#### INDIGENOUS EDUCATION INSTITUTE



NATIVE SKY WATCHERS

### TWO-EYED SEEING DINÉ (NAVAJO) ASTRONOMY

LIVE (VIRTUAL) SHOW

INDIGENOUS EDUCATION INSTITUTE: Nancy C. Maryboy, MFA, PhD David Begay, PhD Ashley C Teren, M.Ed

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"Two Eyed Seeing is learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing and from the other eye with the strengths of Western knowledges and ways of knowing and to use both these eyes for the benefit of all."

Bartlett, Marshall and Marshall, 2021

#### LAND ACKNOWLEDGMENT

The Two Eyed Seeing program would like to acknowledge the land of Diné Bikeyah, the land of the Navajo People, bound by the Four Sacred Mountains (east, south, west and north). We also acknowledge the rivers located in Dine Bikeyah: the Rio Grande River to the east, the San Juan.



MAP OF THE NAVAJO NATION



Map: Rio Nuevo Publishing SEEING THE SKIES THROUGH NAVAJO EYES

For countless generations, the Diné (Navajo) people have observed the night skies, from which they developed a sophisticated philosophy and complex astronomy. We hope that this booklet will help promote the sense of **wonder**  and awe that we all feel as we gaze at the sky overhead, day and night, summer and winter, following the age-old patterns of the stars, planets and other cosmic energies.

Traditional stories of the Night Sky were often spoken aloud with the enhancement of vocal performance, movement



Image by Nancy Maryboy and Troy Cline

and animal sounds. Most teaching traditionally took place during the winter months of late September to early March among family and clan members. Teachings associated with the Night Sky were shared within the traditional hogan, which itself was modeled and constructed in alignment with cosmic directions and principles. Navajo cosmology reflects the emphasis that Navajos place on the Night Sky and its holistic interconnection with the earth.

Navajo ways of knowing, including Navajo astronomy, are based on a sense of the power and significance of place. Navajo astronomy is based on the relationship of the four Sacred Mountains of Navajoland with the celestial bodies above. The movement of the Sun, the four cardinal directions, the colors of the directions (white, blue, yellow and black), the phases of the moon, and the Navajo constellations, all these and more reflect the importance of the relationships of Mother Earth and Father Sky.

# Diné Ui

#### Characteristics of Yadilhil (the Navajo Sky)

January Yasnih'ees In the st

Ma'ii Bizo' (Coyote Star) is in the South, on the right side of the poster, as traditionally observed from Diné Bikéyah (Navajo Country)

Haashch'éshzhini (Black Spirit) and Coyote play important roles in the creation of the constellations

The Sun and the Moon are important parts of the Diné Universe Táán Nobelhech ild



12. li'ni - Thunderbird (includes Pegasus for li'ni's body and six

### NIVERSE

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ar map below, the primary Diné (Navajo) constellations are illustrated. Find the number on the star map to see approximately where each constellation is in the sky.

1. Náhookos Bi'ka' - Male Revolving One (includes parts of Big Dipper and Ursa Major)

2. Náhookos Bí'áád - Female Revolving One (includes Cassiopeia)

3. Náhookos Biko' - Central Fire of Náhookos (North Star/Polaris)

4. Dilyéhé - Seed-like Sparkles (Pleiades) ril

Tigasoh

May

5. Átsé Ets'ózí - First Slender One (includes Orion)

> 6. Hastiin Sik'ai'ii - Man with Solid Stance (includes Corvus)

> > - anidatshchill

July

September Bini'ant' éétsoh 7. Átsé Etsoh - First Big One (upper part of Scorpius) 8. Gah Hahat'ee - Rabbit Tracks (lower curved hook of Scorpius) tober 9. Yikáísdáhá - Awaits the Dawn (Milky Way) Tsetah Dibé - Mountain Sheep (includes Beehive Cluster in Cancer) Thish Tsoh - Big Snake (includes parts of Puppis and Canis Major)

stars for its feather, beginning with Denebola in Leo)

14.

