# Traditions of the SUN



# THE SUN-EARTH CONNECTION AT CHACO CULTURE NATIONAL HISTORICAL PARK

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# OUR DYNAMIC SUN

Each day begins when the morning sky starts to get light over the eastern horizon, where the Earth meets the sky. Sunrise is so predictable that we rarely stop to think about what is happening or why. Have you ever wondered what mysteries the Sun holds?

Today, NASA solar scientists are finding out more about the Sun, our nearest star. We know the Sun is 93 million miles (150 million kilometers) from Earth. It is so huge that 109 Earths could fit across its diameter. It is a gigantic ball of hot, moving gases. When you see images of the Sun from a solar telescope, you see its dynamic forces at work. The Sun sends energy to Earth and other planets in our solar system in the form of heat and light, and in the particles that make up the solar wind. Life on Earth depends on the Sun.

> Left: Image of the Sun taken by the TRACE (Transition Region and Coronal Explorer) satellite. Right: Sunset behind Pueblo Bonito in Chaco Canyon.

### "The Sun is a violent, variable, magnetic star whose activity affects the Earth."

-DR. ISABEL HAWKINS, DIRECTOR OF SCIENCE EDUCATION, SUN-EARTH CONNECTION EDUCATION FORUM



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### SUN WATCHERS

Scientists today observe the Sun with satellites and telescopes, but Sun watching isn't new. People have been observing the Sun and its patterns for a very long time. Sun watchers studied the Sun's yearly cycles to know when to plant crops or get ready for winter. They also watched the Sun to plan ceremonies or celebrations connected to the changing seasons. Do you know when the seasons are ready to change? What clues do you look for?

Ancient Sun watchers studied the Sun, day after day, year after year. They noticed that the Sun rose and set in a different place on the horizon every day. They may also have observed rays of light from the Sun shining through special windows and doorways to mark important times of the year. By carefully watching where the Sun rose and set, Sun watchers could use the landscape and buildings like a calendar.

Why do you think it's important to know when to plant and harvest crops?



Far Left: Sunrise over the great kiva, Casa Rinconada, in Chaco Canyon.

Left: A shaft of sunlight strikes the corner of an ancient wall of the great house, Pueblo Bonito, on the winter solstice, the shortest day of the year.

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# CHACO CULTURE NATIONAL HISTORICAL PARK NEW MEXICO, USA

Chaco Canyon is in a part of the United States called the Four Corners region, where the states of Colorado, New Mexico, Arizona, and Utah come together at a single point. Chaco Canyon is in the northwest corner of New Mexico. Where is your state located in the United States? Are you north, south, east, or west of Chaco Canyon?



Far Left: A Space Imaging satellite picture of Chaco Canyon. Can you find the dry riverbed called Chaco Wash and the roads? How many buildings can you find?

Left: Images taken by the MODIS (Moderate Resolution Imaging Spectroradiometer) imager of the Four Corners and the United States.

Below: Earth as seen from space.



Ancestors of today's Pueblo Indian people settled in Chaco Canyon and its surrounding region. A thousand years ago, they constructed monumental buildings, the remains of which can still be found today.



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### WIDE-OPEN SKY

Chaco Canyon is a great place for observing the sky, and especially for Sun watching. The sky seems really big here. Look at the pictures of the landscape, paying close attention to the horizon. Each horizon has a unique look, due to the shapes of the mesas, buttes, and plateaus. It is easy to see across the wide-open canyon. When you look at pictures of the canyon, do you see trees? Is the horizon easy to see? What shapes do you notice in the landscape?

Blending into the natural features of Chaco Canyon are the stone structures built by the ancestors of today's Pueblo people starting about a thousand years ago. These buildings are one of the mysteries of Chaco Canyon. Why do you think they were built? What do you think they were used for?



Above: Narrow-leaved Indian Paintbrush along the South Mesa Trail in Chaco Canyon.

Right: An ancient wall of the great bouse, Una Vida, in the canyon with Fajada Butte visible in the background.

Far Right: A view from South Mesa in Chaco Culture National Historical Park.

### "The sky was of extreme importance to them." —J. MCKIM MALVILLE, ASTRONOMER







### THE GREAT HOUSES

The largest of the stone structures built by the Ancestral Puebloans are called "great houses." The most famous one in Chaco Canyon is Pueblo Bonito. It is a huge building that once rose four stories tall and had over 600 rooms. Skilled stone workers built the walls using pieces of sandstone they cut from the walls of the canyon. Mud held the stones together. Roofs, ceilings, and floors were made of wood. Many people worked together to add rooms and levels over time to create these large and complex structures. The buildings may have been used as places to trade, places to live, or gathering places for ceremonies.

