

A FILM REVEALING  
THE BRILLIANT SCIENCE AND CULTURE  
OF AN ANCIENT PUEBLO INDIAN PEOPLE  
OF THE AMERICAN SOUTHWEST

## Study Guide for Teachers

Addressing National Standards in Social Studies,  
Science, Language Arts, and Geography

THE MYSTERY OF CHACO CANYON is broadcast nationally by PBS and internationally by National Geographic and is narrated by Robert Redford. Film and Study Guide are produced by Anna P. Sofaer and the Solstice Project, Inc., Washington, D.C.



# The Mystery of **CHACO** Canyon

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Anna P. Sofaer and the Solstice Project, Inc.  
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# CONTENTS

About the film, THE MYSTERY OF CHACO CANYON . . . . .	1
Using the Study Guide and Addressing National Standards . . . . .	2
Summary of THE MYSTERY OF CHACO CANYON: KEY IDEAS . . . .	4
<b>UNIT I: EXPLORING CHACOAN COSMOLOGY &amp; CULTURE . . . .</b>	<b>16</b>
Lesson Plan: Social Studies, Grades 9-12	
Review Questions and Answers . . . . .	22
Social Studies Activity 1:	
Mock Committee Meeting on the Future of a Chacoan Site . . . .	24
Social Studies Activity 2:	
Build a Model of a Chacoan Building . . . . .	27
Social Studies Activity 3:	
Write About The Ideas Expressed In	
THE MYSTERY OF CHACO CANYON . . . . .	29
<b>UNIT II: EXPLORING CHACOAN ASTRONOMY . . . . .</b>	<b>30</b>
Lesson Plan: Earth and Space Science, Grades 5-8	
Review Questions and Answers . . . . .	36
Earth and Space Science Activity 1:	
Observe the Sun and the Moon, A Science Writing Project . . . .	40
Earth and Space Science Activity 2:	
Use Simple Tools to Determine Cardinal Directions . . . . .	40
Earth and Space Science Activity 3:	
Observe the Sun's Seasonal Movement with Simple Tools . . . .	44
Earth and Space Science Activity 4:	
Design Your Own Timekeeping Device Using The Sun . . . . .	46
<b>UNIT III: ENRICHMENT . . . . .</b>	<b>47</b>
Grades 5-12	
Traditional Literature . . . . .	47
Pueblo Culture . . . . .	49
Art, Symbols, and Architecture . . . . .	50
Archaeoastronomy and Calendars . . . . .	52
Archaeology . . . . .	54
Geology . . . . .	55
Ethnobotany . . . . .	55
<b>Resources . . . . .</b>	<b>57</b>
<b>Participants in the Film . . . . .</b>	<b>72</b>
<b>Glossary of Terms . . . . .</b>	<b>73</b>
<b>National Standards . . . . .</b>	<b>76</b>
<b>Credits . . . . .</b>	<b>77</b>

## About THE MYSTERY OF CHACO CANYON

THE MYSTERY OF CHACO CANYON presents new discoveries about the intricate astronomical knowledge of an ancient Pueblo Indian people, ancestors of today's Pueblo people. Their immense buildings in Chaco Canyon, a remote, barely habitable canyon in northwestern New Mexico, have been the subject of heated archaeological debate for decades. Begun more than a thousand years ago and taking twelve generations to complete, Chaco Canyon was thought to be an ancient trading center. This film, however, shows Chaco Canyon to be the center of a complex ceremonial system involving the Earth, the Sun, and the Moon. Dramatic aerial and time-lapse footage, computer modeling, and interviews with scholars reveal how the Chacoan people designed, oriented, and located twelve massive buildings to express a profound knowledge of an order in the universe. Members of the Zuni, Acoma, and Laguna Pueblos offer insights to their ancestors, and speak of the spiritual significance of Chaco Canyon in Pueblo culture today.

“Well-paced and absorbing, simultaneously poetic and analytical, this film provides a new benchmark of understanding,” remarked Peter M. Whiteley, Curator, Division of Anthropology, American Museum of Natural History, New York, N.Y.

Rina Swentzell, architect, Santa Clara Pueblo, New Mexico, states, “The film [is] part of the ongoing dialogue between archeologists, anthropologists, and native peoples. [It is] a multi-leveled phenomena, like Chaco, which embraces complexity, beauty, and mystery.”

THE MYSTERY OF CHACO CANYON helps students to appreciate the scientific and cultural achievements of a significant civilization in pre-Columbian North America. This film is relevant to secondary- and college-level courses in Social Studies, Earth and Space Science, Traditional Literature, Pueblo Culture, Art, Symbols, and Architecture, Archaeoastronomy and Calendars, Archaeology, Geology, Ethnobotany, Geography, Civics, Anthropology, Astronomy, and the History of Science.

Note: THE MYSTERY OF CHACO CANYON is available in its complete 57-minute version or a classroom version that divides the program into two 27-minute segments clearly marked in the film. This divided program is useful for two or more classroom discussions and activities. The first half of the film concerns the Chacoan people's alignments of their buildings to the Sun, and the second half, the alignments of their buildings to the Moon.

# USING THE STUDY GUIDE AND ADDRESSING NATIONAL STANDARDS

The teaching materials in the Guide are designed to be used with the film THE MYSTERY OF CHACO CANYON. A summary of the film provides the teacher with useful background knowledge for his or her own preparation and to share with students prior to viewing the film.

The activities in the Guide are primarily for grade-levels 5-12, although they also may be useful to college students.

The Guide is organized into three Units:

- Unit I: Exploring Chacoan Cosmology and Culture, Social Studies, Grades 9-12.
- Unit II: Exploring Chacoan Astronomy, Earth and Space Science, Grades 5-8.
- Unit III: Enrichment, Grades 5-12.

We encourage teachers to integrate disciplines as the ancient Chacoan people did: their achievements combined art, science, and religion. In order to facilitate interdisciplinary learning, each Lesson Plan in Units I and II refers teachers to additional Enrichment projects (Unit III) and suggested activities in Traditional Literature, Pueblo Culture, Art, Symbols, and Architecture, Archaeoastronomy and Calendars, Archaeology, Geology, and Ethnobotany. We also encourage teachers to team teach in Science, Math, History, Literature, and Art. In each content area, Language Arts are developed. The three Units are summarized below.

## Unit I

### **Exploring Chacoan Cosmology and Culture, Social Studies, Grades 9-12**

In this Unit students will learn about the achievements of one of the most significant cultures of pre-Columbian North America and their development of astronomy, monumental architecture, and roads. THE MYSTERY OF CHACO CANYON and this Guide show how an oral culture produced an advanced, stable civilization that integrated art, science, and religion. In the film the descendent Pueblo people suggest important insights to the cosmological meaning of Chaco Canyon.

## Unit II

### **Exploring Chacoan Astronomy, Earth and Space Science, Grades 5-8**

In this Unit students will learn about the importance of astronomical cycles and sky watching to ancient cultures. They also will learn about the relationship of the Sun, the Moon, and the Earth, as we understand it today. In addition, the disciplines of archaeoastronomy, archaeology, remote sensing, and geodesy are explained. Students learn how observation and the scientific process lead to changes in knowledge over time.

## Unit III

### Enrichment, Grades 5-12

In this section, students will explore various cultural expressions of cosmology and astronomy in traditional stories, literature, art, architecture, and the environment; and they will learn about the disciplines that help us understand ancient cultures. There are independent study projects in Traditional Literature, Pueblo Culture, Art, Symbols, and Architecture, Archaeoastronomy and Calendars, Archaeology, Geology, and Ethnobotany. The Resources section has related texts and web sites for each subject area.

### Valuable Background Resources

The Solstice Project bases the major findings presented in the film and explored in this Guide on the 25 years of research in archaeoastronomy of the Chacoan culture. The Project's research papers can be found on <http://www.solsticeproject.org>. These papers are of interest to teachers and students.

### ADDRESSING NATIONAL STANDARDS

This film and Guide address National Curriculum Standards in: Social Studies, Science, Language Arts, and Geography. Knowledge of the content of these standards has been identified as an integral part of the education of all children, with language arts developed across the curriculum. The incorporation of the activities in this Guide will help ensure that your students are given the skills and knowledge they need to pursue life's goals and to participate fully as informed, productive members of society.

#### NOTE:

Teachers also need to know that as of July 2002, the National Standards do not acknowledge the accomplishments of this ancient North American civilization. This omission in our history will be amended when teachers, students, and their communities begin to explore such material as presented in this film and Guide and request that the achievements of the First Americans be more fully included in textbooks and supplementary materials.

## Summary of THE MYSTERY OF CHACO CANYON



### *Key Idea*

The people of Chaco Canyon demonstrated extraordinary observations of astronomical phenomena, which they incorporated into their buildings in accordance with their spiritual beliefs.

The Chacoan people expressed their knowledge of an order in the universe by designing, orienting, and locating their major buildings in relationship to the Sun and the Moon. Building the monumental structures at Chaco Canyon required advanced architectural and design skills, scientific observation, and social cohesion. An American civilization flourished here that parallels the Aztec, Mayan, and Incan cultures of the ancient Americas.



### *Key Idea*

The Chacoan people are considered to be the ancestors of the modern Pueblo Indian people.

They have been known as “Anasazi” although this is an anglicized term with Navajo roots meaning “ancient ones” or “ancient enemy.” We do not know what word they used for themselves. The term currently used by researchers is “ancestral Pueblo people,” or “Chacoan people.” The Zuni use the term, “Capaquesliwa,” which means, “the people who live in the round house;” and the Hopi call them, “Hisatsinom,” which translates as, “people of the remote past.”



### *Key Idea*

Chaco Canyon is located in a remote, high-desert area of New Mexico — to us today, an unlikely site for a major center.

Chaco Canyon is in the northwestern corner of New Mexico, in the Four Corners region of the United States. See **Fig 1**, page 5. The closest modern towns are Gallup to the southwest, and Farmington to the northwest. The canyon is a desolate and beautiful landform surrounded by miles of high-desert country. Prominent in the center of the canyon is the towering Fajada Butte. The Chacoan people chose the canyon despite its harsh conditions of extremes of temperature, short growing seasons, and marginal rainfall. They imported most of their food and pottery, as well as enormous quantities of raw turquoise, which they crafted into fine objects. The 220,000 timbers which were used in the buildings were carried from distant mountains across 50 to 70 miles of desert.



### *Key Idea*

The buildings at Chaco Canyon are unlike anything the ancestral Pueblo people had undertaken before.

The building at Chaco Canyon took place between 850 A.D. and 1130 A.D. The massive walls were built of sandstone quarried from the top of canyon

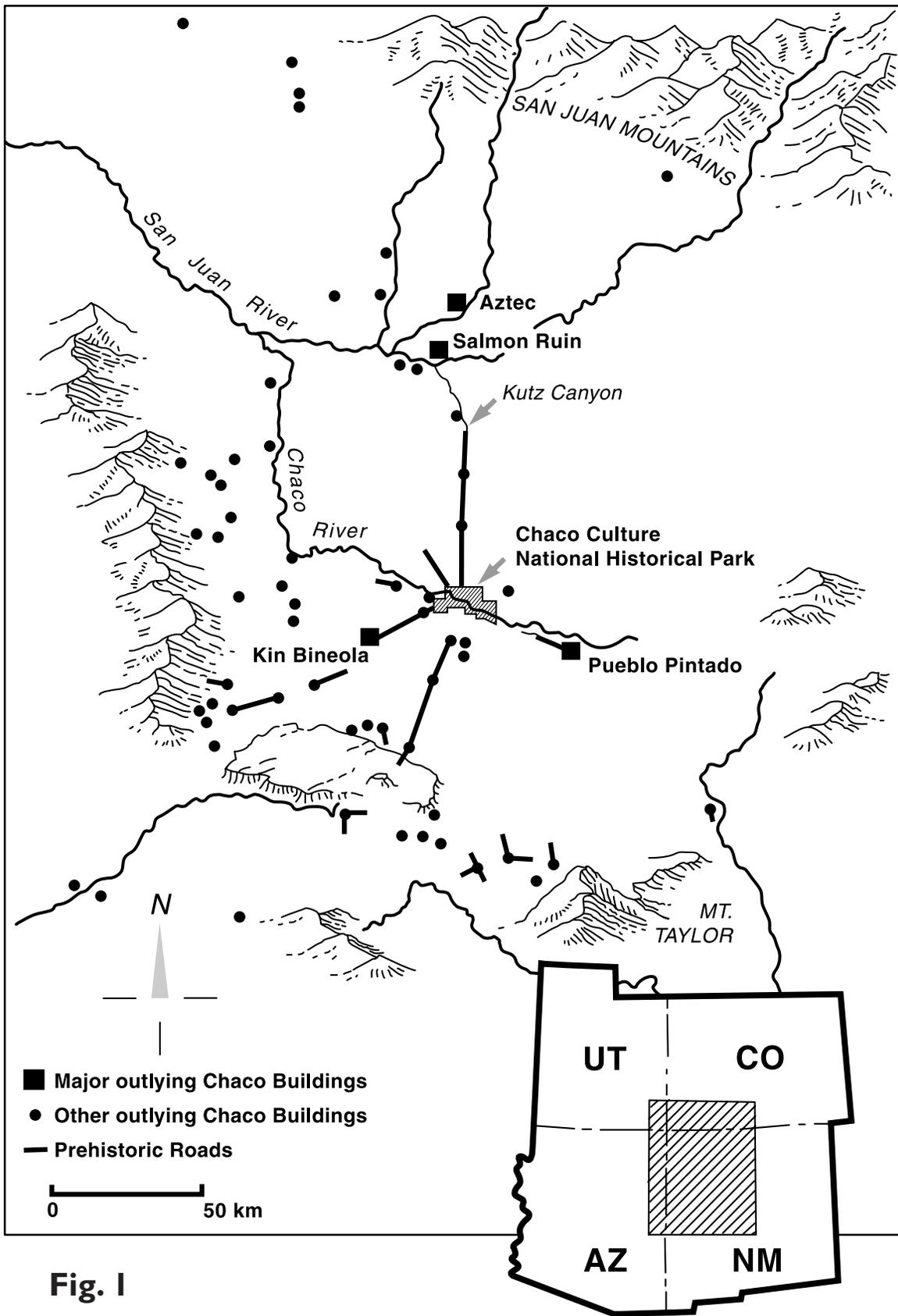


Fig. 1

mesas. Exquisite masonry techniques were used, unique for their time. In some cases tiny, flat pieces of stone were used to build up enormous walls. Fourteen major buildings were eventually constructed in and near Chaco Canyon. Most of the Chacoan buildings were four-stories high. Their roof construction used 220,000 timbers carried from the distant mountains. Some buildings, such as Pueblo Bonito, were built over a 250-year period while others were built in periods as short as five years. The buildings have features in common such as large plazas, fine masonry, and numerous kivas. Most buildings are rectangular; two are curved.



### **Key Idea**

**The Chacoan constructions are, in some ways, like those in ancient Mexico but they also are unique.**

How and why did the people of Chaco Canyon go from building small villages of utilitarian dwellings, called pit houses, to constructing immense multi-storied buildings that took generations to complete? Why did the change take place so rapidly? One theory holds that outsiders, possibly powerful people from Mesoamerica to the south, influenced the people originally living in the area. There is evidence of trade occurring between the Chacoan people and the people of ancient Mexico and Central America. Exotic shells, copper bells, and parrot feathers were found at Chaco Canyon. Some of the architectural features, such as T-shaped doorways, the broad plazas, and the alignments to astronomical events also are found in Mexico and Central America. But the Chacoan buildings have unique features such as their shapes, the inclusion of kivas, and multi-storied construction with numerous rooms.



### **Key Idea**

**The buildings were sited in a landscape surrounded by sacred landforms that still have deep spiritual importance for Pueblo people.**

Though there are different interpretations, the concept of “the center place” is very important in the traditions of contemporary Pueblo tribes. In the film, Laguna Pueblo member, Paul Pino, tells of the search for the center place, the true home of the tribe or clan. Chaco Canyon may have been one such place for a given time.



### **Key Idea**

**Archaeologists and researchers originally interpreted Chaco Canyon as a trade center, but that view recently changed.**

Chaco Canyon was thought to be a political and trade center because of its unlikely location, the immense size of the buildings, number of rooms, and the network of roads connecting to outlying sites. Recently this view changed, following the research of Anna Sofaer and the Solstice Project, and of Richard Friedman, Michael Marshall and John Stein, who appear in the film, and many others. Their work suggests that Chaco Canyon was a cere-

monial center. Pueblo Indian people of today also view Chaco Canyon as a center of spirituality.



**Key Idea**

**Chaco was a ceremonial center.**

Current thought holds that great numbers of people came into the canyon periodically, to join in ceremonies and the construction of buildings, and then returned to homes located elsewhere. Excavations of large mounds have revealed layers of fine pottery, intentionally shattered in ritual offerings. The ceremonies probably took place at important ceremonial times over many years. The great number and size of the kivas at Chaco Canyon suggest that thousands of worshippers could gather at one time.



**Key Idea**

**Few people ever lived in the Chacoan buildings.**

Many of the rooms were too enclosed to have had fires, which would have been essential for cooking and warmth. Very few hearths have been found in the large buildings. Less than 300 burials have been found in the canyon. There are rooms that are inaccessible and walled in, appearing to function as building blocks for the massive exterior forms. Richard Friedman's work with infrared photography, depicted in the film, shows surprisingly low levels of charcoal in and around the buildings, which is a measure of habitation.

The film's narrator poses an important and exciting question, "What could have been their [the buildings] purpose here in this barren canyon? The Chacoans had no written language and therefore no written record was left behind to offer clues." Finally, the clues began to reveal themselves to Anna Sofaer and the Solstice Project.



**Key Idea**

**Although the Chacoan people left no written record, there is a language in their architecture.**

The film shows that new insights into the Chacoan culture come from understanding the buildings' connection to the rhythms of the Sun and the Moon as well as the astronomical use of petroglyphs.



