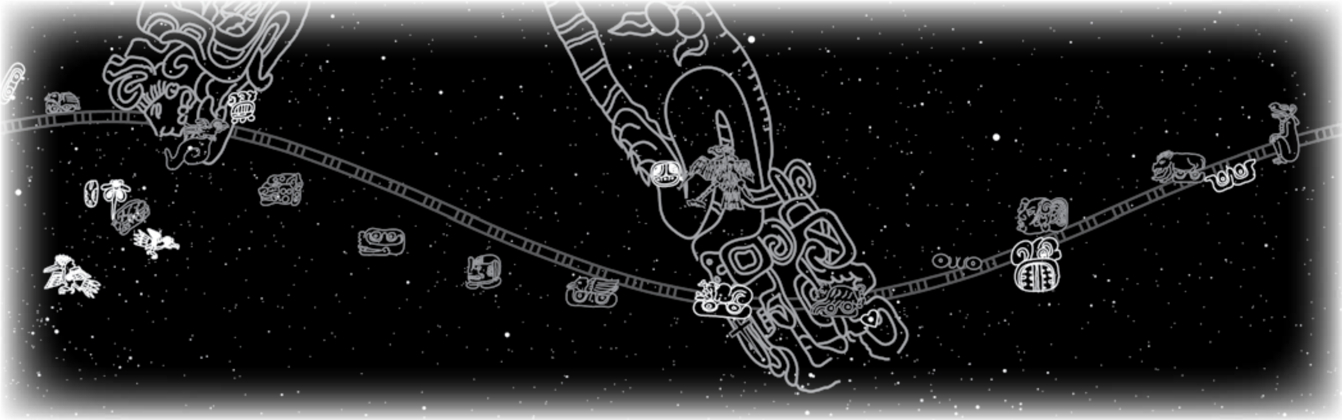


A Collection of Curricula for the STARLAB Maya Skies Cylinder

Including:

The World of the Maya by Eileen M. Starr, Ph.D.

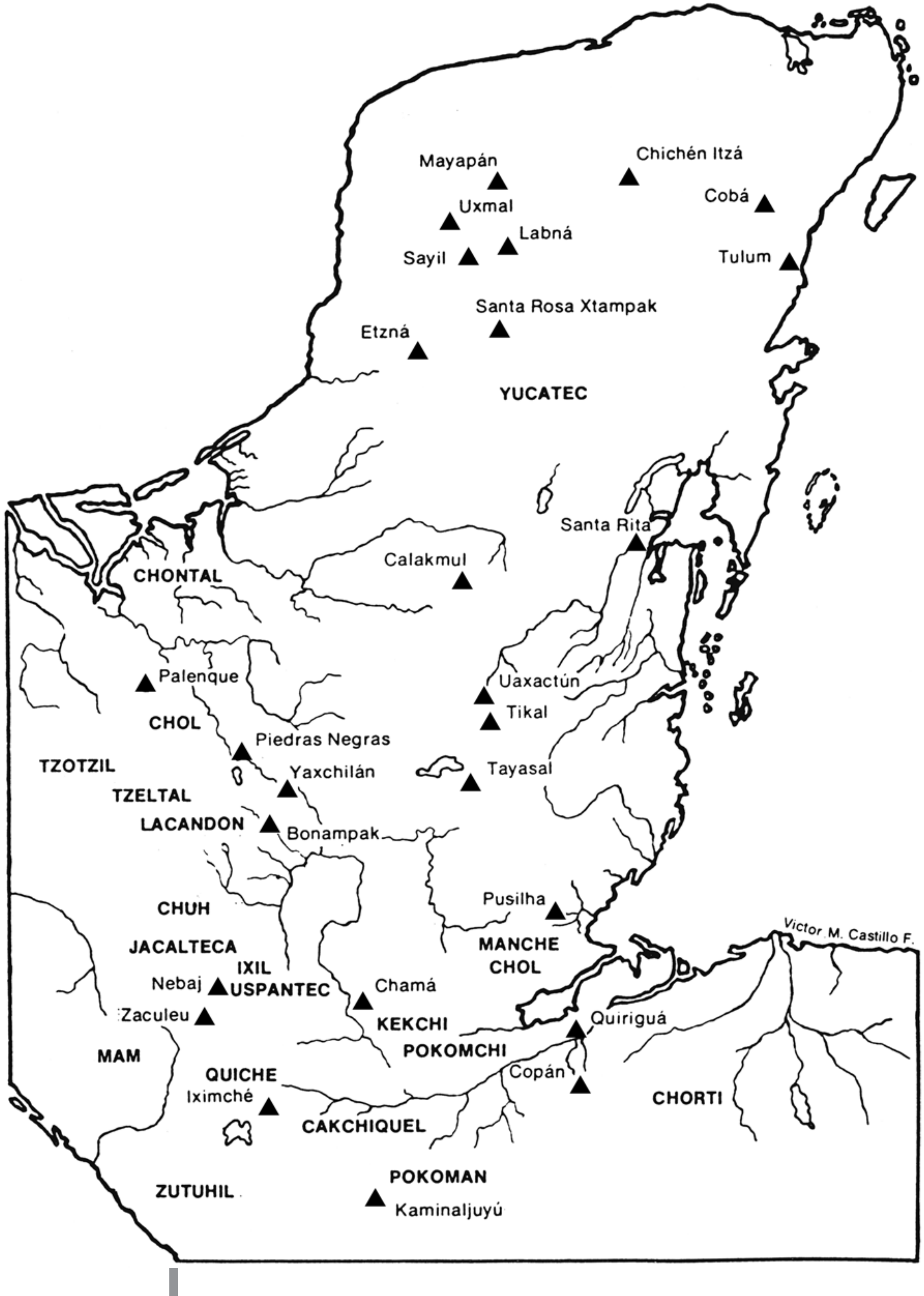
Curriculum Guide Contents

The World of the Maya

The Caracol "Observatory" at Chichen Itza

Contributed by Eileen M. Starr, Ph.D.

The Maya World Map



Matrix of National Standards Addressed in this Curriculum

Activity #	Description of Activity	STARLAB Activity	National Science Standard	National Geography Standard	National English Language Standard	National Art Standard	National School Mathematics Standard
01	Sky Comparison	X	Changes in Sky				
02	Writing				9		
03	Arithmetic						Numbers Operations
04	Book			10	6		
05	Dresden Codex		History	6	6	Exemplary Art	
06	Quarters of Universe				2		
07	Madrid Codex			6	3	Exemplary Art	
08	Sun	X	Changes in Sky				
09	Moon Glyphs		Objects in Sky				
10	Rabbit on Moon		Objects in Sky	4			
11	Eclipses		Objects in Sky				
12	Maya Glyphs		Measurement		1		
13	Calendar		Models		3		
14	Correlating Calendars		Science Inquiry				Pattern Recognition
15	Venus Motions		Motion				
16	Venus Brightness		Changes in Sky				
17	Venus Rise & Set	X	Science Inquiry				
18	Milky Way	X	Position				
19	Stars		History				
20	Maya Zodiac	X	Systems				
21	Pleiades	X	Position				
22	North Star		Changes in Sky				
23	Big Dipper	X	Human Endeavor				
24	Northern Cross	X	Systems				
25	Thieves Cross	X	Objects in Sky				

Pronunciation Guide for Maya Words

Vowels

Maya vowels are pronounced like the vowels in Spanish:

- ***a*** is like the a in "father"
- ***e*** is like the e in "heh!"
- ***i*** is like the double ee in "tree"
- ***o*** is like the o in "hello"
- ***u*** is like the double oo in "zoo"

At the beginning or end of a word, a ***u*** acts like the English letter ***w***. For example ahau is pronounced 'ah-ahw'.

Each vowel is a separate syllable.

Consonants

Maya consonants are pronounced a little different from both English and Spanish consonants.

- The letter ***b*** when at the end of a word is pronounced as a p. It is pronounced stronger than a Spanish b.
- The letter ***c*** is always pronounced like the English k. For example, cauac is pronounced 'kauak'. A final c is very soft.
- The letters ***ch*** are pronounced as 'tsh'.
- The letter ***j*** is always pronounced as a hard h. For example Jaina is pronounced 'Haina'.
- The letter ***l*** is almost silent at the end of a word.
- The letters ***pp*** are pronounced as a explosive p.
- The letters ***th*** are pronounced as an explosive t.
- The letters ***ts*** are pronounced as the first ch in 'church'.
- The consonant ***tz*** or ***dz*** is pronounced just as it looks.
- The letter ***x*** is pronounced sh. For example, Xaman Ek is pronounced 'shah mahn Eek'.
- The accent in Maya words almost always falls on the last syllable. For example, Pacal is 'Pa-cal', Baktun is 'Bak-tun'.

  Note

  Anything to do with people, their cultures, civilizations, literature and artistic products are referred to as ***Maya****. The adjective Mayan refers exclusively to the various languages of the Maya people.*

Student Activity

Practice pronouncing the day and month glyphs found in Activity 5.

Maya Narrative

Maya Location and Geography

Maya civilization, during the time of its greatest expansion, occupied an area of Central America of about 125,000 sq. miles. This is about the size of the state of New Mexico, or the country of Norway. The Maya empire included the present areas of Guatemala, Belize, the western part of the Republic of Honduras, the Mexican states of Chiapas, and the Yucatan peninsula.

The northern lowland Maya occupied the northern part of Yucatan. The southern lowland Maya occupied the southern area of Yucatan, and the highland Maya occupied the other areas. ***[See Activity 01: Comparison of the Maya Sky to Your Sky.]***

The land of the Maya extended between the 13th and 22nd parallels. Because Mayapan and Chichen Itza, two major centers of the lowland Maya, are located at the latitude of 21 degrees north, about 20 degrees North may be used as the representative latitude for the STARLAB. No sections of the continental United States extend this far south.

Maya History

Although the pre-classic Maya civilizations began before 300 B.C., the Maya became known to Europe in the year 1502 with Christopher Columbus' fourth voyage to the New World. He landed at Guanaja, off the coast of Honduras, where he met a Maya trading party.

In 1511, a ship ran onto reefs off Jamaica, and twenty men drifted in an open boat for thirteen days until they came upon Cozumel Island off the coast of Yucatan. The Maya inhabitants put all of the shipwrecked survivors, except two, to death. The two survivors were traded as slaves. Hernando Cortez rescued one of the survivors eight years later. Because of his knowledge obtained while a captive, he helped Cortez defeat the Aztecs in Mexico. The other survivor helped the Maya against the Spanish.

The official Maya conquest by the Spanish lasted nineteen years, from 1527 until 1546, but was not completed until 1697, one hundred fifty years later. Most of our written records of Maya civilization came from the Spanish Conquistadors and the Catholic clergy sent to Christianize the Maya.

The most notable writings come from Fray Diego de Landa, a Franciscan missionary, who was sent to Yucatan in 1649. He became adept in the Maya language and is the principal, somewhat objective, source of late Maya history. It is from his writings that we can date Maya history into the European calendar. ***[See Activity 02: Maya Writing System.]***

Maya archaeology begins in 1773 with the discovery of the ruins of the city of Palenque in the jungles of Chiapas in southern Mexico. This city was apparently abandoned in the ninth century, A.D. In the two centuries that have passed since the discovery of Palenque, a tremendous amount of literature has been collected about Maya sites.