#### WINTER CONSTELLATIONS

#### Náhookǫs Bi'ką' -**Male Revolving One -**Big Dipper

This constellation can be culturally seen as a male warrior, a leader who protects his people. He is sympathetic and charismatic, as well as a provider for his family and home. As a father he



and home. As a father he provides spiritual and physical protection to his family.

The term "Náhookos" refers to the double motion of the constellation as it revolves around the North Star, while rotating at the same time. This constellation is always paired with a female counterpart, Náhookos Bi'áád, in a relationship of complementarily.



Náhookòs Bi'áád -Female Revolving One - Cassiopeia This constellation is the female partner of Náhookos Bi'ką'. She is a woman who exemplifies motherhood and regeneration. She pro-

vides growth, stability in the home and the strength necessary for harmony. Instead of a bow and arrow, her weapons are her grinding stone and stirring sticks, which ensure that she will always be able to feed her family.

Náhookos Bikoʻ - Central Fire - Polaris, North Star

This constellation depicts the central fire of a hogan, a Navajo home. This star never



moves and thus provides stability to the cosmic home. The constellation is the central light and eternal fire that brings comfort to the home. It also represents human consciousness. This star provides the relationship that unites the two other Náhook-s constellations into one. The star gives centrality, balance and guidance to all other stars in the sky. It provides dynamic stability within the cosmic process as a star that appears stationary, not wandering.

#### Yikáísdáhá - That Which Awaits the Dawn - Milky Way

Yikáísdáhá, That Which Awaits the Dawn, is related to the annual Milky Way process. The emergence of pre-dawn is determined by the position of the Milky Way that changes with the nights, months and seasons. Yikáísdáhá can be experienced by the full cyclical emergence of the Milky Way in the early predawn hours of mid January. It is during this time the full circle of the Milky Way aligns with the horizon. Thus, a person can observe the full Milky Way in every direction, as it lays on the horizon in a circle. The Milky Way is depicted in Navajo sand paintings as a crosshatched line, indicating the changes of its position in the night sky, from one side to another. Yikáísdáhá is the last of the eight main constellations and signifies completeness and wholeness.





#### Ma'ii Bizq` - Coyote -Canopus

Ma'ii or Coyote took part in the naming and placing of the star constellations during the Creation. He placed one star directly south, naming it after himself, Ma'ii Bizq', the Coyote Star. This star is Canopus,

which from Navajo land appears to be directly south on the horizon. The visible path of Canopus is of very short duration because its position is due south. It comes out and goes down in a semicircular path, as observed from Navajo country. It can be seen from Navajo land in late December near the date of the winter solstice, around midnight. The star is really a supergiant star with a sparkling movement, which Navajos say is a red-orange color. It is the second brightest star in the night sky after Sirius, when it can be seen.

#### Ma'ii - Coyote Tossing the Stars

The trickster, Ma'ii, or Coyote, is often credited with creating chaos, thus creating a larger order in the universe. One story goes this way. Long ago the Holy

Beings were creating precise constellation forms out of crystals, which were stars. Hashch'éshihiní, Black God, was carefully placing each star with a purpose and location in the Upper Darkness, which we call sky. He created Náhookos Bi'ka' and Náhookos Bi'áád and placed them in the Upper Darkness. He then placed Dilyéhé and Átse' Ets'ózí, then others. Pretty soon, Coyote came along and asked what they were doing. In many





stories the Coyote's curiosity leads him into trouble. The Holy Beings replied that they were creating order and light in the sky. Coyote was immediately enthusiastic and asked to help. He was allowed to participate and he began to take crystals off the buckskin and place them in the sky. He placed one star in the south and exclaimed, "that will be my star, the coyote star." He placed a few other



stars, claiming them for himself, including the North Star, thus separating north and south. He soon grew impatient. When no one was looking, he grabbed the buckskin and tossed it high into the sky. All the remaining crystals flew out of the buckskin in all directions. There was no more precision in the placing and naming of the stars.

This, Navajos say, is why there are so many stars without names or constellation forms.