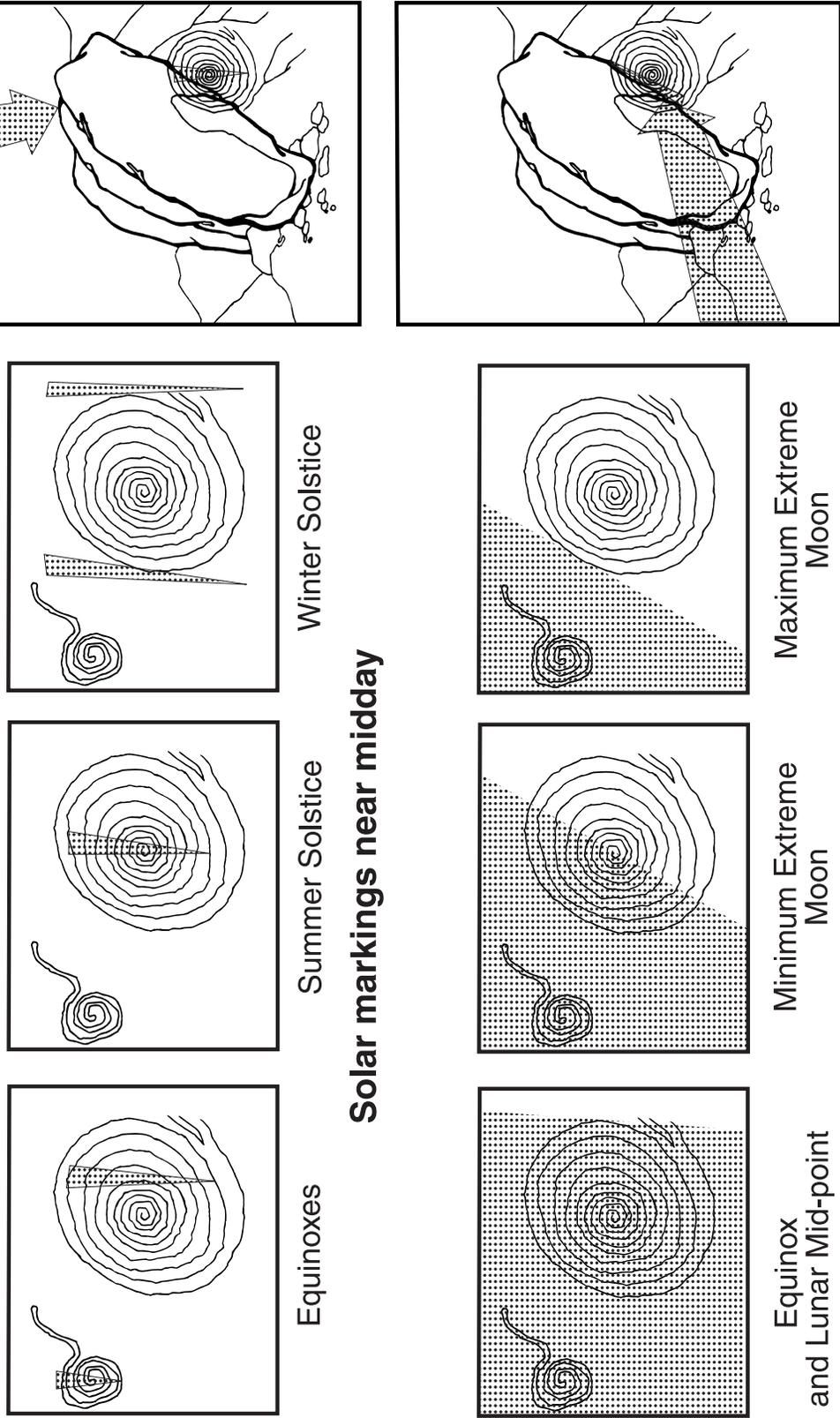
**Key Idea**

**The Sun Dagger site marks the yearly cycle of the Sun and the 18.6-year cycle of the Moon.**

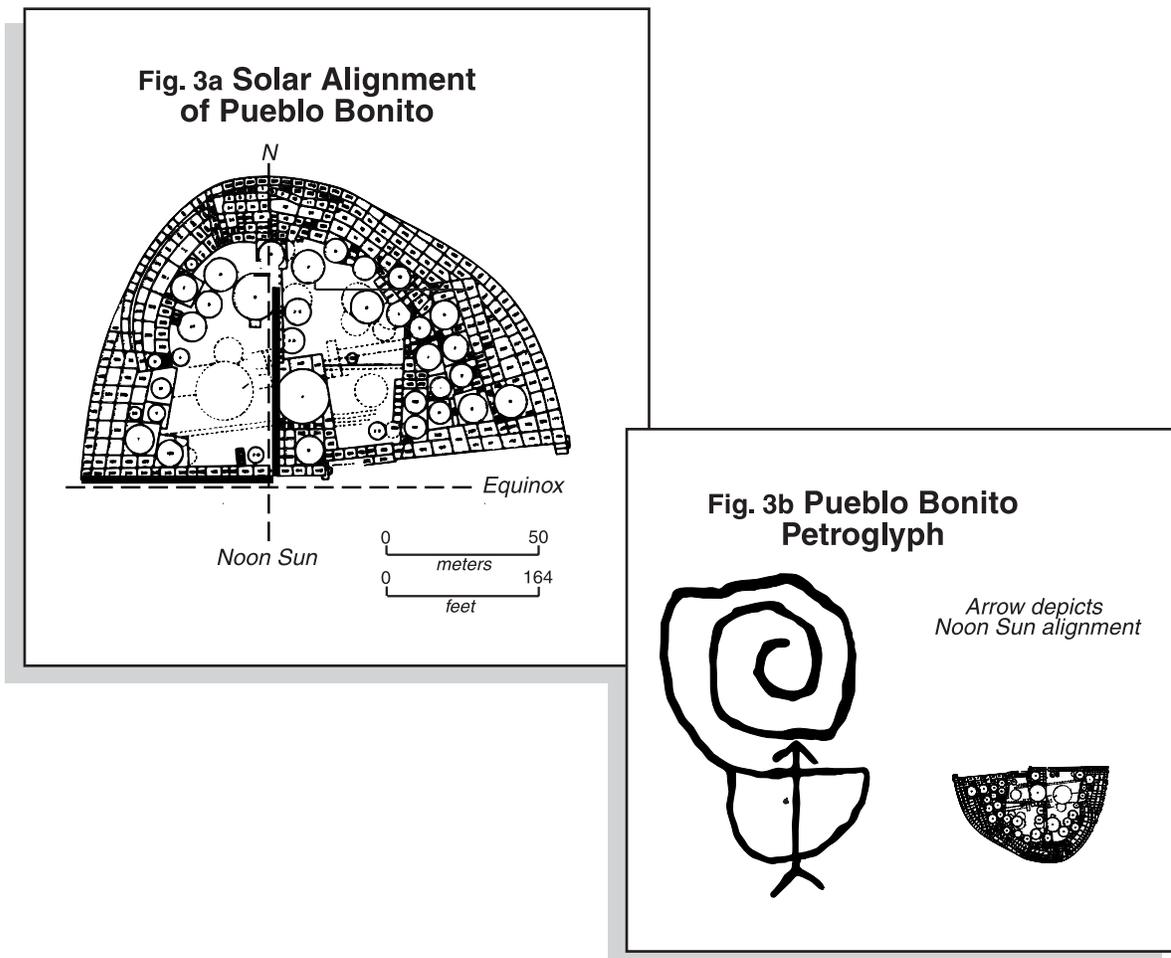
The clues came in 1977 with Anna Sofaer's discovery of the Sun Dagger site, which revealed the extensive astronomical observations of the Chacoan people. Carefully placed giant slabs of sandstone channel sunlight onto two spiral rock carvings. As the Sun's position, relative to the Earth, changes through the year, the dagger of light also moves. It rests in the center of the

**Fig. 2 The Sun Dagger site**

large spiral at summer solstice near noon and then brackets the spirals perimeter with two daggers of light at winter solstice. At equinox, a smaller adjacent spiral also has a dagger of light piercing it. See Fig. 2.



Anna's next clue was a petroglyph near the Sun Dagger site, which shows the design of one of the major Chacoan buildings, Pueblo Bonito, in relationship to the Sun.



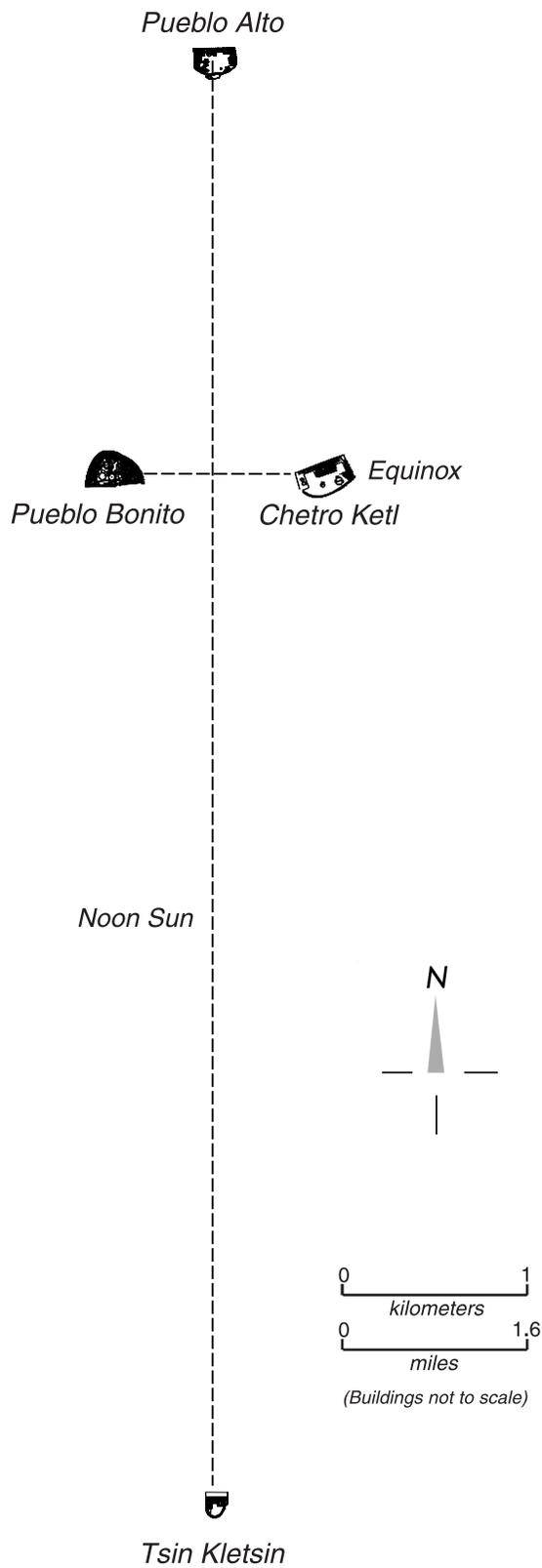
### Key Idea

The Chacoan people aligned massive buildings to key points in the Sun's cycle and they organized their central complex to the Sun.

In the film, Anna Sofaer and Phillip Tuwaletsiwa confirm that Pueblo Bonito, the immense half-circular building that seems to be the center of the Chacoan complex, features two prominent walls that form an exact north-south and east-west axis (cardinal alignment). The Sun's rise and set on the equinox occurs in line with the east-west wall, and noon of every day can be experienced at the moment the north-south mid-wall casts no shadow. In this building, the midpoints of the day and of the year are commemorated. See **Fig. 3a and 3b**, page 9.

This solar alignment is in three other centrally located buildings: Pueblo Alto, Hungo Pavi, and Tsin Kletsin. Pueblo Bonito and Chetro Ketl, and Pueblo Alto and Tsin Kletsin also are aligned to each other along these same lines, forming a solar pattern among these central buildings. See **Fig. 4**, page 10.

**Fig. 4 Solar Interbuilding Alignments**



(NOTE: THE FIRST HALF OF THE FILM ENDS HERE WITH ANNA SOFAER AND PHILLIP TUWALETSTIWA QUESTIONING IF THE BUILDINGS AT CHACO CANYON THAT ARE NOT ALIGNED WITH THE SUN MIGHT HAVE SOME OTHER ASTRONOMICAL SIGNIFICANCE.)



### Key Idea

The Chacoan people also marked key points in the long cycle of the Moon with shadow patterns at the Sun Dagger site.

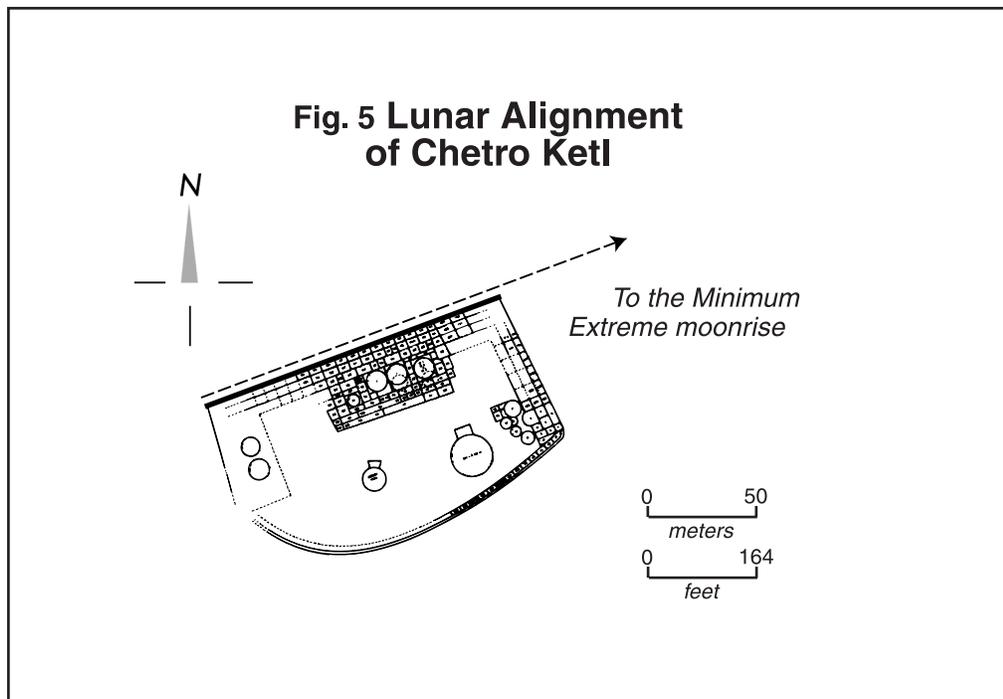
The Sun Dagger site also marks the long cycle of the Moon. The rising mid-winter full Moon lights the slabs, casting a shadow on the spiral. Over a period of years the mid-winter full moonrise shifts on the horizon, like the Sun. It moves to the north for 9.3 years, and then to the south to complete an 18.6-year cycle. The far points in this cycle are called the minimum and maximum extremes (also the minor and major standstills). This causes the shadow to move from the center of the spiral to the outer edge over 9.3 years, and then back the other way. There is a correlation of the turns of the spiral to the number of years in the cycle. See **Fig. 2**, page 8.



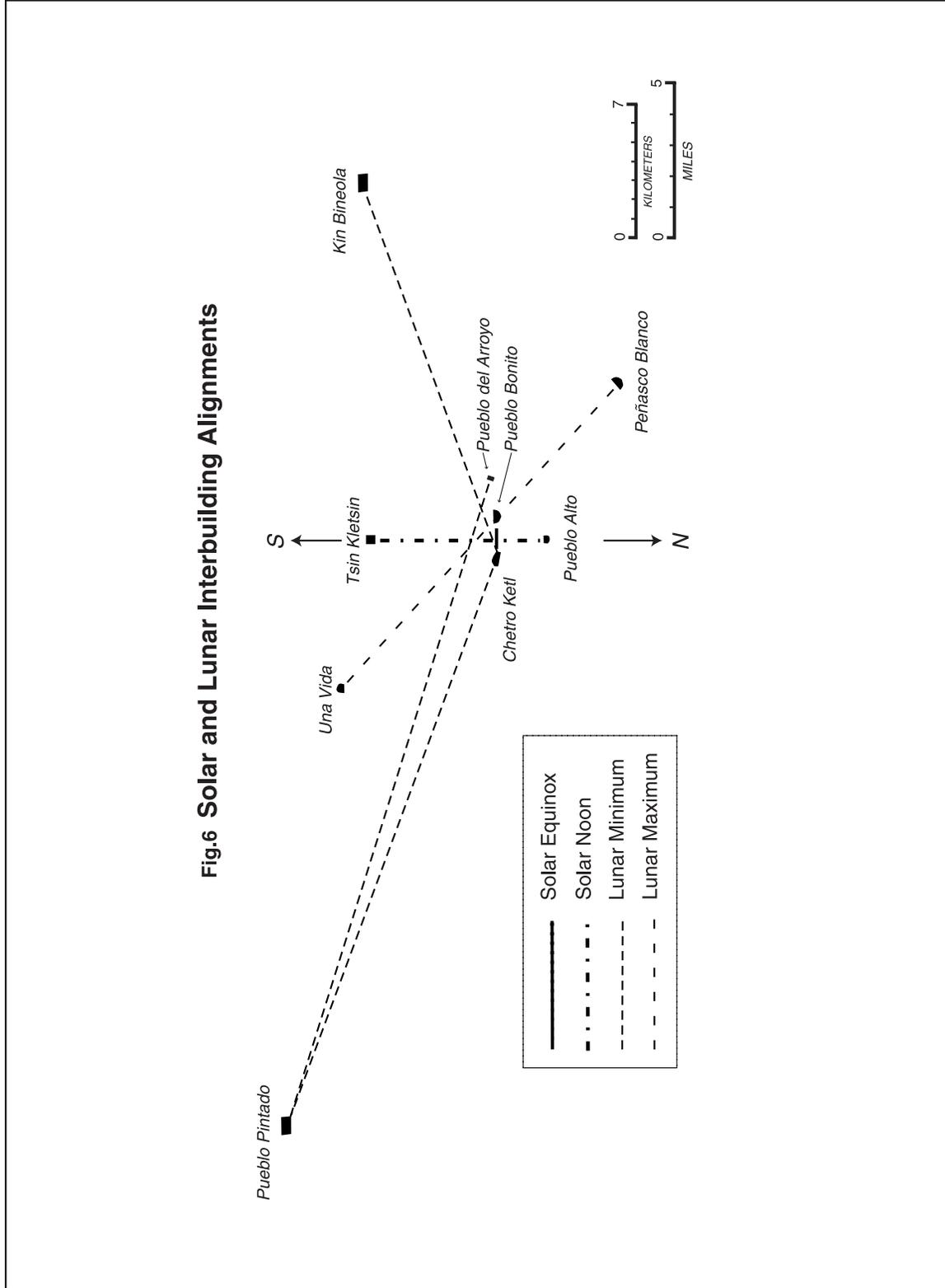
### Key Idea

Chacoan buildings contain alignments to the long lunar cycle, previously not established in the study of ancient architecture.

The Solstice Project found that seven buildings (Chetro Ketl, Pueblo Pintado, Salmon Ruin, Pueblo Del Arroyo, Kin Kletso, Una Vida, and Peñasco Blanco) are aligned to the rising and setting positions of the minimum or maximum extremes of the Moon, the same points that are marked on the Sun Dagger spiral. For one example, see **Fig. 5**, page 11.



The Chacoan lunar buildings, like the solar buildings, align to other buildings on lines to the Moon. Many are out of sight of each other. The Chacoan people organized their buildings in a celestial pattern that united the Sun and the Moon across a vast area. A regional, astronomical pattern of this complexity has not been found in any other ancient architectural complex in the world. See **Fig. 6**.





### **Key Idea**

**The Chacoan people developed and expressed their knowledge of the cycles of the Sun and the Moon beyond what they would need for utilitarian purposes.**

For many Native American peoples, the Sun, the Moon, the planets, and the stars still provide a calendar with which to plan planting, harvesting, hunting, and preparation for winter. These observations of natural cycles also are expressed in people's spiritual traditions and ceremonies. The Sun Dagger markings of light on spirals, at the remote high site on Fajada Butte, appear to be a symbolic, rather than a practical expression. The Chacoan people's knowledge of the long lunar cycle also would seem to have little practical use. In fact it appears that the Chacoan people's painstaking alignment of twelve of their largest buildings to the solar and lunar cycles over generations had the purpose of developing a large-scale cosmological expression.



### **Key Idea**

**The buildings at Chaco Canyon express the cosmology of its people as though to be held in the mind's eye.**

The major Chacoan buildings align to each other along lines to key points in the solar and lunar cycles, forming a vast celestial pattern. Many of these alignments are between buildings that are not in sight of each other. The pattern could never have been seen as a whole. It is as though the Chacoan buildings and their interbuilding alignments form a harmonic unity that could be experienced only in the mind's eye. See **Fig. 6**, page 12.

Although kivas, the ceremonial chambers, also align to events in astronomical cycles, these moments would not have been seen from within the dark, covered rooms; but, they too must have been present in the minds of the people worshipping there.



### **Key Idea**

**The Chacoan people built hundreds of miles of roads, possibly for spiritual reasons.**

The Chacoan roads are thirty-feet wide, remarkably straight, and climb directly over obstacles in the landscape rather than going around them. These were not simple trails formed by foot traffic to outlying villages. Sometimes the roads run parallel, two and even four abreast. Although some roads connect buildings, many seem to have a purpose other than guiding travel. Recent studies show that the roads form directional corridors important to the cosmography of the Chacoan people. The longest of all the known routes, the Great North Road, leads out of the central canyon behind Pueblo Bonito and Chetro Ketl, and heads directly north 35 miles, ending at the deep badlands of Kutz Canyon. The purpose of this road seems to have been to connect the north to the south, and the central Chacoan complex to a deep canyon in the north.



### **Key Idea**

**Research into Chacoan culture benefits from insights offered by the descendant people.**

Features such as the Great North Road can be extremely puzzling to researchers applying utilitarian models from the western scientific tradition. But roads have other meanings to Pueblo people. The importance of the four cardinal directions, as well as the directions above and below, is alive in the traditional practices of today. For many Pueblo people, the direction north leads back to the Creator. In the film, Paul Pino of Laguna Pueblo and Connie Garcia of Acoma Pueblo suggest that the Great North Road of Chaco Canyon may have expressed this concept.



### **Key Idea**

**The reasons for the closure of Chaco remain unrevealed.**

At 1130 A.D., after nearly 300 years of flourishing, all construction ceased at Chaco. The magnificent buildings were carefully sealed and the kiva roofs were burned. In the film, Paul Pino suggests that the closure of Chaco was slow and deliberate. There is no evidence of warfare or forced abandonment. Tree-ring dating shows that the region experienced frequent drought in the final years and this may have been a factor in the closure of Chaco. Breakdown of social order, including violent disruptions, also could have played a role.



### **Key Idea**

**Migrations are important in Pueblo history.**

Migration is a recurrent theme throughout the film as well as in the histories told by contemporary Pueblo people. As Paul Pino of Laguna Pueblo states in the opening of the film, “The Creator told the people that there are certain places that [we] are to live. The migrations began over probably a period of centuries, always looking for that place that was to be the center of our world.” At one time, Chaco Canyon may have been one of those places, but at the end of the film it is speculated that the misuse of power in Chaco Canyon, “may have been one of the reasons why the migrations were set to start again.” Today, each Pueblo clan still passes on its migration stories, informing clan members of how they came to where they now live. Exactly who are the direct descendents of the Chacoan people is not clear to non-Pueblo people; however, the influence of these ancient ones continues to be felt throughout the Pueblo world and beyond.