The earliest known Maya civilization is found in the lowland areas of the Yucatan and Guatemala, which alternate between rain forests with low seasonal swamps, and high bush areas with savannahs of tall grass. This area is similar to Florida, only warmer. The land first appears not to be ideal for the maintenance of a high technology civilization. However, the forest supplied food in the form of birds and animals, which supplemented the Maya corn-based agriculture. The forest also supplied the raw materials for building mats, canoes, dye, and other necessities.

There are no rivers in the Yucatan, and so the Maya constructed reservoirs and cisterns. In northern Yucatan, cities developed around natural sink holes.

From archaeological evidence, the ancestors of the Maya, about 2300 years ago or 300 B.C., had agriculture, trade, glyph writing, and a calendar based on twenty-day months. This was the beginning of the Classic period in Maya history. The Maya numbering system used a base of 20, the number of fingers and toes, rather than the base 10 system we now use. ***[See Activity 03: Maya Arithmetic.]***

Expansion of the Maya into additional lowland sites began about the mid 3rd A.D. century and the Classical Period of the Maya had begun. By the turn of the 10th century, many of the Lowland Maya sites were abandoned to the forest, until found by archaeologists. Until we can decipher the glyphs found in the ruins, we can only ponder the fate of this culture. Basic theories for the decline are: internal social conflict; invasion by Mexicans from Vera Cruz; agricultural problems, or a combination of these.

Early in the tenth century, the Maya-speaking Itzas who were related to the Mexican Toltecs, began moving across Yucatan where they came upon the ruins of a decaying city. The Itza rebuilt the city, named it Chichen Itza, and made it their ceremonial center. The name of the previously abandoned city is not known, but Chichen Itza literally means "the mouth of the well of the Itza." The Itza formed a league of Maya states, and erected a new city, Mayapan, as the capital. However civil war continued among the Maya, and by the year 1441, Mayapan and the power-base of the Lowland Maya were destroyed. However, the Highland Maya continued to live in southern Mexico and surrounding lands.

Within the ruins of the Maya civilization are found over one thousand stelae and altars covered with glyphs. These glyphs, most of which cannot be translated, do show that time was an all-consuming interest to the Maya. Apparently glyphs were erected every five or ten years, much in the same way we now dedicate a monument. Inscribed on the monument was the date, the age of the moon, and the gods then ruling.

The Maya also constructed books, but only about 40% of the existing Maya texts have been deciphered, and these glyphs are the ones that deal with dates and calendration. Those that deal with ritual and history cannot yet be decoded. There are only three surviving pre-conquest Maya books although hundreds once existed. According to Diego deLanda, the rest of the books were burned by the Spanish Friars in 1562 in an attempt to stamp out the worship of idols. ***[See Activity 04: Making a Maya Book.]***

One of the three surviving books is the astronomical *Dresden Codex*, so named for its current location, the Royal Library in Dresden where it was brought in 1739. About half of the glyphs can be deciphered in this astronomical almanac, including three centuries of observations of the planet Venus. The other two existing books are the *Codex Tro-Cortesiono* located in Madrid, also called the 'Madrid Codex', and the *Codus Peresiaus*, in Paris, also called the 'Paris Codex', which is ritualistic in content. ***[See Activity 05: The Dresden Codex.]***

Some books were written after the Spanish Conquest. The *Books of Chilam Balam* were written between the mid-16th and late 18th century. The Maya priests dictated from the books that were not burned and had a bilingual scribe set down the information in European script.

Maya Structure of the Universe

According to the translated glyphs, the Maya had a very complicated cosmology. There were three main areas to their universe: the earth which was the visible domain of the Maya people; the sky above, the invisible realm of the celestial deities; and Xibalba below, the invisible realm of underworld deities. The earth was situated on the back of a huge reptile, either a caiman or a turtle that swam in an ancient sea. Mountains were formed from the ridges on the back of the reptile.

They believed that the sky was divided into thirteen areas, which resembled a Maya pyramid. Each area had several gods that resided at each area. These thirteen areas were arranged in steps, six ascending upward on the east and six descending downward to the west. The seventh area was at the top. The areas were so arranged that compartments one and thirteen were on the same level, as were two and twelve, etc. Four gods, the Bacabs, who stood at the four sides of the world, sustained the sky. ***[See Activity 06: The Quarters of the Universe. See Activity 07: Madrid Codex Calendar.]***

There were five directions in the Maya world. At the center of the world was the great tree of life, a ceiba tree, whose roots were in Xibalba, and whose branches reached the sky. Almost all of Maya religion and much of the calendar was connected with a world direction and color, which corresponded to that direction.

It appears that the Maya believed that there were nine underworlds in Xibalba, which were stepped, just like the sky. The fifth underworld was the bottom-most. Caves, common in the limestone in the lowlands, were considered the way to enter Xibalba. Most Maya gods were in groups of four, each associated with world direction and color. The gods of each group could be regarded either as individuals or collectives, and could have both good and bad aspects. Gods could change their locations and resulting associations.

The sun, called Kinich Ahau or the sun-eyed lord, and the moon were the most important o the celestial deities. The sun god was naturally, a sky god, but at night he passed into the underworld to become one of the lords of the night. He emerged at dawn with the insignia of death. To show him during his journey through the underworld, it was necessary to add attributes such as those of the jaguar, or black, the color of the underworld, or maize foliage, which also denoted the surface of the world and underworld. ***[See Activity 08: Sun.]***

Sun and moon, before they were translated to the sky, were the first inhabitants of the world. The moon's light is less bright than that of the sun because the sun pulled out one of her eyes.

Likewise celestial dragons could become terrestrial monsters. This makes the interpretation of Maya religion very difficult. It appears that Maya gods were a combination of the features of animals and plants but having a human aspect. ***[See Activity 9: Interpreting Moon Glyphs. See Activity 10: Rabbit on the Moon.]***

From repeated observations of the sun and moon, the Maya were able to predict eclipses of the moon and sun. They believed that an eclipse was due to a fight between the sun and moon. The eclipse god was named Kolop-u-uich-kin, wounder of the eye of the sun. Ants nibbling at the sun caused an eclipse of the sun. ***[See Activity 11: Eclipses. See Activity 12: Maya Glyphs.]***

Maya Calendar

Among the Maya, the days themselves were divine. Each day was not merely influenced by a god, it was a pair of gods, for each day was a combination of a number and a name, such as 1 Ik, 3 Ahau, or 17 Pap. Time had no beginning and was everlasting. Although they did have a certain date from which calculations were made, the Maya also believed that time was cyclical, and that history repeated itself, and that the future was predestined. ***[See Activity 13: The Maya Calendar.]***

Currently much of the world uses just one calendar, the day-count calendar which forms years, decades, and centuries. The Maya had five different calendars. To be sure that the calendars were correct, it appears that astronomical data was exchanged between ceremonial centers.

The Maya conceived of the divisions of time as burdens carried through all of eternity by relays of divine bearers. The burdens came to signify the expected good or ill fortune of the year according to the benevolent or malevolent aspect of the bearer god. The burden of one year was drought, another that of good harvest. If the year began with the day Kan, one could look forward to a good crop because Kan was an aspect of the maize god. On the contrary, the day gods Ix and Cauac were bad, so years beginning with these days would be disastrous. However, too literal an acceptance of predestination would affect the welfare of the whole community. There wouldn't be much point in planting a crop if drought was certain to destroy it. Priests would also lose public support unless they could hedge on their predictions. The priests had to master astronomy for astrological ends, and the more factors, such as gods, that could influence their predictions, the more complex the problem grew and the greater the dependence of the community on the priests' specialized knowledge. It was in the attempts to find a key to the conflicting influences of the gods of the many cycles of time, that the Maya had their greatest intellectual successes. If a priest knew what happened in the past, and he did from reading the ancient books, then he knew what would happen this year. The details within a year would vary, but the broad outline of events would follow an established pattern. ***[See Activity 14: Correlating Calendars.]***

The idea of predestination helped defeat the Maya. The Spanish became familiar with the calendar and how to use the predictions. The Spanish convinced the leaders of the Itza, and the Maya people, that only a short time remained, until, according to the ancient prophecies, political change would occur. That political change, according to the Spanish, was the acceptance of Christianity. The Itza were noted warriors but they put up a very poor fight against the Spanish. Why should they fight when the outcome was already known?

Maya Planets, Stars, and Constellations

Among the dwellers of the skies, the deities of the planets were of great importance, and Venus was of supreme importance. Glyphs on the wall of the Palace in Palenque may indicate that this building was an astronomical observatory as well as the administrative heart of the city. The Caracol at Chicken Itza was an observatory. Window openings off of the spiral stairway inside the dome define astronomical lines of sites. The *Dresden Codex* contains a table devoted to the position of Venus, which appears to predict the rising of the planet with the sun each 584 days. Because every moment of Maya life involved the position of the planets, they believed if these gods were not appeased, the end of the world would come again. ***[See Activity 15: The Motions of Venus. See Activity 16: Changes In the Brightness of Venus. See Activity 17: The Changing Rise and Set Points of Venus.]***

The Milky Way, a celestial dragon with two heads, was very important to the Maya, and they watched for when the planets resided among the linear white path in the night sky. ***[See Activity 18: The Milky Way Dragon.]***

Although the Greek constellations names are used to describe the position of Maya star groups, the Maya used very different star groupings, which were associated, in a general way, with the seasons. Maya constellations refer to a general area of the sky. The star names, however, refer to the specific star. ***[See Activity 19: Stars.]***

There were thirteen animal constellations in the Maya zodiac, each of which holds the sun in his mouth. No one archaeological site contains all of the glyphs of the zodiacal constellations, and many of the glyphs are eroded or worn beyond recognition. There is still disagreement among Maya scholars concerning these constellations. ***[See Activity 20: The Maya Zodiac. See Activity 21: Pleiades.]***

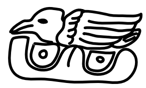
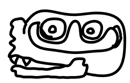
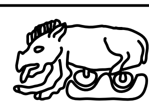
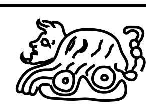
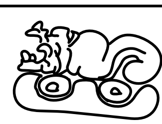
The North Star, located about 20 degrees above the horizon was Xamann Ek, and was used for coastal navigation which was only done at night in dire emergencies. The stars of the Greek constellation Ursa Minor were the guards of the North. ***[See Activity 22: The North Star of the Maya.]***

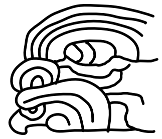
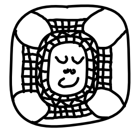
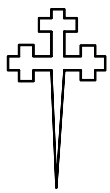
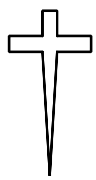
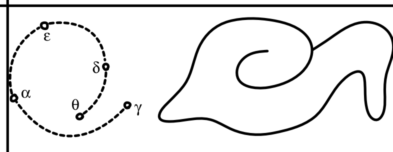
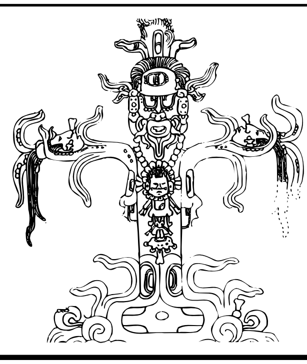
The Big Dipper was Seven Macaw, a parrot who lived in the Cosmic Tree. ***[See Activity 23: Seven Macaw (The Big Dipper).]***

To the Maya, the Northern Cross was a maize plant which is similar to the plant we call "corn". Maize is the most important food item in the Maya diet. The Maya book, the *Popul Vuh*, describes the creation of the first humans by the Corn God from the combination of maize planted in soil, which was then nourished by water. Currently the Maya see three crosses in the night sky. One would be the Northern Cross, the other two are called the "thieves cross" or the "thieves dagger". ***[See Activity 24: The Northern Cross. See Activity 25: The Thieves Crosses.]***

(These are shown in green on the cylinder.)