Ii'ni - Thunderbird - Pegasus and Various Stars The Thunder constellation is related to the Bear constellation (Sagittarius). It is considered a

spring and summer constellation and will first appear with the heliacal rise in the pre-dawn hours of early spring. This occurs about the

same time that the First Thunder of spring sounds on earth signifying the coming of spring. The sounds of the First Thunder and the first appearance of the Thunder constellation in the sky awake the life processes and emergence of spring and moreover signals the rejuvenation of seasonal life cycles on earth. The Thunder constellation manifests the intricate interconnection of all life in the universe, animals, plants, humans, thunder and lightning.

The cosmic essence of the Thunder constellation is depicted as a feather containing six stars. Each star represents a month and can be identified with the morning heliacal rise of the first bright star in the East, following the new crescent moon, for each of the six months.

Also, about this time the Coyote Star (Canopus) will appear in the south and will only appear very clear for about 3

weeks and won't be seen again until next year the same time. It is about gone if not gone already. So, as done in the past, the Coyote Star and Ghaaji crescent moon were used somewhat together to deter-



mine the end of the cold winter season. Unlike most Navajo constellations, the Thunder constellation covers a major portion of the sky and appears over many months. The first indication of its feather comes in the early morning hours in September/October (Denebola in Leo)

Six Stars in the Thunderbird Feather October (helical rise star) - Denebola - tail of Leo the Lion ovember (helical rise star) - Arcturus in Bootes December (helical rise star) - Brightest star in Corona January (helical rise star) - Vega in Lyra February (helical rise star) - Altair in Aquila March (helical rise star) - Beta Pegasus (star in Sagittarius)

and is completed in February/March (tip of Pegasus). The body takes an additional three months to completely appear, March, April and May, and remains visible during the rest of the summer.

#### Jo'hannaa'ei **- Sun**

The Sun and the Moon are usually paired. Together their cycles determine the times of the months and the years. There are usually twelve full moons in a year, but occasionally, every few years, Navajos acknowledge a thirteenth moon

around the time of October, according to old Navajo teachings. This resets the calendar system, so that the Sun and Moon cycles are harmoniously balanced.





There are many stories about the Sun, including the stories of the Sun impreg-

nating two girls which occurs about the time that the Sun is passing through the twin stars of Gemini. The girls give birth to sons - Monster Slayer and Born for Water.



These twins grow up and visit their father the Sun. After many trials they receive supernatural powerful weapons and return to earth to kill the monsters who are



destroying the people. This story can be related though many aspects to the two NASA missions to the Sun the Parker Probe and the Solar Orbiter.

The Sun is said to be a male energy, depicted by a perfectly round turquoise disc. It is said to be carried by a Sun Carrier as it makes its daily rounds across the sky. It is often depicted as



a humanlike person on horseback. The energies of the Sun are used in healing ceremonies. People are reminded not to look at the Sun during an eclipse. If they forget, and look at the Sun, they may develop eye and digestive trou-

bles. These can be healed by the Sun's energies.

#### Tł'éhonaa'éí **-Moon**

The Moon is considered to be a female energy, related to the male energy of the Sun. There are many stories about the



moon, often passed down through the female side of a family. The Moon is often depicted as a perfect white shell disc, carried by the Moon Carrier as he rides his horse across the sky. The phases of the Moon are considered to be very important and there is a Navajo name of each of the nights of the lunar cycle. The meaning of the Moon is life itself, intrinsically connected with the life cycles of all organisms.

#### **ALBERT BRENT CHASE**

Being raised by grandparents, I feel lucky to hear many childhood stories in my Navajo language. They say coyote is our first teacher of what not to do. This art of mine, recollects the image i saw as I was told of how coyote grew impatient and grabbed the buckskin full of stars and through them into the sky.



Painting by Albert Brent Chase, Diné

#### WILPHINA BECENTI

Little Singer Community School students first learn the importance of clanship. Clanship is the foundation of understanding self-identity, family roles, and respect. Diné language is also an essential tool used to make connections between Diné vocabulary and emotions. Once these are established, students work to further their awareness of how they fit in between Mother Earth -Nihimá Nahasdzáán and Father Sky -Nihitaa' Yádiłhił.