### **Key Idea**

**Pueblo people consider Chaco Canyon a sacred place and a place where great power and knowledge were accumulated.**

Descendant people speak of Chaco Canyon with reverence. Great knowledge was developed and expressed there. Some descendants also see it as a society that fell out of balance with the world around it, perhaps with abuses of

power and knowledge. In the film, Paul Pino of Laguna Pueblo states, “Here at Chaco there were very powerful people who had a lot of spiritual power. And these people probably used their power in ways that caused things to change. And that may have been one of the reasons the migrations were set to start again.” Petuuche Gilbert of Acoma Pueblo says, “I think that they were so in tune with the natural forces that they were able to control these forces and sometimes, it has been said, that this could be abused by people and that perhaps there were decisions made in the past not to continue this accumulation of knowledge and control of the natural forces.” He concludes that the Chacoan buildings should be left alone, to return to nature.

# UNIT 1

## UNIT I: EXPLORING CHACOAN COSMOLOGY AND CULTURE

**Subject:** Social Studies

**Grade Levels:** 9-12 (easily adaptable for lower grades)

**Length of Unit:** 2-5 classes

### **Learning Objectives:**

Students will gain an understanding of:

- The astronomical and architectural achievements of early Native Americans;
- The importance of ceremony at Chaco Canyon;
- The importance of landforms and place in the belief system of the Chacoan people;
- The connection of Chaco Canyon with the cultures of Mesoamerica; The relationship between the Chacoan people and contemporary Pueblo people; and
- The importance of sky watching and astronomical cycles to ancient cultures;
- How the concept of time differs among cultures;
- The evolution of scientific knowledge over time.

### **Language Objectives:**

Students will be able to:

- Listen for specific information;
- Use a specialized vocabulary;
- Find information in reference materials;
- Present oral reports; and
- Contribute to and write committee reports.

### **Viewing the film in Two Parts**

In order to accommodate classroom time, the screening of THE MYSTERY OF CHACO CANYON can be divided into two class periods, with time for questions and analysis. Part One of the film ends at 30:58 (elapsed time,) and is clearly marked in the classroom version with a title saying “End of Part One.” It ends with the scene in which Anna Sofaer and Phillip Tuwaletsiwa conclude that many buildings are aligned to the Sun and they question whether other buildings also are part of the astronomical pattern. After five seconds of black, Part Two begins with the section about lunar alignments at Chaco.

### **Procedure for viewing Part One of THE MYSTERY OF CHACO CANYON: Before viewing the film**

1. Initiate a discussion with your students about the people who lived, and whose descendants continue to live, in the American Southwest before Europeans arrived.

- What do you think life was like for them?
- What kind of dwellings did they build?
- What was their culture like?

- How do you think they kept time and observed the seasons?
- What do you know of temperatures, frosts and growing seasons as they relate to the Sun?

Ask the students if they have ever heard of the Anasazi (more properly known as the Chacoan people or ancestral Pueblo people), the civilization that erected dozens of immense stone buildings and elaborate roads in the arid lands of the Southwest over a thousand years ago. Introduce the idea of a mystery to be solved. Students will see massive empty buildings in a remote desert canyon that have baffled archaeologist for decades. In the film, students gradually will follow clues that show the buildings have an astronomical purpose.

2. Locate Chacoan culture (often called Anasazi) on a time line of ancient American cultures. (See Cordell, Linda **Archaeology of the Southwest Academic Press**, 1997 or Townsend, Richard F. (ed.) **The Ancient Americans: Art from Sacred Landscapes** Munich: Prestel Verlag, 1992.) It would be interesting also to compare Chaco Canyon's development with European history at this time. Have students create their own time line. The website, <http://www.sarissa.org> has regional and world-wide time lines. Ask students to look at time lines from the Americas, Europe, Asia, and Africa. The website [http://www.teach-nology.com/web\\_tools/materials/timelines/](http://www.teach-nology.com/web_tools/materials/timelines/) lets students to create either vertical or horizontal time lines.



### **Key Idea**

The dynamic growth of Chacoan culture was fast and surprising. In the previous period, the Basketmaker people built modest dwellings known as pit houses and they lived in small gatherings of families. Their structures are unlike the immense stone buildings of the Chacoan people. It is difficult to know why this culture initiated the great building projects of Chaco Canyon. Some archaeologists speculate that Mesoamerican people were present in the development of Chaco Canyon.

3. Locate Chaco Canyon on a map. (See **Fig. 1**, page 5.) It is in the northwestern corner of New Mexico in the Four Corners region of the United States. The closest towns are Gallup, to the southwest, and Farmington, to the northwest. Ask students to locate the contemporary Pueblo communities of Picuris, San Juan, Pojoaque, Santa Clara, San Ildefonso, Nambe, Tesuque, Cochiti, Santo Domingo, San Felipe, Jemez, Zia, Santa Ana, Sandia, Isleta, Laguna, Acoma, Zuni, and Hopi. (Today's Pueblos can be located on a map of New Mexico and Arizona.)

4. Discuss the climate and terrain.

Chaco Canyon is in high-desert country, windy, arid and barren, with extremes of temperature from well below 0-degrees Fahrenheit in the winter and to 110-degrees Fahrenheit in the summer. In a 24-hour period the temperature can change 60-degrees Fahrenheit. The average annual rainfall is only eight inches. Growing crops at Chaco Canyon would have been a

challenge. One of the enduring questions about Chaco Canyon is, why did people choose this place for the construction of such elaborate buildings?

#### 5. Vocabulary preparation

There are several words you may want to discuss with the students before viewing the film. We suggest choosing 10-12 from among the following: A.D., Anasazi, archaeoastronomy, archaeology, badlands, cardinal, codices, cosmology, equinox, hearth, horizon, kiva, latitude, longitude, Mesoamerica, midden, obsessive, organic, petroglyph, solstice, ceremonial.

#### **During or following the screening of Part One**

Ask students to take notes during or following the screening regarding:

- Their own hypotheses about the purposes of the Chacoan buildings as they see the material presented in the film;
- The reasons people may have chosen Chaco Canyon for the construction of such elaborate buildings; and
- The information presented in the film about the seasonal movement of the Sun.



#### **View THE MYSTERY OF CHACO CANYON, Part One**

Zero the timer on the VCR to time the first 30-minute portion.

#### **After viewing Part One**

##### 1. Review:

- Describe the two solstices and the equinoxes and how they are marked on Fajada Butte. How are the equinoxes also commemorated in the architecture?
- When and where were the Chacoan buildings constructed?
- Why has it been especially hard to determine the intent of the Chacoan people in constructing their buildings?
- How did researchers determine that fewer people lived in Chaco Canyon than originally thought and that many thousands came to Chaco Canyon for ceremonial activity?
- What does infrared photography reveal at Chaco Canyon?
- Why might the Chacoan people have built rooms that were closed off from the outside?
- What is a kiva?

##### 2. Lead a discussion covering one or more of the following suggested topics:

- What are student hypotheses about the purposes of the Chacoan buildings and the choice of Chaco Canyon for a center?
- What did the Pueblo people speaking in the film mean about the knowledge and the power of the ancient Pueblo people? What did they mean by knowledge and power?
- What do you think of the explanation by Phillip Tuwaletstiwa that the Chacoan people sought to order their lives through the ordering of their buildings to the Sun's cycle?
- List reasons why it would be important for people to understand the movements of the Sun? Why would equinox and solstice be of such importance?

- Why and how do you think the Chacoan people maintained their building effort over so many years?
- If people did not live at Chaco Canyon, where did they live? There are hundreds of known outlying communities that were contemporaneous with Chaco Canyon, and more such sites continue to be documented. For a database and map of these sites visit: <http://sipapu.gsu.edu/html/outliers.html>.
- How do the buildings of Chaco Canyon compare with other monumental architecture such as Egyptian pyramids, Machu Picchu, or European cathedrals? Can you compare the dates of these structures with the timing of Chaco's architecture? Discuss the differences in their purposes. For regional and world-wide time lines, see: <http://www.sarissa.org>.

Inform students that they will view the second part of the film tomorrow, which focuses on the movement of the Moon. For homework, have students ask their parents or grandparents for any stories they know about the Moon; or, have them look in books of poetry, traditional stories, mythology, or children's literature to find images and stories of the Moon (See Resources section, Traditional Literature). You also could have students begin to work on one of the many Enrichment projects found in Unit III.

### **Procedure for viewing Part Two of THE MYSTERY OF CHACO CANYON Before viewing Part Two**

1. Review key points from the first half of the film and have students report on any stories about the Moon they may have heard or found.
  - Anna Sofaer's discovery of the Sun Dagger;
  - The Solstice Project's study and discovery of building alignments to the Sun's cycle;
  - The hypothesis that the buildings are no longer viewed as dwellings; and that Chaco Canyon was the center for large-scale ceremonial pilgrimages;
  - The understanding that the Chacoan people were an oral culture;
  - The view of descendants of ancient Pueblo people that Chaco Canyon is a sacred place;
  - The theme that powerful people with a lot of knowledge were in Chaco Canyon;
  - The question by Anna Sofaer and Phillip Tuwaletsiwa, if the buildings at Chaco that are not aligned to the Sun might have some other astronomical significance.

#### 2. Vocabulary preparation:

There are several words you may want to discuss with the students before viewing the film. We suggest that you choose 10-12 from the following: vivid, perpendicular, intuition, symmetry, esthetic, pragmatic, enigmatic, drought, famine, butte, meridian, lunar, solar, geodesist.

### **During or following the screening of Part Two**

Ask students to take notes during or following the screening regarding:

- The 18.6-year cycle of the Moon and how the Chacoan people aligned their buildings to the Moon's extreme positions;

- The purposes the Chacoan people had in making these complex alignments and the work required to accomplish the astronomical regional pattern; and
- Any questions they have for discussion.



**View THE MYSTERY OF CHACO CANYON, Part Two.**

Begin the film at 30:58 (elapsed time) at the section on the Moon at Chaco Canyon.

**After viewing Part Two**

1. Review:

- What evidence is there that Chacoan buildings were used primarily for ceremonial purposes?
- Why are the roads not seen as purely functional?
- What are some of the reasons why the Chacoan people may have left?
- How do the viewpoints of the different people interviewed in the film help bring new understanding to Chaco Canyon?

2. Lead a discussion covering one or more of the following suggested topics:

- Why and how do you think the Chacoan people tracked the movements of the Moon?
- How do you think the Chacoan people aligned their great buildings to the Moon as well as to each other over long distances to the Moon?
- In the film, Petuuche Gilbert wonders if there was a decision by the ancestors not to continue their accumulation of knowledge and control of the Chacoan people. Can you think of ways that this idea of the danger and responsibility of knowledge is expressed in literature, history, or culture?
- How might the Chacoan people's sense of time have differed from modern industrialized cultures of today? What would it have been like to be a part of a culture that undertook projects over hundreds of years, guided by an oral tradition, carried over generations?
- What might be some of the values to a culture of an oral rather than written tradition? Do you believe, as Anna Sofaer states in the film, that there is a language in the architecture and astronomical light markings?
- In today's cities and towns, people are less likely to live with awareness of the natural rhythms and cycles of the Earth and the sky. What have we lost or gained because of this?
- What questions about Chaco Canyon were answered and what ones were left unanswered in the film?
- In Pueblo society today, and most likely in the Chacoan culture, religion and astronomy are intertwined. In contrast, western science has, in general, sought to maintain a separation between the scientific view and the religious perspective. Compare the cultural differences.
- What are some of the reasons Chaco Canyon may have been misinterpreted by those studying it in the past?

**Further discussion topics: choose one or more of the following:**

- The amount of time devoted to the construction of buildings at Chaco is almost inconceivable today. Select a building, Pueblo Bonito for example, and compare the time span of its construction to the span of history elsewhere during that period. It is estimated that Pueblo Bonito was built between 870 A.D. and 1120 A.D., 250 years. Create a time line to compare Chacoan development with other parts of the world during these years. Or, using 250 years as a measure, compare to U.S. history from 1750 to 2000.
- Study relationships between the Chacoan and contemporaneous Mesoamerican cultures. Look at similarities and differences in the architecture and in the recording of astronomical cycles. Look at evidence of trade with Mesoamerica in the artifacts found at Chaco Canyon.
- Explore the commemoration of the Sun around the world, for example in Japan, Egypt, Mexico, and megalithic sites in Europe. Study the oldest known calendrical devices.
- Explore the culture that lived in and around Chaco Canyon before the great building period. They are known as the Basketmaker people. What did their dwellings look like? How did they live? Develop a hypothesis stating whether they were or were not the people who built the large buildings at Chaco Canyon and explain why.

**Student Activities**

After completing the viewing and discussion of THE MYSTERY OF CHACO CANYON, student interest will be heightened. Provide them with the opportunity for further exploration by using the Social Studies Activities and a choice of one or more of the Enrichment projects presented in Unit III.

**Assessment Suggestions**

In order to assess student understanding of the material covered in the Lesson Plans and the degree to which the learning and language objectives have been met, a combination of any or all of the following may be used to assess student understanding of the material covered and the degree to which language and learning objectives have been met.

- Social Studies Review Questions;
- Participation in classroom discussion;
- Independent student research and enrichment activities;
- Cooperation and participation in group projects; and
- Writing assignments.



## SOCIAL STUDIES REVIEW QUESTIONS

1. How is the Sun commemorated in the buildings' alignments and on Fajada Butte?
2. Describe the Chacoan buildings. When were they built and with what materials? What did they look like?
3. Name five reasons why researchers now believe that the buildings were not lived in like large pueblos.
4. What is a kiva? Describe its shape and probable use in Chaco Canyon. What does the great number of kivas in Chaco Canyon tell us about the activity there?
5. Describe the alignments of the Chacoan buildings to the Sun and the Moon. How does the astronomy used by the Chacoan people go beyond what we would consider practical?
6. Describe what you know about how Chaco was closed and what happened to the people.
7. What is your hypothesis about Chacoan society and its values? Can you contrast this with your own culture? Provide supporting evidence for your discussion.

# A

## SOCIAL STUDIES REVIEW ANSWERS

1. The Sun is commemorated in the alignments of five buildings. On Fajada Butte, the solstices and equinoxes are marked in shadow and light patterns on numerous petroglyphs including the Sun Dagger spirals, the double spiral, and the snake.
2. The Chacoan buildings were constructed between 850 A.D. and 1130 A.D. The huge walls were built of sandstone quarried from the top of the canyon mesas. Most of the buildings were four-stories high. Roof construction used 20,000 timbers carried from the mountains 50 to 70 miles away. Some of the buildings, such as Pueblo Bonito, were built over a 250-year period. The buildings have features in common such as large plazas, fine masonry, and numerous kivas. Most buildings are rectangular; two are curved.
3. Many of the rooms are too enclosed to have had fires, which would have been essential for cooking and warmth. Very few hearths, and less than 300 burials, have been found in the canyon. There are rooms that are inaccessible and walled in, appearing to function as building blocks for the massive exterior form. Richard Friedman's work with infrared photography shows surprisingly low levels of charcoal in and around the buildings, a measure of habitation.
4. A kiva is a round chamber usually at least partially underground. Kivas are traditionally ceremonial rooms of the Pueblo people. The numerous great kivas in Chaco Canyon, including 15 great kivas, were probably used for large ceremonial gatherings.
5. The Chacoan people aligned twelve of their major buildings to the Sun and the Moon; and they created a regional pattern of these buildings aligned to each other on lines to the Sun and the Moon. The Chacoan people's commemoration of the cycles of the Sun and the Moon goes far beyond what would be necessary for utilitarian purposes. The Chacoan people's painstaking alignment of their buildings to astronomy suggests that Chaco Canyon was constructed as a center of cosmology.
6. The Great Chacoan Era ended around 1130 A.D. The buildings were carefully sealed and the kiva roofs were burned. At the end of the film, Paul Pino suggests that the closure was slow and deliberate. There is no evidence of warfare or forced abandonment. The region experienced frequent drought in the final years. Breakdown of social order also could have played a role.

## SOCIAL STUDIES ACTIVITY 1

### Mock Committee Meeting on the Future of a Chacoan Site

Chacoan sites and many of the outlying Chacoan sites are under the jurisdiction of the National Park Service (NPS). In determining maintenance and access to the sites, the NPS continually weighs the wishes of scholars, the general public, and Native American people. For this reason, the NPS convenes consultation committees of members of the southwestern tribes affiliated with Chaco Canyon, archaeologists, other scholars, and the general public. In this activity, we create a hypothetical situation concerning the future of a Chacoan building to be addressed by a committee of students representing various viewpoints. The focus of the discussion is the future of the building called Hungo Pavi. (Though this is an actual Chacoan building, the situation conceived for this activity is entirely fictitious.)

#### Learning Objectives:

Students will gain an understanding of:

- Federal policy and regulations regarding Native American sites;
- The stewardship of public lands and sites;
- Native American conflicts with the federal government;
- The connection that Native peoples have with Chaco Canyon and other sites;
- Differences between tribes such as the Pueblo and Navajo people; and
- How to publicly advocate and discuss sensitive cultural issues.

#### Language Objectives:

Students will be able to:

- Listen for specific information;
- Find information from a variety of sources;
- Answer questions and/or ask questions for clarification;
- Participate in group and class discussions;
- Present oral reports; and
- Write formal reports.

**Group Work:** Students will be chosen or may choose to represent various viewpoints in a discussion.

**Time:** 3 class periods with research homework.

#### First Class Period

1. Introduce the building, Hungo Pavi.

Provide a basic description for students to get a feel for the building. They will continue studying the building on their own.

- Hungo Pavi is a medium-size building in Chaco Canyon. Researchers believe there were about 73 ground-floor rooms, and that at one time it may have reached four-stories high. It is located in the central canyon to the east of Chetro Ketl. It was built between 950 A.D. and 1050 A.D.
- For more on Hungo Pavi, you can go to:  
<http://www.nps.gov/chcu/home.htm>.

- Use images to illustrate the building. Some are available online at: <http://www.colorado.edu/Conferences/chaco/tour/pavi.htm>.
2. Explain to students that because of the very sensitive nature of Native American sacred sites, the NPS sometimes convenes meetings of an advisory board to help reach a decision. The students will participate in a simulation of such a meeting.
  3. Present the case to be addressed by the committee:

National Park Service employees have determined that one of the longest walls at Hungo Pavi is in danger of collapsing. It is potentially dangerous to people walking around the site. The NPS must decide whether to:

- Repair the wall using steel braces;
- Backfill dirt which would stabilize the wall but would cover the rooms now visible;
- Excavate the rooms prior to backfilling; or
- Close the site entirely to visitors and let the building naturally return to the Earth.

Teachers are encouraged to add detail to this description and personalize it for your class. Although it is a fictitious situation, there is documentation available online about similar issues of preservation. You also may wish to give students the assignment of coming up with a believable scenario. Before you begin, all students should receive a print out of what the issue is that the committee meeting will address.

4. Divide the class into groups to represent the various viewpoints involved. The committee should be made up of an equal ratio of representatives from the various viewpoints. In the case of a deadlock, the teacher/moderator can cast the deciding vote.

Committee Members:

- Director of Chaco Culture National Historical Park
- One or more National Park Service archaeologists
- One or more Pueblo representatives
- One or more Navajo representatives

Community Representatives:

- Archaeologists from the local university
- Acoma Pueblo members
- Hopi Pueblo members
- Laguna Pueblo members
- Navajo Tribal members
- Zuni Pueblo members
- Other citizens with an interest in Chacoan history

5. Homework assignment:

All students should study the issues around the stewardship of cultural historic sites in the Southwest.

Recommended:

**The Native American Graves Protection and Repatriation Act of 1990**, available online at: <http://www.cast.uark.edu/other/nps/nagpra/DOCS/lgm003.html>

**Reburying History**, by National Park Service employee Theresa F. Nichols. Available online at: <http://crm.cr.nps.gov/archive/23-09/23-09-12.pdf>. This brief article describes many of the issues involved.

**Navajos and Hopis at Odds Over Remains of Anasazi**, by Christopher Smith, The Salt Lake Tribune, November 22, 1999. Available online at: <http://www.goldrush.com/~cbjork/ownership.html>

### Second Class Period

1. Discuss the homework readings in class.
2. Describe how the hearing process will take place (using outline given below in Third Class Period.)
3. Separate the class into the predetermined groups. Each representative should research their role and how they might work with others to promote a common point of view. Discuss agendas with each individual group.