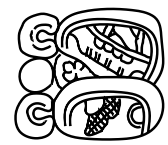
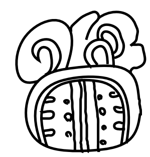
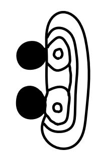
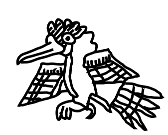
Maya Constellations Guide

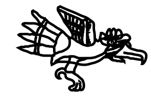
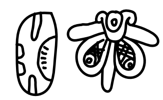
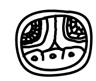
Maya Zodiacal Constellation	Glyph	Western Zodiacal Constellation	Solar Conjunction at A.D. 0
Bird 3		Capricornus	January
Bat		Aquarius	February
Skeleton		Pisces	March
Ocelot/Jaguar		Aries	April
Rattlesnake		Pleiades in Taurus	April to mid May
Turtle		Orion	May to mid June
Bird 2		Gemini	June
Frog		Cancer	July
Peccary		Leo	August
Moon Goddess?		Virgo	September
Bird 1		Libra	October
Scorpion		Scorpius	November
Fish-snake		Sagittarius	December

Maya Constellation Name	Glyph	Western Constellation Name	Reference
Quiche Maya **Seven Macaw**		**Ursa Major** **(Big Dipper)**	**Milbrath p. 274**
Shield		**Ursa Minor** **(Little Dipper)**	**Milbrath p. 273**
Quiche Maya **Hawk** **Xik**		**Aquila**	**Tedlock p. 29**
Thieves Cross 1 **Yucatec Maya** **Crux ek**		**Crux**	**Milbrath p. 271**
Thieves Cross 2 **Quiche Maya** **Repib' al elaq' omab'**		**Sagittarius**	**Tedlock p. 29**
Head of the Rattlesnake		**Perseus**	**Milbrath p. 259**
Wedding Party **Los Casorios** **Cakchiquel,** **Conch** **Maya**	 **Alpha (Aldebaran): the Godfather** **Epsilon Tauri: The Godmother** **Theta & Delta: The Couple** **Gamma: The Priest**	**Taurus**	**Remington p. 83**
Maize Plant		**Cygnus**	**Milbrath p. 271**

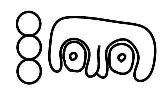
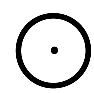
Maya Star Names Guide

(These are shown in yellow on the cylinder.)

Current Star Name	Greek Constellation Name	Maya Star Name	Meaning of Name	Reference Source	Glyph
Regulus	Leo	Quiche Maya hun ch'umil	One star	Remington p. 84	
Capella	Auriga	"Announcer Star"	When it rose at sunrise it announced the zenith passage of the sun.	Aveni 1977	
Spica	Virgo	Quiche Maya "pix"	Spark	Tedlock 1992, p. 29	
Castor/Pollux	Gemini	Quiche Maya Kib'chuplinik	Two shiny ones	Remington p. 84	
Alnitak/Saiph/ Rigel	Part of Orion	Tzotzil Maya 'osh-lot	Three big stars	Milbrath p. 252	
Polaris	Ursa Minor	Lacandon Maya Xaman Ek	Star of the North	Milbrath pp. 39, 253	
Antares	Scorpius	Tzotxzil Maya	Heart of the Scorpion	Milbrath p. 39	
Sirius	Canis Major	Lacandon Maya "ah ch'uhum"	Big woodpecker	Milbrath pp. 39, 253	

Current Star Name	Greek Constellation Name	Maya Star Name	Meaning of Name	Reference Source	Glyph
Rigel	Orion	Lacandon Maya "Tunsel"	Little woodpecker	Milbrath pp, 39, 253	
Theta Tauri	Taurus	Lacandon Maya Chamuhuy	Small bird	Milbrath p. 253	
Pleiades	Taurus	Motz	"Handful"	Milbrath p. 253	
Betelgeuse	Orion	Lacandon Maya Chak tulix	Red dragonfly	Milbrath p. 39	
Altair	Aquila	Quiche Maya Sk ek'ap	"Giving notice of the night"	Remington p. 85	

(Additional stars, not included on the cylinder.)

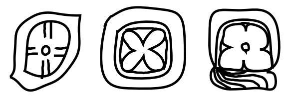
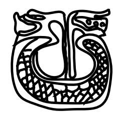
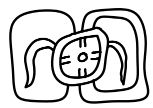
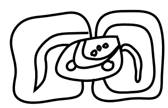
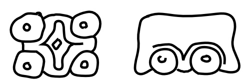
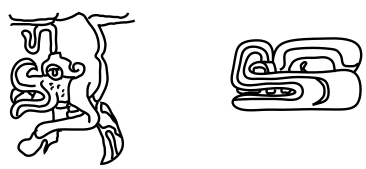
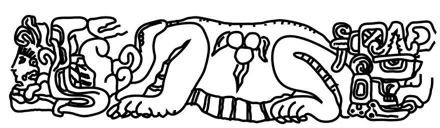
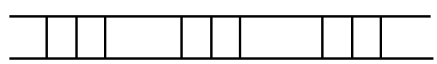
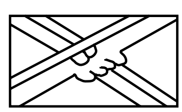
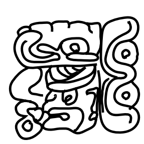
Orion's Belt	Orion	Tzeltal Maya "oktu rey"	Three stars	Milbrath p. 39	
Alpha Crux	Crux	Quiche Maya Xukut ch'umil	One of the "Corner Stars" (along with Polaris	Tedlock p. 39	

(These are shown in red on the cylinder.)

Venus Maximum Brightness	
Venus Maximum Elongation East of the Sun	VME

Maya Sun, Moon, & Other Glyphs Guide

(These are shown in red on the cylinder.)

Object	Maya Name	Glyph	Reference Source
Sun	Kinich Ahau		Longhena p. 130
Moon	Ix Chel		Henderson 1981
Solar Eclipse			Bricker & Bricker 1992
Lunar Eclipse			Bricker & Bricker 1992
Venus	Choc ek: Morning Star		Aveni 1980
Mars			Longhena p. 136
Milky Way	Cosmic Monster Saki be: Summer Xibalba be: Winter		Milbrath pp. 275, 287
Ecliptic	Sky Rope tamacz		Milbrath p. 282
Planet Conjunction	Cross band glyph		Gates p. 137
Comet	Quiche Maya Uje ch'umil "tail of the star"		Kelley p. 39

Activity 01: Comparison of the Maya Sky to Your Sky

MATERIALS

- STARLAB Portable Planetarium
- Maya Cylinder

Introduction

As you change latitude on the earth, the stars that are visible also change, as does their motion. At the Poles, a limited number of constellations are visible. They are circumpolar (neither rise or set) whenever it is dark, and move around the North Celestial Pole in a circle. At the equator all of the constellations are visible, and none are circumpolar as they all appear to rise and set. The latitude of the major ceremonial centers of the Maya were between 15 and 20 degrees north.

Objective

Observe compare and describe the changes between the Maya and your night sky.

Integrated Subjects

Science

Process Skills

Pattern recognition, compare and contrast.

National Science Standard

Earth and Space Science – Changes in the sky.

Procedure

- Set the STARLAB for your latitude and watch how the stars move throughout the night. Describe this motion. Move throughout another night and watch how the Milky Way appears and disappears. Describe the change.
- Move the STARLAB to 20 degrees north latitude. How is the motion of the stars the same? (Note that the stars rise and set almost vertically at 20° N.) How is the motion different? How is the position and the motion of the Milky Way the same? Different? Does the Milky Way look different in appearance at your latitude? If so, describe the difference.

MATERIALS

- de Landa alphabet
- paper
- pencils

Activity 02: Maya Writing System

Introduction

Maya writing is a combination of phonetic signs and logographs or word signs. Phonetic signs represent syllables that consist of a consonant and a vowel, which were put together to spell out words. Logographs represent entire words and sometimes resemble the words they represent. The Maya used both phonetic signs and logographs which were written together in a variety of combinations depending on the scribe.

The interpretation of Maya hieroglyphs was made easier because one of the Spanish clergy, Bishop Diego de Landa, recorded the information he received from a literate Maya man, Gaspar Antonio Chi, who explained the hieroglyphic writing. Chi wrote an incomplete list of syllabic signs and the names for the months and days, which, later, made it possible to understand the glyphs that had to do with calendration.

Maya writings are in columns and are read from left to right, and from top to bottom.

This is Bishop de Landa's Alphabet (Sharer).

Objective

To write in the Maya language.

Integrated Subjects

English Language Arts • Art

Process Skills

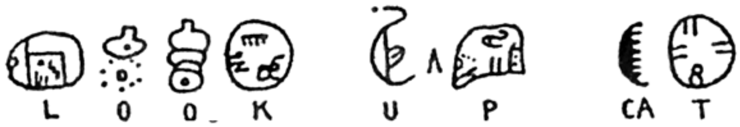
Hand-eye coordination.

National English Language Arts Standard 9

Students develop an understanding of and respect for diversity in language use, patterns and dialects across cultures, ethnic groups, geographic regions, and social roles.

Procedure

- Using the de Landa alphabet, create simple words and phrases in English. An example might be:



Look up cat.

Bat a ball.

- Have the students create English words using the Maya alphabet, without having the English letter below.
- Have the students exchange their work with another. Can others read the glyphs?

Activity 03: Maya Arithmetic

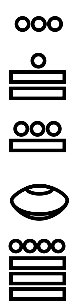
Introduction

Maya mathematics was based on a base twenty system (fingers and toes), rather than the Base 10 system (fingers), which is used throughout most of the world now.

The most common method of writing numbers used a dot for one, and a bar for five. For numbers more than nineteen, they placed a notation for zero, a stylized shell, below the first number. The values of the places increase by 20 as you read up the column. The third place would be 400 except for measurements of time, which used the third place as 360.

From early writings at Monte Alban (275 BC), archaeologists can tell that the bar was derived from an extended finger. The dots may represent the tips of the fingers. This was one of the few civilizations in the world that understood the concept of zero.

The Maya also used place values for larger numbers, but their place values were determined by the vertical placement of numbers rather than the horizontal placement in Arabic notation today.



highest place	$(20)^4$	=	3	x	160,000	=	480,000
	$(20)^3$	=	11	x	8,000	=	88,000
	$(20)^2$	=	8	x	400	=	3,200
	$(20)^1$	=	0	x	20	=	0
lowest place	(1)	=	19	x	1	=	19

For example:

From Aveni, 2001, p. 134. The sum of the numbers in the right-hand column is 571,219 in Arabic notation.

Objective

To understand and write Maya numbers.

Integrated Subjects

Language Arts • Mathematics

Process Skills

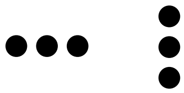
Manipulating numbers using a different Base System, understanding systems.

National Mathematics Standard

Number and Operations — Instructional programs from prekindergarten through grade twelve should enable all students to understand numbers, relationships of numbers, and number systems.

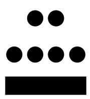
Procedure

- To write the number 3, three dots would be placed in a row, either horizontally or vertically.



- For the number 21, the Maya placed a zero (a shell glyph) in the 1-19 place, and one dot above.