Painting by W. Becenti

Students at LSCS gain an understanding of how their k'é (relationships) with the Earth, Sun, stars, moon, universe, and the four elements impact them every day. They study the seasons through Diné teachings and storytelling of the moon phases, sun travel, shadows, animal behaviors, and sweatlodge. Students learn k'é is found everywhere and in anything they do. They are never alone and are always connected to nature and others.

#### **THOMAS TOMAS**



Educator Mr. Tom Tomas, M.Ed. 6<sup>th</sup> grade teacher at Little Singer Community School in Bird Springs, Arizona recommends the NASA Astrobiology graphic novel series. It "... explores the many facets of astrobiology: the study of the origin, evo-

lution, and distribution of life in the Universe." These fascinating resources can be found at https://astrobiology.nasa.gov/resources/graphic-histories/ We started with issue #1 The Origin of Science and issue #2 Mission to Mars (4th Edition) when working within the NASA themes: STEM on Station for Students and Moon to Mars.

NASA website also made reference to R.O.A.D.S. on Mars which involves planetary science research, application of engineering design processes with robotics and code writing as well as piloting drones. R.O.A.D.S. stands for Rover Observation And Drone Survey and has been developed by NESSP: Northwest Earth and Space Sciences Pipeline. Our Colts' Robotics team is in its infancy but this and FIRST LEGO League are helping us take small, informed steps forward.



#### **PEDAGOGY OF PLACE:**

At Little Singer Community School, we start with our children's prior knowledge, experiential knowledge, and honor what family and extended family teach through the intergenerational transference of knowledge. Story-telling, Navajo songs, and art help provide context and build an anticipatory set. Within such indigenous context and consciousness we interweave the STEM standards, although we call it STREAM = STEM + Reading and the Arts.

Not only is content culturally contextualized, but also learning processes: reading processes, writing processes, scientific processes of inquiry, engineering design processes, etc. These cyclical processes are mapped out by the Navajo Philosophy of Learning and given cultural depths of meaning when conveyed in the Navajo language.

We believe that these wealth of Navajo cultural assets help our children strengthen identity awareness and groundedness. Yet, when applied to investigating space-time, space travel, astrobiology, NASA's STEM on Station, and Moon to Mars, such assets transfer and transport our children through their imagination, and they take flight. Take for example the NASA Gateway space station, and preparations for lunar exploration, the Navajo six directions of thinking can help orientate our astronauts.



The Navajo six directions and one's relationships are like a gyroscope and keep us orientated. For example, Earth's gravity helps us determine our orientation. If we were on the lunar surface, the Moon's gravity, Sun's location and path, Earth's position in the Moon's celestial dome, and shadows would help us determine our orientation. At Little Singer Community School, we ask, how can the six directions in Navajo culture help astronauts become orientated during space travel?



Photo by Ashley Teren

#### SARAH MARGOLES

Educator, Sarah Margoles, MS, M. Ed, 8th grade science teacher at Miller Middle School in Durango, CO says:

Incorporating different cultural perspec-



tives in astronomy (or other science subjects) does more than simply enrich my classroom lessons, discussions, and projects - it honors the diversity of my classroom. For me, a positive classroom communi-

ty where everyone feels comfortable and respected, is essential. Without that, learning doesn't happen. I've taken baby



steps toward being a more culturally relevant teacher, and have found that even small steps, such as incorporating Navajo constellations or the Navajo



creation story into classroom discussions and projects, reaches many Native (and non-Native) students that

often feel disengaged and uninterested in traditional western science instruction. I have much to learn, but am excited to learn it. I'd like to share one of these projects with you: **Two-Eyed Seeing Constellations Project (Margoles)**. Inspiration for this project came from **NASA's Educator Guide: Planetary Poetry Educator Guide: Planetary Poetry** 