#### Pueblo Representatives

- Pueblo leaders often have expressed the point of view that their tribes already know what they need to know about Chaco Canyon, and that further digging or preservation efforts are not necessary. As Petuuche Gilbert says in *THE MYSTERY OF CHACO CANYON*, "These buildings should be left the way they are. They served a purpose then and now that purpose is over." Chacoan buildings are considered sacred by many Pueblo people, and are thought to contain remains of ancestors as well as their spirits. However, Pueblos all have differing traditions, and they do not always agree with each other. Representatives should try to study their tribe's particular concerns regarding Chaco Canyon and present that during the hearing.

#### Navajo Representatives

- Navajo people claim a history in Chaco Canyon. Though scholars believe that the Navajos entered the area after the great construction period ended, there is a rich tribal history having to do with Chaco Canyon. Navajo legends refer to Pueblo Bonito as the home of the Great Gambler who had enslaved Pueblo people. A Navajo hero arrived to challenge the Gambler and won the freedom of the slaves. Navajo lands surround Chaco Canyon (which is held in trust by the federal government) and more Navajo people work at the Chaco Canyon sites than Pueblo people (whose lands are farther away).

#### Archaeology Representatives

- The archaeologists will be interested in preserving the site so that further study can be done. For instance, they may be waiting for funding and permission to do more excavation at Hungo Pavi because there is a chance that the site holds significant clues to the history of Chaco Canyon. Many archaeologists might not favor re-filling the excavated rooms with dirt.

### Citizen Representatives

- As taxpaying U.S. citizens, these representatives are interested in maintaining access to all of the sites in the park. They feel it is a cultural treasure that all citizens should be able to share for generations to come.

### Park Service Representatives

- The Director and other NPS members will want to get input from the various representatives, and also carry out their mandates of maintaining the Park within their budget, providing access, and making sure the sites are safe. The NPS has responsibilities that sometimes conflict such as preservation, research, and education.

4. Students should develop their roles through in-class work, library research, and homework. The Resources section contains many leads for this study.

### Third Class Period

#### THE COMMITTEE MEETING

1. The Committee convenes the hearing with each member giving a brief (1 minute) introductory remark.
2. Community Representatives are then each allowed 3-5 minutes to speak (depending on size of class.)
3. The Committee members can then each propose a course of action.
4. The Committee members vote on each course of action. If there is a tie, the teacher/moderator can cast the deciding vote.
5. The Committee formally recommends a course of action to the Director.
6. The Committee prepares a formal written report for the communities.

## SOCIAL STUDIES ACTIVITY 2

### Build a Model Chacoan Building

This activity is designed to enable students to gain insights into the enormous effort and expertise required to construct a Chacoan building. The construction at Chaco Canyon took place between 850 A.D. and 1130 A.D. The massive walls were built of sandstone quarried from the top of canyon mesas. Exquisite masonry techniques were used, unique for their time. In some cases tiny, flat pieces of stone were used to build up enormous walls.

Most buildings are four-stories high. The roofs were constructed using 220,000 timbers carried 50-70 miles from the mountains. Some buildings, such as Pueblo Bonito, were built over a 250-year period. The buildings have features in common such as large plazas, fine masonry, and numerous kivas. Most buildings are rectangular; two are curved. Fourteen major buildings were eventually constructed in and near Chaco Canyon.

#### Learning Objectives:

Students will gain an understanding of:

- The unique features of Chacoan architecture by modeling on a small scale.
- Translating large scale to small scale using graph paper.

- The buildings' alignments and formulate hypotheses as to how they were developed and used.

**Language Objectives:**

Students will be able to:

- Follow directions for construction;
- Explain and demonstrate a process; and
- Find information in reference materials.

**Group Work:** May be done with teams or as individuals.

**Time:** Two to three class periods.

**Supplies:**

- Wood base
- Clay
- Cardboard
- Large sheets of graph paper (18"x24")
- Adhesive tape
- Ruler
- Calculator
- Compass

**Procedure:**

1. Choose a Chacoan building to construct. Study your building. Information and plans for the twelve major Chacoan buildings and some outliers can be found at: <http://www.solsticeproject.org> (See the paper, "The Primary Architecture of the Chacoan Culture: a Cosmological Expression;" or <http://www.ets.uidaho.edu/chaco/> )
2. Attach the graph paper to your base with adhesive tape. Determine the scale of your construction.
3. Translate the data from the scale plan to your graph paper to create an outline of the walls. If this is a multistoried building, this must be done for each floor.
4. The clay either can be rolled and cut, using a rolling pin and knife, or the walls can be built up with small individual bricks, which are more in keeping with Chacoan style.
5. Though it would be impossible to replicate the intricate detail of the masonry walls, an approximation of the exterior patterns could be used. See examples at: <http://www.nps.gov/chcu/masonry.htm>
6. Identify the solar and/or lunar alignments of your building on the Solstice Project website (<http://www.solsticeproject.org/> and see there the research paper, "The Primary Architecture of the Chacoan Culture: a Cosmological Expression.") Also, check your building's astronomical relationship to other Chacoan buildings. Where does it fit in the pattern?

7. Orient your building with shadow and light observations (See Unit II, Activity 2) or use a compass to determine cardinal direction in order to orient your building.

Consult these reference books:

Lekson, Stephen et al., **Great Pueblo Architecture of Chaco Canyon**, New Mexico Albuquerque: University of New Mexico Press, 1986.

Nabakov, Peter and Easton, Robert **Native American Architecture** New York: Oxford University Press, 1989.

## ACTIVITY 3

### **SOCIAL STUDIES ACTIVITY 3**

#### **Write about the Ideas Expressed In THE MYSTERY OF CHACO CANYON**

In this activity, students think and write about the ideas presented in THE MYSTERY OF CHACO CANYON. First, they should describe the celestial pattern of the Chacoan buildings. They can refer to the film or to the web site, <http://www.solsticeproject.org>, to review the Chacoan buildings' specific alignments to the Sun and the Moon. Then they can describe the work that was involved in constructing and aligning the massive buildings to form this pattern. And finally, students should consider why they think the Chacoan people made this enormous effort. Why did they then deliberately close their buildings and leave Chaco Canyon? Students can review the quotes from Pueblo people regarding the spiritual knowledge and power of the Chacoan people and their deliberate decision to leave the canyon. (For these quotes, see the film again or Unit III, Enrichment, Pueblo Culture.)

# UNIT 2

## UNIT II: EXPLORING CHACOAN ASTRONOMY

Subject: Earth and Space Science

Grade Levels: 5-8 (Easily adaptable for higher grades)

Number of Lessons: 2-5 class periods

### Learning Objectives

Students will gain an understanding of:

- The importance of astronomical cycles and sky watching to ancient cultures;
- How and why early people experienced and tracked the Sun and the Moon;
- The relationship between the Sun, the Moon, and the Earth as we understand it today;
- The relationship of cardinal directions to astronomy;
- The cycle of the seasons and how seasons can be determined astronomically;
- The origins of keeping time and calendars;
- The tools used by early astronomers; and
- The evolution of scientific knowledge over time.

### Language Objectives

Students will be able to:

Listen in order to:

- Understand demonstrations;
- Follow directions for experiments and activities; and
- Listen for specific information.

Read in order to:

- Understand specialized vocabulary;
- Follow directions for experiments; and
- Find information in reference materials.

Speak in order to:

- Answer questions;
- Participate in discussions; and
- Ask for clarification.

Write in order to:

- Write answers to questions;
- Note observations;
- Write an essay; and
- Contribute to group reports.

### Viewing the film in two parts

In order to accommodate classroom time, the screening of *THE MYSTERY OF CHACO CANYON* can be divided into two class periods, with time for questions, discussion, and analysis. You may choose to have the students participate in hands-on activities between parts as a way of reinforcing the concepts learned, or conduct activities after viewing the entire film. Part One of the film finishes at 30:58 (elapsed time,) and is clearly marked in the classroom version with a title saying “End of Part One.” It ends with the scene in which Anna Sofaer and Phillip Tuwaletsiwa conclude that many buildings are aligned to each other along lines to the Sun and they question whether other

buildings also are part of the astronomical pattern. After five seconds of black, Part Two begins with the section about the lunar alignments at Chaco.

**Procedure for viewing Part One of THE MYSTERY OF CHACO CANYON:**

**Before viewing Part One**

1. Initiate a discussion with your students about calendars and keeping time using one or more of the following suggestions:

- How do we know what day it is and what hour?
- Imagine how people, living in a desert, a thousand years ago, would have kept track of time.
- Would these ancient people have needed to keep track of time? If so why?
- If you were living alone in a desert, could you do it?
- Tell students that many ancient societies such as the Aztec, the Inca, and the Egyptians, commemorated the Sun's cycle in rituals and in the construction of monumental buildings. They also marked the cycles of the Moon, the stars, and the planets. See:

Aveni, Anthony F, **Ancient Astronomers**, Washington, DC: Smithsonian Institution, 1993.

Krupp, Edward C. **Beyond the Blue Horizon: Myths & Legends of the Sun, Moon, Stars, and Planets** New York: Oxford University Press, 1991.

2. Explain how knowledge of the solar cycle is the basis of many calendars. Ask your students to describe what they know about how the length of the day and the night change throughout the year with the changing seasons. Write the words equinox and solstice on the board. This film presumes some basic knowledge of the cycles of the Sun, the Moon, and the Earth, including equinoxes and solstices. Introduce or review this material with your class. The use of physical models is quite beneficial. The web site <http://library.thinkquest.org/29033/begin/EarthSunMoon.htm> has good illustrations of the relationship of the Earth, the Sun, and the Moon.

3. Ask students to consider how ancient people were able to determine their location on the Earth. Introduce the idea that, along with knowledge of the landscape, knowledge of the predictable movements of the Sun and the stars can be used to figure out where you are and where you are going.

- How did ancient people, or explorers and traders, find their way over thousands of miles and then back again before maps were available?
- If you were lost in the wilderness, what techniques would you use to find your way?

4. Now tell your students that there was an ancient civilization living in the desert of the American Southwest that developed astronomical observations to such an extent that they erected huge four-storied stone buildings that work as giant solar and lunar calendars. They also marked the solar and lunar cycles in shadow and light patterns on stone carvings. And, they were able to navigate great distances on foot to ancient Mexico and Central America in order to trade goods.

5. Locate Chaco Canyon on a map for the class. (See **Fig. 1**, page 5, or use a map of the United States.) It is in the northwestern corner of New Mexico, in the Four Corners region of the United States. The closest towns are Gallup, to the southwest, and

Farmington, to the northwest. This was the place that was chosen as the center of this ancient civilization. Today Pueblo people live in a number of communities in New Mexico and Arizona. Ask students to locate the contemporary Pueblo communities of: Taos, Picuris, San Juan, Pojoaque, Santa Clara, San Ildefonso, Nambe, Tesuque, Cochiti, Santo Domingo, San Felipe, Jemez, Zia, Santa Ana, Sandia, Isleta, Laguna, Acoma, Zuni, and Hopi. (Today's Pueblos can be located on a map of New Mexico and Arizona.)

#### 6. Vocabulary Preparation

There are several words you may want to discuss with the students before viewing the film. We suggest choosing 10-12 from among the following: A.D., Anasazi, archaeoastronomy, archaeology, badlands, cardinal, codices, cosmology, equinox, hearth, horizon, kiva, latitude, longitude, Mesoamerica, midden, obsessive, organic, petroglyph, solstice, ceremonial.

#### **During or following the screening of Part One**

Ask students to take notes during or following the screening regarding:

- The different ways the Chacoan people marked the Sun's cycle;
- How the directions north - south and east - west relate to the Sun's cycle and the seasons;
- The different theories about the purposes of the Chacoan buildings; and
- Any questions they have for discussion.



#### **View THE MYSTERY OF CHACO CANYON, Part One**

Zero the timer on the VCR to time the first 30-minute portion.

**After viewing Part One, choose one or more of the following focuses for your discussions.**

#### **FOCUS 1**

What are the students' hypotheses about the purposes of the Chacoan buildings?

#### **FOCUS 2**

Using **Fig. 2**, page 8, *The Sun Dagger Site*, as a guide, draw on the board or use an overhead projector, to lead a discussion on how the Sun's light markings indicate the equinoxes, and solstices. (You can block out the lower half of the diagram to focus attention on just the solar markings.) Carefully placed, giant slabs of sandstone channel sunlight onto the spiral rock carvings. As the Sun's position, relative to the Earth, changes throughout the year, the dagger of light also moves. It rests in the center of the large spiral at summer solstice and brackets its perimeter with two daggers of light at winter solstice. At equinox, a smaller adjacent spiral also has a dagger of light piercing it.

#### **FOCUS 3**

Using **Fig. 3a and 3b**, page 9, *Solar Alignments of Pueblo Bonito and Pueblo Bonito Petroglyph* as a guide, discuss how a building can be aligned to the Sun and how the equinox and noon positions of the Sun also are the north-south and the east-west cardinal directions.



### **Key Idea**

Pueblo Bonito, the immense half-circular building at the center of Chaco Canyon, features two prominent walls that align north-south and east-west, the cardinal directions. The Sun rises and sets at equinox in line with Pueblo Bonito's east-west wall, and the Sun at noon every day can be experienced at the moment the north-south mid-wall casts no shadow. Thus, Pueblo Bonito commemorates the midpoints of the day and of the year.

### **FOCUS 4**

Lead a discussion around the following quote from Phillip Tuwaletstiwa in the film, “As these people would view the heavens, there was an order of things up there. What you had here, of course, contrasted to that. If there was a way to transfer the orderly nature of the cosmos down onto what seems to be chaos that exists here, then you begin to integrate heaven and Earth.”

- How did the Chacoan people's astronomical knowledge go beyond practical purposes such as planting and harvesting?
- What did you learn from the film about why the Chacoan people marked the movements of the Sun so elaborately? How might those observations have empowered certain people? Can you imagine what ceremonies or stories people would have experienced in Chaco Canyon, or in other traditional societies, about the power of the Sun?
- What is known in modern science about the power of the Sun in biological life? (See Ensminger, Peter A., **Life Under the Sun**, New Haven: Yale University Press, 2001)
- How do we know what time it is, or which day of the year? How do our methods differ from traditional peoples?
- How would knowledge of the Sun's changing position be useful in designing a building today? What about in the layout of a town?

### **FOCUS 5**

In **THE MYSTERY OF CHACO CANYON**, Phillip Tuwaletstiwa says, “The ancestors were scientists, they were close observers of nature.” What evidence have we seen that supports this statement? This topic could be used as a focus of discussion or a writing assignment.

### **Procedure for viewing Part Two of THE MYSTERY OF CHACO CANYON**

Before showing the second half of the film you may want students to do Earth and Space Science Activity 2 or 3. These activities relate to topics presented in the first half of the film. Possible homework assignments that students could begin include projects found in Unit III, Enrichment.

#### **Before viewing Part Two**

1. Review key points from the first half of the film.
  - Anna Sofaer's discovery of the Sun Dagger;
  - The Solstice Project's study and findings of building alignments to the Sun's cycle;

- The hypothesis that the buildings are no longer thought to be dwellings;
- The understanding that the Chacoan people were an oral culture;
- The view of the descendants of the Chacoan people that Chaco Canyon is a sacred place; and
- That Anna Sofaer and Phillip Tuwaletstiwa were interested to see if the buildings at Chaco that are not aligned to the Sun might have some other astronomical significance.

## 2. Vocabulary Preparation:

There are several words you may want to discuss with the students before viewing the film. We suggest that you choose 10-12 from the following: vivid, perpendicular, intuition, symmetry, esthetic, pragmatic, enigmatic, drought, famine, butte, meridian, lunar, solar, geodesist.

### **During or following the screening of Part Two**

Ask students to take notes during or following the screening regarding:

- How the Sun Dagger site also works for the Moon;
- How buildings were aligned to the Moon; and
- Any questions the students may have for discussion.



### **View THE MYSTERY OF CHACO CANYON, Part Two.**

Begin the film at 30:58 (elapsed time) at the section on the Moon at Chaco.

**After viewing Part Two, choose one or more of the following focuses for your discussions.**

#### **FOCUS 1**

Using **Fig. 2**, page 8, *The Sun Dagger Site*, as a guide, draw on the board or use an overhead projector to review how the Moon's minimum and maximum extremes are marked on the spiral.

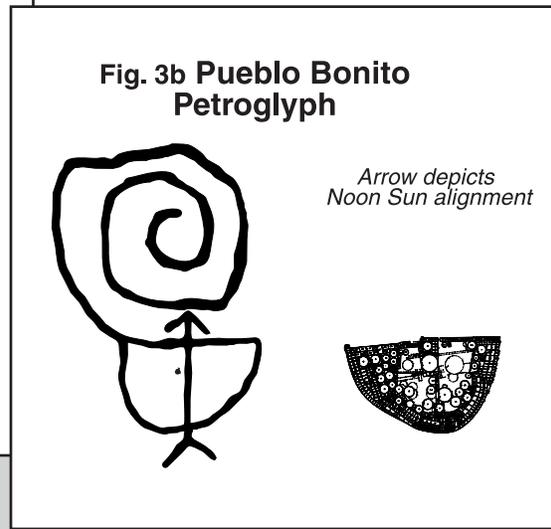
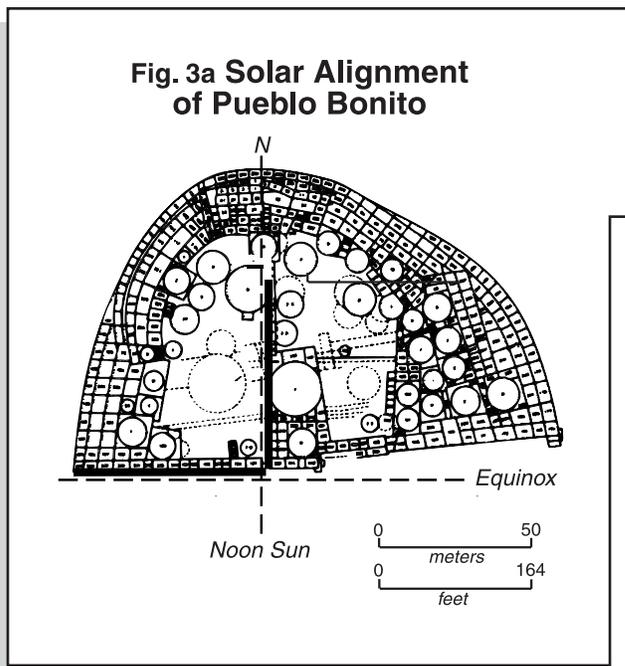
#### **FOCUS 2**

Using **Fig. 6**, page 12, *Solar and Lunar Interbuilding Alignments*, as a guide, review how buildings are connected over great distances along lines to the Moon.

#### **FOCUS 3**

Lead a discussion covering one or more of the following topics:

- Why might the Chacoan people have commemorated the movements of the Moon in their buildings?
- In today's cities and towns, people are less likely to live with awareness of the natural rhythms and cycles of the Earth and the sky. What have we lost or gained because of this?
- How might the Chacoan people have aligned their buildings over such great distances?
- Can you think of what the significance of the spiral, the arrow shape, or the half circle of Pueblo Bonito Petroglyph might have been? (See **Fig. 3a and 3b.**)



- Why was this an important clue for Anna Sofaer?

**Further discussion topics: choose one or more of the following:**

- How did Anna Sofaer's research team determine the alignments of the buildings? Consider inviting a professional surveyor to demonstrate techniques using a theodolite and/or Global Positioning System for the class.
- How do the students now consider their earlier hypotheses about the purposes of the Chacoan buildings? Did viewing the second half of the film change their thinking?
- How did the research team come to a new understanding of Chaco Canyon? What tools did they use?
- What earlier hypotheses did the team's research help to change?
- What insights did the students gain from the Pueblo people speaking in the film?

**Student Activities**

After completing the viewing and discussion of Part Two, THE MYSTERY OF CHACO CANYON, student interest will be heightened. Provide them with the opportunity for further exploration by using as many of the Earth and Space Science Activities as time permits. Your students also will benefit from the Enrichment projects found in Unit III.

**Assessment Suggestions**

In order to assess student understanding of the material covered in the Lesson Plan and the degree to which the learning and language objectives have been met use:

- Earth and Space Science Review Questions
- Participation in classroom discussion
- Independent and Enrichment student activities
- Cooperation and participation in group projects;
- and Writing assignments.



