (or from) space were almost always directly tied to the origin of life since we already thought back then that organics are a requisite for life's emergence. Since then, we have detected a myriad of organics in a wide range of extraterrestrial environments. For instance, in diffuse clouds, denser star-forming regions, protoplanetary disks, interplanetary dust particles, comets and asteroids, and of course on the surfaces of other planets and moons.

The fact that we can obtain such precise measurements from celestial objects which usually are many light years away speaks wonders about our – quickly improving – technical capabilities. These detections tell us much about how general molecule complexification takes place in the Universe. There is a vast variability in the reaction mechanisms producing organic molecules, and the general trend is that the more complex - i.e. the more physical phases it contains - an environment is, the more 'complex' the resulting organic molecules are (i.e. the more chemical bonds they contain). For example, (mostly) monophasic environments such as diffuse clouds tend to contain organics which are rather simple, such as CH_2, CH_3CH, and CH_3OH, even though astronomers usually refer to some of them already as 'complex' organic molecules. On the other hand, more complex and multiphasic environments such as ice or dust grains (and of course planets and moons) increase the amount of possible abiotic (i.e. non-biological) reaction pathways towards larger molecules, and thus the array of organics we find in such environments is more varied and the molecules are, in average, larger.

Here you can see a glimpse of a real problem for us in the business of science regarding what we deem to be *simple* vs *complex*. This is not trivial, and in the case of origin of life research - as well as in several other subfields within the life sciences - it has generated a series of rather arbitrary moot discussion points regarding the study of complexity. In general, I would say that complexity is (almost entirely) in the eye of the beholder and that something ceases to be complex to us once we understand the associated mechanisms. For origin of life research, we all agree that we are indeed moving up through real complexity levels (from atoms to molecules, to chemical reactions, to chemical systems, to a reproducing/partially-living system, and finally to a fully-living system), but I hope that by the end of this piece I manage to convince you that *complexity* origin of life-wise has very little to do with how many covalent bonds a given molecule has.

It is worth noting at this point that a molecule is referred to as being 'organic' if it simply contains carbon and hydrogen atoms bound via covalent bonds. Organic molecules (or organics as they are commonly referred to) do not necessarily have to be synthesized or processed by living entities. In fact, the overwhelmingly vast majority of organics in the known Universe have been produced by non-enzymatic (i.e. non-living) mechanisms. Even many organics found on Earth are not being produced by living organisms, and instead are the product of abiotic reactions such as serpentinization-related CO_2 reduction deep inside Earth's crust to name just one. In extraterrestrial environments we have no reason to believe that any organics we have detected so far have been produced by living entities. In fact, astrochemists are experts at simulating extraterrestrial conditions - either in the wet lab or *in silico* - and at elucidating the abiotic mechanisms responsible for the synthesis of organics. Some of these abiotically-produced space organics are remarkably large and 'complex'. For instance, ~60-carbon fullerenes - or 'buckyballs' as they are sometimes referred to - are large organics which accumulate in several interstellar media due to their very high stability.

Despite all the above, in modern literature we can very often read claims that the detection of X, Y, or Z organic molecule in A, B, or C extraterrestrial environment is likely to be related to the origin of life (on Earth and putatively beyond). This, in my humble opinion, is a big mistake. However, it is an understandable confusion since virtually everyone is interested in solving the primordial problem of life's emergence. On top of this, the fact that decades of origin of life ('OoL' from now on) research being laser-focused in obtaining the so-called 'building blocks of life' has exacerbated this issue. Let us list and discuss – in an admittedly shallow manner here – the reasons why this is a far-fetched and quite unreasonable argument:

1. As we already discussed, organics do not (necessarily) mean life. In fact, they almost never do when looking at this from a Universe-wide perspective. Organics are just C-H molecules of varying degrees of complexity. Many abiotic mechanisms produce large amounts of organics (on Earth and beyond), some of them being remarkably complex (and/or large) such as is the case with 60-carbon fullerenes. There is also the example of the even larger, extremely ramified, and insoluble kerogen-like organics which we find in many organic-rich meteorites known as carbonaceous chondrites. I would like to point out that there is a big research area within the field of Astrobiology which studies *biosignatures* (literally the signatures of life). The goal of this field is to detect extraterrestrial life - if it indeed exists, of course - whilst minimizing the chances for false negatives and false positives. So far, this field has not come up with any biosignature (chemical, morphological, or electromagnetic) which is universally agreed upon. This exemplifies the difficulties we face when studying the origin and evolution of organics in the Universe: the organics of life often very much resemble the organics of non-life.

2. Most of the claims that the detection of Y molecule in B extraterrestrial environment could somehow be linked to life's emergence is based on the notion that the most important aspect of the abiogenesis process (i.e. the process responsible for the origin of life) is synthesizing the right so-called 'building blocks' (amino acids, sugars, small N-bearing organics, also the even simpler precursors to all of these, etc.). Now, of course this is a requirement, but as I explain in point 4 below, this is not nearly enough. However, as a requirement, the source(s) of organics for abiogenesis is indeed something we must find an answer to. It is worth noting though that the OoL community is very divided on which organics (as well as inorganic species) were the key players during each of the stages of the OoL process. Just to mention one notable example, many researchers - particularly those who tend to favor the seafloor as the cradle of life – favor the direct usage of CO_2 as the primordial building block upon each biomolecule is derived from; not unlike the basic metabolism of cellular life on Earth. However, starting with the famous Miller-Urey experiment in the mid-20th century, another school of thought within the OoL community favors much more reduced (i.e. electron-rich) carbon species such as CO and HCN as the building blocks.

This is relevant for space scientists since I have met many who look for one or the other molecule in extraterrestrial environments since they are convinced this is the way life on Earth started - and many assume the OoL community has reached a tacit consensus on this, but that is simple not true. Of course, each OoL 'side' tells everyone else (including astronomers) that their prebiotic chemistry (i.e. the chemistry which gives rise to life) is the correct one, but the unbiased truth is that we are as far from a consensus as we could be on this matter. So, the choice of target 'building block' or precursor molecule(s) to look for in extraterrestrial environments is a very loaded, divisive amongst experts, and ultimately potentially wrong endeavor.

3. In any case, one possible answer as to the origin of (some of) these building blocks or precursors could indeed occur by delivery of such molecular species to a newly-formed planetary body after its accretionary and cooling-down processes. This so-called *exogenous* delivery of materials from extraplanetary sources is controversial within the origin of life community, where roughly half of the field does not see the need for any organic delivery since most organics abiotically made in space can also be made on a multiphasic planet such as the Hadean Earth (i.e. *endogenous* source). The delivery process itself is often very violent and destructive, which of course are negative aspects. The other half of the field is not opposed to the idea that some materials delivered were important for life's emergence, with some authors proposing this as the main source. The point here, is that many prominent OoL researchers (~50%) do not think the delivery of extraterrestrial organics (post-accretion) aided life's emergence in any meaningful way. This is of course 'only' an informed opinion, but it is something which space scientists would do well to keep in mind.

4. Frankenstein's monster is - unfortunately for us OoL researchers - fiction. Yes, we think organic molecules are a requirement for life's emergence (at least for life-as-we-know-it), but their presence is certainly not enough. This might sound counterintuitive at first, but let me explain a bit further: Imagine that in the lab we have a dead animal or a bunch of dead microbes. This chemical system (which in this case I would agree is/was a complex system) contains all the 'building blocks' necessary for it to be alive. Yet, there is no experimental treatment we can do to this 'primordial soup' which will make it spring up to live again. Not in the format of when it was a living animal (or cell), and neither in any alternative, more primitive way. In other words, no electricity, ultraviolet light, X-rays, hot-cold or wet-dry cycles, radioactivity or any other form of energy will promote that these 'building blocks' start behaving as a living system (i.e. displaying biological functions: reproduction, homeostasis, energy conservation, etc.) again.

Something else, a secret ingredient, seems to be missing. Yet again, there is no consensus here either on what is/are this/these missing ingredient/s, but one slowly emerging consensus which I favor argues for autocatalysis being a key component. Autocatalysis is a phenomenon by which chemical species in a network of chemical reactions ultimately help each other to become more concentrated over time. This, for example, can be achieved by some of the products of some reactions acting as catalysts (which speed up reaction rates) for other reactions which in turn feed the initial ones. This naturally 'cooperative' chemistry is not only speculative, we find this in life's metabolism. So the question now is whether this phenomenon – arguably together with some other important ones such as directional or vectorial chemistry as the seed of chemical system asymmetry – could result in a naturally-occurring chemical system which is capable of making copies of itself in a way which allows evolution via natural selection to start making these 'replicators' more efficient at exactly this: replicating, which is the most crucial function of a living system. In any case, we are entering another fascinating topic which is probably better fit for another piece in the future.

But it is not all doom and gloom for organics in space! In my mind, there is a big lesson we learn from the growing number of organic detections beyond Earth from an OoL perspective: Organic molecules – even those which are rather complex – are not rare beyond our planet. If indeed, organics were needed for life on Earth to emerge, then the chances of life emerging elsewhere are not bottlenecked because of the lack of availability of organics. It is still early to judge whether the Universe is emptier than 'we thought', but perhaps planetary *habitability* (or more accurately when discussing OoL: *genesity*) is much more strongly bottlenecked by other processes beyond the presence/absence of organics and of liquid water. The classic concept of the 'goldilocks' or habitable zone around a star where planetary bodies can contain liquid water in their surface (making them habitable) is becoming rapidly outdated. Again, a topic for another day.

If anything, I would like to end this piece by stressing out that the presence of a wide range of organic species was and is a given for many planetary bodies. The OoL problem is not (anymore) a grocery delivery problem: the 'food' is and was there. The problem now is understanding under which external/environmental conditions, as well as internally-emerging constraints within the evolving chemical network, these 'ingredients' start spontaneously and actively displaying the traits of life. This is in a way reminiscent to how a glucose molecule in our body is itself not alive, but participates in a larger game where the system as a whole, is. ★

Biography

Eloi Camprubí is an Assistant Professor of Astrobiochemistry within UTRGV's Departments of Biology and Chemistry. He is from Barcelona (Spain) and, thanks to a 'la Caixa' Foundation doctoral fellowship, he earned his PhD in Chemistry from University College London (UK) in 2018. He was then awarded a 3-year postdoctoral fellowship to join the Origins Center (Utrecht University, Netherlands). In 2021 he obtained a 3-year Human Frontier Science Program fellowship to join the Earth-Life Science Institute (Tokyo Institute of Technology, Japan). In 2022 he joined UTRGV as an awardee of the University of Texas System's STARs Program. His main research areas are the origin and early evolution of life, as well as developing tools for life's detection within the Solar System. He teaches a new Astrobiology course at UTRGV which is at undergraduate level each Fall, and at graduate level each Spring.

Give Eloi a follow on Twitter (@Eloi_CC) and be sure to check out his website at eloicamprubi.com!

The Deafening Roar of Rockets: The Auditory Beauty of Rocket Engines and their Application into the Creative World

Mykel Del Angel

Introduction

The word "rocket" conjures up so much imagination and awe in the psyche of the general public and specialists alike. If one ever watches a rocket launch, it is very hard to not be impressed by the thunderous roar of the rocket, spewing enormous flames and smoke as it soars to outer space [1].

My first rocket launch happened to be the Starship launch that happened in April of 2023 and I truly didn't know what to expect as I had never experienced a rocket launch in person before. All I knew was, I was sent on a mission by Cosmic Perspective to capture video and audio the reactions of the people at Isla Blanca. When I finally heard the thunderous roar I was stunned. I had never heard anything so powerful and deafening before. It was beautiful. Immediately after the rocket flew out of our view, I ran to my laptop and checked the audio I had captured and I had never felt so much joy in my life. The moment I heard the roar of the rocket over the audience I realized the potential in the sound of a rocket. Before working with Cosmic Perspective, never did I think I'd be mesmerized by such an event, but witnessing a rocket launch has definitely brought a whole new perspective and interest into my life. It's a sound that represents humanity's ability to reach beyond the bounds of our planet and explore the cosmos. It's a sound that inspires wonder and amazement and reminds us of the incredible technological advancements we've made as a species. It's a sound that can be applied into the creative world and its multiple industries in a countless amount of ways. Before we dive into that, let's discuss what causes rocket sounds, why and how they get recorded, and what we can learn from them.

How Is the Sound of a Rocket Produced?

One of the loudest sounds ever recorded was NASA's Saturn V rocket, which registered 204 decibels [2].

When a rocket engine ignites, it releases a massive amount of energy in the form of rapidly expanding gases. This expansion generates intense pressure waves that propagate through the surrounding air, creating sound waves. The sound produced by a rocket launch is characterized by its powerful low-frequency components and loud nature. These low-frequency sounds result from the large volume of gas being expelled and the immense energy involved. The intense vibrations caused by the combustion process and the interaction of exhaust gasses with the surrounding atmosphere also contribute to the unique sound profile. The acoustic properties of a rocket launch can be influenced by various factors, including the design and configuration of the rocket, the number and arrangement of engines, and the distance from the observer. The sound intensity and frequency content can vary significantly depending on these variables. Entrainment of the cooler atmospheric air and heat transfer from the rocket plume would both act to reduce the speed of sound in the plume, further decreasing the peak frequency of the radiated sound [3]. During a rocket launch, the sound travels as pressure waves through the air. The waves undergo diffraction, reflection, and interference as they interact with the launch structure, the ground, and other objects in the vicinity. This interaction can result in complex acoustic phenomena, such as sonic booms, shock waves, and resonances. Explanations for some rocket noise characteristics have been suggested on the basis of the properties of the highly supersonic rocket exhaust plume [3].

Why Is the Sound of a Rocket Important to Capture and How Do They Do It?

Recording rocket audio is of significant importance as capturing the sound generated during rocket launches provides valuable data for scientific analysis and research. By analyzing the audio recordings, scientists can study the characteristics of the rocket's propulsion system, engine performance, and aerodynamic forces at play. This information helps in refining and improving rocket and launch support design, optimizing fuel efficiency, and enhancing overall performance and efficiency. Additionally, studying rocket audio aids in understanding the intricate details of acoustic dynamics, helping researchers improve noise reduction strategies and design quieter launch systems. From a safety perspective, analyzing rocket audio assists in monitoring and evaluating potential structural anomalies, detecting any unexpected noises or vibrations that may indicate technical issues or malfunctions, discrepancies to the nearby communities and environments. The prediction of noise generated by launch vehicles is required to assess the structural integrity of launch support structures and to estimate the impact of frequent launches on nearby communities [3]. This proactive approach enhances the safety protocols for both crewed and unmanned missions, ensuring the well-being of astronauts and the success of space exploration endeavors.