- For 49, the Maya would use:

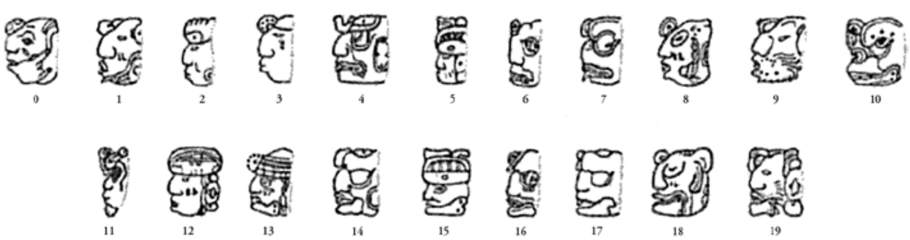


= 20 + 20 or 40
= 4 + 5 bottom bar and dots above it = 9

- Add 12 plus 12:

  Why is the shell needed in the total?

- Another way to write the numbers between 1 and 19 is to use face glyphs:



  Each number from one through twelve is represented by a distinct face, while the glyphs for thirteen through nineteen are formed by taking the sign for ten (jaw) and adding it to the heads of the numbers that represent three through nine.

- How would you write your age in bars and dots both horizontally and vertically?
- Which face would you draw to indicate your age?
- Ask an adult for their age, and write the age in Maya numbers.
- Make up your own arithmetic problems and see if others can solve them.

MATERIALS

- one 8.5 x 14-inch paper per student
- soft cardboard
- paint or crayons

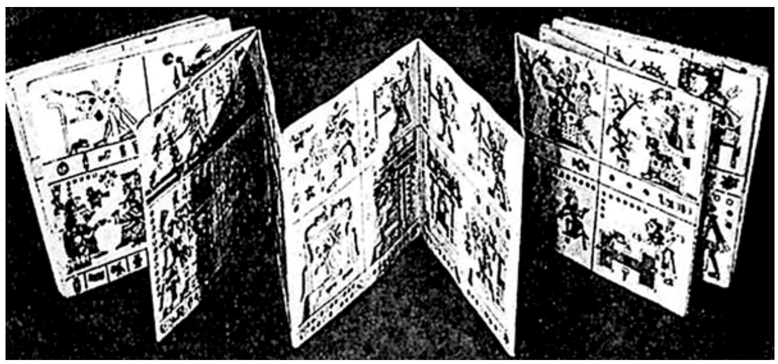
Activity 04: Making A Maya Book

Introduction

There are only three surviving pre-conquest Maya books although hundreds once existed. The books are:

- The *Dresden Codex*
- The *Codex Tro-Cortesiono*, (also called the *Madrid Codex*)
- The *Codus Peresiaus*, or the *Paris Codex*.

A book was written on a large sheet of lime-coated inner bark cut from the roots of the amate (tropical fig) tree. The glyphs and drawings were painted with vegetable dyes. The writing was done in columns, and on both sides of the sheet. The sheet was then folded accordion-style and enclosed between two decorated boards.



The photograph above shows how a Codex was written

Objective

To create a Maya book.

Integrated Subjects

Science • Art • Language Arts

Process Skills

Pattern recognition and interpreting symbols.

National Geography Standard Ten

The characteristics, distributions, and complexity of Earth's cultural mosaic.

National English Language Arts Standard Six

Students apply knowledge of language structure, language conventions, media techniques, figurative language, and genre to create a critique and to discuss print and non-print texts.

Procedure

- As a class, create a set of glyphs or symbols that represent words. For example use a drawn eye for the pronoun "I", a drawn carpenter's saw for the word 'saw', a drawn foot for the word 'go', a stick figure for a person, or a happy face for the feeling happy. Actual Maya glyphs for objects such as the sun or moon or Maya letters can also be used.

- Fold the paper into thirds crosswise, accordion style so that one fold is out, and one fold is in, and place a piece of cardboard on the front and back of the book to protect it.
- Have the students create their own book, or create a class book where everyone is responsible for one page. Topics might include “one day in my life,” “where I live,” or “my family.”
- Decorate the cardboard covers with designs that have to do with the subject of the book.

MATERIALS

- Copy of p. 49 of The Dresden Codex

Activity 05: The Dresden Codex

Introduction

The *Dresden Codex* is 3.5 meters in length and is folded into 39 leaves. Each leaf is 9 cm wide and 40.4 cm high. The book is made from the inner bark, the phloem, of a fig tree. The pages were covered with a fine lime sizing. The book is painted on both sides except for four pages. The *Codex* is painted mainly in black and red, although some pages have the background or details in blue, a bluish green, dark yellow, brown, and maybe gold. Except for one page, a red frame encloses each page. Most pages are divided horizontally into thirds, separated by a red line. It appears that eight scribes were responsible for the writing.

The existing *Codex* is thought to be a new edition of a much older original work, possibly written in A. D. 934. The new book appears to have been created somewhere between A. D. 1200 – 1250. Analyzing the glyphs of the book, and the glyphs on ceremonial centers seems to indicate that the book was written near the ceremonial center named Chichen Itza, located in the Yucatan.

It appears that in 1519, Hernando Cortes sent the *Dresden Codex* to Emperor Charles V who lived in Vienna. The *Codex* was purchased in 1739 from a private library in Vienna. Through the years the text has sustained water damage, and damage from exposure to light. It suffered additional water damage during the bombings of World War II, but the manuscript has been restored. It is now housed at the Sachsische Landesbibiothek in Dresden, Germany.

Objective

To interpret the *Dresden Codex*.

Integrated Subjects

Art • Science • Geography • English Language Arts

Process Skills

Recognizing and interpreting symbols.

National Geography Standard Six

How culture and experience influence people's perception of places and regions.

National Art Standard

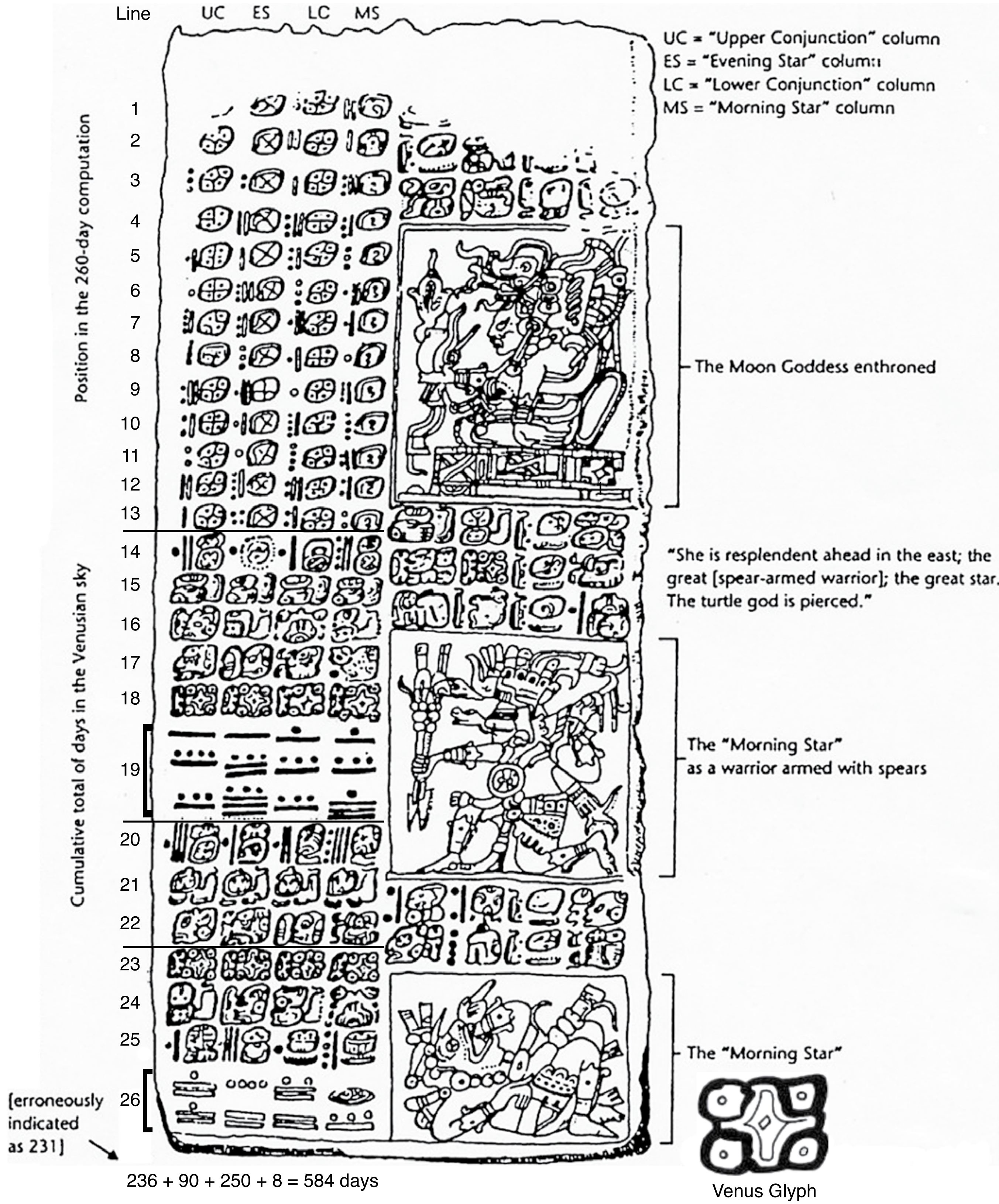
Students should have an informed acquaintance with exemplary works of art from a variety of cultures and historical periods.

National English Language Arts Standard Six

Students apply knowledge of language structure, language conventions, media techniques, figurative language, and genre to create, critique, and discuss print and non-print texts.

Procedure

- Look at graphic labeled "Page 49 of the *Dresden Codex*, from Longhena p. 125" (following). The columns along the far left give the position of Venus at "Upper Conjunction" (superior conjunction), when the planet is farthest from earth, and on the other side of the sun from earth. Venus is not visible from earth at this time. The date given on page 49 of the Codex for the rise of Venus with the sun is 2 Cib 14 Uo, which was November 13, 1225.



Page 49 of the Dresden Codex, from Longhena p. 125

Venus then became visible in the evening sky, gradually moving farther from the sun. When the planet was as far from the sun in the night sky as it would appear, this is known as maximum elongation (46 degrees).

After maximum elongation the planet brightens and moves closer to the sun, until it disappears for over a week when the planet is between the earth and sun. This is known as "Lower Conjunction," or inferior conjunction. The second column from the left shows the date of "Lower Conjunction."

The planet, continuing around the sun, now rises before the sun and is seen as the "Morning Star." The planet becomes brighter as the planet moves away from the sun, reaching its maximum brightness when it is located 39 degrees from the sun. The planet starts to grow fainter as it moves farther from the earth, reaching maximum elongation. The planet continues to grow fainter and appears, from earth, to move closer to the sun until it disappears at superior conjunction. The dates of superior conjunction or "Upper Conjunction" are shown in the third column from the left.

- See Activity 15 for Venus glyphs. What evidence is there on this page of the *Dresden Codex* that tells you that this page has to do with Venus? [Nine Venus glyphs.]
- Using the pages showing the day and month glyphs used in the *Dresden Codex*, try to interpret what page 49 says. Check your work with the explanation given below.

The *Dresden Codex* is an astronomical work, which contained many tables about the movements of the planet Venus. On page 49, the planet is personified as a warrior holding two spears. Page 49 gives the date for the rising of Venus with the sun between the 10th through the 14th century. The current date for the Venus table, when written, was 2 Cib 14Uo, which was for November 13, 1225 in the Gregorian Calendar. The actual rise date for Venus was earlier, on November 4, 1225.