## EARTH AND SPACE SCIENCE REVIEW QUESTIONS

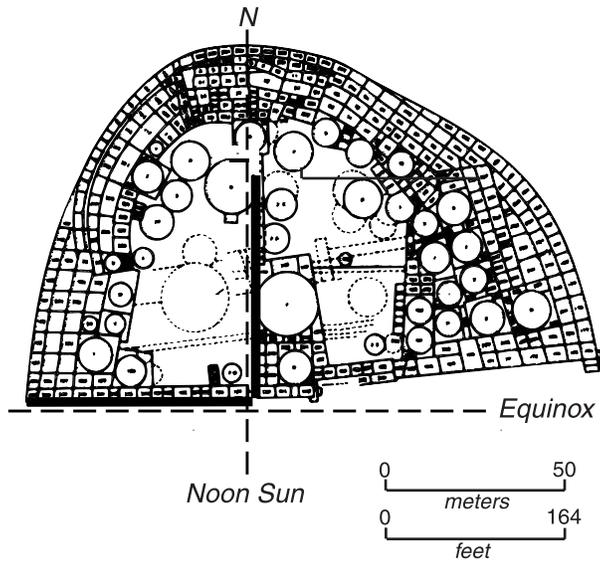
1. Where is Chaco Canyon?
2. Describe why Chaco Canyon would have been a difficult place in which to live.
3. Describe why Chaco Canyon would be a good place to track the Sun and the Moon.
4. Why would it be important for ancient cultures, the Chacoan people in particular, to keep track of the cycle of the Sun?
5. Define these terms:
  - equinox
  - solstice
  - cardinal directions
6. Using this picture of Pueblo Bonito and the Pueblo Bonito petroglyph describe:

How is the Sun commemorated at noon every day?

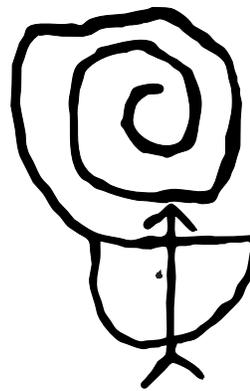
How is the Sun commemorated on the two equinox days?

Explore the image of the petroglyph and discuss how it shows the relationship of Pueblo Bonito to the Sun.

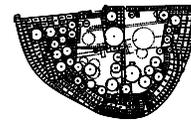
**Fig. 3a Solar Alignment of Pueblo Bonito**



**Fig. 3b Pueblo Bonito Petroglyph**



*Arrow depicts  
Noon Sun alignment*



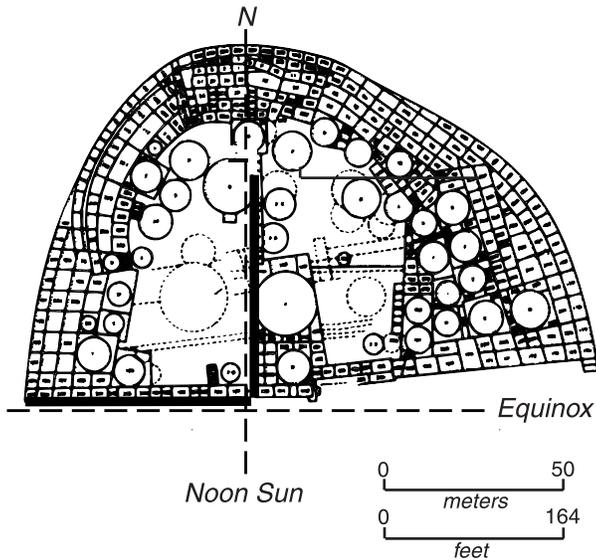
7. The Chacoan people were aware of two different cycles of the Moon. Describe them.

# A

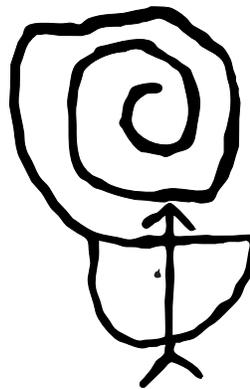
## EARTH AND SPACE SCIENCE REVIEW ANSWERS

1. Chaco Canyon is located in northwestern New Mexico, in the Four Corners region of the United States.
2. Chaco Canyon would have been a difficult place in which to live because there are extremes of temperature, short growing seasons, and marginal rainfall. Most of the resources, including food, pottery, turquoise, and timbers had to be carried into the canyon.
3. Chaco Canyon would have been a good place to track the Sun and the Moon because of the flat, barren plains, and mesas surrounding it. Chaco Canyon affords a stunning view of the Sun and the Moon rising and setting on the horizon.
4. Ancient people tracked the Sun's cycle to guide their planting and harvesting. The Chacoan people also marked the Sun's cycle for spiritual reasons.
5. Equinox - An equinox is a midpoint in the Sun's yearly cycle. There are two each year. In the Northern Hemisphere the vernal (spring) equinox occurs near March 21. The autumnal (fall) equinox is near September 21. These are the times of the year when the hours of the daylight equal the hours of the night.  
  
Solstice - The solstice is the extreme points in the Earth's yearly orbit around the Sun. There are two each year. Summer solstice occurs near June 21 and is the day with the most amount of daylight in the year; winter solstice, near December 21, is the day with the least amount of daylight of the year.  
  
Cardinal directions - The cardinal directions are north, south, east, and west.
6. See below.
  - The Sun is commemorated at noon everyday at Pueblo Bonito the moment no shadow is cast on the north-south wall.
  - The Sun is commemorated on the two equinox days at Pueblo Bonito when the Sun rises and sets in line with the east-west wall.
  - The relationship of the petroglyph to the building is as follows: the arrow aligns with the mid-wall of the building, which marks noon. Because the petroglyph is on a vertical cliff face, this arrow appears to point up to the midday sun.

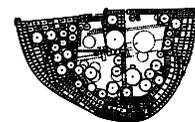
**Fig. 3a Solar Alignment of Pueblo Bonito**



**Fig. 3b Pueblo Bonito Petroglyph**



*Arrow depicts Noon Sun alignment*



7. The monthly cycle of the changing phases of the Moon, and also the 18.6-year cycle of the Moon were well known and recorded by the Chacoan people. The Moon's orbital axis around the Earth is nearly parallel to the Earth's orbital axis around the Sun. The Moon follows daily and seasonal paths in the sky that resemble the Sun's path. However, because of a small difference in the axes of the Earth and the Moon, the rising and setting positions shift in a monthly cycle. In addition, the Sun's gravitational pull leads to a shift of the Moon's orbital axis, over a period of 18.6 years. The ancient Chacoan people experienced this cycle on the horizon as the changing positions of the full moonrises over 18.6 years (see Part Two, THE MYSTERY OF CHACO CANYON).

**EARTH AND SPACE SCIENCE ACTIVITY 1****Observing the Sun and the Moon,****A Science Writing Project**

This activity is designed to help students relate the seasonal, daily, and nightly changes of the Sun and the Moon to the relationships of the Earth, the Sun, and the Moon in space. It requires careful writing and illustrating of observations and understanding.

Ask students to recall the changing arcs of the Sun over Pueblo Bonito as shown in the film and to write an essay describing the change of seasons that are affected by the changing positions of the Sun. When is the arc of the Sun the highest or the lowest in the sky and the days the longest and shortest? How do these changes affect plant life, the climate, and the scheduling of holidays? Ask students to show how these different times are created by the changing relationship of the Earth and the Sun in space.

Request students to observe the Moon's changing shape over several nights and write notes and make drawings that show the changes in the Moon's position and timing as well as shape. These observations will give students a sense of what the early scientists of Chaco Canyon so rigorously observed over decades. Note to students that if they continued their observations over many years they might come to observe the 18.6-year cycle of the Moon. Ask students also to illustrate and describe how the changing position of the Earth, the Sun, and the Moon affects the changing phases of the Moon. Students living close to the sea might observe and describe how the Moon's cycles govern the tides.

One of the best exercises to help students understand the phases of the Moon is to have the children each take a styrofoam ball, stick it on top of a pencil, stand around a light in the middle of the room, use their head as the Earth, and then move the "Moon" around their head to observe the changes in the phases. This takes only a few minutes to get the concept across. This exercise is detailed in the Astronomical Society of the Pacific's, "The Universe at Your Fingertips" activity set, available on line at: <http://www.astrosociety.org>.

**EARTH AND SPACE SCIENCE ACTIVITY 2****Use Simple Tools to Determine Cardinal Directions**

The ancient astronomers of Chaco Canyon determined north, south, east, and west, cardinal directions probably through the use of shadow and light. This activity challenges students to brainstorm about the problem of how people like the Chacoan people could know directions without tools like the modern compass. This activity will guide students to solve the problem by making a "compass" with simple tools that use the Sun's shadow throughout the day.

**Learning Objectives:**

The students will gain an understanding of:

- How to identify the cardinal directions: north, south, east, and west using the Sun and simple tools as the Chacoan people may have done;
- The relationship of cardinal directions to the solar cycle.
- Scientific measurement and data collecting; and
- Practical applications of geometry.

**Language Objectives:**

Students be able to:

- Follow demonstrations;
- Follow directions for experiments and activities;
- Work in a team on an experiment; and
- Explain and demonstrate a process.

**Group Work:** Teams of 2-3 students

**Time:** The activity takes course over an entire day, in short intervals - should be started at the beginning of the day.

Supplies:

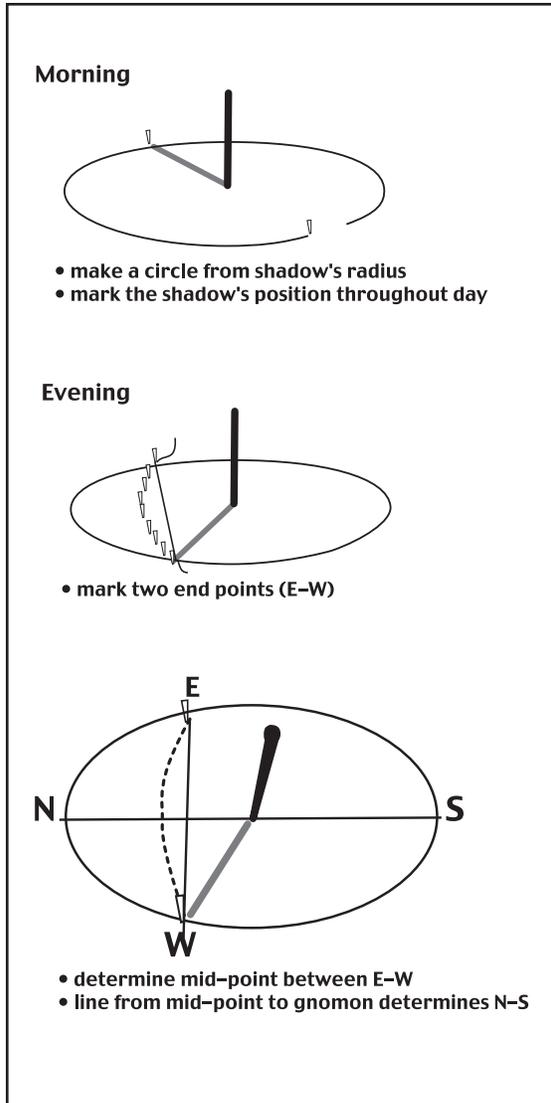
- Flat and level ground area
- Straight stick, 2-3 feet long
- Modeling clay
- 20 short sticks to use as markers
- Plumb bob (a weighted string for determining a vertical)
- String, several feet long
- Chalk
- Notebooks or Data Record Forms

**Procedure:**

1. Choose a flat area outside that gets sunlight throughout the day. An area of flat, hard-packed dirt is best or even blacktop (such as basketball court). Test its flatness using water in a dish or plate as a level. In the morning, at the beginning of the school day, plant your stick vertically, using the plumb bob to ensure that it is perpendicular to the ground (if working on a blacktop surface, you will need to mount the stick in modeling clay). The stick will function as a gnomon to cast a shadow.
2. Tie a piece of string to the base of the stick and extend the string to the end of the stick's morning shadow. Swing an arc with the string to make a complete circle, scoring the dirt (or drawing with chalk on blacktop) to mark the circle. The radius of the circle is the length of the stick's shadow when you start.
3. Use a stick or other marker to record the point where the shadow first falls on the circle.

4. Students mark the tip of the stick's shadow with a new marker every half-hour during the day. Use notebooks or a Data Record Form to record what you observed. How does the shadow change during the day? Why does it do this?

5. In the late afternoon, the shadow should once again intersect the drawn circle. Mark this point and record your observations.



6. All participants should be present for this part. Stretch a length of string between the two points that intersect the circle. This is the east-west, or equinox line.

7. Fold the string in half to determine and mark a center point between the two east-west points. Mark a line from this point to the center stick. This is the north-south or meridian line. The direction north leads away from the center stick, passing through the east-west axis.

8. Draw a smooth curve between all the intermediary shadow points of the day. Describe this shape in your notebooks or a Data Record Form.

9. You now have found the cardinal directions, using tools and methods similar to those the Chacoan people may have used.

10. Referring to your notebooks or Data Record Forms, discuss with the class your observations.

11. Describe the shadow's curve. How would the shape of the curve change during the different seasons? Would it change?

12. Describe, as completely as you can, how this activity determines the Cardinal directions. Why does it work? Use pictures to describe what is happening.

Note: You can expand on this project using the same tools with the next activity.

**A Sample Data Recording Form**  
Data Record  
Earth and Space Science Activity 2

Student's Name \_\_\_\_\_

Date \_\_\_\_\_

The question/problem investigated:

The hypothesis made:

When we collected data:

Observations of the stick's shadow:

Draw a smooth curve between all the intermediary shadow points of the day.  
Describe this shape:

## EARTH AND SPACE SCIENCE ACTIVITY 3

### Observe the Sun's Seasonal Movement with Simple Tools

The ancient sky watchers at Chaco Canyon saw the dramatic rise and set of the Sun along the horizon in the wide-open desert country. They were most likely up at dawn to watch the Sun return to the world. In order to create the complex Sun Dagger site, the Chacoan people also must have made extensive observations of the Sun's shifting shadows throughout the day and throughout the seasons. This activity gives students the opportunity to engage in a small part of the Chacoan people's complex solar cosmology.

#### Learning Objectives:

The students will gain an understanding of:

- The continual seasonal shift of the Sun relative to the Earth;
- Scientific measurement and data collecting; and
- Processes used by ancient astronomers.

#### Language Objectives:

The students be able to:

- Follow directions for experiment;
- Work with a partner on an experiment;
- Ask for clarification;
- Participate in discussions;
- Note observations; and
- Describe experiments.

**Group Work:** Individuals or small teams.

**Time:** Minimum - at least two weeks to see results.

Maximum - one year.

#### Supplies:

[Note: If you are continuing on from **Activity 2: Use Simple Tools to Determine Cardinal Directions**, the same supplies and observatory can be used again. In choosing the site and supplies however, it is crucial that the markings can remain undisturbed over a period of weeks or months.]

- A straight stick approximately 7" long (can be a pencil)
- Some modeling clay
- Sheet of 18"x24" paper
- Adhesive tape
- Marking pen
- Reliable source for keeping time
- Notebook

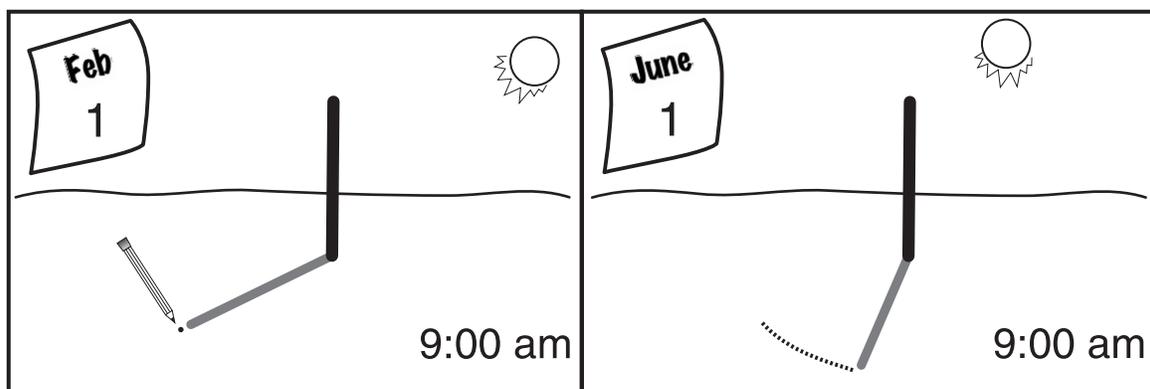
#### Procedure:

1. Before starting the project, students should be familiar with the concepts behind the Earth's seasonal shifts. A web site with clear diagrams can be found at: <http://library.thinkquest.org/29033/begin/EarthSunMoon.htm>.

2. Pick a time of day when you know you will be able to make observations of the Sun's shadow from the same location over a period of at least two weeks. Then pick a location, which gets direct sunlight at that time. This can be a sunny window, or a place outside. Keep in mind that you are going to build a small observatory, which must remain at this spot for the duration of the project. The location is critical. Consider that a window, facing north, gets no sun in the northern hemisphere; and, a window facing east gets sun only in the morning. A window, facing west, receives sun only in the afternoon.

3. Mount the stick or pencil vertically in modeling clay so that it casts a shadow at the chosen time onto a piece of paper lying flat beside it. Use a plumb bob to be certain that the stick is vertical. The stick is known as a gnomon. Test the flatness of the surface using water in a bowl or dish as a level. Make sure the paper is on a level surface and tape or otherwise secure it so that it does not move.

4. At the chosen time, make a mark on the sheet of paper to record the first position of the shadow, and date it. Do this at the same time each day. (If a switch to, or from, Daylight Savings Time occurs during the project, do not adjust your project timepiece—stay consistent by not adjusting to the change in clock time.)



5. Use a notebook to make observations.

- What do you observe over the course of time?
- Describe the pattern that emerges?
- If you have done a complete year, what happens at the solstices and the equinoxes?
- How might this kind of recording be useful to the Chacoan people?

6. If you are able to conduct the project over several months you will observe large changes in the shadow formations, especially from fall equinox to winter solstice and from winter solstice to spring equinox. At these times, you may wish to make a design on which the light pattern would fall to commemorate the extremes or midpoints of the Sun's cycle. For these observations you may need an environment more open to the Sun than a window. If the observations are made over this long period, you may be able to project the positions for the rest of the Sun's cycle.

## EARTH AND SPACE SCIENCE ACTIVITY 4

### Design Your Own Timekeeping Device Using The Sun

Before the clock, peoples in many cultures constructed devices such as sundials to record the Sun's seasonal and hourly changes. This activity will help students construct a basic sundial. After completing Earth and Space Science Activities 2 and finding out your local latitude (see the Tiger Map Server through <http://spacekids.hq.nasa.gov/starshine/viewfaq2.cfm?uid=1>), students will have the essential information needed in order to create their own sundial. This information, cardinal directions and latitude, also can be obtained using a compass and map. For excellent instructions see: <http://www.Sundials.co.uk/projects.htm>.

#### Learning Objectives:

Students will gain an understanding of:

- The Sun's relationship to the Earth; and
- How to develop a creative response to the age-old pursuit of keeping time and the commemoration of the Sun.

#### Language Objectives:

Students will be able:

- Follow directions for activities; and
- Explain and demonstrate a process.

**Group Work:** In small teams or as individuals.

**Supplies:** See <http://www.Sundials.co.uk/projects.htm> or <http://grex.cyberspace.org/~jh/dial/>.

Or in book form: **Easy-to-make Wooden Sundials** by Milton Stoneman, New York: Dover Publications, 1981.

**Put it to the test!** Try doing away with all clocks and watches in the classroom for a day or two and see if the Sundials can be used to determine lunchtime, the end of the school day, etc.

## UNIT III: ENRICHMENT

# 3

**Subjects:** Traditional Literature, Pueblo Culture, Art, Symbols and Architecture, Archaeoastronomy and Calendars, Archaeology, Geology, and Ethnobotany.

**Grade levels:** 5-12

This section of the Guide contains suggestions for Enrichment projects in Traditional Literature, Pueblo Culture, Art, Symbols, and Architecture, Archaeoastronomy and Calendars, Archaeology, Geology, and Ethnobotany. The Resources section has related texts and web sites for each subject.

### 1. Traditional Literature:

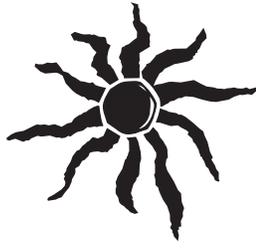
1.1 Many cultures have traditional stories about the creation of the Sun and the Moon and their relationship to seasonal changes. For instance, in Greek culture, the well-known story of Icarus illustrates the power of the Sun. See: D'Aulaire, Ingri and Edgar. **Book of Greek Myths**, New York: Random House (Picture Yearling), 1992.