#### **EDWARD GONZOLAS: NASA**



Advocating For Underserved Communities

Days before his 13th birthday, Edward Gonzales lost his father. In spite of childhood hardships, the strong work ethic that his father instilled drove him to obtain employment at one of the largest law firms on the West O'Melveny and Myers LLP. After working for the firm for over a decade and furthering his education, a friend mentioned an opening at NASA>s Jet Propulsion Laboratory (JPL). He was hired as a business administrator, but quickly gravitated to the education side of the house. Since 2001, he has worked with underserved, underrepresented minorities and communities in the capacity of mentoring, co-managing various programs, attending and supporting national conferences, including the American Indian Science and Engineering Society (AISES), and the Society of Advancement of Chicanos/ Hispanics and Native Americans in Science (SACNAS). During his time with NASA, he has won numerous awards. In 2018, he was promoted to lead STEM engagement for underserved, underrepresented minorities at NASA Goddard Space Flight Center. Eddie is giving virtual presentations at various schools in the Southwest, including Miller Middle School in Durango, CO and Little Singer Community School, in Bird Springs on the Navajo Nation.



Annette Lee, PhD

PERSEVERANCE, ARTEMIS, PARKER PROBE, SOLAR ORBITER

**PERSEVERANCE** - Save the Date...!!! on Feb. 18, 2021 around noon pst NASA's Perseverance rover and the Ingenuity helicopter drone will touch down in Jezero crater on Mars!

"The Mars 2020 mission with its Perseverance rover is part of NASA's Mars Exploration Program, a long-term effort of robotic exploration of the Red Planet. The Mars 2020 mission addresses high-priority science goals for Mars exploration, including key **Astrobiology** questions about the potential for life on Mars.

The Mars 2020 Perseverance rover will investigate a region of Mars where the ancient environment may have been favorable for microbial life, probing the Martian rocks for evidence of past life. Throughout its investigation, it will collect samples of soil and rock, and cache them on the surface for potential return to Earth by a future mission.

Perseverance will carry an entirely new subsystem to collect and prepare Martian rocks and soil samples that includes a coring drill on its arm and a rack of sample tubes. About 30 of these sample tubes will be deposited at select locations for return on a potential future sample-retrieval mission. In laboratories on Earth, specimens from Mars could be analyzed for evidence of past life on Mars and possible health hazards for future human missions."



Ref - https://www.jpl.nasa.gov/missions/ mars-2020-perseverance-rover/



https://www.jpl.nasa.gov/images/perseverance-on-mars/



https://www.jpl.nasa.gov/missions/ mars-2020-perseverance-rover/

**ARTEMIS PROGRAM** – Space travel anyone? NASA's exciting plan to 'send the first woman and the next man to the Moon by 2024' and then to use this knowledge and experience to send a team to Mars sometime around 2030...

"Humanity's Return to the Moon...With the Artemis program, NASA will land the first woman and next man on the Moon by 2024, using innovative technologies to explore more of the lunar surface than ever before. We will collaborate with our commercial and international partners and establish sustainable exploration by the end of the decade. Then, we will use



what we learn on and around the Moon to take the next giant leap – sending astronauts to Mars.... America has entered a new era of exploration. NASA's Artemis program will lead humanity forward to the Moon and prepare us for the next giant leap, the exploration of Mars. It has been almost 50 years since astronauts last walked on the lunar surface during the Apollo program, and since then the robotic exploration of deep space has seen decades of technological advancement and scientific discov-



eries. For the last 20 years, humans have continuously lived and worked aboard the International Space Station 250 miles above Earth, preparing for the day we move farther into the solar system. Sending human explorers 250,000 miles to the Moon, then 140 million miles to

Mars, requires a bold vision, effective program management, funding for modern systems development and mission operations, and support from all corners of our great nation as well as our partners across the globe...."



Ref https://www.nasa.gov/specials/artemis/

#### https://www.nasa.gov/sites/default/files/ atoms/files/artemis\_plan-20200921.pdf

#### https://www.nasa.gov/specials/artemis/

**PARKER SOLAR PROBE** – NASA's probe to study the Sun close up just completed it 7<sup>th</sup> orbit around the Sun (out of 24 total)! At about 8 million miles away and traveling at nearly 300,000 mph it is breaking its own records for speed and proximity to the Sun. Researchers are learning that it is a lot more dusty (bits of rock and ice) than expected in the Sun's corona



that is also changing more quickly than anyone expected (over months versus years).