There are many companies and professionals and novice individuals who practice the art of recording rockets such as NASA and SpaceX engineers. They use specialized equipment and techniques to capture the unique sounds of a rocket launch. Recording audio of rocket launches typically involves the use of specialized equipment and techniques. To capture the sound, microphones are strategically placed near the launch pad or in close proximity to the rocket's trajectory. These microphones are often designed to withstand the intense vibrations, high decibel levels, and harsh environmental conditions present during a launch. They may be housed in protective casings or placed inside insulated chambers to minimize interference from wind noise. In some cases, multiple microphones are positioned at different locations to capture a comprehensive audio profile.

When I recorded audio of the rocket I completely did not know what I was doing. It was my first actually doing this kind of work so there was a lot of trial in error. I was provided a zoom recorder by Cosmic Perspective and brought my own Behringer condenser mics. My goal was to record the audience reaction/island environment alongside with the rocket so I had placed the Zoom recorder facing the crowd at Isla Blanca and connected a condenser mic to it facing the ocean and the rocket in the jetties. At our base of operations, a tent my comrade Blaine Allen brought, I used the remaining three condenser mics to get another perspective of the audience. I placed one in the center of the tent and one of each side of it and hooked it up my laptop via a mixer interface. I set them up and had them running for hours patiently waiting for Starship to launch.

Is There an Application of the Sound of Rockets Outside of Scientific Data?

The sound of a rocket launch isn't just something to be appreciated by only space enthusiasts and scientists. They can be used to create realistic sound effects for film, television, video games, educational media, or even music production, allowing viewers to experience these projects in a more immersive way.

Rocket launch recordings can be used extensively in the film industry to enhance the authenticity and impact of space-themed scenes. By incorporating actual rocket launch audio into space-related sequences, filmmakers can create a more immersive experience for viewers. The thunderous roar, crackling flames, and rumbling vibrations of the launch can be synchronized with visual effects to heighten the realism of rocket lift offs and space exploration sequences. These recordings provide a sense of scale, power, and intensity that helps to convey the awe-inspiring nature of space travel. Additionally, rocket launch audio can be utilized creatively in science fiction or futuristic films to evoke a sense of grandeur, technological advancement, or suspense. By integrating these authentic sound elements, filmmakers can transport audiences into the thrilling world of space exploration and make the on-screen experience more captivating. They have been featured in movies such as *Gravity*, *The Martian*, and *Interstellar*! We obviously used a lot of rocket recordings, some rocket motor tests that we recorded out at Mojave here, as well as a number of recordings of rocket engines in general [4]. The unique and powerful sounds of a rocket launch can add a sense of drama and excitement. It even has the potential to be used in the music industry and the wider audio world.

Rocket engine sounds can be utilized creatively in the music industry to add unique and unconventional elements to compositions. The raw power and distinctive sonic characteristics of rocket engine sounds can be incorporated into electronic music and experimental genres. By manipulating and processing these recordings, musicians and producers can create atmospheric textures, rhythmic patterns, or even melodic elements. The dynamic range and complex frequencies of rocket engine sounds offer a vast palette for sound designers and musicians to explore, enabling them to evoke a sense of awe, excitement, or futuristic ambiance in their compositions. Incorporating rocket engine sounds into music provides an innovative and captivating sonic experience for listeners, pushing the boundaries of traditional musical expression and this is not anything new. Musicians and sound designers have been incorporating recordings of rocket launches into their work for decades. In recent years, the use of rocket launch sounds in music has become more popular than ever. Artists like DJ Shadow, Boards of Canada, and Public Service Broadcasting have all used samples of rocket launch audio in their music, creating a new genre of "space music" that celebrates humanity's achievements in space exploration. I am even joining this train by developing my own sample library from my audio recordings of the Starship launch test.

Conclusion

The significance and beauty of the rocket engine sound are undeniable, and it's no wonder that many people are captivated by rocket launches. There is a unique thrill and suspense that accompanies witnessing a launch or even a scrubbed launch, which draws people together to experience these awe-inspiring events. The deafening roar of a rocket as it blasts off into the sky is an intense and powerful sound. It resonates with people from all walks of life and has the ability to transcend boundaries, reaching almost every industry and aspect of human creativity. It is remarkable to think about the diverse ways in which people are inspired by rocketry. From musicians creating compositions based on the sounds of rockets to writers crafting stories that explore the excitement and wonder of space exploration, rocketry has become a source of inspiration for artistic expression. These creative endeavors not only showcase the impact and influence of space exploration on our culture. It highlights the power of human creativity and the ability of rocketry to ignite imagination and innovation and I am glad and honored to be able to join the conversation about the auditory beauty of the rocket engine sound. ★

References

[1] W.-S.Ohm and T. Park. *Introduction to the special issue on acoustics of rockets*. The Journal of the Acoustical Society of Korea, 39(4), 319-321 (2020) https://www.jask.or.kr/articles/xml/MO8R/

[2] Seeker. *How Loud Are Rocket Launches?* Seeker (2014) https://www.seeker.com/how-loud-are-rocket-launches-1792496122.html

[3] S. A. Mcinerny. *Rocket noise - A review*. (1990) https://doi.org/10.2514/6.1990-3981

[4] *SoundWorks Collection - The Sound of Interstellar*. (n.d.). YouTube. Retrieved June 8, 2023, from https://www.youtube.com/watch?v=Wwu9xprKNqI

Biography

Mykel Del Angel is a high school graduate from Pace Early College High School and has worked with STARSociety as a media intern and volunteer. He holds many awards from the Technology Student Association for music production and audio podcasting, including a national champion award for digital video production. He was awarded Best News Package by the MACA Student Film Awards. Mykel will be attending Berklee College of Music in the spring to study composition and music technology.

AstroPharmacy and Beyond

Paulo Markaj & Marshall Tomat

A part of learning and understanding the cosmos is being able to study it, and to conduct research in the field. In order to do this we, as a species, need to send brave and inquisitive explorers forth in hopes of uncovering what is out there. This process started with trips past the atmosphere, orbiting the Moon, and eventually landing on the Moon's surface. Our technology and strategic planning has allowed us to send forth drones in order to learn more past these shorter manned missions. So while we are learning as much as we can about deep space from a distance, we can begin to plan for when we conduct manned missions on trips longer than to our neighboring satellite. The planning of these longer missions allows one to think about how our astronauts will get there, and what they will need to survive. We are here to discuss that last question and the subsequent questions that follow.

Life has its many struggles. One we are all familiar with is disease. The challenge of battling disease when on a space mission is a difficult one to prepare for. Can we predict when our voyagers will get sick? What will it be that ails them? NASA scientists anticipate that round-trip planetary missions to Mars will exceed two years in length [1]. Longer missions will be unlikely to involve an ISS resupply, and will need to be self-sufficient. Moreover, astronauts will be exposed to new dangers and hazards, which makes the availability of pharmaceuticals that much more important. The potency of pharmaceuticals has shown to degrade faster than the Earth shelf life when packaged and exposed to higher levels of radiation in space [2]. One way NASA scientists are currently trying to combat these issues is by introducing a way our astronauts can synthesize pharmaceuticals on-demand during their mission. A class of biologics, peptide- or protein-based therapeutics, are of interest to this discussion because the method of synthesis can be made amenable to space travel. There are a variety of them in the clinic: being used to treat embolisms, hemorrhages, renal stone formation, bone density loss, thrombotic complications, and complications due to radiation. These issues are relevant to what our astronauts might experience during long space travel. "Astropharmacy" is the first step toward answering this question [3, 4, 5]. A group of scientists at NASA are researching ways to utilize bacteria in order to grow these classes of biologics. In theory, this on-demand production would both eliminate the degradation over time, while also minimizing the resources needed to maintain a healthy crew.

The astropharmacy project set out in 2020 with the goals of: the synthesis and purification of two biologics; testing their purity and activity; quantifying parameters for production; assessing the parameters necessary for production in space, in the context of a long term space mission; identifying key knowledge gaps; outlining a road map for technological development; assessing the impact of this technology for terrestrial impact [4, 5]. Their work employs the space hardy spore *Bacillus subtilis* to secrete two different biologics of importance for astronaut health. One is teriparatide, a biologic with a base of 34 amino acids. It is an anabolic agent for combating osteoporosis. Another is filgrastim, a biologic with a base of 175 amino acids. It is an effective countermeasure for radiation-induced neutropenia [6, 7]. Neutropenia is the abnormally-low presence of neutrophils in the blood which can lead to increased infections [8]. See Figure 1 for more details of teriparatide and filgrastim.

The *Bacillus subtilis* spores would be transfected with modified sequences of these drugs that would then

Figure 1. Ribbon diagram of teriparatide and filgrastim. Folded structure of 34 amino acid teriparatide (left). Folded structure of 175 amino acid filgrastim (right) [3].

allow the spores to synthesize and secrete the different biologics, aiming to have enough for one dose in about 24 hours. These spores are then dried on paper for easy storage and the ability to be grown later once reconstituted. Once reconstituted and expressed in fresh LB media, one would then isolate the biologics using an affinity column which utilizes a histidine tag purification to separate the biologics with the histidine tag modification from the rest of the bacteria and medium. This is then followed by a series of buffer washes to obtain optimal purity and concentration of the expressed biologics [3]. With further modifications such as growth conditions, promoter sequence, and expression conditions, the yield and execution of this technology can be improved. NASA has also begun work to include other biologics in their phase II study, as well as establishing cell assays for validation that are suitable for long term missions and also validating the purification system [5]. Once researched, more tests can be done to eventually implement this process and ready it for space travel. As we look at the future of the NASA space program, the Asclepios III is a student-led analog lunar surface mission that could be a great opportunity to test this technology in a pseudo-space environment, allowing for more data and more process development before being implemented on actual lunar missions [5, 8]. They also hope to learn how this technology can benefit in the industry as well as the DOD.

As we applaud and appreciate the tremendous work that has been done and is currently ongoing at NASA and other space organizations to advance the study of pharmaceuticals, drug design, and process, being scientists involved in the pharmaceutical industry ourselves, more questions come to mind. We invite you to think about a bigger, more advanced picture of where this technology can potentially be pushed further in drug development and other scientific areas in deep space and here on Earth. Can more drugs be synthesized and provided this way to our astronauts? Can we find a way to modify bacteria to grow fuel stocks in a way recently demonstrated in algae [10]? If so, can we introduce refueling stations on other planets and moons to increase the distance we travel through space?

Taking the scope of this back down to Earth, do we see areas where this on-demand pharmacy technology can be implemented. More and more new drugs coming to market are protein- and peptide-based biologics. Surely this process can be adapted to synthesize more therapeutics. Shelf life here on Earth is not as big of a problem as availability and access, not only in the long term, but more importantly in the short term during which an outbreak can happen (as we have seen with COVID-19). Can we establish emergency medical stations for potential outbreaks where, using this bacterial technology, people can reconstitute, grow, harvest, and administer therapeutics before an outbreak happens, granted that this disease is treated with a biologic-based medicine?

Can we think of an analogous system, but grown in algae for coastal and island communities? Instead of finding ways to transport doses of therapeutics to hard-to-reach communities, we can more easily transport spores of bacteria or modified algae to a location and then use that to address medical concerns in those communities.

Does this door open the possibility of the commercialization of this "on-demand" synthetic process? While the shelf of pharmaceuticals is not as drastically reduced here on Earth compared to space, does this open the door for drug targets that were once internally defunded due to shelf life? Drug targets that are potentially more potent in fighting infection or disease and now can be accessed through an on-demand synthetic process? We are a long way from that milestone, but one would be reluctant not to think of a future in which synthesizing certain types of medicine in your home could be a possibility.

Studying the cosmos and our universe will be around for the foreseeable future, and we should all be thankful to experience this fact during our lifetime. Longer manned missions beyond our orbit will bring forth great discoveries of which we could only dream. It is imperative that we realize that all of this work impacts us whether we are directly involved or not. Through interdisciplinary relationships, science builds upon itself and allows us to ask new questions. This understanding, along with continuous exploration and invention, will not only keep our explorers alive, but will also improve our lives back on Earth. ★

References

[1] B. G. Drake, J. D. Baker, S. J. Hoffman, D. Landau and S. A. Voels. *In Human Exploration of Mars Design Reference Architecture 5.0, Addendum #2.* NASA Johnson Space Center, 17-66 (2014) https://www.nasa.gov/sites/default/files/files/NASA-SP-2009-566-ADD2.pdf

[2] J. F. Reichard, S. E. Phelps, K. R. Lehnhardt, M. Young and B. D. Easter. *The Effect of Long-Term Spaceflight on Drug Potency and the Risk of Medication Failure*. npj Microgravity, 9, 35 (2023) https://www.nature.com/articles/s41526-023-00271-6

[3] A. Vallota-Eastman, C. Bui, P. M. Williams, D. L. Valentine, D. Loftus, and L. Rothschild. *Bacillus subtilis Engineered for Aerospace Medicine: a Platform for Off-Planet Production of Pharmaceutical Peptides*. bioRxiv 2023.02.22.529550 (2023) https://doi.org/10.1101/2023.02.22.529550

[4] Lynn Rothschild. *An AstroPharmacy*. NASA Ames Research Center (2020) https://www.nasa.gov/directorates/spacetech/niac/2020_Phase_I_Phase_II/Astropharmacy/

[5] Lynn Rothschild. *A Flexible, Personalized, On-Demand AstroPharmacy*. NASA Ames Research Center (2023) https://www.nasa.gov/directorates/spacetech/niac/2023/Astropharmacy/

[6] *Filgrastim*. PubChem. National Center for Biotechnology Information. https://pubchem.ncbi.nlm.nih.gov/compound/Filgrastim

[7] *Forteo.* PubChem. National Center for Biotechnology Information. https://pubchem.ncbi.nlm.nih.gov/compound/Forteo

[8] Mayo Clinic Staff. *Neutropenia*. Mayo Clinic (2022) https://www.mayoclinic.org/symptoms/neutropenia/basics/definition/sym-20050854

[9] *Asclepios III*. Asclepios.
http://asclepios.ch/asclepios-iii/

[10] *Biofuels: The Promise of Algae*. Biotechnology Innovation Organization.
https://archive.bio.org/articles/biofuels-promise-algae

Biographies

Paulo Markaj is a graduate of Manhattan College ('16), where he received a Bachelor's of Science in Biochemistry. He received a Master's of Science in Organic Chemistry from the University of Pittsburgh ('20) where he researched multi-step organic synthesis. He currently works as a Senior Research Associate, Discovery Chemistry for Moderna Therapeutics. He is a staunch AC Milan fan, and enjoys watching anime, listening to podcasts, and playing video games.