The Sun also is a source of absolute life in religion and state power in Europe and Asia. The Japanese and the French have royal symbols commemorating their descent from the Sun. For sources about comparative folk stories, see:

Krupp, Edward C. **Beyond the Blue Horizon: Myths & Legends of the Sun, Moon, Stars, & Planets** New York: Oxford University Press, 1991.  
Campbell, Joseph and Abadio, M.J., **The Mythic Image**, Princeton: Princeton University Press, 1981.  
Frazer, James George. **The Golden Bough** New York: Simon and Schuster, 1996.

Native American stories of the Sun, the Moon, the planets, and the stars can be found in:

Miller, Dorcas S. **Stars of the First People: Native American Star Myths and Constellations** Boulder, CO: Pruett Publishing Co., 1997.  
Krupp, Edward C. **Beyond the Blue Horizon: Myths & Legends of the Sun, Moon, Stars, and Planets** New York: Oxford University Press, 1991.  
Williamson, Ray A. and Farrer, Ginger, editors **Earth & Sky, Visions of the Cosmos in Native American Folklore** Albuquerque: University of New Mexico Press, 1992  
Krupp, Edward C. **Skywatchers, Shamans, and Kings** New York: John Wiley & Sons, 1997.  
Aveni, Anthony F. **Stairway to the Stars** John Wiley & Sons, 1997.  
Farrer, Claire R. **Living Life's Circle: Mescalero Apache Cosmvision** Albuquerque: University of New Mexico Press, 1991.  
Griffin-Pierce, Trudy **Earth Is My Mother, Sky Is My Father: Space, Time, and Astronomy In Navajo Sandpainting** Albuquerque: University of New Mexico Press, 1992.



Ask students to speak with their parents or grandparents about traditional stories regarding the Sun and the Moon. Invite them to show THE MYSTERY OF CHACO CANYON to their family. Students also can read traditional stories about the Sun and the Moon from other cultures. Ask students to write an essay comparing how the Sun and the Moon are regarded in their culture with the traditional stories they have read. Ask students to write their own story.



Some cultures see a man in the Moon, some a rabbit. The Moon is seen as associated with birth and death for many peoples. Ask your students to observe the Moon over a period of time and write a poem or essay about what they see. A group poem can be composed in class where each student contributes their impressions and thoughts. Have one student be a scribe for the group and each student contributes a word, line, or stanza of the poem. This can be done with each student speaking in turn or, invite the students to write a word, line, or stanza, put their contribution in a basket, and then the group composes the poem from what emerges from the basket. Students can illustrate their stories or observations with pastels or colored pencils. Students may want to explain and illustrate the position of the Earth, the Moon, and the Sun that affect the changing phases of the Moon that they observe. A similar experience can be written about observing the rising or setting of the Sun. For inspiration, see:

Ortiz, Simon J., **After and Before the Lightning**, Tucson: University of Arizona Press, 1998.

Sachs, Maryma, **The Moon**, New York: Abbeville Publishers, 1998.

Brueton, Diana, **Many Moons: The Myth and Magic, Fact and Fantasy of our Nearest Heavenly Body**, New York: Prentiss Hall, 1991.

Krupp, Edward C. **Beyond the Blue Horizon: Myths & Legends of the Sun, Moon, Stars, and Planets** New York: Oxford University Press, 1991.

Campbell, Joseph **Historical Atlas of World Mythology, Volume II: The Way of the Seeded Earth, Part 3: Mythologies of Primitive Planters: The Middle and Southern Americas** New York: Harper & Row, 1989.

1.2 Seasonal traditional stories are present in every culture. The story of Persephone and Demeter is the Greek version of such a story. See:

D'Aulaire, Ingri and Edgar. **Book of Greek Myths**, New York: Random House (Picture Yearling), 1992.

Krupp, Edward C. **Beyond the Blue Horizon: Myths & Legends of the Sun, Moon, Stars, and Planets** New York: Oxford University Press, 1991.

Williamson, Ray A. and Farrer, Ginger Ed. **Earth & Sky, Visions of the Cosmos in Native American Folklore**, Albuquerque: University of New Mexico Press, 1992.

Ask students to retell different stories and to write an essay comparing the main points and the various versions of the stories. How are they similar and how are they different? What stories do their families have?

Ask students to write and perform their own skit or shadow puppet drama explaining the seasonal shifts in the sky and the environment from a local perspective. Students create the characters and dialogue as well as any props or costumes. What plants grow and when? What symbols of spring are eagerly awaited? What materials best represent these changes? If students reside in a climate where wet and dry seasons are commemorated more than winter or spring, they can weave elements of those seasons into the tale. Publish the dramas in the school newspaper and consider a community performance.

Ask students to write an essay examining local holidays. Do local or family holidays coincide with cosmological events such as solstices and equinoxes? Are these coincidental? Why would any culture want to commemorate the change of the seasons throughout the year? Does the cycle of the Moon affect the holiday calendar? Ask students to work together to make a winter solstice commemoration in the winter holiday season.

## 2. Pueblo Culture

2.1 In *THE MYSTERY OF CHACO CANYON*, Pueblo people reflect on the knowledge and power of the Chacoan people, their ancestors. Ask students to write about the themes that they develop. What is the meaning of using astronomy for ordering your world or what is the significance of having too much knowledge?

Phillip Tuwaletsiwa, of Hopi, thinks that the Chacoan people aligned their buildings to astronomy to express the order they, “viewed in the heavens.” He says that they wanted to, “transfer the orderly nature of the cosmos down onto what seems to be the chaos that exists here [on Earth].”

Edward Ladd, of Zuni, suggests that very powerful people were at Chaco Canyon, especially Pueblo Bonito and that, “People had magical powers, powers over animals, and so forth.”

Paul Pino, of Laguna, says, “Here at Chaco there were very powerful people who had a lot of spiritual power. And these people probably used their power in ways that caused things to change. And that may have been one of the reasons why the migrations started again, [sic] because these people were causing changes that were never meant to occur.”

Petuuche Gilbert, of Acoma, states, “I think that they were so in tune with the natural forces that they were able to control these forces and sometimes it’s been said that this could be abused by people and that perhaps there were decisions made in the past not to continue this accumulation of knowledge of control of the natural forces.”

According to Paul Pino, of Laguna, and Petuuche Gilbert, of Acoma, there seems to be a planned movement or migration from Chaco Canyon and a decision to leave the structures of Chaco Canyon to return to nature.

2.2 How does the Pueblo people's view of Chaco Canyon's, "powerful people with too much knowledge" relate to similar stories in other cultures? For instance, think of the biblical tale of Babel. Ask students to write a research paper that considers issues of modern scientific research such as genetic engineering, nuclear science, or cloning and how societies deal with the moral implications of knowledge.

2.3 In small groups, ask students to write an essay about how they might close down their communities. What tools or artwork would they leave behind and what would they deem absolutely necessary to bring with them. What foodstuffs and clothing would they bring? How would they decide where to migrate? What history and objects would they carry? Create a time capsule for the school and bury it for a specific number of years. Invite students to return to the school for its opening during a reunion.

To learn more about Pueblo history and culture, see the following films, "Surviving Columbus: The story of the Pueblo People." Other films of interest include, "In the Reverence of Light," and "Coming to Light." (See the **Resources Section** for ordering information.) See also books on contemporary Pueblo culture in the **Resources Section**.

### 3. Art, Symbols, and Architecture:

3.1 Ask students to remember and draw the petroglyph images in the film and to look up other petroglyphs on the websites and books below as well as in the **Resources Section**. Have students choose symbols to study and report to the class.



Ask students to do a research paper on rock art sites in the American Southwest and compare their findings with the rock art at Chaco Canyon. Petroglyphs and pottery of the ancestral Pueblo people have recurring symbols and patterns: spirals, circles, and other geometric shapes, the Sun and the Moon, human and animal figures. The Pueblo Bonito petroglyph shown in THE MYSTERY OF CHACO CANYON appears to represent the building of Pueblo Bonito and its relationship to the Sun with an arrow pointing to the noon Sun. Some petroglyphs, such as the Sun Dagger, and others on Fajada Butte, use shadow and light to mark the solar and the lunar cycle. There are thousands of rock art sites throughout the American Southwest.

Ask students to make a petroglyph panel of their own on paper and write and/or speak to the class about the meaning of their symbols with their own interpretations. Students may want to design one with astronomical light markings. See:

Web sites:

[http:// www.solticeproject.org](http://www.solticeproject.org) for the Solstice Project's scientific papers on the Pueblo Bonito petroglyph and the solar and lunar markings on petroglyphs in Chaco Canyon.

Books:

Patterson, Alex. **A Field Guide to Rock Art Symbols of the Greater Southwest.**

Boulder: Johnson Books, 1992.

Patterson-Rudolph, Carol. **On the Trail of Spiderwoman: Petroglyphs, Pictographs, and Myths of the Southwest.** Santa Fe: Ancient City Press, 1998.

Schaafsma, Polly. **Indian Rock Art of the Southwest.** Albuquerque: University of New Mexico Press, 1986.

3.2 Sacred architecture and ceremonial structures are prominent features of society. In order to understand how different cultures have expressed cosmology in their architecture, consider the following resources:

Aveni, Anthony F. **Skywatchers : A Revised and Updated Version of Skywatchers of Ancient Mexico.** Austin: University of Texas Press, 2001.

Aveni, Anthony F., **Ancient Astronomers,** Washington: Smithsonian Institution Press, 1993.

Aveni, Anthony F. **Stairways to the Stars** New York: John Wiley & Sons, 1997.

Carrasco, David, **Religions of Mesoamerica, Cosmivision and Ceremonial Centers,** Prospect Heights: Waveland Press, Inc., 1990.

Hadingham, Evan **Early Man and the Cosmos** Norman: University of Oklahoma Press, 1985.

Hawkins, Gerald S. **Beyond Stonehenge** Albuquerque: Hubert Allen and Associates, 2001.

Hawkins, Gerald S. with John B. White. **Stonehenge Decoded.** New York: Doubleday & Co., 1966.

Heilbron, J.L., **The Sun in the Church,** Cambridge: Harvard University Press, 1999.

Nabakov, Peter and Easton, Robert, **Native American Architecture,** Oxford: Oxford University Press, 1989.

Specific features of traditional architecture, such as mandalas, rose windows, domes, or steeple-like constructions, have symbolism related to the Sun and the Moon, heaven and Earth. For ideas see:

Heilbron, J.L. **Geometry Civilized** Oxford: Clarendon Press, 1998.

Jung, Carl G. **Man and His Symbols** New York: Bantam (Laureleaf), 1997.

Ask students to design their own building and/or monument using cosmological symbols with pastels, colored pencils, or crayons.

Visit a local monument or house of worship. Get permission to check the alignments of the building, any windows or doorways where the Sun or the Moon rises or sets. Are there any cosmological events commemorated in the elements of the building such as in the windows, murals, or placement of doorways? Have these elements been purposefully included or excluded? Ask small teams of students to gather data and present to the class. Ask students to write an essay describing their findings and their personal beliefs about the inclusion of cosmology or nature in monuments and places of worship. (Note: buildings such as Masonic Temples, or places of worship often have such alignments.) For information on the rising and setting points of the Sun and the Moon at any location, see: [http://aa.usno.navy.mil/data/docs/RS\\_OneYear.html](http://aa.usno.navy.mil/data/docs/RS_OneYear.html).

Ask students to design a meditation garden that would include cosmologically significant features such as a Sundial, plants, or stones of special significance, or a meditative path such as a labyrinth. How is their garden aligned? Have students construct such a garden on school grounds to commemorate a special time or a memorable occasion for the school. See:

- Bremness, Lesley, **The Complete Book of Herbs** New York: PutnamPenguin USA (Viking Studio Books), 1988, for garden designs.
- Curry, Helen and Houston, Jean, **Way of the Labyrinth: Powerful Meditations for Everyday Life** New York: PutnamPenguin USA, 2000.
- Ashmun, Barbara B. **Garden Retreats: Creating an Outdoor Sanctuary**. San Francisco: Chronicle Books, 2000.
- Gilmer, Maureen. **Rooted in Spirit: Exploring Inspirational Gardens**. Dallas: Taylor Publishing Co., 1997.
- <http://www.healinglandscapes.org>)

Ask students to find a special place in nature that gives them a sense of belonging and inspiration. Some students may find that their own rooms have objects and space that have special significance. Ask them to write a poem or story about such a place or object. Haiku forms or other examples can be introduced to students to help them to focus on aspects of space, the significance of objects, and the sounds and sensations of place. For an example of seeing expressions of modern artists connecting with the Sun and the Moon and ancient sacred sites, see:

- Lippard, Lucy R. **Overlay: Contemporary Art and the Art of Prehistory** New York: Random House (Pantheon), 1983.

#### 4. Archaeoastronomy and Calendars

4.1 Ask students to try to consider the Sun and the Moon as traditional people have: Have students explore why the Sun was considered the source of all life by many traditional societies. How does the Sun affect the growth of plants, the changing seasons, and the behavior of humans and animals? See:

- Caduto, Michael J. and Bruchac, Joseph. **Keepers of the Earth: Native American Stories and Environmental Activities for Children** Golden, Colorado: Fulcrum, Inc., 1989.
- Ensminger, Peter A., **Life Under the Sun** New Haven: Yale University Press, 2001.

Watch the shadows of the Sun in your classroom or at home at 15-minute intervals, or at the same time each day over two weeks. Can you draw the changes or mark them on a paper? (Set up an open soda can and place it with the tab toward the Sun near noon-time, toward the south: it can be like a Sundial.) What changes occur?

Do this same observation of the Moon's shadow over a few hours on the night of, or near the night of, full Moon.

#### 4.2 Life as a Chacoan person:

Ask students to imagine they are an ancient Pueblo person coming to Chaco Canyon. Instruct students to keep a daily journal as an ancient Pueblo person. Why are they on this journey? How far have they come? What difficulties have they encountered traveling through the desert? Why is tracking the Sun and the Moon along the way important? Why is it important when they arrive? What sources of water and food do they have? Do the Sun and the Moon play a role in the motivation to make this great journey? What do they feel as they approach the large buildings in the canyon? Are they coming to build the buildings, to worship here? What kind of experience would this be? What will it be like observing astronomical events with others here?

The environment of Chaco Canyon is spare and harsh: the work to build the buildings would be very demanding. Transporting the materials would require enormous strength, persistence, and coordination of hundreds of people. Ask small groups of students to describe the work, the motivation of the people, and the experience of being in Chaco Canyon. Ask students to describe the people who come on this journey and how they are related to each other. Keeping a daily journal with illustrations, diagrams, and sketches, have students prepare a series of dioramas with accompanying descriptions.

Collect a series of visual illustrations or pictures of places in the world valued for their spare beauty. Is there a relationship of an ascetic environment and spiritual life? Create See:

Davidson, A.K. **The Art of Zen Gardens: A Guide to their Creation and Enjoyment** Los Angeles: JP Tarcher, 1987.

Townsend, Richard F. (ed.) **The Ancient Americans: Art from Sacred Landscapes** Munich: Prestel Verlag, 1992.

Website: <http://www.huntington.org/Education/lessons/Lpzen.htm>

4.3 Calendars are cosmological expressions that bind traditional societies. The people, who have controlled the calendars, also have controlled agriculture, massive construction projects, migrations, prophecies, and warfare. Lunar and solar calendars reveal very different information. For more information on how various societies have created and been inspired by calendars, see:

Campbell, Joseph and Abadio, M.J., **The Mythic Image**, Princeton: Princeton University Press, 1981.

Carrasco, David, **Religions of Mesoamerica, Cosmovision and Ceremonial Centers**, Prospect Heights, Waveland Press, 1990.

Aveni, Anthony F. **Ancient Astronomers**, Washington: Smithsonian Institution Press, 1993.

Krupp, Edward C. **Skywatchers, Shamans, and Kings** New York: John Wiley & Sons, 1997.

Ask students to read about various calendar systems around the world and how they were used. Assign a writing task, either a short story or a poem, describing the

worldview of a calendar maker. What special knowledge do they have? How do they see themselves in the social order? Do they want to share all they know and with whom? How will their observations guide the society? Or, after reading about calendar systems, students can write essays comparing the Chacoan astronomical alignments and light markings with those of another traditional cultures.

Ask students to view the Moon for several nights. How does it feel to sit under the Moon for an hour? Describe the changes that students observe if they see the Moon for several nights or better yet over weeks. Draw how it changes its shape, position in the sky, and time of rising or setting. Imagine having no source of light at night but the Moon. Study how traditional peoples use the Moon's cycles as an essential calendar and how the Moon may affect the timing of traditional ceremonies of their own culture.

Over the course of the year, ask students to mark the phases of the Moon, the rising and setting times of the Sun, and the rising and setting times of the full Moon. At the end of the school year, use the data gathered to create a celestial calendar for the upcoming school year; students could create a lunar and a solar calendar. Illustrate the calendar; create names for lunar months that correspond to what you know about local botany, history, or school events. Distribute the calendar throughout the school.

Have students study and write about modern timekeeping methods which are derived from highly accurate astronomy. How does this technology derive from our culture and affect our lives? Do modern astronomers look at the Sun and the Moon and the stars with the naked eye? Ask students to study observatories and their relationship to space travel and modern theories about the beginning and the end of the universe.

The most accurate timekeeping devices used today are atomic clocks. For a description and project using atomic clocks visit the web site:  
[http://hea-www.harvard.edu/ECT/the\\_book/Chap3/Chapter3.html#rtpot](http://hea-www.harvard.edu/ECT/the_book/Chap3/Chapter3.html#rtpot)

The U.S. Naval Observatory site provides the official current U.S. time at <http://tycho.usno.navy.mil/>. This site has interesting information about the technologies that will be involved in keeping time in the future.

## 5. Archaeology:

5.1 The film presents many findings of archaeology that have recently changed our views of Chaco Canyon. Have students study how archaeologists made these determinations and how the understanding of Chaco Canyon has changed over the past century.

- What was the earlier view of Chaco Canyon?
- How did archaeologists determine that a massive number of pots were broken intentionally over many years, and only at certain times of the year? What meaning did this finding have in understanding Chaco?
- How do we know that the Chacoan roads were probably not built for practical purposes and that they may have been built for cosmological purposes?
- How was it determined that not many people lived in Chaco Canyon and many came on pilgrimages?
- How do we know about the droughts in the region in 12th century?

- How do we know that kivas were eventually dismantled and burned by the Chacoan people? What did this suggest about the Chacoan people's departure?

5.2 Ask students to describe, as best as they can, the effort by the Chacoan people to plan, align, and construct their fourteen massive buildings and to engineer their extensive roads. Consider the organization of materials and labor in cutting and transporting timbers, quarrying rocks, building the four-storied walls, as well as planning and engineering the alignments of the buildings and roads. What food and water supplies were needed for this effort? How do you think they made astronomical alignments between buildings that are out of sight of each other?

5.3 Ask students to describe how the Sun Dagger was developed step by step. Consider whether the rock slabs may have been modified and/or moved; and how the cliff where the spirals were carved may have been modified.

## 6. Geology:

6.1 Geology is the study of land formations over time. The land is history. Have students study the environment of Chaco Canyon and report on the geologic history of the canyon. Ask students to consider how Chaco Canyon's climate, resources, and extreme environment made it a uniquely special place for a religious center?

6.2 Ask students to collect and study geologic samples from their locale. What do the samples reveal about the geologic history of their community. How does that geology support the environment of the community of today? How much has the human community altered the landscape? Has the community created an economic base from the local geology? If so, how does this compare with Chaco Canyon? How does an activity like mining affect the environment? How does water use affect the economy? See:

Cajete, Gregory **Native Science: Natural Laws of Interdependence** Santa Fe: Clear Light Publishers, 2000.

6.3 Ask students to interview elders in the community and their families about their understanding and memory of how the community has used local resources in the past, especially during the world wars. Do they have any stories about the use of local resources such as coal, copper, uranium, or other minerals or oil? How was certain land chosen for planting or grazing? Students can collect these local histories for publication in the school and/or local newspaper and make the collection available to their local historical society. Students may want to film the interviews after getting permission from those to be interviewed.

6.4 For many cultures, the land is alive with spirit and history. Ask students to interview elders in their family and community about these traditions. Ask students to join together in a project of writing poems and/or creating wall murals to illustrate their traditions.

## 7. Ethnobotany

7.1 Historically, local plants are used by all cultures. Initiate a discussion about the definition of ethnobotany (See Glossary) and the use of plants in culture. Ask students

to develop a hypothesis about one of the questions noted below and then write a paper to discuss their findings.

Study questions:

- What plants are indigenous to Chaco Canyon?
- Develop a hypothesis about how the Chacoan people used local plants?
- How do Pueblo communities of today use local plants?