One interesting thing to notice about Pueblo Bonito is how well it lines up along the north, south, east, and west—which are known as the "cardinal" directions. Placing this building so precisely required observations of the Sun and the stars. Did you know you can figure out direction by watching the Sun and stars? Ancient Sun watchers studied where the Sun rose and set during the year. They observed the stars moving in the night sky. Some scientists and native people today think these patterns of movement in the sky showed the ancient people how to place their buildings.

### "In looking at the architecture of Chaco, the Sun was a very wonderful teacher—a classic example of an outdoor classroom." —DR. SHELLY VALDEZ, LAGUNA PUEBLO

Left: A view of Pueblo Bonito today.

Right: An artist's rendering of Pueblo Bonito at its beight.



## LEARNING FROM THE PAST

Archaeoastronomy brings together the two sciences of archaeology and astronomy. Archaeology is the study of artifacts of ancient cultures. Archaeologists learn about people of the past and how they lived and thought by looking at artifacts they left behind, including pottery, tools, pictures, and buildings. Astronomy is the science of space. Astronomers observe the Sun, Moon, planets, and stars. They study how these objects move in the sky and look for patterns in all they observe.

Archaeoastronomy is the study of ancient astronomy and culture. Archaeoastronomers study the clues that ancient astronomers left behind. At Chaco Canyon, they also talk with the Pueblo people of today, to learn about the Sun knowledge passed down to them from their ancestors. Ancient astronomers at Chaco Canyon left behind lots of evidence of Sun watching in their buildings and rock art.



Above: One of many spiral petroglyphs carved into the rock of Chaco Canyon.

Right: Many different styles of pottery sherds found at the park.

Far Right: Pictographs from the oldest site in the park, known as Atlatl Cave. The paintings are believed to be about 3,000 years old. Archaeoastronomers study special features of the great houses, their placement, and their specific locations in the canyon. They also study ancient rock carvings called petroglyphs and rock paintings called pictographs. This rock art sometimes gives important clues about how ancient people marked the movements of the Sun, Moon, and stars.





## THE CHANGING SEASONS

The weather at Chaco Canyon might surprise you. We usually think of the desert as simply hot and dry. However, this high desert is well above sea level on top of the huge Colorado Plateau. Chaco Canyon is over 6,000 feet above sea level—as high as some mountain ranges. While it is dry, it is not always hot.

The changing seasons bring extremes in this high desert. The winter is very cold and it is not unusual to see snow on the ground. When spring arrives, the winter snow melts into water that helps the wildflowers bloom and the crops grow. Summer is usually hot and dry with temperatures ranging from 80 to 100 degrees. But there can be strong storms that stop as suddenly as they start. In autumn, it continues to be very warm during the day, but the nights are longer and colder.

How do the seasons in Chaco Canyon compare to the seasons where you live?



Above: The bright red flowers of Indian Paintbrush can be seen in spring.

Right: Light snow and ice blankets the area around Fajada Butte at Chaco Canyon in the winter.

> Far Right: Lightning strikes during a summer storm near the great house of New Alto.







## CELEBRATING THE SEASONS

Celebrating the Sun connects the past and present in Chaco Canyon. According to Dr. Shelly Valdez of the Laguna Pueblo, "The Sun is seen through our culture in many different forms. We're connected with the Sun spiritually through the ceremonies that we have, through the seasons, through the cardinal directions, how we live, and how we see that all nature is connected."

### "I'm thankful for the Sun and everything that it provides us." —andrew Garcia, san Juan Pueblo

Andrew Garcia of the San Juan Pueblo shares one way he celebrates the Sun and seasons, "Every morning just when the Sun is coming from the east, I'm out there with my cornmeal, and I pray. I throw my cornmeal to the north, and then after that I go to the west, to the south, to the east, up to the heavens, down to Mother Earth, and then it comes to me. This is how we're taught." Do you or your family have special traditions to celebrate the Sun or seasons?



Far Left: Valerie Martinez of the Tewa Dancers of the North performs in Pueblo Bonito during the summer solstice.

Left: Eugene Sekaquaptewa, a Hopi farmer in the Southwest, growing corn in the traditional way.

### MARKING THE SEASONS

Ancestral Puebloans had to know exactly when to plant and when to harvest because of the harsh climate in the region. A few poor harvests in a row could threaten the survival of the community. How do you think they knew what time of year it was? How would you know that a warm, sunny day in February was not the beginning of spring? The answers to these questions bring us back to the Sun watchers.

While scientists do not know for sure, they believe Sun watchers could mark the seasons in several ways. They watched, from specific locations, where the Sun rose and set on the horizon. The locations could be inside a room of a great house or outside by a rock formation. When the Sun got to a special spot each season—like the edge of a rock cliff or between two distant peaks—the Sun watchers could tell what time of year it was. They also observed when the Sun would appear through special windows or doorways carefully placed in their buildings. Sometimes they observed the shadows or rays of light cast by the Sun on petroglyphs or pictographs they made on stone, or on their interior walls.