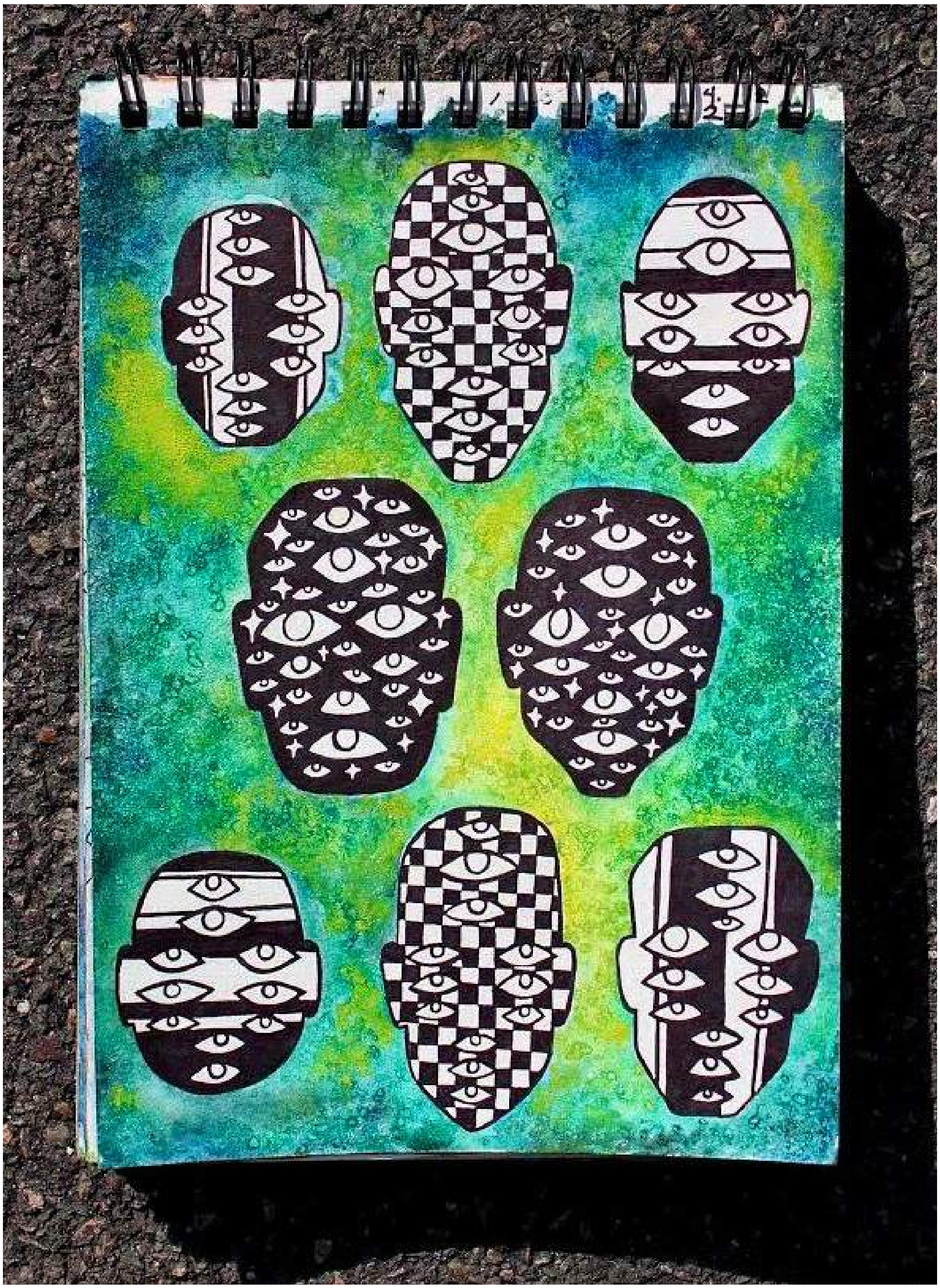
Marshall Tomat is a graduate of Franklin & Marshall College ('16), where he received a Bachelor's of Arts in Chemistry. He received a Master's of Science in Chemistry from North Carolina State University ('18) where he researched synthetic organic chemistry methodology. He currently works as a Senior Research Associate, Process Chemistry for Moderna Therapeutics. He is a life-long science nerd, and enjoys watching sports, hiking, camping, listening to music, playing video games, and being with his friends.

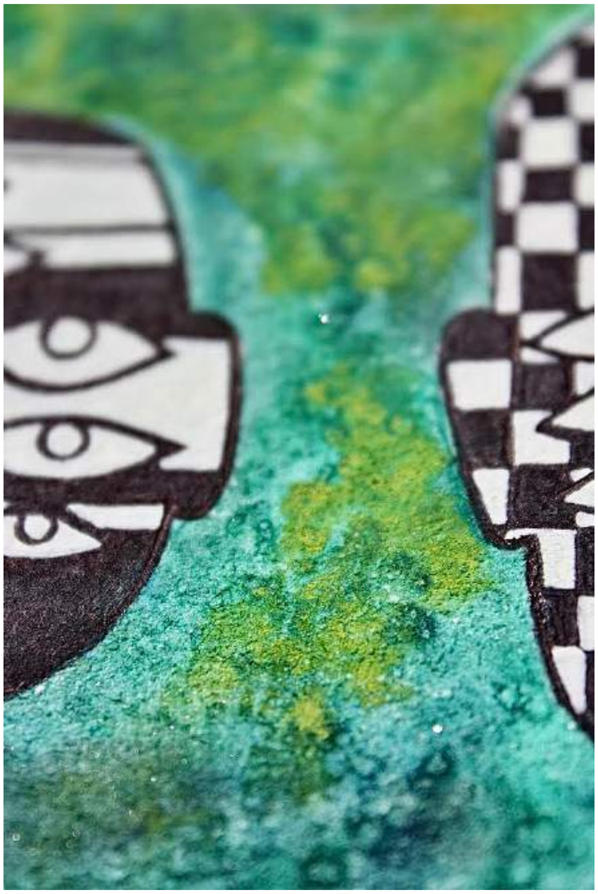
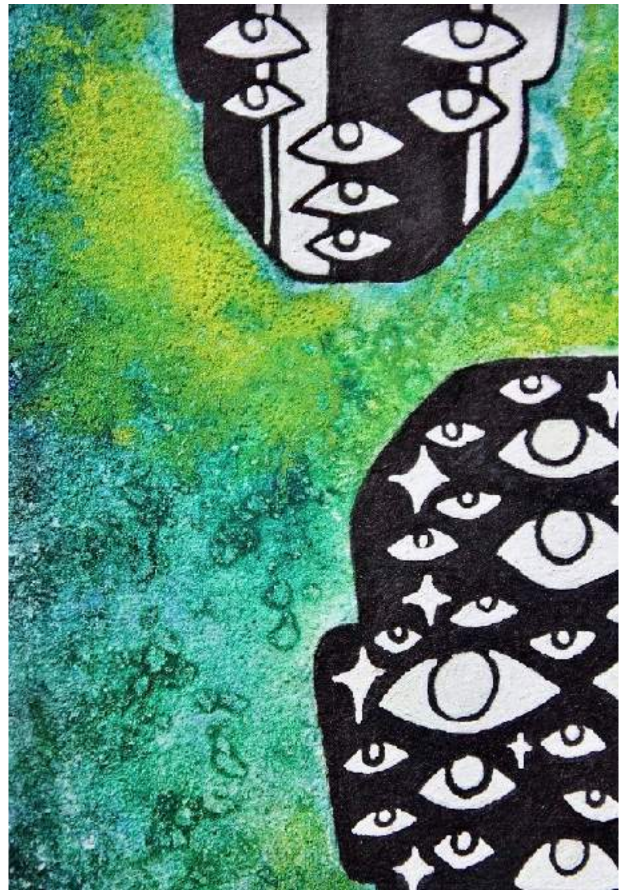
Figure 1.
Name: Nautical Rose
Medium: Sculpture
Materials: Polymer clay and glass
Dimensions: 19cm x 12.6cm x 0.6cm

Haber relies on somatic factors to assist in the choice of materials used. As a neurodivergent artist, the act of making is symbolic of self recognition and creative synergy. "Is the artist inspired to make Art, or does the art inspire the Artist?" For this question is the reason the eyes of the beholder and the eye of the work hold each others gaze in a calm curiosity.

The asymmetric precision of sectioned chambers is representative of an organized plan within a chaotic atmosphere. This piece is 5th in her series of nautilus shells created between 2020-2021. Each color is hand mixed to allow for dynamic transitions between the layered levels.

Figure 2.
Name: Eight Oracles
Medium: Painting
Materials: Watercolor paint, ink, and salt
Dimensions: 9in x 5in



The painted oracles are a guiding group that bolster trust in exploration. Color and value (i.e. light and darkness) of the paints are experimented with. What is formed behind the oracles is not important. Haber's colors in this painting are inspired by pea galaxies. The colorscapes indicate energy shifts that give birth to crystal plots, or the "stars". The salt used absorbs the water, pulling the solution towards the salt crystal. The pigment that doesn’t get absorbed, leaves behind the rings and bands you see.

Hannah Haber is a Visual Artist from Bronx, NY currently living in Boston, MA. She has an M.Ed. in Teaching Visual Arts (Pre K-8), a B.A. in Art History and Historic Preservation, and a background in the restoration and conservation of ancient art. Fascinated by color and science, she holistically explores different mediums. Check out her work on Instagram: @haberscreatureclub

The Morality of Space Settlements: Human Limits

Jaqueline Peña

The thought of a human role in space exploration, let alone space habitation, gives the pretense to a discussion of human rationale. It's a growing thought of dispute within the space industry; a thought to be sought at the initial ethical expectancy and the well anticipated diffusive matter of revolutionary sciences. Pulsating with every discovery, we stand at the cusp of prospects. We look up at the night sky into a sea of grand stars past the clouded haze of hope. Progressing means pushing the limits of our atmosphere and pushing the limits of our empathy.

As would any jump in innovation cause, moralistic debate has surged through the possibility of future conditions. However, simply put, humans are not apt to live long-term out of Earth's atmospheric and pressurized comforts. In any form of environmental change a biologically responsive system will undergo alterations through descending lineage in the name of survival; this idea can be transposed when humans leave their home planet.

Are we willing to risk human life for this venture? Are we willing to genetically modify our candidates? Is human experimentation under the guise of space exploration to simultaneously be reflected on the forefront of biotechnology?

As it comes down to the line, we must ask ourselves: Are we willing to play God?

The Threat of Human Enhancement

A concept that sounds fitting to the future, cyborgization, is exactly as science fiction would frame it. As touched upon in length within *Human Enhancement in Space Missions: From Moral Controversy to Technological Duty* by Konrad Szocik and Tomasz Wójtowiczb, radiation, microgravity, and isolation will play a part in challenges to setting the Martian terrain [1].

If we send our very own human candidates to live in the conditions of space, will we allow the opportunity to do everything we can in our power to ensure safety just slip? After all, a crew is codependent, the mission cannot afford contingency failure, and life is beyond money.

Bio-chipping our candidates will provide up-to-date vital reports on physiological stress. Physical enhancements, like altering cardiovascular and skeletal systems, will improve the strength of physical systems (although stimulating the brain for comprehension in problem solving is invasive). Yet, as phrased by Szocik and Wójtowiczb, "biotechnological improvements in humans may profit from risk-benefit analyses of each type of enhancement, followed by debates on the ethical aspects related to their use" [1]. Simultaneously, would the alteration of humans for intended performance not be transmitted to further use? Can uniform upgrades in strength not be used in high demand missions like first responders and military personnel? This rising industry could entirely catapult new testing, facilitate, and perhaps lay the path to revolutionary health science in the diffusion of space technology.

The counterargument to limit would fall in space policy. Within a chapter not yet considered, would infesting a planet that has no justice system be smart to arm with loaded cyborgs? At what point will enhanced human presence be considered militarization?

Genetic Drift & Specialization

When a species is separated from a large population by a random event, the genetics of an organism might exhibit a change in gene variant. With this separation and subsequent culmination of hybrid viability, speciation can facilitate [2]. Is sending a crew into the isolation of the Martian atmosphere not building the basis for DNA distinction?

Taking a step further, presume these altercations of biological enhancement and the gradual effects of genetic drift occur amongst our candidates. What allows the perception of a sentience to not draw a conclusion to identity? As outlined by Douglas A. Vakoch in *The Human Factor in a Mission to Mars,* "These changes in cosmology and self-perception have been seen time and again in human communities on Earth among people who move from rural to urban environments" [3]. If natural migration within the bounds of earthly regions poses an incentive to question a self-aware identity, what would humans 192.19 million miles away still identify with when it comes to Earth-living counterparts? May we expect the shift in genetics to be the first to show inconsistencies through DNA analysis? And when will we know what to call what we have created?

Reproduction

Interplanetary long-term settlement requires reproduction of a population. Considering the previous biological challenges of out-of-Earth conditions, reproduction poses a risk of health for mother and child. Even with perfect health conditions, consanguinity, limited oxygen and radiation during the embryonic process is a hazard [4]. Gene editing could ensure the strength and health of children, yet will not stray away from moral, ethical, and physiological discomfort. That is not to say this process will not extensively be researched before being properly enforced. However, should we question the idea of data that looks back at you?

Conclusion

Discussion on moral rights for human betterment starts further into the image of ethical debate in the question of human adaptation. What continues is understanding that the idea of living on a separate planet would no longer be considered adaptation, but rather alteration through our own hands in shipping humans away. It will come with inherent sacrifice of what we consider human testing.