For background information and research see:

Dunmire, William W. and Tierney, Gail D. **Wild Plants and Native Peoples of the Four Corners** Santa Fe: Museum of New Mexico Press, 1977.

Dunmire, William W. and Tierney, Gail D. **Wild Plants of the Pueblo Province, Exploring Ancient and Enduring Uses** Santa Fe: Museum of New Mexico Press, 1977.

Moerman, Daniel **Native American Ethnobotany** Portland: Timber Press, 1998.

Moore, Michael **Medicinal Plants of the Desert and Canyon West** Santa Fe: Museum of New Mexico Press, 1989.

Moore, Michael **Medicinal Plants of the Mountain West** Santa Fe: Museum of New Mexico Press, 1979.

Web site:

<http://homel.gte.net/ericjw1/ethnobotany.html>

A guide with bibliographic references and Internet resources.

7.2 Ask students to create a survey of the indigenous plant life of their local community. Create a garden of these plants or press samples using a flower press (or place between acid-free paper and heavy books) and write a report about their uses. Suggest that students include a section in their report about invasive plants in their community and how these newcomers found a home. Invite a National Park Service ranger, town arborist, or nursery owner to speak to the students about local flora. Conduct a field trip into a local wilderness area and ask students to identify ten plants and give an oral report about the history and use of the plants. For inspiration see:

Cajete, Gregory **Native Science: Natural Laws of Interdependence** Santa Fe: Clear Light Publishers, 2000.

Caduto, Michael J. and Bruchac, Joseph **Native Plant Stories** Golden Colorado: Fulcrum Publishing, 1995.

Coffey, Timothy and Foster, Stephen **The History and Folklore of North American Wildflowers** Boston: Houghton Mifflin, 1994.

Moerman, Daniel E. **Native American Ethnobotany** Portland: Timber Press, 1998.

Vitale, Alice Thomas **Leaves In Myth, Magic, and Medicine** Stewart, Tabori & Chang, 1997.

7.3 Ask students to interview elders in their community and families about local plants and how they have been used. Were any plants used medicinally? Who taught each generation about plants and their uses? How was the information passed along - through story, ceremony, apprenticeship? Ask students to write a biography of a young person learning about plants. Write the biography in the first person. If possible film the interviews after receiving permission from those to be interviewed. See:

Caduto, Michael J. and Bruchac, Joseph **Keepers of Life: Discovering Plants Through Native American Stories and Earth Activities for Children** Golden Colorado: Fulcrum Publishing, 1997.

Caduto, Michael J. and Bruchac, Joseph **Native Plant Stories** Golden Colorado: Fulcrum Publishing, 1995.

Cajete Gregory **Native Science: Natural Law of Interdependence** Santa Fe: Clear Light Publishers, 2000.

Vitale, Alice Thomas **Leaves In Myth, Magic, and Medicine** Stewart, Tabori & Chang, 1997.

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## RESOURCES

### SOCIAL STUDIES

#### Books:

Aveni, Anthony F. **Ancient Astronomers** Washington DC: Smithsonian Institution Press, 1993.

Aveni, Anthony F. **Stairways to the Stars: Skywatching In Three Great Ancient Cultures** New York: John Wiley & Sons, 1997.

Benedik, Emily **The Wind Won't Know Me: A History of the Navajo-Hopi Land Dispute** Norman: University of Oklahoma Press, 1991.

Cordell, Linda **Archaeology of the Southwest** Academic Press, 1997.

Erdoes, Richard and Ortiz, Alfonso (eds.) **American Indian Myths and Legends** New York: Random House (Pantheon Books), 1985.

Gathering 160 tales from 80 tribal groups to offer a rich and lively panorama of the Native American folk heritage including stories about the Sun, the Moon, and the stars.

Gabriel, Kathryn **Gambler Way: Indian Gaming In Mythology, History, and Archaeology In North America** Boulder: Johnson Publishing Company, 1996.

Gabriel, Kathryn **Roads to Center Place: A Cultural Atlas of Chaco Canyon and the Anasazi** Boulder: Johnson Publishing Company, 1991.

Gies, Frances and Joseph **Cathedral, Forge, and Waterwheel: Technology and Invention In the Middle Ages** New York: HarperCollins, 1994.

Hadingham, Evan **Early Man and the Cosmos** Norman: University of Oklahoma Press, 1985.

Hawkins, Gerald S. **Beyond Stonehenge** Albuquerque: Hubert Allen and Assoc., 2001.

Lekson, Stephen J., **Great Pueblo Architecture of Chaco Canyon, New Mexico** Albuquerque: University of New Mexico Press, 1986.

Lepre, J.P. **The Egyptian Pyramids: A Comprehensive, Illustrated Reference**  
Jefferson, N.C.: McFarland and Co., 1990.

McClellan III, James E. and Dorn, Harold (eds.) **Science and Technology In World History: An Introduction** Baltimore: Johns Hopkins University Press, 1999.

A Survey of the history of science, “not only as a western phenomenon but as the result of wide-ranging human curiosity about nature and the attempts to harness its powers in order to serve human needs.”

Minge, Ward Alan **Acoma: Pueblo In the Sky** Albuquerque: University of New Mexico Press, 2002.

The only official history of Sky City sanctioned by the Tribal Council chronicles the social, economic, and political history of the Acoma tribe. Foreword by Simon Ortiz. Nabakov, Peter and Easton, Robert, **Native American Architecture** Albuquerque: University of New Mexico Press, 1989.

Sando, Joe S. **Pueblo Nations: Eight Centuries of Pueblo Indian History** Santa Fe: Clear Light Publishers, 1992.

Townsend, Richard F. (ed.) **The Ancient Americans: Art from Sacred Landscapes** Munich: Prestel Verlag, 1992.

#### **Websites:**

<http://www.solsticeproject.org>

Includes scientific research papers by Anna Sofaer and Solstice Project on Chaco Canyon's archaeoastronomy and computer-3D models of two major Chacoan buildings.

<http://www.sarissa.org>

Regional and world-wide time lines.

[http://www.teach-nology.com/web\\_tools/materials/timelines](http://www.teach-nology.com/web_tools/materials/timelines)

Create your own time line.

<http://www.pbs.org/wgbh/pages/nova/pyramid/>

The Egyptian pyramids on NOVA.

<http://www.astro.uva.nl/michielb/maya/astro.html>

The Maya Astronomy Page.

[http://members.aol.com/mcnelis/medsci\\_Index.html](http://members.aol.com/mcnelis/medsci_Index.html)

The Medieval Science Page.

<http://sipapu.gsu.edu/htm/outliers.html>

A database and map of outlier sites.

<http://www.ets.uidaho.edu/chaco/>

To study specific Chacoan buildings, plans, and maps.

<http://www.nps.gov/chcu/home.htm>  
For Information about Hungo Pavi.

<http://colorado.edu/Conferences/chaco/tour/pavi.htm>  
Images and Illustrations of Hungo Pavi.

<http://www.cast.uark.edu/other/nps/nagpra/DOCS/lgm003.html>  
Text of the Native American Graves Protection and Repatriation Act of 1990.

<http://www.crm.cr.nps.gov/archive/23-09-12.pdf>  
Reburying history by Park Service employee, Theresa F. Nichols.

[http://www.goldrush.com/\(cbjork/ownership.html](http://www.goldrush.com/(cbjork/ownership.html)  
Article from the Salt Lake Tribune regarding Navajo and Hopi disagreements over the remains of ancient Pueblo Indian people.

<http://www.nps.gov/chucu/masonry.htm>  
Excellent examples of the masonry styles at Chaco Canyon.

## EARTH AND SPACE SCIENCE

### Books:

Aveni, Anthony F. **Ancient Astronomers** Washington DC: Smithsonian Institution Press, 1993.

Cajete, Gregory **Native Science: Natural Laws of Interdependence** Santa Fe: Clear Light Publishers, 2000.

Ensminger, Peter A., **Life Under the Sun** New Haven: Yale University Press, 2001.

Krupp, Edward C. **Beyond the Blue Horizon: Myths & Legends of the Sun, Moon, Stars, and Planets** New York: Oxford University Press, 1991.

Krupp, Edward C., **Echoes of the Ancient Skies: Astronomy of Lost Civilizations**, New York: Harper Row, 1983.

Pasachoff, Jay M. **Astronomy: From the Earth to the Universe** Fort Worth: Saunders College Publishing, 1998.

Stoneman, Milton, **Easy-to-make Wooden Sundials**, New York: Dover Publications, 1981.

Walker, Barbara G. **The Woman's Encyclopedia of Myths and Secrets** San Francisco: Harper Row, 1983.

**Websites:**

<http://www.solsticeproject.org>

Includes scientific research papers by Anna Sofaer and Solstice Project on Chacoan archaeoastronomy and the Sun Dagger Site.

<http://library.thinkquest.org/29033/begin/EarthSunMoon.htm>

Good illustrations of the relationship of the Earth, the Sun, and the Moon.

<http://spacekids.hq.nasa.gov/starshine/viewfaq2.cfm?uid=1>

The Tiger Map Server allows you to determine your Lat/Long to a very high degree of accuracy.

<http://www.Sundials.co.uk>

Excellent Instructions for easily constructed Sundials.

[http://www.k12.ut.us/utahlink/lp\\_res/TRB047.html](http://www.k12.ut.us/utahlink/lp_res/TRB047.html)

Simplified description of the astronomy of the Earth, Sun, and Moon.

<http://library.thinkquest.org/29033/begin/EarthSunMoon.htm>

Illustrations of Earth, Sun, and Moon orbits.

<http://space.jpl.nasa.gov/>

Animations which show one Earth year as seen from the Sun, and the Moon's orbit around the Earth.

[http://hea-www.harvard.edu/ECT/the\\_book/index.html](http://hea-www.harvard.edu/ECT/the_book/index.html)

Hands-on astronomy activities for students.

<http://www.astro.wisc.edu/~dolan/java/MoonPhase.html>

Chris Dolan's interactive animation of the Moon phases, viewable from Earth or space.

<http://www.eyeonthesky.org/>

Good lesson plans for elementary-school teachers on astronomy and weather that foster reading through science and technology. Wonderful references and links.

<http://www.solar-center.stanford.edu>

On-line activity resources for solar exploration. Very cool solar images, daily solar reports, and classroom activities. Free solar posters.

<http://www.teachspace.com>

This is NASA's space and science education resource directory. Very thorough.

<http://sunearth.gsfc.nasa.gov/sunearthday/act2002.htm>

This website has very good lesson plans and useful links.

<http://www.astrosociety.org>

The Astronomical Society of the Pacific's website has online activities and a store with fabulous materials and resources as well as teaching guides. "Hands on the Universe" is recommended.

<http://www.lhs.berkeley.edu>

They sell many publications. We recommend, "The Real Reason for the Seasons." This publication, available through Berkeley has a very fine set of activities and includes a CD-ROM. They also have a number of valuable teaching guides for astronomy, earth science, general science, and math. In addition, the site has a Star Clock that is a fun, online activity.

<http://www.nsta.org/301>

This website for the National Science Teachers Association's Astronomy with a Stick program, has daytime astronomy lesson plans for elementary and middle-school children that are teacher-tested and fun.

## TRADITIONAL LITERATURE

### Books:

Aveni, Anthony F. **Stairway to the Stars** New York: John Wiley & Sons, 1997.

Brueton, Diane, **Many Moons: The Myth and Magic, Fact and Fantasy of Our Nearest Heavenly Body**, New York: Prentice Hall, 1991.

Campbell, Joseph **Historical Atlas of World Mythology, Volume II: The Way of the Seeded Earth, Part 3: Mythologies of Primitive Planters: The Middle and Southern Americas** New York: Harper & Row, 1989.

Campbell, Joseph, **The Mythic Image**, Princeton: Princeton University Press, 1974.

Carrasco, David, **Religions of Mesoamerica: Cosmvision and Ceremonial Centers**, Prospect Heights, Waveland Press, Inc., 1990.

D'Aulaire, Ingri and Edgar Parin, **Book of Greek Myths**, New York: Random House (Picture Yearling), 1992.

Erdoes, Richard and Ortiz, Alfonso (eds.) **American Indian Myths and Legends** New York: Random House (Pantheon Books), 1985.

Gathering 160 tales from 80 tribal groups to offer a rich and lively panorama of the Native American folk heritage including stories about the Sun, the Moon, and the stars.

Farrer, Claire R. **Living Life's Circle: Mescalero Apache Cosmvision** Albuquerque: University of New Mexico Press, 1991.

Griffin-Pierce, Trudy **Earth Is My Mother, Sky Is My Father: Space, Time, and Astronomy In Navajo Sandpainting** Albuquerque: University of New Mexico Press, 1992.

Hadingham, Evan **Early Man and the Cosmos** Norman: University of Oklahoma Press, 1985.

Krupp, Edward C. **Beyond the Blue Horizon: Myths & Legends of the Sun, Moon, Stars, and Planets** New York: Oxford University Press, 1991.

Krupp, Edward C. **Skywatchers, Shamans, and Kings** New York: John Wiley & Sons, 1997.

Frazer, James **The Golden Bough** New York: Simon & Schuster, 1996.

Miller, Dorcas S. **Stars of the First People: Native American Star Myths and Constellations** Boulder, CO: Pruett Publishing Co., 1997.

Momaday, N. Scott, **House Made of Dawn**, New York: Quality Paperback Book Club, 1994.

Ortiz, Simon J., **After and Before the Lightning**, Tucson: University of Arizona Press, 1998.

Sachs, Maryam, **The Moon**, New York: Abbeville Press Publishers, 1998.

Tyler, Hamilton, **Pueblo Gods and Myths**, Norman: University of Oklahoma Press, 1984.

Williamson, Ray A. **Living the Sky: The Cosmos of the American Indian** Boston: Houghton Mifflin, 1984.

Williamson, Ray A. and Farrer Ginger (eds.) **Earth & Sky, Visions of the Cosmos In Native American Folklore** Albuquerque: University of New Mexico Press, 1992.

## PUEBLO CULTURE

### Books and articles:

Aveni, Anthony F, **Ancient Astronomers**, Washington DC: Smithsonian Institution, 1993.

Billard, Jules B. ed., **The World of the American Indian: A volume in the story of man library**, Washington DC: National Geographic Society, 1979.

Caduto, Michael and Bruchac, Joseph. **Keepers of the Earth: Native American stories and environmental activities for children**. Golden Colorado: Fulcrum, Inc., 1989. An excellent activity book and good resource for Native American stories from many nations.

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Contemporary culture and history of many Southwestern tribes including: the Pueblos, O'odham, Yaqui, Yuman, Navajo, Apache, and Southern Paiute.

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Scully, Vincent. **Pueblo: Mountain, Village, Dance** Chicago: University of Chicago Press, 1989.

Illustrated ethnography of Pueblo ceremonies.

Tyler, Hamilton, **Pueblo Gods and Myths**, Norman: University of Oklahoma Press, 1984.

Williamson, Ray A., **Living the Sky: The cosmos of the American Indian**, Boston: Houghton Mifflin Co., 1984.

#### **Web sites:**

<http://www.ilt.columbia.edu/k12/naha/>

The Native American History Archive site designed for use by K-12 students using the web for classroom projects.

<http://www.4Directions.org>

A project administered by the Laguna Department of Education which focuses on integrating Native American culture and technology into education. 4Directions schools welcome opportunities to work with other schools.

<http://www.Earthmeasure.com/>

Site on Native American geometry by Chris Hardaker.

[www.kstrom.net/isk/stars/starmenu.html](http://www.kstrom.net/isk/stars/starmenu.html)

Native American astronomy site that focuses mostly on Lakota Tribe and the Bighorn Medicine Wheel — a site with stone cairns marking the solstices and possible star dates.

<http://www.solar-center.stanford.edu/folklore.html>  
On-line, traditional stories from many indigenous societies.

## ART, SYMBOLS, AND ARCHITECTURE

### Books and articles:

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Jung, Carl **Man and His Symbols** New York: Bantam (Laureleaf), 1997.

Lippard, Lucy R. **Overlay: Contemporary Art and the Art of Prehistory** New York: Random House (Pantheon), 1983.

Nabakov, Peter and Easton, Robert, **Native American Architecture**, New York: Oxford University Press, 1989.

Patterson, Alex. **A Field Guide to Rock Art Symbols of the Greater Southwest**. Boulder: Johnson Books, 1992.

Patterson-Rudolph, Carol. **On the Trail of Spider Woman: Petroglyphs, Pictographs, and Myths of the Southwest** Santa Fe: Ancient City Pr. 1998.

Schaafsma, Polly **Indian Rock Art of the Southwest** Albuquerque: University of New Mexico Press, 1986.

#### **Websites:**

<http://nmculturenet.org/features/swa/Index.html>  
Southwestern architecture.

<http://www.healinglandscapes.org>  
Healing and garden design - wonderful references.

[http://aa.usno.navy.mil/data/docs/RS\\_OneYear.html](http://aa.usno.navy.mil/data/docs/RS_OneYear.html)  
Wonderful website of the US Naval Observatory with the rising and setting times of the Sun and the Moon for most locations.

## **ARCHAEOASTRONOMY AND CALENDARS**

#### **Books:**

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Pioneering text on archaeoastronomy.

Heath, Robin. **Sun, Moon, & Earth**. New York: Walker & Company, 1999.  
A short book which clearly describes the way the primary heavenly bodies move in space, including legends and beliefs of early astronomers. Beautifully illustrated.

Krupp, Edward C., **Echoes of the Ancient Skies: The Astronomy of Lost Civilizations**. New York: Harper Row, 1983.  
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Weiss, Malcolm E., **Sky Watchers of Ages Past**, Boston: Houghton Mifflin Co., 1982.  
Delightful easy reader for younger students interested in archaeoastronomy.

Williamson, Ray A., **Living the Sky: The Cosmos of the American Indian**, Boston: Houghton Mifflin Co., 1984. ISBN 0-395-35414-5.

**Websites:**

<http://www.solsticeproject.org/>

Includes scientific research papers by Anna Sofaer and Solstice Project on Chacoan archaeoastronomy.

<http://www.astro.wisc.edu/~dolan/java/MoonPhase.html>

Chris Dolan's interactive animation of the Moon phases, viewable from Earth or space.

[http://www.k12.ut.us/utahlink/lp\\_res/TRB047.html](http://www.k12.ut.us/utahlink/lp_res/TRB047.html)

Simplified description of the astronomy of the Earth, Sun, and Moon.

<http://library.thinkquest.org/29033/begin/EarthSunMoon.htm>

Illustrations of Earth, Sun, and Moon orbits.

<http://space.jpl.nasa.gov/>

Animations which show one Earth year as seen from the Sun, and the Moon's orbit around the Earth.

[http://hea-www.harvard.edu/ECT/the\\_book/index.html](http://hea-www.harvard.edu/ECT/the_book/index.html)

Hands-on astronomy activities for students.

[www.kstrom.net/isk/stars/starmenu.html](http://www.kstrom.net/isk/stars/starmenu.html)

Focuses mostly on Lakota Tribe and the Bighorn Medicine Wheel — a site with stone cairns marking the solstices and possible star dates.

<http://tycho.usno.navy.mil/>

U.S. Naval Observatory site provides the official current U.S. time.

<http://www.hao.ucar.edu/public/education/archeoslides/>

Southwestern archaeoastronomy site with photos.

<http://www.umass.edu/Sunwheel>

The Sunwheel is an outdoor observatory and astronomy exhibit made of a stone circle at the University of Massachusetts, Amherst. It is open to the public and school groups.

<http://www.huntington.org/Education/lessons/Lpzen.htm>

Valuable zen garden designs.

## ARCHAEOLOGY

### Books:

Cordell, Linda, **Archaeology of the Southwest**, Academic Press, 1997. ISBN 0121882268. A coherent and comprehensive summary of the major themes and topics central to the practice of and interpretation of Southwest archaeology.

Frazier, Kendrick. **The People of Chaco: A Canyon and Its Culture**. New York: W.W. Norton, Rev&Updtd. 1999.

Combines scientific and ethnographic data for a good basic introduction to all aspects of Chacoan culture.

Gabriel, Kathryn. **Roads to Center Place: A Cultural Atlas of Chaco Canyon and the Anasazi** Boulder: Johnson Books, 1991.

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Lekson, Stephen H., et al. "The Chaco Canyon Community," **Scientific American**, July 1988, Vol. 259, No. 1, pp. 100-109.

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Essays by three Chaco scholars: archaeologists Lekson and Stein, and poet and Acoma native Ortiz. Promotes the theory of Chaco Canyon as a ceremonial center.

Morrow, Baker H. and Price, V.B. (eds.) **Anasazi Architecture and American Design** Albuquerque: University of New Mexico Press, 1997.