According to Milbrath, the morning star god of page 49 (middle) has been identified with Xiuhtecuhtil, the central Mexican Fire God who is spearing the turtle god (lower picture), the constellation we call Orion. The Morning Star aspect of this god shows it is the beginning of the dry season and his spearing of the turtle god is a sign of drought. The Moon Goddess (top picture) is pouring seawater from her seashell jar. Below her is her skyband throne, which depicts the crossing of the ecliptic with the Milky Way. In the skyband are found the constellations, and planets in opposition to the Morning Star. In our modern sky, Orion is on the edge of the Milky Way.

On this date in A. D. 1225, Venus was moving away from the sun, just after inferior conjunction, and had just becoming visible. As the Morning Star rose, the god hurled his atlatl (throwing stick) across the sky, killing the astronomical deities at the opposite side of the sky, in the west.

The number of days between 4 Etz'ab and 7 Lamat was 250 days.

The number of days between 7 Lamat and 2 Cib was 8 days.

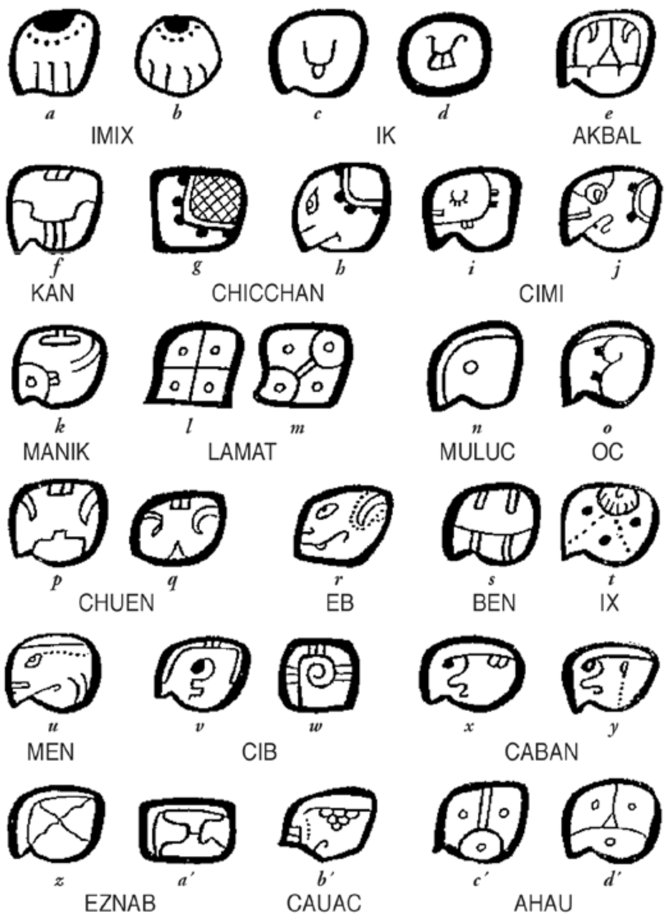
The number of days between 2 Cib and 4 Eb is 236 days.

The number of days between 4 Eb and 3 Ik was 90 days.

The number of days between 3 Ik and 6 Eb was 250 days

The number of days between each of the pages in the *Dresden Codex* is 340 days.

- How do the above dates relate to the appearances of Venus? (See Activity 15: The Motions of Venus.)



The day glyphs found in the codices

The month glyphs in the codices

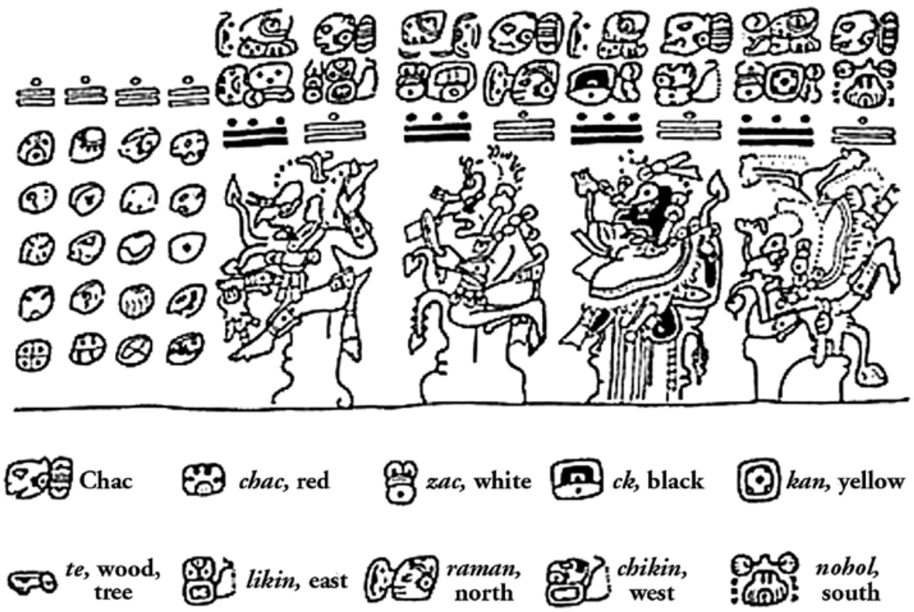
Line	Lamat	Etz'nab	Lamat	Cib
1	13	12	2	10
2	8	7	10	5
3	3	2	5	13
4	11	10	13	8
5	6	5	8	3
6	1	13	3	11
7	9	8	11	6
8	4	3	6	1
9	12	11	1	9
10	7	6	9	4
11	2	1	4	12
12	10	9	12	7
13	5	4	7	2
14	11	1	6	14
	Zip	Mol	Uo	Uo
16	N	W.	S.	E.
17	M	N	0	P
18	Red	Red	Red	Red
	Venus	Venus	Venus	Venus
19	1988	2078	2328	2336
20	16	6	11	19
	Yaxkin	Ceh	Xul	Xul
21	Winged	Winged	Winged	Winged
	Chuen	Chuen	Chuen	Chuen
22	L	M	N	0
23	Red	Red	Red	Red
	Venus	Venus	Venus	Venus
24	E.	N.	W.	S.
25	6	16	1	9
	Kankin	Chuen	Mac	Mac
26	236	90	250	8

The interpretation of page 49 of the Dresden Codex , Milbrath

Activity 06: The Four Quarters of the Universe

Introduction

The four quarters of the universe are shown on pages 30 and 31 of the *Dresden Codex*. Each of the four sections shows Chac, the rain god, in the world tree that supports a quarter of the universe. The glyphs above each picture are made up of four parts. The upper two glyphs are an introductory glyph and Chac's name. The lower pair gives the color of the tree and the direction associated with each quarter.



From Henderson, p. 84

Objective

To interpret Maya glyphs.

Integrated Subjects

English • Language Arts

Process Skills

Pattern recognition, compare and contrast.

National English Language Arts Standard Two

Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions of human experience.

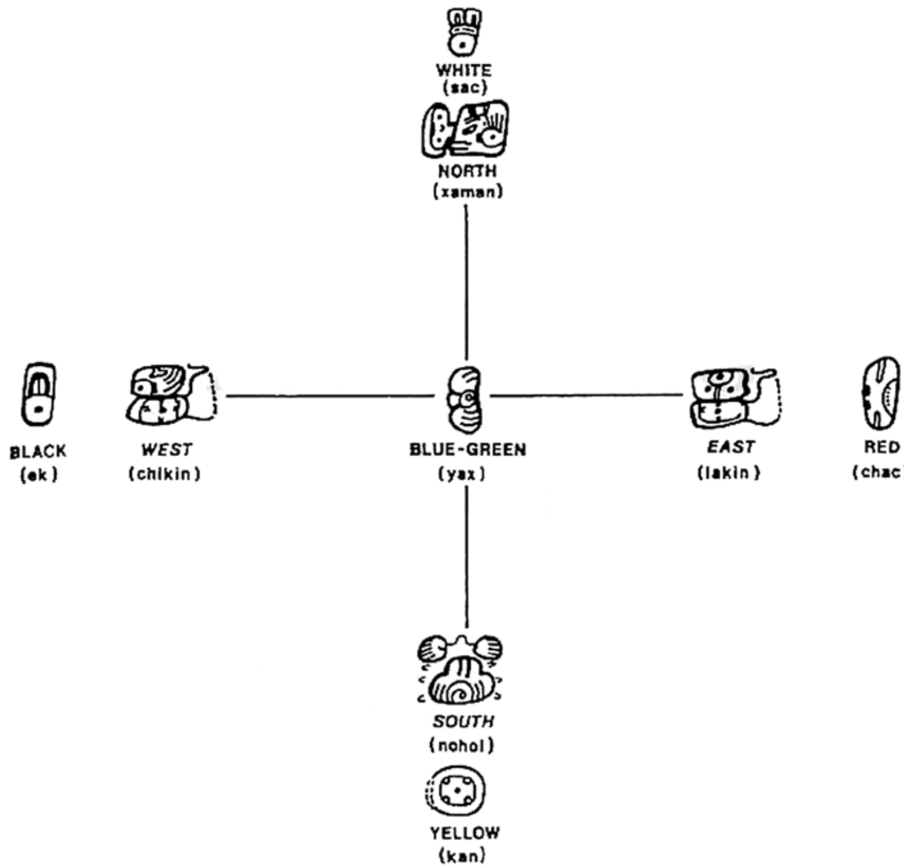
Procedure

- The glyphs in the diagram above depict the four directions of the universe. Each direction has its own color and glyph. There is also a fourth color, green, which represents the earth. Using the key below the Chacs, identify the directional glyphs, and the color glyphs.
- Identify which glyphs represent the directions of North, South, East, and West.

MATERIALS

- The drawing of the seasonal Chacs.

- The following diagram is another representation of the world directions. How is it similar to the painting above? How is it different?
- Pronounce the world directions and colors. See the Pronunciation Guide for Maya Words.