 Parker Solar Probe will swoop to within 4 million miles of the Sun's surface, facing heat and radiation like no spacecraft before it. Launched on Aug.
12, 2018, Parker Solar Probe will provide new data on solar activity and make critical contributions to our ability to forecast major space-weather events that impact life on Earth.



In order to unlock the mysteries of the corona, but also to protect a society that is increasingly dependent on technology from the threats of space weather, we will send Parker Solar Probe to touch the Sun.



In 2017, the mission was renamed for Eugene Parker, the S. Chandrasekhar Distinguished Service Professor Emeritus, Department of Astronomy and Astrophysics at the University of Chicago. In the 1950s, Parker proposed a number of concepts about how stars—including our Sun—give off energy. He called this cascade of energy the solar wind, and he described an entire complex system of plasmas, magnetic fields, and energetic



particles that make up this phenomenon. Parker also theorized an explanation for the superheated solar atmosphere, the corona, which is – contrary to what was expected by physics laws -- hotter than the surface of the Sun itself. This is the





first NASA mission that has been named for a living individual."

http://parkersolarprobe.jhuapl.edu/ The-Mission/index.php

https://www.colorado.edu/today/2020/12/09/researchers-get-look-suns-dusty-environment

https://blogs.nasa.gov/parkersolarprobe/2021/01/21/parker-solar-probemarks-seventh-successful-swing-aroundthe-sun/

**SOLAR ORBITER** – An exciting mission to study the Sun launched just one year ago (Feb. 2020) is sending back its first data from the Sun! What surprises will the Sun share with us...

"Solar Orbiter is an international cooperative mission between ESA (the European Space Agency) and NASA that addresses a central question of heliophysics: How does the Sun create and control the constantly changing space environment throughout the solar system? The Sun creates what's known as the heliosphere — a giant bubble of charged particles and magnetic fields blown outward by the Sun that stretches more than twice the distance to Pluto at its nearest edge, enveloping every planet in our solar system and shaping the space around us. To understand it, Solar Orbiter is traveling as close as 26 million





miles from the Sun, inside the orbit of Mercury to measure the magnetic fields, waves, energetic particles and plasma escaping the Sun while they are still in their pristine state, before being modified and mixed in their long journey from the Sun.

With a scientific payload of 10 different instruments — each complementing and supporting the others — Solar Orbiter combines high-resolution telescopes with measurements from the environment directly surrounding the spacecraft. Together the observations create a oneof-a-kind, comprehensive picture of the Sun's inner workings and how they can affect the space environment further out in the solar system."

Ref- https://www.nasa.gov/content/solar-orbiter-overview https://www.nasa.gov/solar-orbiter http://www.esa.int/Science\_Exploration/

Space\_Science/Solar\_Orbiter/Solar\_Orbiter\_releases\_first\_data\_to\_the\_public

http://www.esa.int/Science\_Exploration/ Space\_Science/Solar\_Orbiter/Solar\_Orbiter\_releases\_first\_data\_to\_the\_public Page 26





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## AHÉHEE

#### Thank You

PRODUCED BY: INDIGENOUS EDUCATION INSTITUTE Friday Harbor, WA & Window Rock, AZ www.indigenouseducation.org

> Nancy C. Maryboy, PhD David Begay, PhD Ashley C. Teren, M Ed

LITTLE SINGER COMMUNITY SCHOOL BIRD SPRINGS, AZ

> Tom Tomas, M Ed Brent Chase Wilphina Becenti, M Ed

MILLER MIDDLE SCHOOL DURANGO, CO

Sarah Margoles, M Ed, MS

NATIVE SKYWATCHERS www.nativeskywatchers.com

Annette S. Lee, PhD, MFA

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Navajo constellations paintings by Melvin Bainbridge, from collection copyrighted© by Indigenous Education Institute

Space Science images from NASA.gov

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