Applying the progression of natural selection, Vakoch counts our losses as, "These are not signs of weakness, but ultimately, signs of human progress in establishing the beginnings of a lasting community" [3]. We could simply land right back on the undeniable fact that these are humans we have extensively trained for prodding, and picking, and perhaps, an inevitable death. Or better yet, will this all lead to the speciation of a separate, biologically enhanced and genetically altered, extraterrestrial race? ★

References
[1] K. Szocik and T. Wójtowicz. *Human Enhancement in Space Missions: From Moral Controversy to Technological Duty*. Technology in Society, Volume 59, 101156 (2019) https://doi.org/10.1016/j.techsoc.2019.101156

[2] J. S. Schiffman and P. L. Ralph. *System Drift and Speciation*. Evolution, Volume 76, Issue 2, pp. 236-251 (2022) https://academic.oup.com/evolut/article/76/2/236/6728497

[3] K. Szocik. *The Human Factor in a Mission to Mars: An Interdisciplinary Approach*. Springer International Publishing (2019) https://link.springer.com/book/10.1007/978-3-030-02059-0

[4] K. Szocik et al. *Biological and Social Challenges of Human Reproduction in a Long-Term Mars Base. Futures*. vol. 100, pp. 56-62 (2018) https://doi.org/10.1016/j.futures.2018.04.006

Biography
Jaqueline Peña is an intern and ambassador for the South Texas Astronomical Society. She is also a blogging contributor for the Space Time Archives, where her publications, such as this one, can also be found. She is going to pursue Astronautics and Aeronautics at Stanford University.

Journey to Centauri: The Potential of Interstellar Travel

Olivia Lincoln

In the final scene of the 1997 sci-fi movie *Gattaca*, main character Vincent Freeman prepares for his journey to Saturn's moon Titan. As he contemplates during the launch, he remarks, "For someone who was never meant for this world, I must confess I'm suddenly having a hard time leaving it. They say every atom in our bodies was once part of a star." In a moment of solace, he says, "Maybe I'm not leaving; maybe I'm going home" [11]. Though Gattaca is not a space-centric sci-fi movie, the ending scene actually captures a profound sentiment that aligns with the motivations behind space exploration. Vincent's introspection embodies our desire to explore the unknown, rediscover our celestial origins, and find a place of belonging among the distant stars.

This sentiment reflects our fascination with interstellar travel. It reminds me of the phrase "ab astris venimus, ad astra redibimus" which is Latin for, "we came from the stars, and to the stars we shall return." It carries both a philosophical contemplation of life and death and a reflection on the driving force behind our quest to explore the cosmos. Our connection to the stars, as the source of our very being, compels us to venture out and expand our knowledge of them. The desire to explore stars up-close is met by the potential of interstellar travel, which acts as a gateway to fulfill this innate curiosity. With every new aerospace project and discovery, we are propelled forward on the path towards the realization of interstellar travel.

Defining Interstellar Travel and the Challenges

Interstellar travel refers to the hypothetical journey of spacecraft between star systems. It is the journey beyond the confines of our Solar System and in reach of other stars. Despite its popular use in science fiction, however, interstellar exploration poses far greater challenges than interplanetary spaceflight due to the vast differences in distances involved. While the space between planets in our Solar System is relatively small, measured in AU, the gap between stars is much greater, often spanning hundreds of thousands of AU and commonly expressed in light-years. As a result of these immense distances, achieving interstellar travel using currently understood physics would require traveling at a substantial fraction of the speed of light, if not faster. However, even with these speeds, travel times would still be lengthy, spanning decades, millennia, or even longer periods [1].

To provide some perspective, here's an analogy: Imagine the Sun as a standard 1/2 marble. The distance from the Sun to the Earth, what we refer to as an astronomical unit (AU), would be about four feet. On this scale, the Earth would be as thin as a sheet of paper, and the Moon's orbit would be approximately 1/4 inch in diameter. With this scale, the closest neighboring star is 210 miles away [1]. That's about the distance between Boston and New York City or between Houston and San Antonio.

To grasp the scale further, we should note that light, which is basically the maximum speed limit of the universe (aside from the rate of the universe's expansion itself), takes over eight minutes to complete that four-foot AU mentioned earlier. Now, if it takes light over eight minutes to travel just four feet, consider how long it would take to cover a distance of 210 miles. The answer would be around 4.2 years! Our nearest neighboring star, Proxima Centauri, is located 4.2 light years away from us, emphasizing the vastness of interstellar distances [8]. This substantial gap highlights the challenge of capturing up-close images of stars beyond our own Sun. To date, humans have not yet been able to obtain detailed photos of any other star.

Even reaching Pluto, which is approximately 4.28 billion kilometers away from Earth at its closest, pales in comparison to the distance of the closest star system, Alpha Centauri, which is almost 10,000 times farther away. If we were to achieve 100% efficiency in converting an energy source into propulsion, it would still take a humongous amount of energy to accelerate only one kilogram of mass (the mass of the smallest standard CubeSat) to 1/10th of the speed of light (referred to 0.1c). This speed is about 30,000 kilometers per second, and amounts to approximately 450 trillion joules.

To explain the unit 'joules' briefly, we know that 'newtons' measure the force of applied to an object, like a push or a pull. Joules measure the energy transferred or the work done by that force. So, when you use a force of one newton to move something one meter, you've done one joule of work or transferred one joule of energy.

Returning to the example, if we were to scale this use of energy to the size of the Voyager probes, which weigh 720 kilograms each, the energy requirement would be 720 times greater, equivalent to 0.06% of the world's entire energy output for an entire year. On top of that, the energy demands for decelerating or stopping when reaching the target would increase the energy requirement by as much as a factor of two [7].

Meeting the energy requirements is just one aspect of the challenge. Enormous advancements in

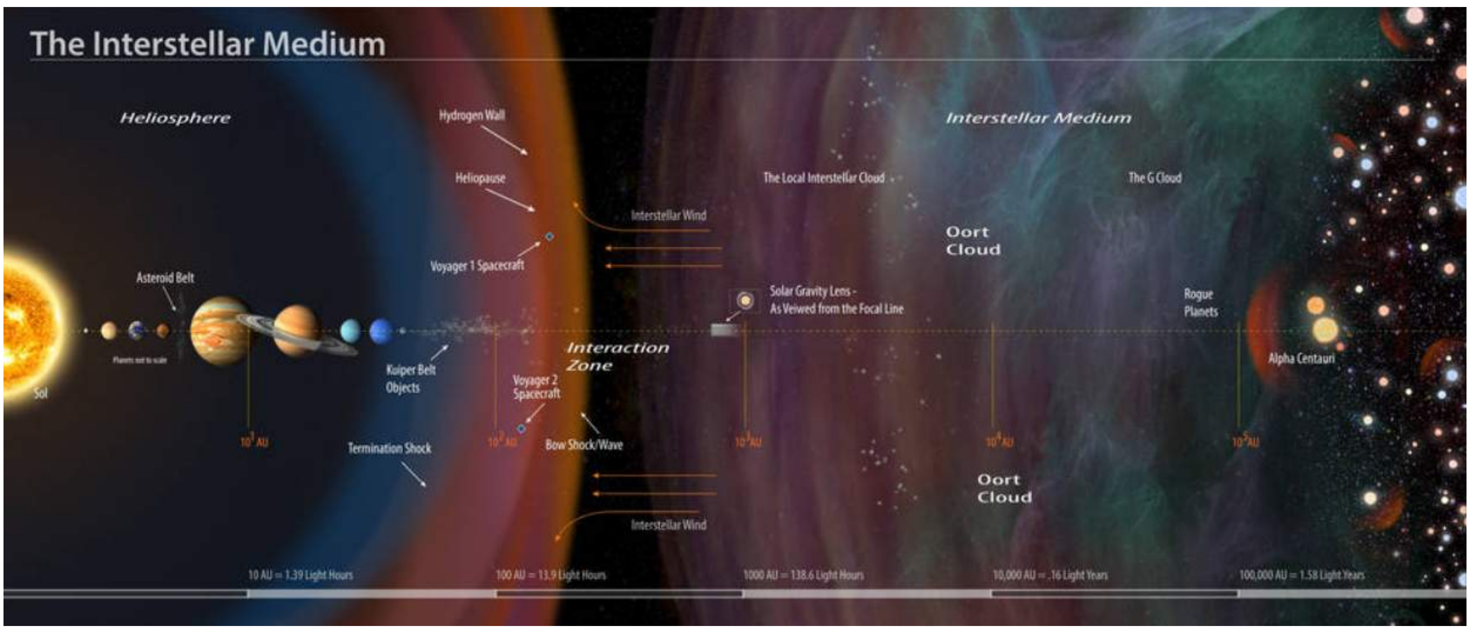


Figure 1. This image shows a representation of our Solar System and objects from other star systems, displayed on a scale that increases logarithmically, meaning that each step on the scale represents a multiplication by a fixed factor. Missions to the interstellar medium would go beyond the heliosphere to investigate the region where our Solar System interacts with the space between stars, while the interstellar missions would travel to nearby star systems like Alpha Centauri. [Credit: Charles Carter/Keck Institute for Space Studies]

technology would also be necessary for a spacecraft capable of interstellar travel. For example, communication delays would span several years and make ground-controlled operations impossible. Every part of the spacecraft, like propulsion, power, thermal control, and communications, would need to operate autonomously. The spacecraft would need to be capable of identifying, isolating, and recovering from errors without human intervention. It would have to navigate through a rough interstellar environment, tolerate high-speed impacts from dust particles, and rendezvous with the target star system independently. Lastly, it would need a way to send the collected scientific data back to Earth. The developments to achieve a spacecraft that would fit this criteria will likely span across generations of scientists and engineers.

Propelling Dreams Into Reality

Cracking the code of interstellar spacecraft propulsion is a challenge that, once overcome, will propel us significantly closer to our destination. Here is the ongoing thought process among scientists regarding the propellant situation:

There is a significant difference between accelerating materials using chemical methods and electromagnetic methods. In order to achieve relativistic flight, where objects travel at a significant fraction of the speed of light, the spacecraft needs a propulsion system that can release energy at relativistic speeds.

When looking at propellants, it's important to think about the energy released for each amount of mass. If we turn to physics equations, we can use a metric called ε (epsilon), which compares the energy released (ΔE) to the rest mass energy (mc^2) of the mass involved (m), with the equation being $\varepsilon = \Delta E/mc^2$. In chemical processes, the energy released for each molecular bond is about one electron volt (eV), while the rest mass energy of the molecule is billions of eV. This means that ε is going to be less than 10^{-9} (one billionth), which makes it impossible to reach relativistic speeds using any modern chemical process on a spacecraft. Achieving these speeds would require much higher energy releases per unit mass, which can be explored through alternative propulsion technologies like electromagnetic or directed energy systems.

This need for high energy release per unit rest mass is applied to any propellant carried onboard. We can't achieve this with chemical processes, and even nuclear fission (about $\varepsilon < 10^{-4}$) and fusion (about $\varepsilon < 10^{-3}$) have limited potential to achieve relativistic speeds. The two options that align with known physics are antimatter engines and standoff directed energy propulsion. However, both options face challenges, such as the need for large masses for confinement and reaction in matter annihilation engines [9].

Nuclear fusion involves combining lightweight atomic nuclei to form a heavier nucleus, releasing a significant amount of energy. In this concept, a spacecraft would carry a fusion power source that controls fusion reactions. The released energy would be used to propel the spacecraft forward. Despite being considered a potential solution for interstellar travel, this has a relatively low yield of energy and requires large extra masses, resulting in large systems with modest performance. Even enhanced systems like thermonuclear weapons, with their high energy yield per unit mass, still have a relatively low effective system energy release metric.

So, annihilation engines may seem like the next best step. Antimatter or annihilation engines are a type of propulsion system that uses the annihilation of matter and antimatter to generate energy and propel a spacecraft. Antimatter is the opposite of ordinary matter, with particles having opposite charges. When matter and antimatter come into contact, they annihilate each other, releasing a tremendous amount of energy [2]. The challenges associated with antimatter engines are usually the production and storage of antimatter, which is not yet feasible. On top of that, the engines require large masses for confinement and reaction processes, making them impractical for most spacecraft designs. While antimatter engines seem promising, the practical limitations and technological constraints make them currently unfeasible for use in interstellar travel [8].

Another approach involves using photons from an external source to propel the spacecraft, eliminating the need for carrying propellant. This method relies on transferring the momentum of photons (particles of light) to the spacecraft through reflection. Solar sails operate similarly, as they are a type of spacecraft propulsion system that uses the pressure of sunlight to generate thrust. By deploying a large, thin reflective sail, they can capture the momentum of the Sun's photons as they collide with the sail and bounce off.

Unfortunately, solar sails cannot achieve the required relativistic speeds for interstellar travel, especially with the relatively low intensity of sunlight once leaving the Solar System. Laser-driven sails, however, have the potential to reach these speeds and remove the dependency on sunlight. They replace the photon source with a directed laser beam from a remote source, enabling propulsion even in dimly lit areas of space [10]. The photon driver, in this case, is a laser phased array consisting of multiple laser amplifiers arranged in a "master oscillator power amplifier" (MOPA) configuration. With a fully scaled system, it is possible to propel a gram-scale spacecraft with a meter-sized reflector (laser sail) to a speed of about one-fourth the speed of light in a few minutes of laser illumination! With this system, traveling from Earth to Mars would take only 30 minutes, passing Voyager 1 in less than three days, reaching 1,000 AU in 12 days, and arriving at Alpha Centauri in approximately 20 years. This system is flexible and can be scaled up or down depending on the desired speed, array power, array size, and spacecraft mass. The same photon driver can propel payloads of varying sizes, ranging from 10 kilograms to 10,000 kilograms, to significant speeds. The system's scalability depends on finding the right balance between array power, array size, spacecraft mass, and mission objectives [8].