25 The world-directions as discovered by de Rosny, and the associated colors later discovered by Eduard Seler.

From Coe, 1999, page 117

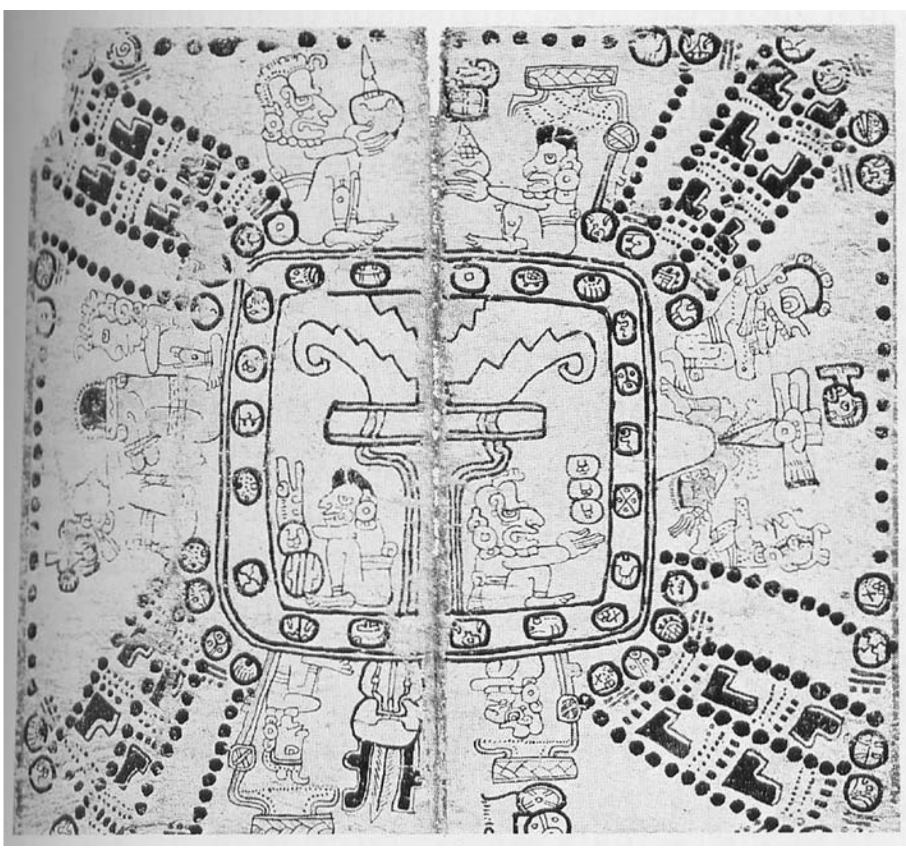
Activity 07: The Madrid Codex Calendar

Introduction

The *Madrid Codex* was written in the region of the Yucatan during the fifteenth century. The diagram below from the *Madrid Codex* is organized as a flower having two sets of four petals. One set of petals is horizontal and vertical. The other set of petals, shaped like an 'X', is attached to the corners of a large central square. Around the petals are 260 circles, divided into sets of 13 (or 12). This diagram is thought to show the union of time and space in Maya cosmology.

When the 260-day agricultural calendar and the 365-day solar calendar coincided with each other, every 52 years, this completed the Calendar Round. The unification of both calendar cycles seems to have been the driving force behind the Maya calendar (See Activity 13).

The cardinal directions of the world and the color associated with each region are show in the vertical and horizontal petals. East is represented by the color red, and is where the sun is born each day. North is shown by the color white, found to the right of East, and is the direction up. West, which is black, is where the sun goes to die each night. South is yellow, is opposite north, and is the direction down.



The Madrid Codex Calendar, from Aveni, 2001, p. 149

MATERIALS

- Calendar from the *Madrid Codex*.

Objective

To interpret the calendar from the *Madrid Codex*.

Integrated Subjects

English Language Arts • Geography • Art

Process Skills

Applying previous knowledge, symbol interpretation.

National English Language Arts Standard 3

Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts.

National Geography Standard 6

How culture and experience influence people's perceptions of places and regions.

National Arts Standard 4

Students should have an informed acquaintance with exemplary works of art from a variety of cultures and historical periods.

Procedure

- Why do you suppose there is a ragged portion to the calendar that seems to run through the middle from top to bottom? [This diagram is from a Codex, which was folded. The calendar must have occupied two pages of the Codex.]
- Using the diagram of the calendar from the *Madrid Codex* (previous page), decide which of the vertical/horizontal cross pieces represents north. [Note Cosmic Tree at bottom to the left of the fold line that designates north.]
- Where is west and what is your evidence? [West is where the sun goes to die each day. (Note knife on right side of calendar, and blood spurting from the victim.)]
- Where is south and east? How do you know this? [South is at the top, across from north, and east is to the left, across from west.]
- Although the picture is in black and white, what colors would each direction be colored?
- What do the 20 glyphs surrounding the square represent? See Activity 5: The *Dresden Codex*. [They are the 20 day glyphs.]
- What do the glyphs around the outside of the calendar represent? [They appear to also be day glyphs.]
- Based on the artwork, describe the clothing and jewelry worn by the Maya. [Men seem to be wearing a loincloth because material is shown surrounding the waist. Jewelry includes necklaces, headdresses, earrings shaped like discs with holes, ankle bracelets, and some sort of lower leg jewelry that has a hole near the top.]
- It appears that some areas of the Codex are missing. How might that have happened? [The Codex is damaged at the edges.]

Activity 08: Sun

Introduction

The chief god of the Maya was the sun god, named Kinich Ahau who was the sun during its journey across the daytime sky. Its journey corresponded to the journey of humans from birth, at sunrise, to death at sunset. Maya glyphs may show a young sun, or an old sun. At night the sun became a jaguar god as it completed its journey through the depths of the earth. Many Maya rulers identified themselves with the sun and were worshiped as the sun's incarnation on earth. In Maya writings, the sun glyph often appears as a part of a king's name.

From late Preclassic times to the Spanish conquest, the sun glyph showed four petals of the celestial flower, and was associated with the "kin" glyph which means "sun" and also "day". The ball game held on the ceremonial ball court of ceremonial centers represented the passage of the sun. A large hoop was attached to the wall in the ball court. The point of the ball game was to put a large rubber ball through the hoop. Inscriptions from the Postclassic period tell us that the players on the losing team were decapitated because it was believed that they would prevent the sun from rising. Maya astronomers knew the eclipse cycles and may have been aware of the sunspot cycle.

The Maya astrologers noted the zenith passage of any celestial object. At 20 degrees North, the sun's zenith passage was on May 21 and July 24.

From Aveni, 2001

Objective

To describe the motion of the sun during its yearly journey through the sky.

Integrated Subjects

Science

Process Skills

Compare and contrast.

National Science Standard Earth and Space Science

Changes in earth and sky.

Procedure

- Set the STARLAB projector for your home latitude. Place the sun at the Vernal (Spring) Equinox position. In which Maya constellation is the sun located? [Skeleton constellation.]
- Move through a 24 hour period, explaining where the sun rises and sets at this time of the year. What is the altitude of the sun when it is due south (at noon)?
- Move the STARLAB projector in latitude to 20 degrees north latitude and repeat the above directions. Has the constellation where the sun is located changed? [No.] Are the rise and set points different at this latitude when compared to your

MATERIALS

- STARLAB Portable Planetarium
- Maya Cylinder

home latitude? [No.] At noon, is the sun higher or lower in altitude than at your latitude? Why?

- Move the sun to the summer solstice position (Bird 2 constellation) by removing the summer solstice light block. Repeat the two previous steps, comparing if there is a change in the zodiacal constellation with different latitudes, if the altitude of the sun at noon is different, and if the sunrise and sunset positions are different. [The Maya sun should appear higher in the sky at noon, and be in the northern sky at noon because the direct rays of the sun, at 23.5 degrees, are falling north of the Maya latitude.]

  Also note if the sun is in the sky for a longer or shorter period than at your latitude. [The farther away from the equator that your home latitude is, the longer the sun is in the sky, and the longer the daylight hours should be.]

- Move the sun to the Autumnal Equinox position (Moon Goddess constellation), and then to the Winter Solstice position (Fish Snake constellation). At each position, repeat the first two steps, comparing the constellation that the sun is sitting in, where the sun rises and sets, and the altitude of the sun.

Activity 09: Interpreting Moon Glyphs

Introduction

The Maya attempted to relate the lunar calendar to the solar calendar and thus kept careful records of the Moon's motions. In A. D. 649, Copan scientists began using a formula (4400 days divided by 149 moon cycles) to establish that the average lunar month was 29.53020 days in length. This figure was adopted by other Maya centers. In actuality, the lunar cycle is 29.53050 days.

There is little doubt that the Maya attempted to predict both lunar and solar eclipses, not based on the position of the sun, moon, and earth, but based on long observation of the heavenly bodies. Eight pages in the *Dresden Codex* deal with moon cycles and lunar eclipses recorded over a 33-year period. Eclipses generally were bad omens.

The moon was thought of as the goddess of childbirth.

moon

From Avini, 2001

Objective

To visualize the similarities in moon glyphs.

Integrated Subjects

Science • Art

Process Skills

Symbol recognition, similarities and differences.

National Science Standards

Earth and Space Science — Objects in the sky.

Procedure

- Diagrams A and B below each show a glyph of the moon. What features are similar in both glyphs? [Each shows a crescent moon. Each has three flattened circles. Each shows a double line on the inside of the crescent.]

  Describe how the glyphs are different. [Glyph A has a criss-crossed pattern not seen in Glyph B.]
- Is Glyph C a moon glyph? [Yes, the crescent moon is present, along with the double line on the inside of the crescent. The three flattened circles are present. This glyph also has a hatched pattern seen in Glyph A.]

Glyph A

Glyph B

Glyph C

Activity 10: The Rabbit on the Moon

MATERIALS

- A full moon in the night-time sky.

Moon glyph from Codex Borgia (Milbrath)

Introduction

During the time of the Classic Maya, the glyphs often show a young girl, holding a rabbit, and sitting on a crescent moon. During the Colonial period, after Spanish conquest, the moon is replaced with an old woman who no longer has teeth.

A young moon goddess holding a rabbit (Longhena)

An old moon goddess pouring water (Milbrath)

A modern Chol Maya myths says that the sun god gave the rabbit to his mother, the moon, after he found the rabbit causing the weeds to grow in the garden during the night.

Objective

To visualize the rabbit on the moon.

Integrated Subjects

Science • Art

Process Skills

Pattern recognition.

National Geography Standard 4

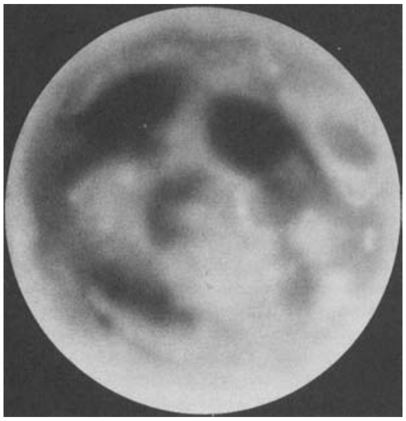
The physical and human characteristics of place.

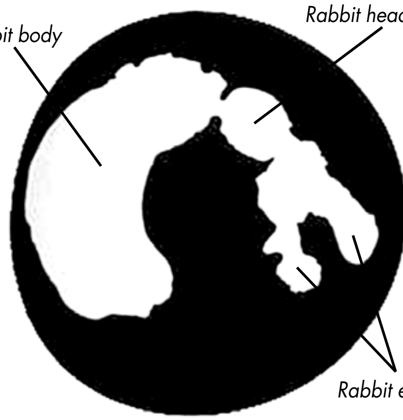
National Science Standard

Earth and Space Science — Objects in the sky.

Procedure

- What evidence do you see that the drawing entitled "A young moon goddess holding a rabbit" (above) is of the moon? [Crescent moon with double line on inside of crescent. Hatched lines in crescent.]
- Look outside at the Full Moon. The Full Moon rises as the sun sets. Some of us can see the Man in the Moon. The maria (seas) of the moon become the face. But there is a side view of a rabbit in the moon. During a Full Moon, see if you can find the outline of the rabbit.





Drawings from Krupp (1991): Beyond the Blue Horizon, p. 76 and 73.

MATERIALS

- Glyphs for eclipses of the sun and moon.

Activity 11: Eclipses of the Sun and Moon

Introduction

To the modern Cakchiquel Maya, eclipses of both the sun and the moon appear to occur because the celestial object is sick. The moon also causes illness in people. Children born near the time of an eclipse may be blind, or mute, or deaf. During a solar eclipse, women who go outdoors must be fully covered so that their future children will be protected. To help the sun to recover from its illness, people travel to the top of a hill and use noisemakers such as a drum, flute, or bowl beaten with sticks, to drive the illness away so that the sun won't die.