Noble, David Grant, (editor). **New Light on Chaco Canyon**, School of American Research Press; 1984. ISBN: 0933452101

Examines the latest findings about the Chacoan culture.

Pringle, Heather, **In Search of Ancient North America: An archaeological journey to forgotten cultures**, New York: John Wiley & Sons, Inc., 1996.

**Web sites:**

<http://www.nps.gov/chcu/home.htm>

National Park Service site with sections on architecture, roads, masonry, pottery, natural history, maps.

<http://www.taosnet.com/architectVRe/html/VRArchaeology.html>

Dennis Holloway's three-dimensional models of Chacoan buildings.

<http://www.ets.uidaho.edu/chaco/>

A very well-designed site by Anne Lawrason Marshall with floor plan diagrams of many Chacoan buildings, and also QTVR (interactive 3-D) imaging of buildings and landscape.

<http://sipapu.gsu.edu/html/outliers.html>

A database and map of the known Chacoan outlying communities.

<http://www.sidecanyon.com/features/chaco1.htm>

An informative travel guide to Chaco Canyon, with basic history and photos.

<http://www.colorado.edu/Conferences/chaco/tour/chacomap.htm>

Map of the central canyon with links to descriptions of all the major buildings.

<http://www.sidecanyon.com/features/chacom.htm>

A site showing examples of Chacoan masonry techniques.

[http://www.ghcc.msfc.nasa.gov/archeology/chaco\\_compare.html](http://www.ghcc.msfc.nasa.gov/archeology/chaco_compare.html)

A site showing NASA imaging of Chacoan roads.

<http://www.ghcc.msfc.nasa.gov/archeology/>

Remote sensing archaeological research at NASA. Aerial photography and ground survey of Chaco Canyon.

<http://www.cr.nps.gov/aad/>

National Park Service's site covering archaeology and ethnography. Very thorough with links to over 300 websites about Chaco Canyon.

## GEOLOGY

### Books:

Cajete, Gregory **Native Science: Natural Laws of Interdependence** Santa Fe: Clear Light Publishers, 2000.

Craig, Steven D. **Geologic Framework of the San Juan Structural Basin of New Mexico, Colorado, Arizona, and Utah, with Emphasis on Triassic Through Tertiary Rocks** Washington, DC: US Geological Survey, 2001.

Elias, Scott A. **The Ice-Age History of the Southwestern National Parks** Washington DC: Smithsonian Institution Press, 1997.

### Web sites:

<http://www.nps.gov/chcu/geology/htm>

National Park Service page on the geology of Chaco Canyon.

<http://www.usgs.gov/education/learnweb/>

The U.S. Geologic Survey website with lesson plans and good information.

<http://www.geolsoc.org.uk/template.cfm?name=geoteac>

The British Geology Society's website with good resources.

## ETHNOBOTANY

### Books

Caduto, Michael J. and Bruchac, Joseph **Keepers of Life: Discovering Plants Through Native American Stories and Earth Activities for Children** Golden Colorado: Fulcrum Publishing, 1997.

Caduto, Michael J. and Bruchac, Joseph **Native Plant Stories** Golden Colorado: Fulcrum Publishing, 1995.

Cajete, Gregory **Native Science: Natural Laws of Interdependence** Clear Light Publishers, 2000.

Coffey, Timothy and Foster, Stephen **The History and Folklore of North American Wildflowers** Boston: Houghton Mifflin, 1994.

Dunmire, William W. and Tierney, Gail D. **Wild Plants and Native Peoples of the Four Corners** Santa Fe: Museum of New Mexico Press, 1977.

Dunmire, William W. and Tierney, Gail D. **Wild Plants of the Pueblo Province, Exploring Ancient and Enduring Uses** Santa Fe: Museum of New Mexico Press, 1977.

Moerman, Daniel **Native American Ethnobotany** Portland: Timber Press, 1998.

Moore, Michael **Medicinal Plants of the Desert and Canyon West** Santa Fe: Museum of New Mexico Press, 1989.

Moore, Michael **Medicinal Plants of the Mountain West** Santa Fe: Museum of New Mexico Press, 1979.

Vitale, Alice Thomas **Leaves In Myth, Magic, and Medicine** Stewart, Tabori & Chang, 1997.

**Website:**

<http://www.home1/gte.net/ericjw1/ethnobotany.html>

A guide with bibliographic references and internet resources.

**Related Film Titles:**

All are available from Bullfrog Films at:(800) 543-FROG  
[www.bullfrogfilms.com](http://www.bullfrogfilms.com)

The Sun Dagger - The astonishing discovery of an ancient celestial calendar in Chaco Canyon, NM.

The Mystery of the Lost Red Paint People - Advanced seafaring culture lived in New England 7000 years ago.

In the Light of Reverence - A stunning portrait of land-use conflicts over Native American sacred sites on public and private land around the West.

The Buffalo War - The battle over the yearly slaughter of America's last wild bison outside Yellowstone National Park with protests led by Native Americans and environmentalists.

Chief Seattle - Profiles the legendary leader who welcomed the Americans to settle on the land that now bears his name.

Norse America - Evidence that the Icelandic sagas were fact not fiction.

Voices of the Land - Our spiritual connection to the land, and how wilderness can heal the soul.

Drumbeat for Mother Earth - Toxic chemicals are the greatest threat to the survival of indigenous peoples.

Coming to Light - An in-depth portrait of Edward S. Curtis, the preeminent photographer of North American Indians.

Surviving Columbus - A Native American production about the history of the Pueblo people since contact. (Available through <http://www.pbs.org> )

Searching for the Great Hopewell Road - A production of the Ohio Historical Society that explores roads, Earthworks, and lunar alignments. Available from the Ohio Historical Society at <http://www.ohiohistory.org/market/multimed.html>

### **Related Music**

Stearns, Michael. **The Middle of Time**. Soundtrack CD for the film *The Mystery of Chaco Canyon*. 1999, Earth Turtle Music. Available from: Earth Turtle Music, PO Box 8008, Santa Fe, NM 87504.

Littlebird, Harold. **The Road Back In**. 1987, Littlebird Studios. Native American music and poetry (cassette.) Title song directly influenced by visits to Chaco Canyon. Available from: Littlebird Studios, 6 Buskirk Lane, Peralta, NM 87042.

### **Other Related Resources**

National Geodetic Survey  
<http://www.ngs.noaa.gov/>  
History and definition of the Survey and its ongoing projects.

Guide To Dendochronology For Educators  
<http://tree.ltrr.arizona.edu/lorim/lori.html>  
Site about dendochronology, the dating of past events (climatic changes) through study of tree ring growth. Used extensively at Chaco Canyon to determine construction dates of buildings.

Southwestern Architecture  
<http://nmculturenet.org/features/swa/index.html>  
Site on Southwestern architecture with activities designed for students in grades 3-8.

## PARTICIPANTS IN THE FILM:

*(In order of appearance)*

**PAUL PINO** - Laguna Pueblo Tribal Council Member, and counselor at the Laguna Community Service Center.

He offered insight to the Chacoan people, based on his spiritual traditions at Laguna Pueblo.

**JOHN R. STEIN** - Supervisory Archaeologist with the Navajo Nation Division of Natural Resources, Chaco Protection Sites Program.

He studies the roads and buildings of Chaco Canyon and he has helped develop evidence of Chaco Canyon as a center of cosmologically designed buildings.

**MICHAEL P. MARSHALL** - Director of Archaeological Projects, Cibola Research Consultants.

He has studied Chaco Canyon as an archaeologist for over twenty years, and he believes that the buildings were intended for ceremonial purposes.

**RICHARD FRIEDMAN** - Director of Computer Services, County of McKinley, NM.

He used imaging technology called Geographic Information Systems (GIS) to study Chaco Canyon. Using infrared photography of the areas surrounding the large buildings, he determined that there were few full-time inhabitants in the canyon.

**ANNA SOFAER** - An artist who found the Sun Dagger petroglyph in 1977.

She conducted the research that showed the alignments of the Chacoan buildings to be astronomical through her organization, the Solstice Project. She is the producer, director, and co-writer of the film. She also produced and co-wrote the film, "The Sun Dagger."

**PHILLIP TUWALETSTIWA** - Geodesist, former Deputy Director of the National Geodetic Survey, and a member of the Hopi tribe.

He is a key member of the Solstice Project, who surveyed and determined astronomical alignments in the Chacoan buildings.

**EDMUND LADD** - Archaeologist, member of the Zuni Pueblo, Curator of Ethnology at the Laboratory of Anthropology, Museum of New Mexico.

He offered insight to the Chacoans, based on his studies of Puebloan tradition and his experience as a Zuni person.

**BILL STONE** - Surveyor with the National Geodetic Survey.

He assisted the Solstice Project in determining celestial alignments in the Chacoan buildings with exact surveys of their walls.

**CONNIE GARCIA** - Member of the Acoma Pueblo, and Coordinator at the Acoma Tribal Health Program.

She traveled to Chaco Canyon with Anna Sofaer and shared her experiences there as a descendant of the ancient Pueblo people.

**DAVID WARREN** - Ethno-historian and member of the Santa Clara Pueblo.

He shared his perspective on the topic of the oral tradition that organized the construction of Chaco Canyon.

**ADRIEL HEISEY** - Photographer who records desert landscapes from an ultra-light airplane.

He flew with Anna Sofaer to document Chaco Canyon's Great North Road.

**PETUUCHE GILBERT** - Tribal Council Member of Acoma Pueblo.

He shared his thoughts on the closing of Chaco, and the way that the Chacoan legacy is treated from a Pueblo perspective.

## GLOSSARY OF TERMS

Acoma	A Pueblo in northwestern New Mexico.
A.D.	anno Domini, the time after the birth of Christ.
Anasazi	Anglicized version of either the Navajo naassazi (ancestors), or Anaaʼsazi (ancient enemy). Name used to describe the Chacoan people. Now, the currently accepted term for the Chacoan people is Chacoan people or Ancestral Puebloan people.
archaeoastronomy	The scientific study of the practice of astronomy by ancient people.
archaeology	The scientific study of the life and cultures of past, especially ancient, peoples using remote sensing technologies and mapping as well as excavation of sites and artifacts.
Aztec	An ancient people of Central Mexico.
badlands	An area of barren land characterized by eroded ridges, peaks, and valleys.
butte	A hill rising abruptly above the surrounding area having sloping sides and a flat top.
Capaqueslsiliwa	The name for the Chacoan people in the A:shiwí language of the Zuni, meaning “the people who live in the round house.”
cardinal	Directed towards the four directions: north, south, east, and west.
Casa Rinconada	Spanish name for the great kiva meaning “house of corners.”
Chetro Ketl	Inside-Among-Rocks (Navajo).
cosmology	The study of the order and evolution of the universe.
equinox	Two midpoints in the Sun’s yearly cycle. In the Northern Hemisphere the vernal (spring) equinox occurs around March 21, the autumnal (fall) equinox around September 21. These are the days in the year when the hours of daylight are equal to the hours of the night.
ethnobotany	Ethnobotany is the study of the relationship between a people and local plant life.
Fajada Butte	The Sun Dagger site is near the top of this tower-like landform which dominates the center of Chaco Canyon.
geodesist	One who makes measurements of the Earth’s surface.
gnomon	A column on a sundial that casts a shadow indicating the time of day.
Great North Road	The 35-mile directional corridor that leads directly north from Chaco Canyon to the badlands of Kutz Canyon.
hearth	The stone or brick floor of a fireplace.
Hopi	A Pueblo in northeastern Arizona.

horizon	The line where the sky appears to meet the Earth.
infrared photography	A film process that can detect light rays beyond the red extreme of the visible spectrum. In Richard Friedman's research, the use of infrared enhances the image of charcoal content in the ground, which appears very dark.
Kin Bineola	House Where the Wind Whirls (Navajo).
Kin Kletso	Yellow House (Navajo).
Kin Klizhin	Black House (Navajo).
kiva	A room, usually circular and partially below ground used for ceremonial purposes.
latitude	Lines on a globe running parallel to the equator that measure distance north or south on the Earth's surface in degrees from the equator.
Laguna	A Pueblo in northwestern New Mexico.
longitude	Lines on a globe running perpendicular to the equator that measure distance east or west on the Earth's surface measured as an arc of the equator in degrees up to 180.
lunar	relating to the Moon.
Mayan	Native people of southern Mexico and Central America.
meridian	A great circle on the Earth's surface passing through the North and the South Poles and the observer's zenith.
Mesoamerica	An ethno-geographic area in Mexico and Central America, which includes Guatemala, Belize, the northwestern edges of Honduras and El Salvador, and the Mexican provinces of Yucatan, Quintana Roo, Campeche and part of Tabasco. Some scholars now include north and west Mexico as well.
metate	A stone with a flat or concave surface on which corn and grain can be ground using a smaller stone called a mono.
midden	In archaeology, a large mound, usually containing the refuse of an earlier culture.
mono	The smaller stone held by hand in the process of grinding corn or grain against a metate.
minimum or maximum lunar extremes	The far points in an 18.6-year cycle of the Moon, also called minor or major lunar standstills.
National Geodetic Survey	The National Geodetic Survey (NGS) is the U.S. government agency which measures latitude, longitude, height, scale, gravity, orientation, and shoreline throughout the United States.
North Star	Polaris, the star that marks the northern point of the Earth's axis.
oral history	The history of a culture carried through generations in speech and song.

Penasco Blanco	White Rock Point (Spanish).
petroglyph	A rock carving.
precession	In astronomy, a wobble in the axial spin of a planet caused by gravitational pulls.
Pre-Columbian	The time in the Americas before Columbus.
Pueblo	A communal village built of adobe or stone. A term used to describe the 21 Southwestern Native American tribes who are the descendants of the Chacoan people.
Pueblo Bonito	Beautiful Town (Spanish).
Pueblo Del Arroyo	Town of the Gully (Spanish).
Pueblo Alto	High Village (Spanish).
Pueblo Pintado	Painted Village (Spanish).
sextant	An instrument used to measure the altitude or angular distance of an astronomical body to the horizon.
solar	relating to the Sun.
solstice	Extreme points in the Earth's yearly orbit around the Sun. Summer solstice near June 21, is the day with the most daylight in the year; winter solstice around, December 21, is the day with the least amount of daylight in the year.
Solstice Project	The organization formed by Anna Sofaer to conduct research on the astronomical expressions of the Chacoan culture.
Sun Dagger	The name given to the petroglyph found by Anna Sofaer on Fajada Butte in 1977. A spiral rock carving on which a dagger of light falls to mark points in the solar cycle, and on which shadows fall to mark the lunar cycle.
time-lapse photography	A technique of photographing a slow process on motion picture film by exposing single frames at widely spaced intervals, and thus speeding up the action to show movement.
Tsin Kletsin	Black Wood or Charcoal Place (Navajo).
Una Vida	One life (Spanish).
Zuni	A Pueblo in northwestern New Mexico.

## NATIONAL STANDARDS

The National Standards addressed for Social Studies include experiences that provide for:

The study of culture and cultural diversity so that the learner can:

- Analyze and explain the ways groups, societies, and cultures address human needs and concerns;
- Predict how data and experiences may be interpreted by people from diverse cultural perspectives and frames of reference;
- Apply an understanding of culture as an integrated whole that explains the functions and interactions of language, literature, the arts, traditional beliefs and values, and behavior patterns;

The study of the ways human beings view themselves in and over time so that the learner can:

- Demonstrate that historical knowledge and the concept of time are socially influenced constructions that lead historians to be selective in the questions they seek to answer and the evidence they use;
- Apply key concepts such as time, chronology, causality, change, conflict, and complexity to explain, analyze and show connections among patterns of historical change and continuity;
- Identify and describe significant historical periods and patterns of change within and across cultures, such as the development of ancient cultures and civilizations, the rise of nation-states, and social and economic, and political revolutions.

The study of people, places, and environments so that the learner can:

- Refine mental maps of locales, regions, and the world that demonstrate understanding of relative location, direction, size, and shape;
- Create, interpret, use and synthesize information from various representations of the Earth, such as maps, globes, and photographs;
- Use appropriate resources, data sources, and geographic tools such as aerial photographs, satellite images, geographic information systems (GIS), map projections, and cartography to generate, manipulate, and interpret information such as atlases, data bases, grid systems, charts, graphs, and maps;
- Use of knowledge of physical system changes such as seasons, climate, and weather, and the water cycle to explain geographic phenomena;
- Examine, interpret, and analyze physical and cultural patterns and their interactions, such as land use, settlement patterns, cultural transmission of customs and ideas, and ecosystem changes;
- Describe and assess ways that historical events have been influenced by, and have influenced physical and human geographic factors in local, regional, national, and global settings;
- Analyze and evaluate social and economic effects of environmental changes and crises resulting from phenomena such as floods, storms, and drought.

The study of relationships among science, technology, and society so that the learner can:

- Identify and describe both current and historical examples of the interaction and interdependence of science, technology, and society in a variety of cultural settings;
- Make judgments about how science and technology have transformed the physical world and human society and our understanding of time, space, place, and human-environment interactions;
- Analyze how science and technology influence the core values, beliefs, and attitudes of society, and how core values, beliefs, and attitudes of society shape scientific and technological change;
- Evaluate various policies that have been proposed as ways of dealing with social changes resulting from new technologies such as genetically engineered plants and animals;
- Recognize and interpret varied perspectives about human societies and the physical world using scientific knowledge, ethical standards, and technologies from diverse world cultures.

The study of the ideals, principles, and practices of citizenship in a democratic republic so that the learner can:

- Analyze and evaluate the influence of various forms of citizen action on public policy;
- Analyze a variety of public policies and issues from the perspective formal and informal political actors;
- Evaluate the effectiveness of public opinion in influencing and shaping public policy development and decision-making;
- Construct a policy statement and an action plan to achieve one of more goals related to an issue of public concern.

(See Social Studies Standards In **Expectations of Excellence: Curriculum Standards for Social Studies** Silver Spring: National Council for the Social Studies. Available for purchase through their publications department 1-800-683-0812.)

**The National Standards addressed for Science include that the student:**

- Knows how the regular and predictable motions of the Earth and the Moon explain phenomena on the Earth such as the day, the year, seasons, and phases of the Moon, eclipses, tides, and shadows.
- Knows characteristics of the Sun and its position in the universe.
- Understands the nature of scientific explanations; for example, use of logically consistent arguments, emphasis on evidence, use of scientific principles, models, and theories, acceptance or displacement of explanations based on new scientific evidence.

(See Content Standards at: <http://www.nap.edu/html/nse/html/6d.html#hn>)

**The National Standards addressed for Language Arts include:**

- Students adjust their use of spoken, written, and visual language to communicate effectively with a variety of audiences and for different purposes.
- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.
- Students use a variety of technological and information resources (e.g., libraries, data bases, computer networks, film) to gather and synthesize information and to create and communicate knowledge.
- Students use spoken, written, and visual language to accomplish their own purposed (e.g., for learning, enjoyment, persuasion, and the exchange of information).

(See Standards for the English Language Arts at: <http://www.ncte.org/standards/standards.html>)

**The National Standards addressed for Geography include knowing and understanding:**

## The World In Spatial Terms

- The characteristics and uses of maps, globes, and other geographic tools and technologies;
- The location of places, geographic features, and patterns of environment;

## Places and Regions

- The concept of regions;
- That culture and experience influence people's perceptions of place and region.

## Human Systems

- The nature, distribution, and migration of human populations on the Earth's surface;
- The nature and complexity of the Earth's cultural mosaics;
- The patterns of human settlement and their causes.

## Environment and Society

- The changes that occur in the meaning, use, distribution, and importance of resources;
- How geography is used to interpret the past.

(See Geography Standards at: <http://www.mcrcel.org/compendium/Standards.asp?SubjectID=8>)

**CREDITS**

This Study Guide was written by Matt Dibble, Anna Sofaer, and Jacqueline Newell. Chris Sims, Brian Bielenberg, Lois Hirst, John Hoskyns-Abrahall, and Debbie Scherrer contributed generously to the Guide. Lars Rahm inspired some of the Earth and Space Science Activities.

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THE MYSTERY OF CHACO CANYON is based on the research of Anna Sofaer, Rolf Sinclair, Phillip Tuwaletstiwa, Michael Marshall, and John Stein.

## TEACHER COMMENTS

The Solstice Project hopes that you found the Study Guide useful. In order to help us organize teacher training and with the hope of a second edition, please let us know what was useful, not, and even in between as well as any inspirations you have about the material. Please return this sheet to:

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Washington, DC 20016

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What Activities in the Study Guide for The Mystery of Chaco Canyon Did You Do?

What Questions Do You Have About Any of the Activities or Text?

What Activities or Text Would You Exclude or Change and How?

What Activities or Text Do You Want Included in a Second Edition?



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