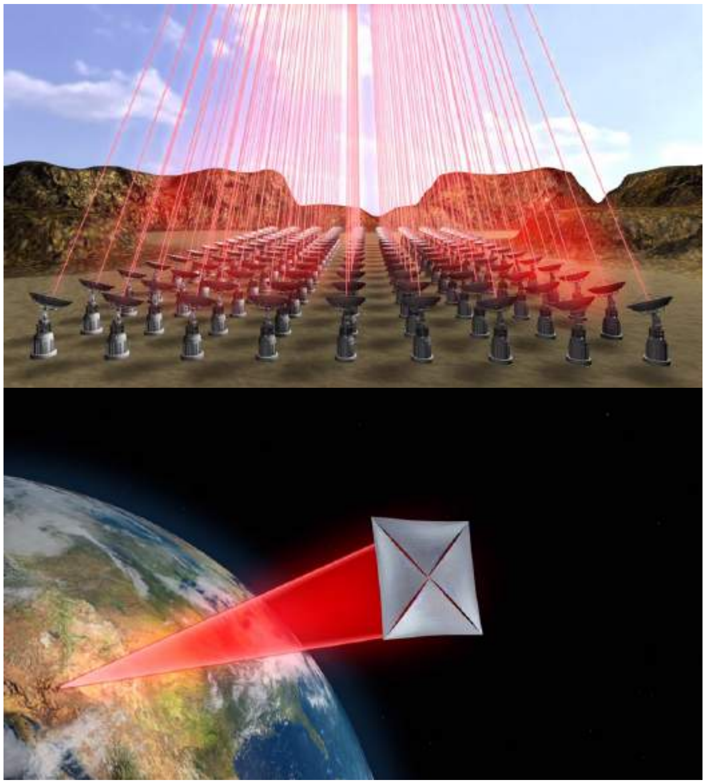


Figure 2. Pictured is a graphic of a laser array propelling a laser sail. As researchers continue to explore the potential of laser-driven sails for interstellar travel, there is growing excitement about their efficiency and capabilities. Several ongoing projects are actively working towards developing and advancing this technology. [Credit: Breakthrough Starshot Initiative]

Numerous groundbreaking laser-driven sail projects have been paving the way for interstellar exploration throughout the past decade, and they are slowly blurring the lines between science fiction and reality by harnessing the power of lasers to propel spacecraft at speeds that defy the conventional limits of space travel. A prevalent contributor to this movement is Project Starlight with the University of California Santa Barbara Cosmology Group. Harnessing the potential of laser-driven sails, Starlight focuses on the search for extraterrestrial intelligence (SETI) and the quest to detect signs of intelligent life beyond Earth. It will utilize sophisticated algorithms and data analysis techniques to distinguish potential signals from interstellar cosmic noise [13]. More pioneering initiatives include Breakthrough Starshot and Project Dragonfly, both of which envision sending gram-scale, laser-driven spacecraft that could potentially achieve speeds of up to 20% of the speed of light, reaching Alpha Centauri within a human lifetime.

A Rationale for our Centauri Dreams

So, why are we going through this monumental effort? What could justify the immense investment, risks, and time required for a multi-billion dollar interstellar expedition to the nearest star? It is only natural to question the rationale behind this bold endeavor. However, the potential benefits that await us in the vast reaches of Alpha Centauri are nothing short of revolutionary and will impact the future of humanity more than we think.

For starters, we know way more about the Sun than any other star, simply by virtue of the fact that it is so close to us. Our current superior understanding of the Sun stems from three key factors: our ability to observe intricate small-scale features, the heightened brightness enabling clearer observations, and the extensive history of studying it [5]. Interstellar space travel would allow us to gather similar information about different types of stars, which could lead to significant advances in stellar astrophysics and information comparable to our sun. Although advancements in astronomical instruments may enhance our observations of nearby stars from our Solar System, it remains true that being in close proximity to a target star will always yield higher-resolution and more distinct data.

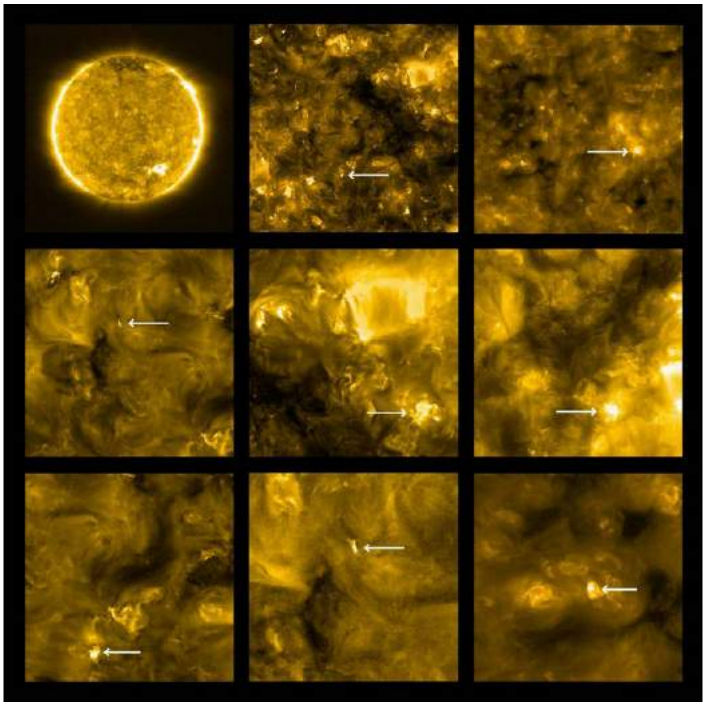


Figure 3. This picture captures different views of our sun taken by the Solar Orbiter spacecraft using the Extreme Ultraviolet Imager (EUI) on May 30, 2020. The images show the Sun's upper atmosphere, called the corona, which has a temperature of over a million degrees. The white arrows point to interesting features called "campfires" that were not fully understood yet. Many scientists aim to reach this sort of proximity with stars in Alpha Centauri. [Credit: Solar Orbiter/EUI Team (ESA & NASA)]

Where there are limitations to observing stars during an interstellar fly-by mission due to time constraints, the prospect of slowing down near the target star system holds even greater advantages. It would unlock the potential for long-term observations of the star's surface, allowing us to delve into the intricacies of its corona, stellar wind, and surrounding matter. The study of protoplanetary disks, which play a crucial role in planet formation, would be particularly groundbreaking. However, it's important to note that the nearest known example of such a disc is quite far from Alpha Centauri, which reduces its priority for the initial interstellar-focused mission.

Aside from studying the target star itself, we would receive valuable insight throughout the journey. In order to reach Centauri, a spacecraft must pass through the interstellar medium, which is the space between our Solar System and the star (pictured in Figure 4). The properties of the interstellar medium and nearby clouds are uncertain and have been estimated using astrophysical techniques. An interstellar probe could provide invaluable in-situ measurements to enhance our understanding of the processes behind these phenomena. These measurements would include determining density, temperature, gas composition, ionization state, dust density, composition, interstellar radiation field, and magnetic field strength as a function of distance between the Sun and the target star system [5]. These measurements would play a vital role in planning future interstellar missions, as the first mission would pave the way, offering essential knowledge about the materials a future spacecraft will encounter.

In addition, interstellar travel would allow us to observe the properties of exoplanets in the Alpha Centauri system up close. We could examine how suitable they are for life and gain insight in the field of astrobiology, even if there's no indigenous life present in the system. This could also give us insights into how planetary systems form and, of course, uncover exciting new phenomena that we never even knew existed. Aside from advancing scientific knowledge, interstellar exploration would serve as a catalyst for extreme developments and advancements in technology, inspire future generations to pursue similarly ambitious projects, and expand our presence beyond Earth.

Figure 4. Pictured is a Hubble image of Proxima Centauri, our closest stellar neighbor, a celestial beacon that fuels our quest for interstellar exploration. [Credit: NASA]

I believe Carl Sagan said the best rationale of all in Chapter 7 of Cosmos [12]:

"Exploration is in our nature. We began as wanderers, and we are wanderers still. We have lingered long enough on the shores of the cosmic ocean. We are ready at last to set sail for the stars." ★

References

[1] The British Planetary Society. *Interstellar Travel.* The British Planetary Society (2017) https://web.archive.org/web/20170616131942/www.bis-space.com/what-we-do/advocacy/interstellar-travel

[2] K. Bonsor. *How Antimatter Spacecraft Will Work*. HowStuffWorks (2010) https://science.howstuffworks.com/antimatter.htm

[3] Breakthrough Initiatives. *Starshot*. https://breakthroughinitiatives.org/initiative/3

[4] Breakthrough. *Breakthrough Starshot Animation (Clip)*. YouTube (2016) https://www.youtube.com/watch?v=wMkWGN1G6Kg

[5] I. Crawford. *Scientific and Societal Benefits of Interstellar Exploration*. Beyond the Boundary: Exploring the Science and Culture of Interstellar Spaceflight, pp. 14-42 (2014) https://www.researchgate.net/publication/275652484_Scientific_and_Societal_Benefits_of_Interstellar_Exploration

[6] Gilster, P. *Centauri Dreams: Imagining and Planning Interstellar Exploration*. Springer Science & Business Media (2013) https://www.centauri-dreams.org/

[7] R. Litchford and J. Sheehy. *Prospects for Interstellar Propulsion*. NASA Technical Reports Server (2020) https://ntrs.nasa.gov/api/citations/20200000759/downloads/20200000759.pdf

[8] P. Lubin. *A Roadmap to Interstellar Flight*. NASA (2011) https://www.nasa.gov/sites/default/files/atoms/files/roadmap_to_interstellar_flight_tagged.pdf

[9] P. Lubin and W. Hettel. *The Path to Interstellar Flight*. Acta Futura, 12, 9-44 (2020) https://doi.org/10.5281/zenodo.3747263

[10] Marshall Space Flight Center. *Solar Sail Propulsion*. NASA (2005) https://www.nasa.gov/pdf/134645main_solar_sail_fs.pdf

[11] A. Niccol. *Gattaca*. Columbia Pictures (1997)

[12] C. Sagan. *Cosmos*. Random House (1980)

[13] UCSB Experimental Cosmology Group. *Starlight: Directed Energy for Relativistic Interstellar Missions.* University of California, Santa Barbara (2016) https://www.deepspace.ucsb.edu/projects/starlight

Biography

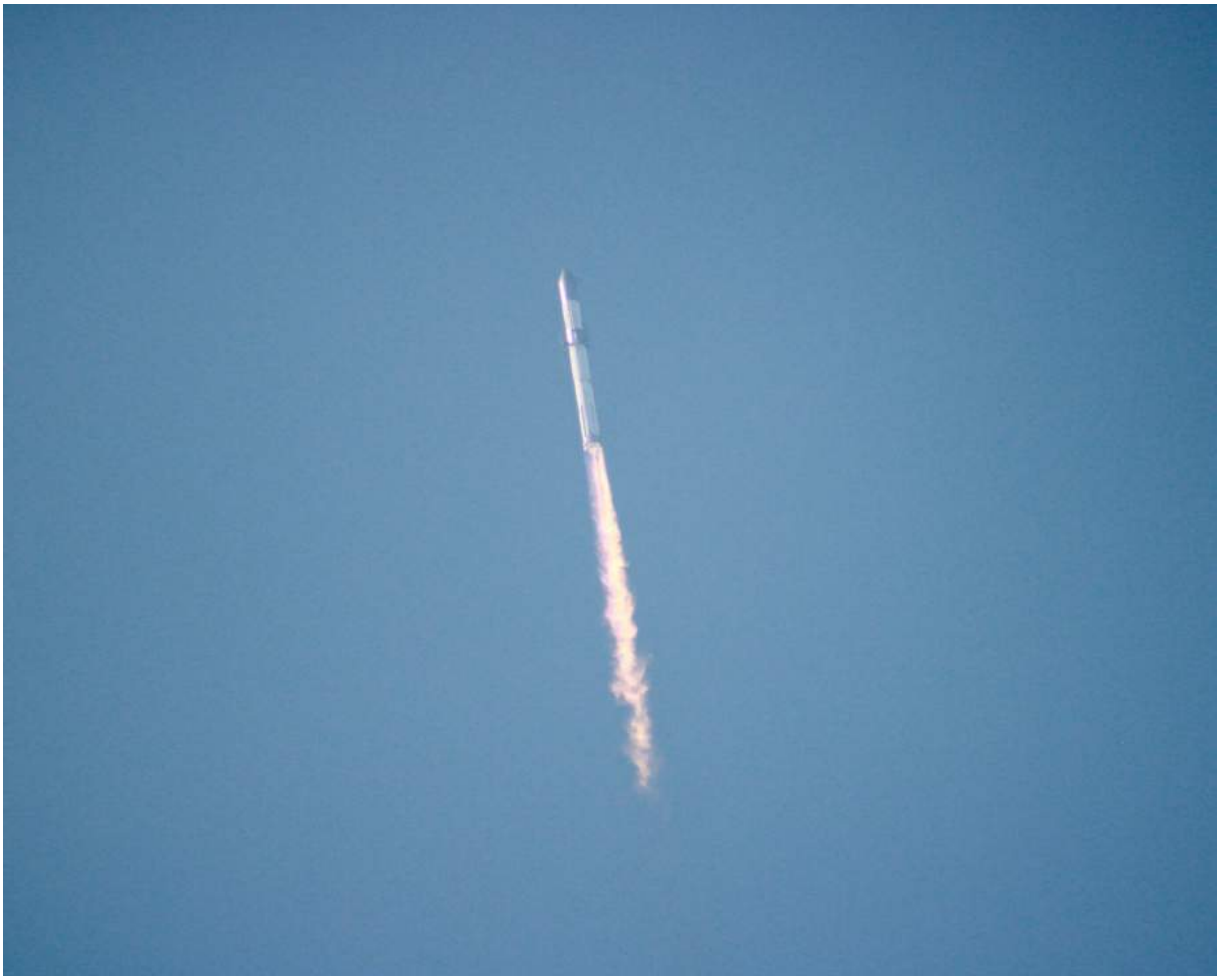
Olivia Lincoln is an intern and ambassador for the South Texas Astronomical Society. She founded and led the Pace Astronomical Society, a school astronomy club sponsored by STARS. In the fall, Olivia will be pursuing a physics major at Simmons University in Boston, Massachusetts. She wishes to pursue research in gravitational wave astronomy and study binary neutron star/black hole systems.

Boats with passengers trying to get a better view of Starship on the Monday morning before the scrub.