Above: A shaft of sunlight begins to illuminate an ancient pictograph during summer solstice, the longest day of the year. Artist Janet Saad-Cook first documented this event in 1983.

Left: A straight east-west wall of the great house of Pueblo Bonito could have been used to mark the seasons at the equinoxes. On the spring and fall equinox, day and night are of equal length.

Right: Light passes through a window on the summer solstice and shines on niches in the great kiva of Casa Rinconada.





### ASTRONOMICAL EVENTS

The ancient sky watchers at Chaco saw some amazing astronomical events about a thousand years ago. In the summer of 1054 A.D., there was a supernova that created the Crab Nebula. This supernova, the explosion of a distant star, would have been very bright in the sky. It would have been seen even during the day, for at least a month. A few summers later, Halley's Comet appeared in the sky with its long tail glowing in the night.

About ten years later, a rare total solar eclipse took place, followed by a second one twenty years after that. During solar eclipses, our view of the Sun is blocked by the Moon. People would have seen the daytime sky get dark, as if night had arrived. The sky above Chaco Canyon must have been awesome to the Ancestral Puebloans observing these astronomical events. What is the most interesting thing you have seen in the sky?





Above: An ancient pictograph found in Chaco Canyon may be a record of the supernova of 1054 A.D.

Left: Halley's Comet shines bright in the night sky.

Far Left: The Crab Nebula is a remnant of a supernova explosion that occurred nearly one thousand years ago.

## TOTAL ECLIPSE

The sky is still awesome today. Solar eclipses give scientists an opportunity to study the Sun and its outer atmosphere, known as the corona. During a total eclipse, we can see the corona streaming away from the Sun. At other times, the Sun is too bright and we cannot see the corona.

Scientists can predict when the Moon will cross in between the Sun and our planet, casting its shadow on the Earth. Scientists know exactly what time of day the eclipse will happen, and where on Earth we will be able to see it. They also use special solar telescopes with filters to safely view the Sun. It is important to remember never to look directly at the Sun to prevent damaging your eyes.

Some archaeoastronomers think that the Ancestral Puebloans might have seen a solar eclipse and recorded the event in a petroglyph found at a place called Piedra del Sol, which is Spanish for "Rock of the Sun." Take a look at the petroglyph—does it look like the Sun and its corona during a total solar eclipse to you?

"A petroglyph called Piedra del Sol may represent the Sun's corona during a solar eclipse."

-G.B. CORNUCOPIA, NATIONAL PARK SERVICE



Left: An ancient petroglyph found in Chaco Canyon may be a record of an eclipse.

Right: The corona streams around the the Sun, which is blocked by the Moon during a total solar eclipse.





### THE SOLAR CYCLE

Most people think of the Sun as unchanging. In fact, the Sun is a very active, dynamic star. One clue to the Sun's activity is the appearance of sunspots. It's quite possible the Ancestral Puebloans observed sunspots. Chinese astronomers recorded seeing them during the same long-ago time period.

Sunspots are places where the Sun's magnetism is very strong. In pictures, they appear as dark spots since they are cooler than other areas of the Sun's surface, but are still very hot. Scientists track sunspots across the face of the rotating Sun. The Sun goes through a cycle of activity. About every 11 years, the number of sunspots changes from a few to many. These changes are called the solar cycle. The peak is called solar maximum, and the low is solar minimum.

The solar cycle is one of the puzzles of the Sun that scientists are studying. They wonder why sunspots are more common during solar maximum. During solar maximum, solar flares and huge, fast-moving eruptions called coronal mass ejections happen more often. Scientists are just beginning to understand how these powerful events affect us here on Earth. NASA solar satellites are helping to unravel the mysteries of our star, the Sun.





Far left: A series of images from the Yohkoh satellite, shows the solar cycle, from solar maximum to solar minimum.

Above: Sunspots, some as large as the Earth, appear on the face of the Sun.

Left: A close-up view of sunspots.

### THE SUN-EARTH CONNECTION

The active Sun directly affects life here on Earth. The Sun is always sending energy toward us. Some of this energy can be harmful, but luckily we are protected by the Earth's atmosphere. Also, our planet's magnetosphere, a huge magnetic shield, helps protect us from energy from the Sun.

Energy from the Sun creates beautiful auroras, known as the Northern and Southern Lights. Viewed from Earth, they look like shimmering curtains of colored light in the night sky. The auroras can also be seen from space, forming an oval shape around Earth's magnetic poles.