These Maya believe that an eclipse of the sun is much more dangerous than a lunar eclipse because when the sun is eclipsed, evil spirits leave the depths of the earth and capture people.

Objective

To recognize the glyphs for eclipses of the sun and moon.

Integrated Subjects

Art • Science

Process Skills

Pattern recognition, compare and contrast.

National Science Standard

Earth ad Space Science – Objects in the sky.

Procedure

- How are the two glyphs above similar? [Both have wings on either side of a glyph, and both show a blackened right side. And, both have a "tail" bending downward on the wings.]
- Based on your knowledge of the glyphs for the sun and the moon, which of the above glyphs shows an eclipse of the sun? [The one on the left.] See activity 8.
- Which of the above glyphs shows an eclipse of the moon? [The one of the right.] Note the crescent moon in the center part of the glyph.
- How is an eclipse of the sun different from an eclipse of the moon?

  [During an eclipse of the sun, the moon moves between the earth and sun so that the shadow of the moon falls upon the earth. From earth, the sun appears to cover part or all of the moon. An eclipse of the sun occurs during the day.]

  [During an eclipse of the moon, the earth is between the sun and moon so that the earth's shadow falls upon the moon. An eclipse of the moon occurs at night.]

Activity 12: Maya Glyphs

MATERIALS

- Copy of Stele F

Introduction

The Maya erected numerous monuments called stele to celebrate the founding of a city, the accession of a new king to the throne, or a win at war. The dates included on the stele give archaeologists a method for dating these significant events into the western Gregorian calendar.

Objective

To read Maya glyphs.

Integrated Subjects

Language Arts • Science • Anthropology

Process Skills

Symbol recognition.

National English Language Arts Standard 1

Students read a wide range of print and non-print texts to build an understanding of the texts themselves, and of the cultures of the United States and the world.

National Science Standard

Unifying concepts — Changes in constancy and measurement.

Procedure

- Using Stele F from Copan graphic (following), see how much of this stela (monument) you are able to read.
- There are several glyphs that refer to numbers. Do you see how they represented the numbers 9, 17, 13 and 18?
- How was "zero" represented on the stela?
- Describe the other moon glyphs present. See Activity 09: Interpreting Moon Glyphs. If the explanation were not included, how would you know that they related to the moon?

INITIAL SERIES (also includes "18 Cumku")	
Introductory glyph. The variable element at the center is the head of the deity representing the month of Cumku.	
9 Baktun	17 Katun
0 Tun	0 Uinal
0 Kin	13 Ahau (260-day calendar)
Ninth lord of the netherworld	F glyph (not yet deciphered)
SUPPLEMENTARY SERIES	
E and D glyphs: the new moon	C glyph: second month of the lunar half-year
X 3 glyph (not yet diciphered)	B glyph: (not yet diciphered)
A 9 glyph: the 29-day lunar month	18 Comku (365-day calendar)

This drawing reproduces Stele F found in the Mayan city of Quirigua. This stele refers to the calendar and the twenty-nine day lunar month. (Longhena, p. 26)

Activity 13: The Maya Calendar

Introduction

The Maya calendar was different from the Gregorian calendar now in use throughout most of the western world. Twenty days, or kins, made up the Maya month, which was the uinal. Eighteen of these 20-day months brought the Maya year to 360 days which was called a Tun. The Maya used 20 years as the next division of time and termed a 20 year period, a 'katun'. A katun was composed of 20 tuns and was 7200 days or kins long. A baktun was 20 katuns or 400 years.

Currently much of the world uses just one calendar, the day-count calendar that contains twelve months, each having between 28 and 31 days. This calendar forms years, decades, and centuries.

The Maya had five different calendars:

- The 360 day Tun calendar
- The 365 day solar year Haab or vague calendar, consisted of 18 twenty-day months and an extra month of five days. The earliest set of Haab glyphs date to about 100 B. C.
- The Tzolkin Sacred Almanac religious calendar, which contained 260 days. The earliest date of Tzolkin glyphs date to about 600 B. C.
- A lunar calendar based on the phases of the moon
- A Venus calendar based on the synodic Venus year of 584 days

To be sure that the calendars were correct, it appears that astronomical data was exchanged between ceremonial centers.

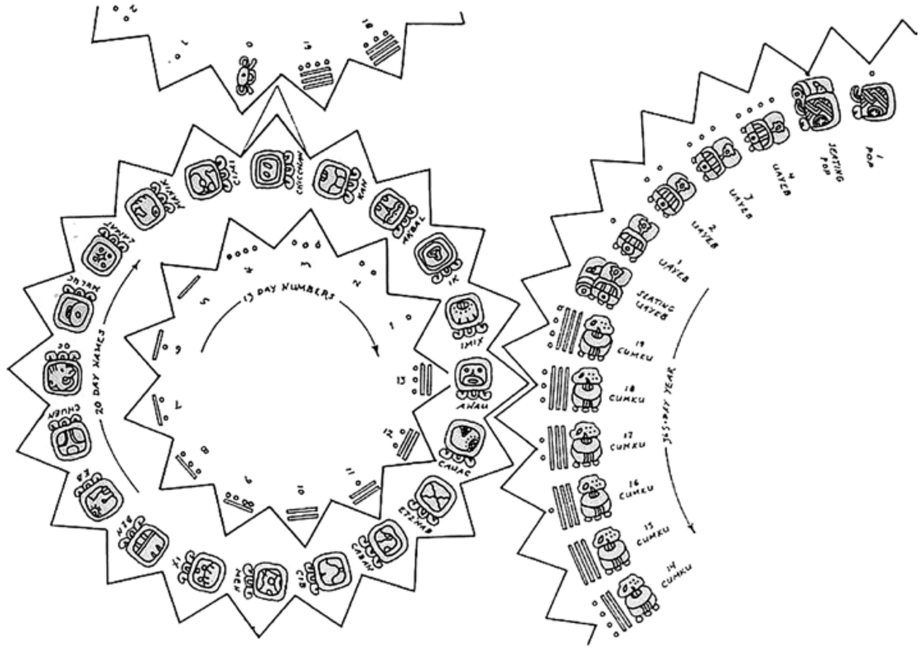
The Maya Long Count, based on the 360 day Tun calendar, was a method the Maya used to exactly record dates, beginning with the creation, about 3000 BCE or about 5000 years ago. The inscriptions help to date Maya structures, and to establish a sequence of history. The oldest Long Count inscription comes from Vera Cruz, and reads 31 B. C. in the Gregorian calendar. The youngest Long Count dates come from the *Dresden Codex* and record the events of A. D. 1225.

Comparing the movements of the planet Venus, the moon phases, and solar and lunar eclipses, which were recorded in the ancient Maya writings and stone glyphs, provide information to correlate the ancient Maya calendar to the current Gregorian calendar.

We can imagine the Maya calendars as a series of gears (see next page), each containing a different number of cogs all working together. The Calendar Round was based on the 260-day Tzolkin calendar, and the true solar calendar of 365 days. When the same day of the Tzolkin calendar exactly again coincided with the same day of the Haab calendar, the Calendar Round was completed. This occurred every 18,980 days, which is 52 years.

MATERIALS

- Today and tomorrow's dates.



Hammond p. 106

The Maya conceived of the divisions of time as burdens carried by relays of divine bearers. The date of December 31, 1987, would have five different bearers. The god of number 31 carried December on his back. The god of number one carried the millennium. The god of number nine bore the centuries; the god of number 8 carried the decades, and the god of number seven, the years. At the end of the day there is a momentary pause before the procession restarts, but in that moment the god of number one, with the burden of January, replaces the god of thirty-one with his December load, and the god of number eight replaces the god of number seven as the bearer of the year. The date has changed from December 31, 1987, to January 1, 1988.

Two burdens of time (Henderson)

Objective

To describe calendar date changes in the Maya calendar.

Integrated Subjects

English • Science • Mathematics

Process Skills

Interpreting information.

National Science Standard

Unifying Concepts: Models and explanations.

National English Language Standard 3

Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts.

Procedure

- Using the above example, describe today's date in terms of the bearers of time.
- How do the burdens of time change when midnight tonight passes?

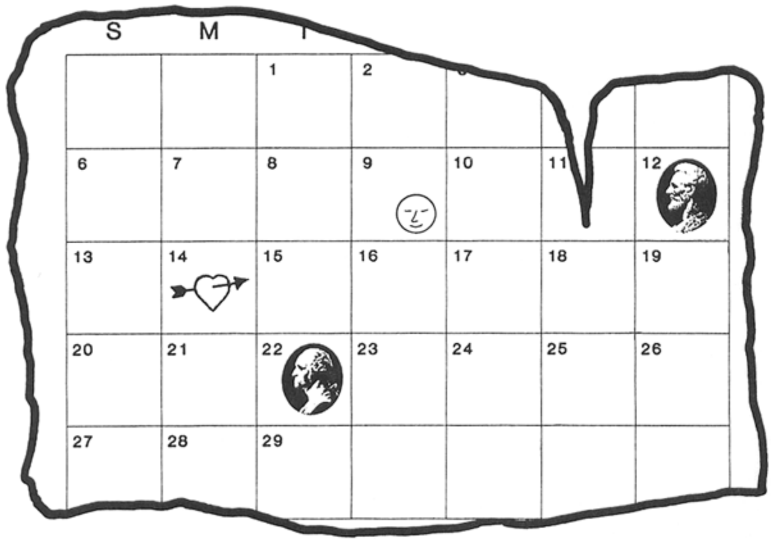
MATERIALS

- One page from a calendar (recent or old.

Activity 14: Correlating Calendars

Note

This activity was suggested in V. R. Bricker & H. M. Bricker's article entitled "A Method for Cross-dating Almanacs with Tables in the Dresden Codex," in A. F. Aveni Sky in Mayan Literature.



Introduction

Let us assume that you find a damaged printed calendar (above) and decide to try to figure out the year it was used. There are enough clues to solve this puzzle.

There are two clues that tell you the calendar page is for the month of February: Valentine's Day on the 14th, and 29 days in the month. The question is "Which February?"

The leap day occurred on a Tuesday, which occurs once every 28 years (7 days/ week x 4 years/leap year cycle). Because both Lincoln's birthday and Washington's birthdays are shown, the date must be before 1970, because during 1970, the U. S. Congress combined both birthdays into "President's Day". The face glyph signifies that there was a full moon on February 9.

The only date between 1901 and 1970 that fits all of the clues is 1944. This date was found by using two American holidays (Lincoln's and Washington birthday), a ritual in American culture (Valentine's Day) and part of an astronomical cycle. This method of using several different clues in the Codices permits Maya scholars to establish a given Maya date into the Gregorian calendar.

Objective

To deduce which month has been torn from a calendar.

Integrated Subjects

Science • Mathematics • Technology

Process Skills

Problem solving, pattern recognition, conducting a search.

National Science Standard

Science as inquiry.

Procedure

- Tear the edges from around a page of a calendar, so that the month is not visible. Be sure that there are clues as to which month is shown. The difficulty of the clues should be determined by the ability of the class.

  National holiday clues might include Labor Day, Veteran's Day, Fourth of July or Martin Luther King Jr's birthday.

  Cultural celebrations might include Christmas, Cinco de Maya, or Yom Kippur.

  Astronomical clues might include solar or lunar eclipses, full or new moon, or the date of a meteor shower.

  Calendar hints might include the number of days in the month, or the day of the week a particular date fell upon.

- Using the clues on the page, have the students work in small groups to deduce which month is represented.