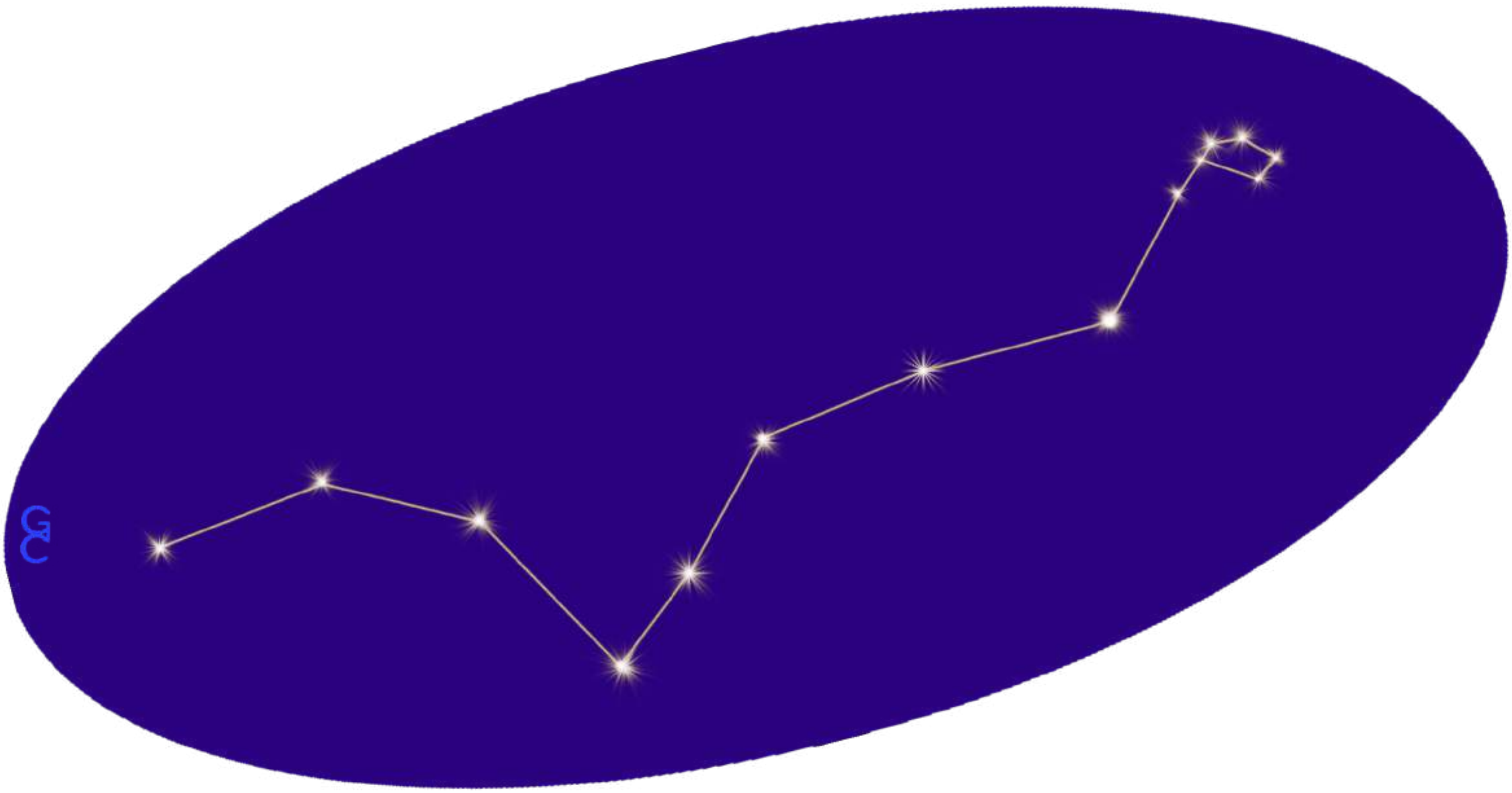
The view of Starship in the fog from Isla Blanca the morning before the launch.

Starship leaving a trail of smoke in the air as it launches into the sky.

Starship starting to tumble out of control after the failure of stage 2 and a couple of engines



Starship soaring through the air successfully after leaving the pad



Constellation of Hydra

Hydra

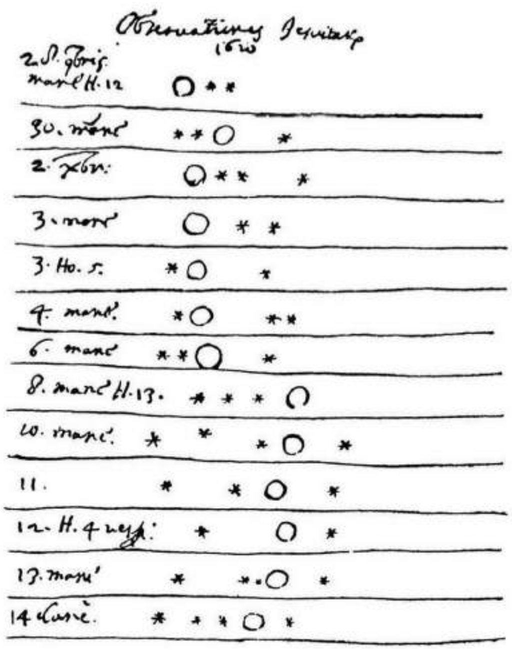
A serpentine water monster.
Hydra regenerates two
heads when one is cut off.

Stardust, the Little Spacecraft that DID!

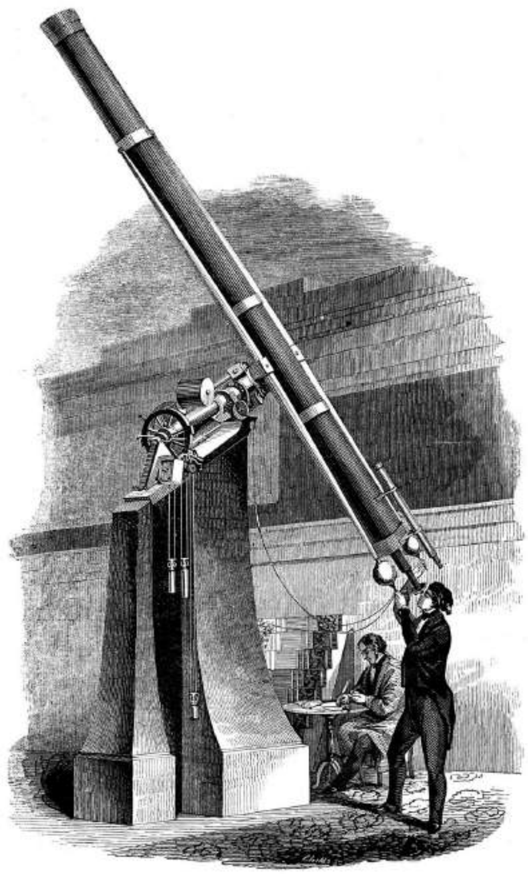
A true-life story by Carol Lee Lutsinger

Long ago, during the beginning of human existence, people looked up at the stars in the sky and wondered what those tiny points of light really were. Although there were many explanations, they were far from accurate. Occasionally a "guest star" would appear in the sky for many nights. Usually, the guest star was a beautiful point of light glowing steadily in the dark sky. Sometimes the guest star had a fuzzy glow around it and a long beautiful tail streaming out behind it like Rapunzel's long hair.

Whenever one of these kinds of fuzzy stars appeared in the nighttime sky, people were often afraid. They worried that something terrible was going to happen or that something terrible had happened. Other times other people would see them and be excited that something wonderful was going to happen or had already happened. Curious men and women watched the sky and tried to learn about those guest stars and what they were. Many of them wrote down their thoughts and observations of those objects so that people can still read about them today.



For thousands of years no one knew what those stars truly were. Finally, someone invented a special tool we call a *telescope*. Telescopes help people see things better that are too far away to understand. Things appear to be closer or brighter in a telescope than with plain eyes.

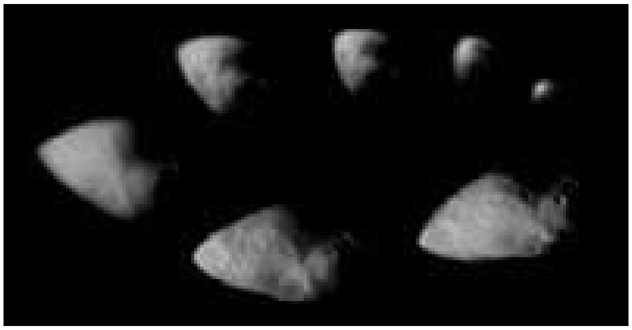


When the telescope was used to study those guest stars people learned that some of them were spheres with patterns on their surfaces; others had rings around them. Several had small moons orbiting around them. When people looked at the different points of light through a telescope, they were more curious than ever about what they were.

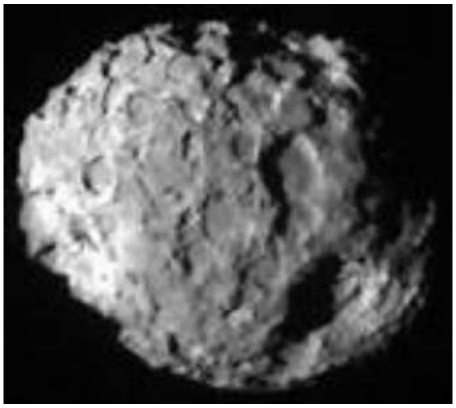
In the late twentieth century several scientists were even more curious than others about what these fuzzy objects really were. Fortunately, they had special training and jobs that made them able to design and build a spacecraft to fly out into space and look at those objects up close.

Over many months the men and women planned a special spacecraft they named STARDUST. It was designed to travel three billion miles into space and fly past a special comet, Wild 2 (pronounced 'Vilt') taking pictures and actually catching bits of the comet that fall off when one is flying through space.

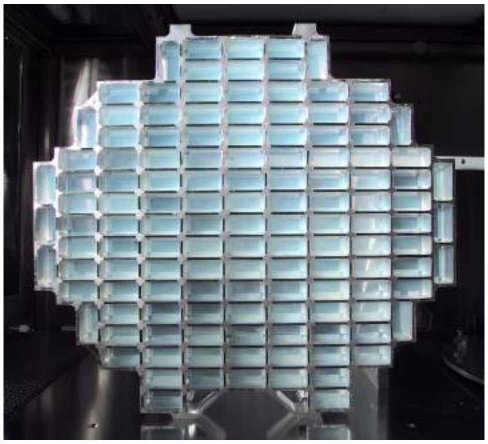
Hundreds of people worked on the project to design the exact special tools this little spacecraft would need to explore the comet. The special tools included special cameras, counters that counted the dust in the area around the spacecraft, communications antennae, and an amazing tool that was stored inside a pie pan-shaped capsule to protect it until it was needed to capture the comet dust and the interstellar dust that it was going to encounter while on its way to meet Asteroid Annefrank.



... and Comet Wild 2.

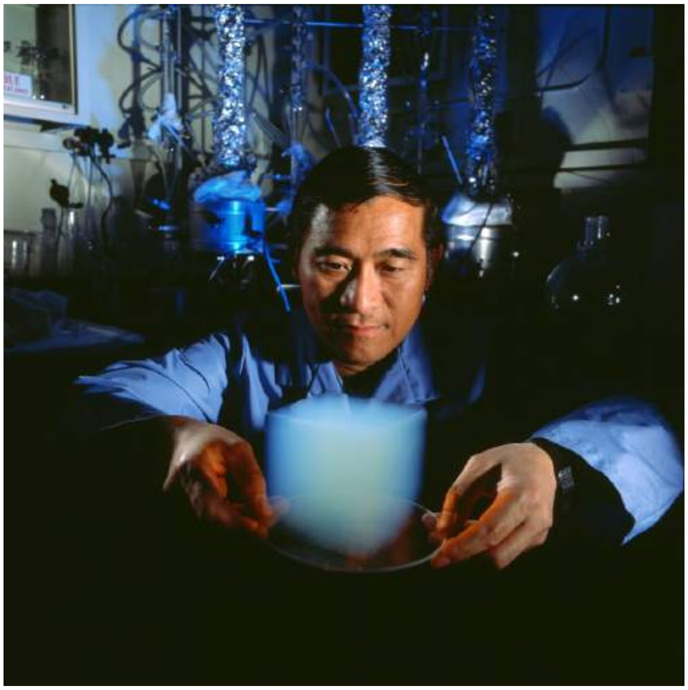


As you can see in the picture, the collector looks a bit like a fly swatter or a tennis racket filled with glue. The blue filling is a very light substance called Aerogel®, a super lightweight, nearly all air substance (99.99% air) that was the perfect medium to capture and hold safely whatever comet or interstellar material hit the sample collector.



Aerogel® looks like solid smoke; it is the least dense solid currently known to people. It is very strong, has incredible insulating properties, and yet is very lightweight. It was invented in 1931 as a result of a bet between two scientists who wanted to replace liquids in gels with gas. It was long forgotten by most people until NASA planned this Stardust mission and Dr. Peter Tsou thought it would be perfect to capture comet particles in Stardust.

When Stardust was finished, it was about the size of a small car. It was placed in a protective capsule on top of a Delta Rocket and launched from Cape Canaveral Florida on February 7, 1999.



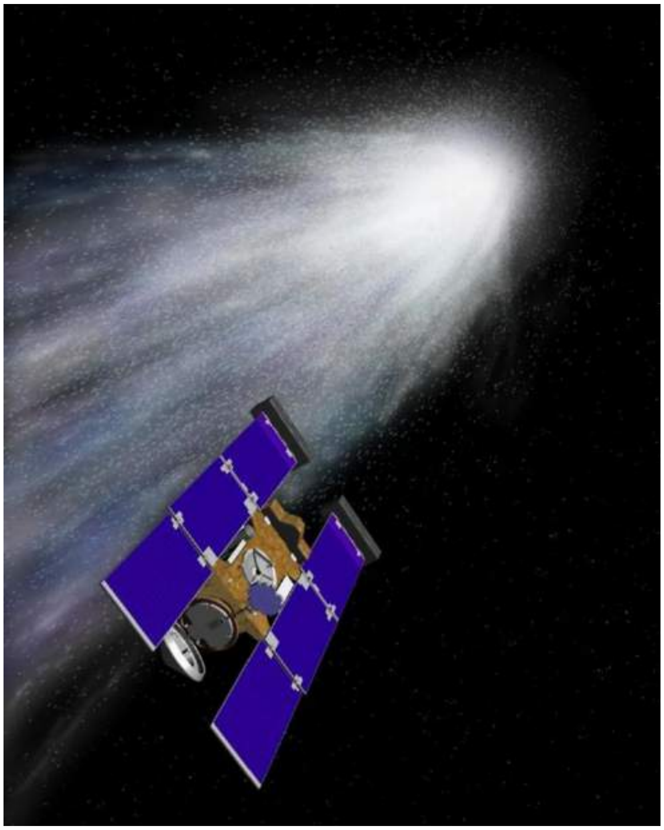
As the eager crowd of watchers stood in the hot sun to watch the launch a small armadillo wandered across the road that led to the launch pad. He didn't care about the Stardust launch, but hundreds of people cared and waited excitedly while the countdown ended...5...4...3...2...1 and Stardust leapt into the sky on top of the Delta rocket to begin its long journey to find out exactly what those fuzzy stars were made of.