Energy from the Sun can disrupt communications, damage satellites, and cause large power blackouts. Astronauts living and working in space must be aware of the dangers from solar storms.



Above: The bright colors of the Aurora Borealis, also called the Northern Lights, are seen over Alaska.

Right: Powerful storms on the Sun's surface appear in this image from the TRACE satellite.

Far right: NASA astronaut Mark Lee on an untethered spacewalk outside of the space shuttle. NASA scientists continue to study the Sun-Earth connection. As we use more high-tech equipment such as cell phones, satellite dishes, and other electronics, we need to find new ways to protect them from solar storms.







# PRESERVING THE PARK FOR FUTURE GENERATIONS

The Sun is not the only thing that affects life here on Earth. You can, too!

Chaco Canyon is fragile and can never be replaced. It is an important part of our past and present. Part of our responsibility for the future is making sure that the canyon and its buildings are well taken care of. It is important to remember that these places are part of the history of the Pueblo and Navajo Indians. Native Americans continue to respect and honor these beautiful and sacred sites.

The National Park Service is working to keep Chaco Canyon a special place. They are stabilizing buildings, restoring native plants, and educating visitors about Chaco Canyon. Do you have a park or a place that you help to care for? Maybe you pick up litter or stay on the trail to keep from harming plants. If so, you are a steward of your community and the beautiful blue planet we call home. "The best thing you can do for the park is to respect it."

-G.B. CORNUCOPIA, NATIONAL PARK SERVICE



Above: A National Park Service restoration sign asks us to help protect the park.

Left: The "Blue Marble," a view of Earth from space.

Far Left: Pueblo Bonito overlook, showing two people viewing the great house.

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### GLOSSARY

Ancestral Puebloans: A term used to describe the ancestors of the Pueblo Indian people who live in the southwestern United States.

**archaeoastronomy**: The study of the astronomical practices of ancient cultures.

**astronomy**: The science that studies the natural world beyond the Earth.

**butte**: A hill rising steeply from the surrounding area. It has sloping sides and a flat top.

**cardinal directions**: The four main directions of the compass: north, south, east, and west.

**Colorado Plateau**: A large, elevated expanse of land that covers parts of Colorado, New Mexico, Arizona, and Utah.

corona: The Sun's outer atmosphere.

**coronal mass ejection**: An eruption of charged particles from the Sun's corona that travels through space at a very high speed.

**equinox**: The spring equinox (March 20th or 21st) and the autumn equinox (September 20th or 21st) occur when the day and night are of equal length at all places on the Earth.

**great houses:** The term used to describe the large Pueblo structures found in Chaco Canyon and in the surrounding region.

Halley's Comet: A comet which can be seen from Earth about every 76 years. It last appeared in 1986.

**kiva**: A circular building used mainly for religious and ceremonial purposes. Most kivas are built underground or partially underground.

**magnetosphere**: A huge magnetic shield that surrounds and protects the Earth from the solar wind.

**mesa**: A broad, flat-topped earth formation with one or more cliff-like sides.

**MODIS imager**: Moderate Resolution Imaging Spectroradiometer, a NASA instrument measuring changes on the land and in the ocean. NASA: The National Aeronautics and Space Administration.

niche: A recess or indented area in a wall.

**petroglyph**: Rock art created by carving or scraping a stone surface.

**pictograph**: Rock art created by painting onto a stone surface.

plateau: An elevated, level expanse of land.

pottery sherd: A piece or a fragment of pottery.

**rock art**: Pictures created by carving or painting a stone surface.

**solar cycle**: A predictable eleven-year cycle during which the Sun becomes more active and then less active.

**solar eclipse**: A solar event that happens when the Moon moves in between Earth and the Sun and covers the Sun from our view. From Earth we can see the Sun's corona during a total solar eclipse.

solar flare: An explosive release of the Sun's energy.

**solar wind**: The charged particles that stream outward from the Sun throughout the solar system and toward the Earth.

**solstice**: The summer solstice is the longest day of the year (June 21st or 22nd) and the winter solstice is the shortest day of the year (December 21st or 22nd).

**sunspots**: Places on the Sun that are highly magnetic. They appear darker and are relatively cool.

**supernova**: The explosion of most of the material in a star. A supernova is very bright and gives off huge amounts of energy.

**TRACE**: Transition Region and Coronal Explorer, a NASA satellite studying the Sun.

wash: The dry bed of a stream.

Yohkoh: A solar satellite which is a cooperative mission of the U.S., Japan, and the U.K.

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# A Photographic Journey to Chaco Canyon and Beyond

Explore Chaco Canyon online with the interactive Website *Traditions of the Sun: Chaco Culture National Historical Park* at: www.traditionsofthesun.org.

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Satellite photograph of Chaco Canyon, New Mexico. Image courtesy of Space Imaging.