While traveling to meet its two objectives, Stardust made two passes by planet Earth and one past Venus to get a push from the gravitational force created by the rotating planets.

On January 2, 2004, Stardust flew past Comet Wild 2 and collected about a million microscopic sized particles of dust from the comet and the interstellar dust from space in the Aerogel® that filled the gaps in the tennis racket dust collector.

The clamshell capsule then unfastened from the spacecraft and began its long journey home, falling through space back to planet Earth. At 5:12 A. M. EST, about 3:12 A. M. CST on January 15, 2006, Stardust landed in the Utah desert outside of Salt

Lake City at the U. S. Army Dugway Proving Ground.



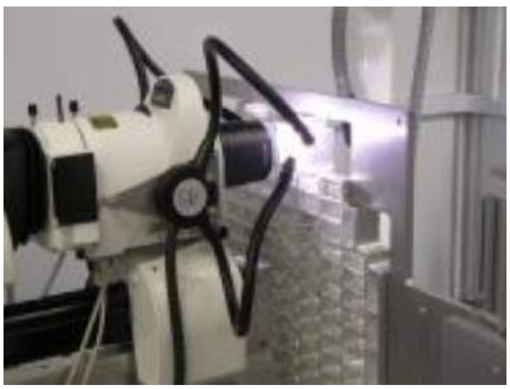
Flying a helicopter to the landing site, a team of scientists checked for harmful gases or radiation; then they wrapped the capsule in plastic wrap-yes, the same kind your mom uses to protect food in the refrigerator!

After making sure nothing harmful was coming off the capsule, it was loaded into a helicopter and taken to a preliminary secure site at Dugway where it was packed carefully in a crate to be sent to the Lunar and Planetary Institute in Houston, Texas at the NASA Johnson Space Center.

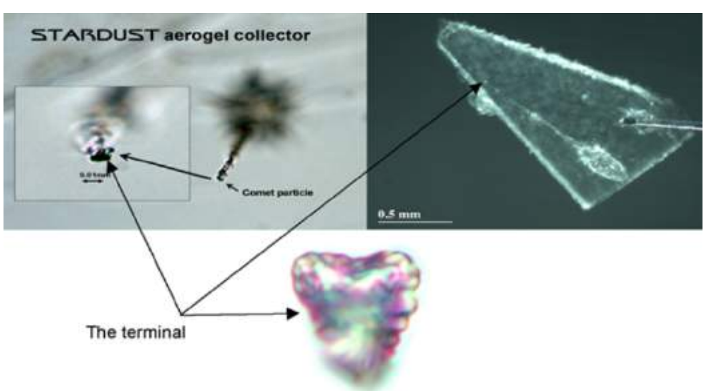
Imagine that you are one of the scientists waiting seven years to open that present! No one knows for certain what is inside the Aerogel® and all those white gowned, hatted, gloved, masked persons inside the clean room and all those teachers present outside looking in, including me, were holding their breath in excitement and anticipation as the capsule was opened very carefully for the first time and the sample collector removed and placed on a stainless steel table in the center of the clean room.

At first since they expected the samples to be covered with black dust and the samples still looked pristine, the scientists felt their hearts fall into their shoes with disappointment. They thought the mission was a failure. On closer inspection they saw tiny furrows in the sections and were able to gesture V for victory.

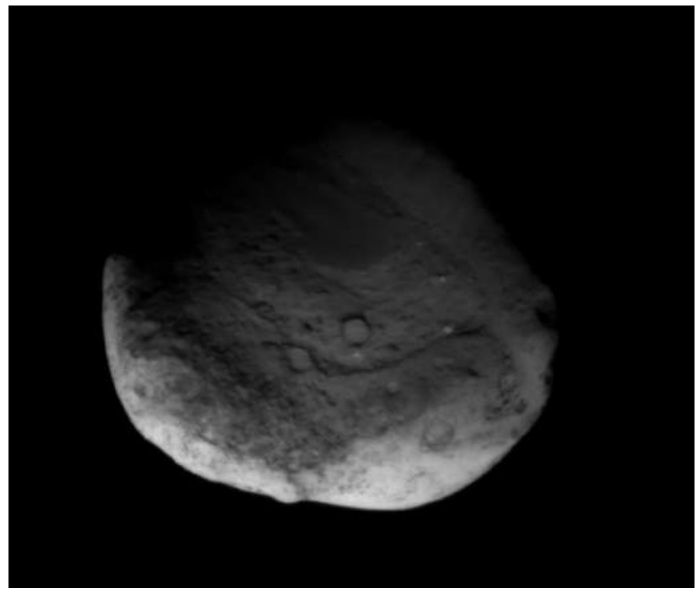
When the collector was placed on the table and sections of Aerogel® were carefully removed, a glass knife was used to slice the sample into thin sheets to be examined under an electron microscope.



The first sample found was removed on Valentine's Day, 2006. Here is what it looked like magnified thousands of times.



Meanwhile, after Stardust released the capsule to return to Earth, the spacecraft was kept in orbit. Some spacecraft don't do what is expected of them, but this little spacecraft has done more than it was supposed to. In fact, it did its primary assignment so well, NASA decided to ask one more task: keep flying and track Comet Tempel 1 and take pictures of what happened after Deep Impact had slammed its projectile into that comet on July 4, 2005.



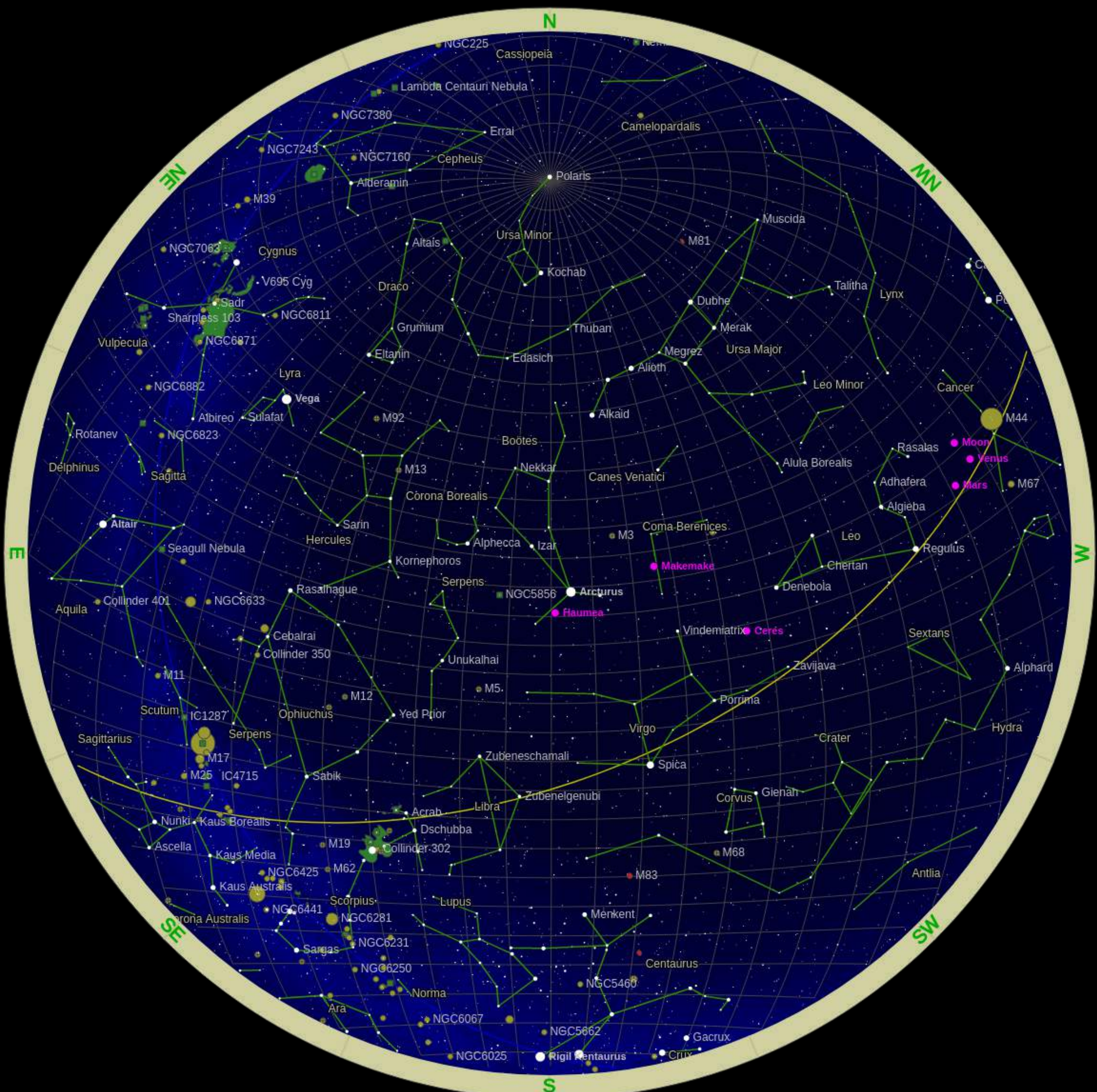
If Stardust were Buzz Lightyear, he would have replied "To infinity and beyond" and done just what Stardust did. Keep on orbiting and waiting for Comet Tempel 1 to catch up to it.

On February 14, 2011 Stardust intercepted the orbit of Comet Tempel 1 and took 72 pictures of the area where Deep Impact struck. All the scientists eagerly waited to see those images and were excited about the new information this "Little Spacecraft that Did" had sent them as a special delivery Valentine.

If you go online to the Stardust NExT mission you can see just what the scientists saw and give a cheer for the Stardust Spacecraft that always did more than was expected of it and returned wonderful information to Earth-bound scientists. ★

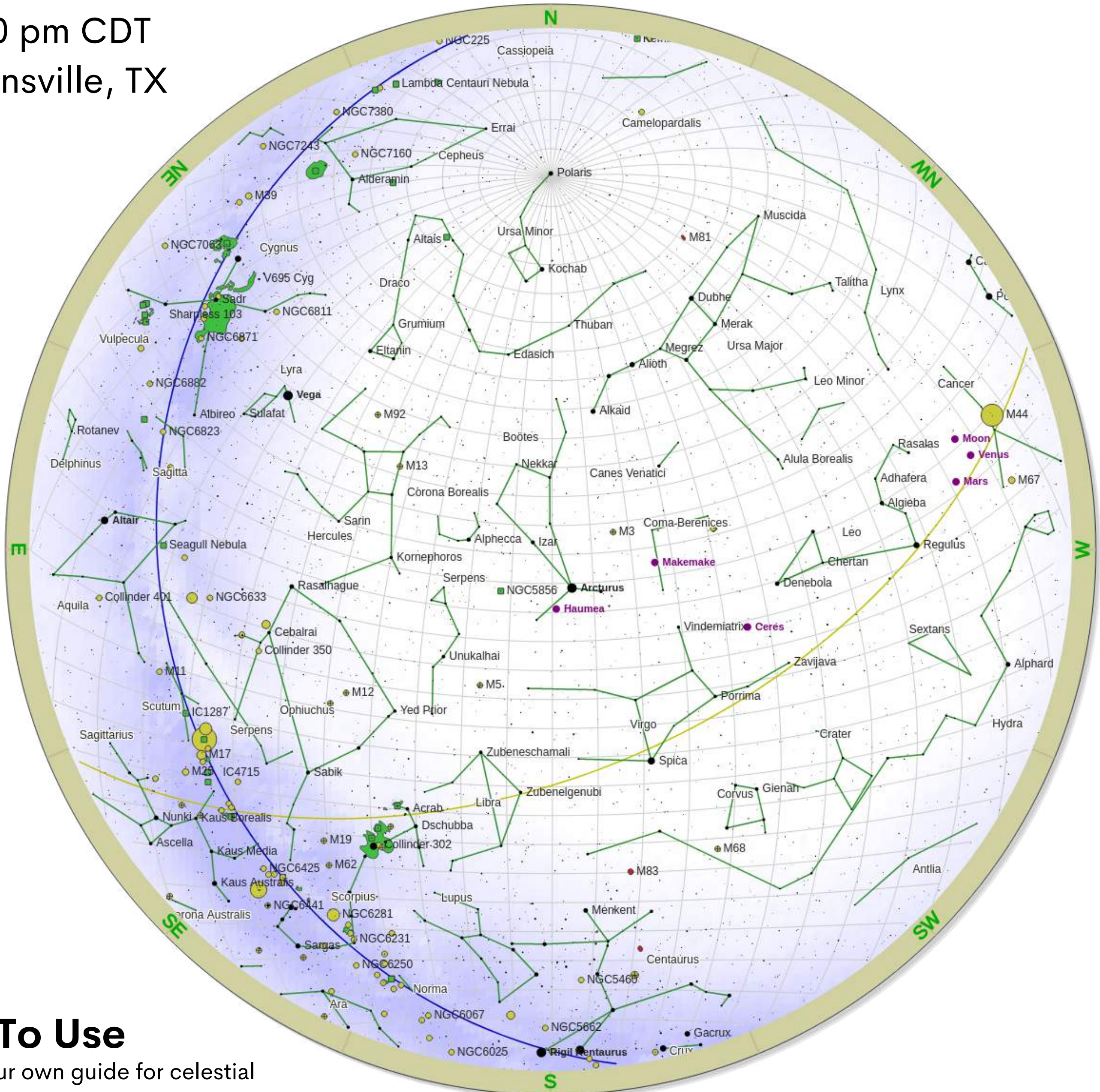
Cosmic Coordinates

Summer 2023



Sky Map

21 June 2023
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! [Source: In-The-Sky.org]

Sky Map Legend

Sky Events

Summer 2023

Apsides

Jun 04, Moon at Aphelion
Jun 06, Moon at Perigee
Jun 17, Moon at Perihelion
Jun 22, Moon at Apogee
Jun 27, Mercury at Perihelion

Jul 01, C/2023 E1 (ATLAS) at Perihelion
Jul 03, Moon at Aphelion
Jul 04, Moon at Perigee
Jul 06, Earth at Aphelion
Jul 18, Moon at Perihelion
Jul 20, Moon at Apogee
Jul 31, C/2021 T4 (Lemmon) at Perihelion
Jul 31, Moon at Aphelion

Aug 02, Moon at Perigee
Aug 08, Venus at Aphelion
Aug 10, Mercury at Aphelion
Aug 16, Moon at Apogee
Aug 18, Moon at Perihelion
Aug 29, Moon at Aphelion
Aug 30, Moon at Perigee

Appulses

Jun 02, Mars and M44
Jun 09, Moon and Saturn
Jun 13, Venus and M44
Jun 14, Moon and Jupiter
Jun 21, Moon and Venus
Jun 22, Moon and Mars

Jul 01, Venus and Mars
Jul 06, Moon and Saturn
Jul 11, Moon and Jupiter
Jul 21, Moon and Saturn

Aug 03, Moon and Saturn
Aug 08, Moon and Jupiter
Aug 09, Moon and M45
Aug 18, Moon and Mars
Aug 30, Moon and Saturn

Conjunctions

Jun 03, Mercury and Uranus
Jun 09, Moon and Saturn
Jun 14, Moon and Jupiter
Jun 16, Moon and Mercury
Jun 21, Moon and Venus
Jun 22, Moon and Mars

Jul 01, Mercury at Superior Solar Conjunction
Jul 06, Moon and Saturn
Jul 11, Moon and Jupiter
Jul 19, Moon and Mercury
Jul 20, Moon and Venus
Jul 20, Moon and Mars
Jul 26, Venus and Mercury

Aug 03, Moon and Saturn
Aug 08, Moon and Jupiter
Aug 13, Venus at Inferior Solar Conjunction
Aug 18, Moon and Mercury
Aug 18, Moon and Mars
Aug 30, Moon and Saturn

Dichotomies

Jun 03, Venus
Jun 04, Mercury

Aug 09, Mercury

Earth

Jun 21, June Solstice

Elongations

Jun 02, Mercury at Highest Morning Altitude
Jun 04, Venus at Greatest Elongation East

Aug 02, Mercury at Highest Evening Altitude
Aug 09, Mercury at Greatest Elongation East

Moon

Jun 03, Full Moon
Jun 10, Last Quarter
Jun 17, New Moon
Jun 26, First Quarter

Jul 03, Full Moon
Jul 09, Last Quarter
Jul 17, New Moon
Jul 25, First Quarter

Aug 01, Full Moon
Aug 08, Last Quarter
Aug 16, New Moon
Aug 24, First Quarter
Aug 30, Blue Moon

Occlusions

Jun 03, Lunar Occultation of Dschubba
Jun 30, Lunar Occultation of Dschubba

Jul 28, Lunar Occultation of Dschubba

Aug 24, Lunar Occultation of Dschubba
Aug 24, Lunar Occultation of Antares

Oppositions

Jun 06, 11 Parthenope

Jul 07, 15 Eunomia
Jul 22, 134340 Pluto

Aug 10, 10 Hygiea
Aug 26, 8 Flora

Retrogrades

Jun 17, Saturn
Jun 30, Neptune

Aug 28, Uranus

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).

Space Rangers

To Mars!
Mario Alejandro Elizondo

Space Rangers

Meet Mario Alejandro Elizondo, a vibrant and imaginative 5-year-old currently enrolled in kindergarten. Affectionately known as Pollito, Bunny, and BunBun. Mario is a young enthusiast with an unwavering passion for science and space. He dreams of one day becoming an astronaut and embarking on a journey to Mars. Mario has actively engaged with the South Texas Astronomical Society, attending various events that have only served to deepen his love for all things celestial. Aside from his extraterrestrial ambitions, Mario enjoys a range of hobbies that keep his young mind active and creative. From playing baseball to building intricate Lego structures, he has a diverse array of interests that reflect his boundless energy and insatiable thirst for knowledge. With his infectious enthusiasm and determination, Mario is undoubtedly on a trajectory to reach for the stars and beyond.

Artemis I

Alexis Mendoza

Our Pale Blue Dot

Giankarlo de la Garza

Trapped Planets

Giankarlo de la Garza

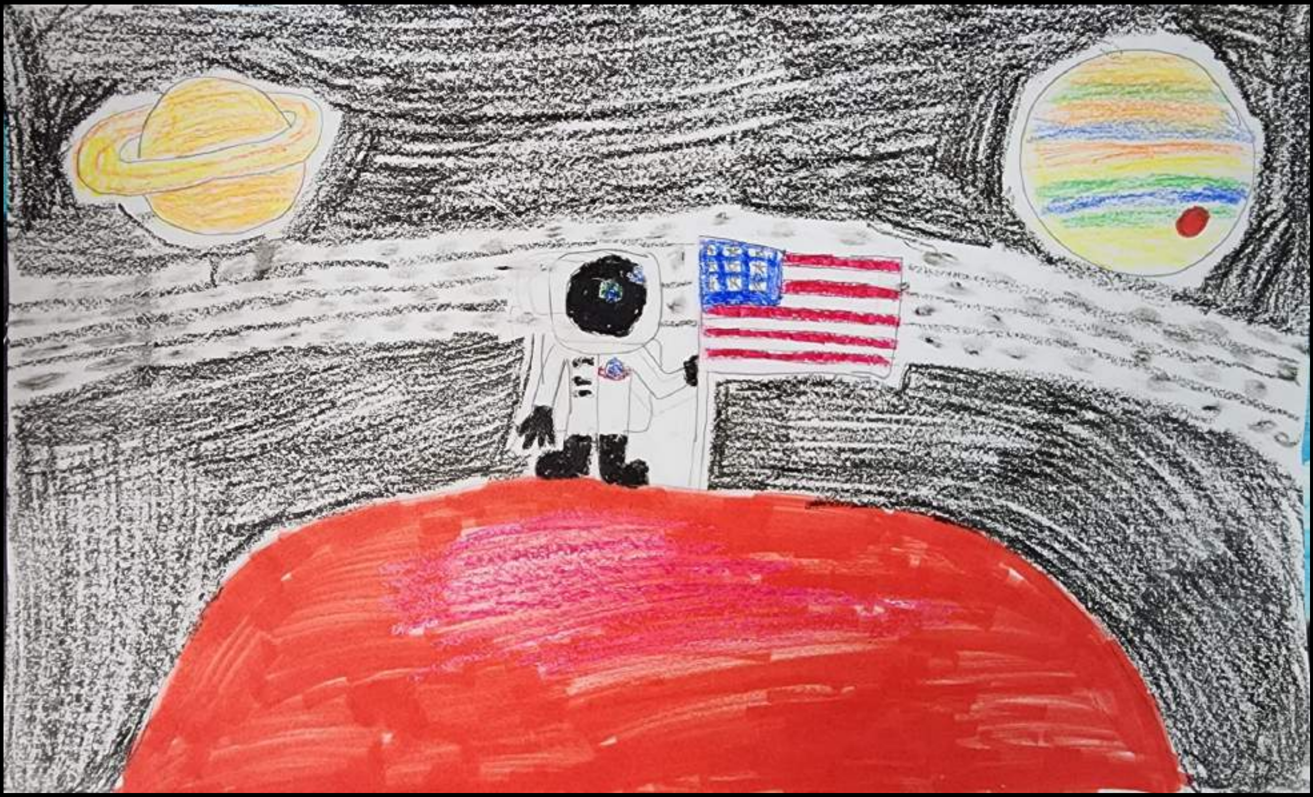
The Portal of Our Universe
Iris Suarez

Jumping from Jupiter
Luis Martinez

Lost in Outer Space

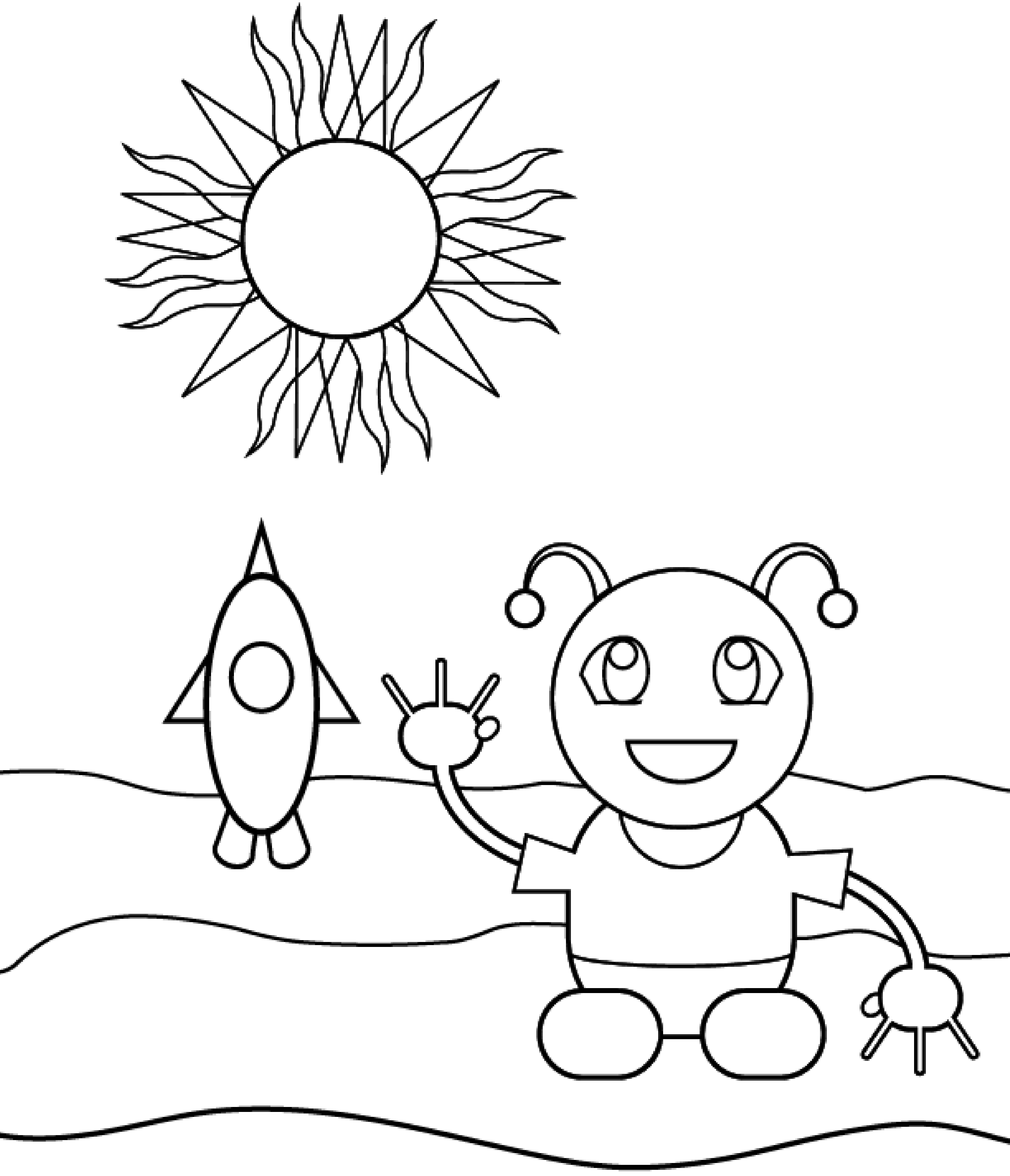
Maritza Manzanares

Swinging on Saturn
Michelle Martinez



A Foot on Mars
Yuliana Banda

Space Rangers Coloring Book



Space Rangers Word Search

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

Space Rangers Word Search

Solutions

P				O		T	E	K	C	O	R
E	Y		E		R				O		S
R		R	P			B			P		P
S			O		T		I	E	E		A
E		E	C	T	U			T	R		C
V		L	S		A			I	N		E
E		T	E		N	V		L	I		S
R		T	L		O		R	L	C		H
A		U	E		R			E	U		I
N		H	T		T			T	S		P
C		S			S			A		B	
E					A			S			O

(1) ASTRONAUT, (2) COPERNICUS, (3) OBSERVATORY, (4) ORBIT, (5) PERSEVERANCE, (6) ROCKET, (7) SATELLITE, (8) SHUTTLE, (9) SPACESHIP, (10) TELESCOPE

STARS Spotlight:
2023 Carol Lutsinger STEM Scholarship

Last year, STARS established the ***Carol Lutsinger STEM Scholarship*** with a goal to support students getting ready to pursue college degrees in science, technology, engineering, and math (STEM). With the help of our community, STARS was able to raise funds to provide $500 scholarships to seven graduating high school seniors from the Brownsville Independent School District. Each one of these students demonstrated ambition, perseverance, and determination to give back to their community after their educational journeys.

Congratulations to the seven recipients of the inaugural Carol Lutsinger STEM Scholarship award!

- Hector Salinas, Rivera Early College High School
- Carolina Meza, Veterans Memorial Early College High School
- Dyllan Lomeli-Lozano, Pace Early College High School
- Jaqueline Peña, Pace Early College High School
- Olivia Lincoln, Pace Early College High School
- Mykel Castillo, Pace Early College High School
- Ashly Sanchez, Rivera Early College High School

Colophon

Contributors
Alexis Mendoza
Carol Lutsinger
Deborah Camuccio
Eloi Camprubí-Casas
Giankarlo de la Garza
Hannah Haber
Iris Suarez
Jaqueline Peña
Lucero Martinez
Luis Martinez
Mario Alejandro Elizondo
Maritza Manzanares
Marshall Tomat
Michelle Martinez
Mykel Del Angel
Olivia Lincoln
Paulo Markaj
Ulises Jarquín
Victor De Los Santos
Yuliana Banda

Art Director
Gabrielle Camuccio

Spanish & Assistant Editor
Ximena Guajardo

Editor-in-Chief
Richard Camuccio

Website
www.starsocietyrgv.org

Submissions
We encourage submissions from anyone interested in contributing to our newsletter. Any readers with ideas for our newsletter, or who are interested in submitting their own articles, illustrations, or other content, please contact the Editor-in-Chief at: richard.camuccio01@utrgv.edu

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.