Extension

Find an old calendar and use one of those pages for this activity. If the students are computer literate, they should be able to find the year of the calendar page by searching the Web for information about the occurrence of an eclipse or other astronomical events such as a full moon.

MATERIALS

- Darkened classroom
- Bright light source
- One white ball-on-a-stick (ball should be smooth on the outside — Styrofoam does not work well but chemistry-model spheres do)
- Paper and pencil for recording observations

Activity 15: The Motions of Venus

Introduction

Venus, called Noh Ek (great star), Chac Ek (red star), Sastal Ek (bright star), and Xux Ek (wasp star) was the most important of the planets, and the most important heavenly object except for the sun. The Maya knew when it rose with the sun, set with the sun, when it increased or decreased in brightness, and when it completely disappeared. Although the Venus glyph is found in numerous texts, on pottery, and incised on rock (stelae or buildings), the most dramatic ephemeris tables are found in the *Dresden Codex*, a beautifully written book of glyphs and drawings painted on lime-coated tree roots using vegetable dyes. The information recorded varies from what would have actually been seen, and may record ritualistic data, rather than actual observations.

Earth orbits the sun once every 365.25 earth days. Venus orbits the sun every 224 earth days. Venus, being closer to the sun than earth, moves the faster of the two. Both planets are moving so that, from earth, the only motion we can observe is the difference between the two orbits. Thus it appears from earth that Venus takes 583.92 days to move around the sun. The Maya calculated Venus' year as 584 days.

Venus returns to the same position in the sky at the same time of the year, and in the same phase every eight years. During that time, the planet seems to follow five different patterns of motion as the Morning Star, and also as the Evening Star. Because of this repeating pattern, predictions about the planet's future movements could be made.

Venus Glyph

Objective

To visualize the orbit of Venus as seen from earth.

Integrated Subjects

Science

Process Skills

Observing, discovering, describing, interpreting.

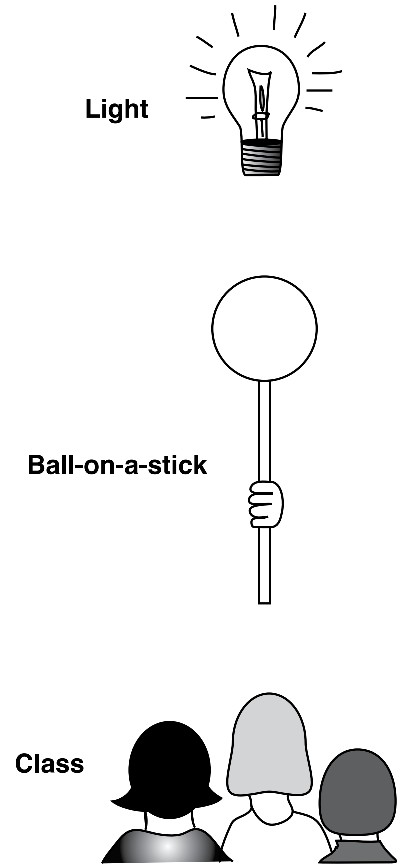
National Science Standard

Physical Science — Position and motion of objects.

Procedure

Demonstrate the phases of Venus and the planet's changing distance from the sun:

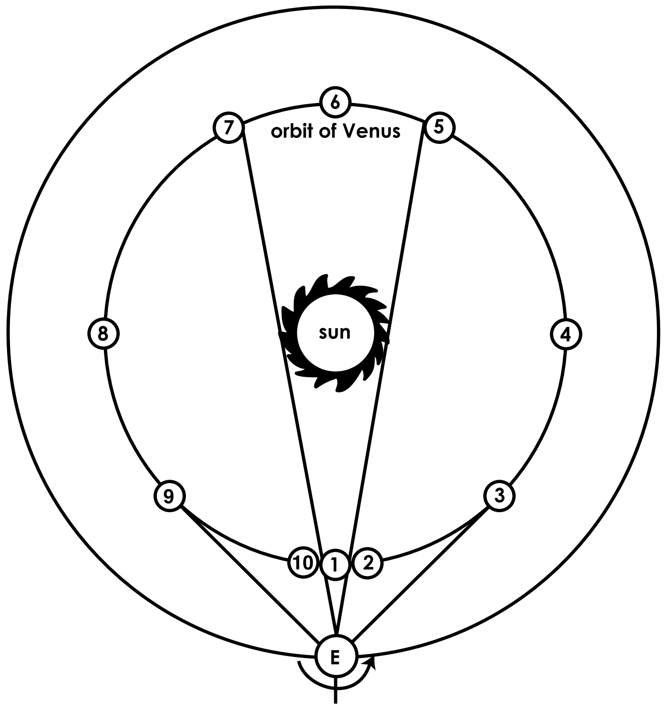
- Put the light source in the front of the room. Place the white ball-on-a stick between the light and the students. (Position 1 in Diagram.) Explain that one-half of the ball, the part facing the light, is always lighted by the bulb.



- Ask the students to pretend that they are located on earth. How much of the lighted portion of the ball is facing them? [None.] When the planet is between the earth and sun, astronomers say that Venus is at inferior conjunction. The planet is invisible for eight days at inferior conjunction, although the value may span as few as 3 days, or as many as 16. (Positions between 8 and 2.)
- As seen from the Northern Hemisphere of earth, the planets move in a counterclockwise direction around the sun. Move the ball-on-a-stick toward the right (counterclockwise) around the light. As the ball moves around the light, the students should see a left-side lighted crescent Venus. (Position 2.) Venus is brightest when it is 39 degrees from the sun, about 36 days before or after inferior conjunction (Position 3). Continue moving the ball until the ball is half lighted (Position 4). Continue until the ball reaches a point where the planet is blocked by the sun (Positions 5 – 7) and is invisible to the students. Also have the students note how the distance separating Venus from the sun seems to change as seen from earth. The distance decreases as the planet approaches the half lighted phase and the planet becomes brighter, (between Positions 7 and 8), and then shrinks as the planet moves in front of the sun. (Positions 10, 1 and 2 .)
- When Venus is farthest from the earth, and disappears beyond the sun, this is termed superior conjunction. (Position 6). Venus may be invisible up to 70 days at superior conjunction, although the average number of days of invisibility is 50. The entire lighted half of the planet faces the sun and towards the earth, except that the large, bright sun usually blots out the planet and we cannot see it. At 20 degrees north latitude, the number of days of invisibility is shorter in March and longer in September because of the angle at which the planet rises or sets. The reason for the difference in days is because Venus' orbit is slightly tilted (3.39 degrees) to the ecliptic, and that the ecliptic is tilted at a different angle to the horizon, depending on the season. At an equinox, the angle between the ecliptic and the horizon is low, while in February the angle between the two is almost 90 degrees (see Activity 16). The greater time spent at superior conjunction is due to the sun being so far from earth that its horizontal motion is very small. Also, if Venus appears less than twelve degrees from the sun, the planet cannot be seen. From earth, there are 292 days between the inferior and superior conjunctions of Venus.
- In the *Dresden Codex*, first written in the early seventh century, it is apparent that the Maya understood that five apparent revolutions of Venus around the sun (5 x 584 days = 2920) was equal to eight revolutions of the earth (8 x 365 days = 2920) although they were not aware that the earth was moving. Thus, every eight years they could expect the planet to repeat its movements. The *Dresden Codex* gives 400 years of planet positions. The Maya especially feared the rising of Venus with the sun, and the *Dresden Codex* told the priests when this astronomical event would occur.
- Continue moving the ball-on-a-stick counterclockwise, toward inferior conjunction. The planet moves in phases from nearly full, back to a crescent except now the sun lights the left side of the planet.
- When the planet is to the right of the sun, it is seen in the morning sky, as the morning star. When the planet appears to the left of the sun, it is seen at night as the evening star. The Maya were among the very first people to realize that one object, Venus, made both morning and evening appearances.
- Have the students describe in words what the Maya would have seen as they observed Venus for a full cycle, beginning at superior conjunction. [At superior

conjunction, Venus would not be visible, and then would appear as an evening star near to the sun. As the planet was observed from earth, it would seem to move away from the sun, and then begin to move closer to the sun. Each night, the planet would become brighter and brighter, whether it was moving toward or away from the sun. Finally, it would disappear for eight days at inferior conjunction. Then it would appear very bright and very close to the sun in the morning sky. Each morning it would move farther from the sun, decrease in brightness; and then begin moving closer to the sun, until the planet disappeared (at superior conjunction).]

The Motions and Phases of Venus



Venus. as viewed from Earth (E)

1. Inferior Conjunction: Planet not visible between positions 10 and 2.
2. First appearance as a Morning Star (heliacal rising). Planet appears as a left-side crescent.
3. Larger left-side-lighted crescent. Planet is at its brightest when 39 degrees from sun.
4. Maximum elongation as a morning star, 47 degrees from sun. Planet's left side is half lighted.
5. Last appearance as a Morning Star. Planet appears in a left-side-lighted gibbous phase.
6. Superior Conjunction: Planet not visible.
7. First appearance as an Evening Star. Planet appears in a right-side-lighted gibbous phase.
8. Maximum elongation as a Morning Star, 47 degrees from the sun. Planet's right side is half lighted.
9. Larger right-side-lighted crescent. Planet is at its brightest when 39 degrees from sun.
10. Last appearance as an Evening Star. Planet is a right-side-lighted crescent.

Activity 16: Changes in the Brightness of Venus

MATERIALS

- Light source
- Ball-on-a-stick

Introduction

As Venus moves through the sky, it also changes in brightness.

Objective

To simulate the changes in the brightness of Venus.

Integrated Subjects

Science • Art

Process Skills

Observing, describing, interpreting.

National Science Standard

Earth and Space Science — Changes in earth and sky.

Procedure. (This is a follow-up to Activity 15: The Motions of Venus.)

The Change in Brightness of Venus

- Repeat the "Motions of Venus Activity" (Activity 15), but make the path of Venus much larger so that the students can see a difference in the size of the ball-on-a-stick as it orbits the light source (a STARLAB projector without a cylinder is an ideal light source). The closer the ball is to their eyes, the larger it should appear.
- Have the students draw the phases of Venus, and correctly draw how the size of the Venus appears to change as it moves around the sun. When Venus is near the earth as a crescent phase, it appears about six times larger in size than when compared to the planet's size when the planet is far from the earth.
- The greater the apparent size, and hence the greater the surface area, the brighter the planet appears.

  Venus is brightest at what phases? [Crescent.] Venus is faintest at what phase? [Near the full phase.]

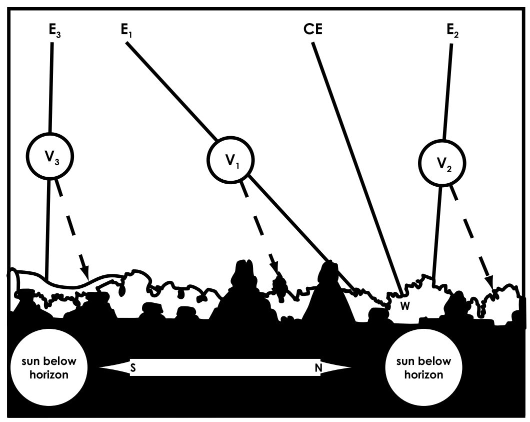
MATERIALS

- STARLAB Portable Planetarium
- Maya Cylinder
- Venus projector or Venus holes in cylinder
- Sun
- Post-It™ Notes

Activity 17: The Changing Rise and Set Points of Venus

Introduction

Just as the sun's rise and set points seems to move along the horizon as the seasons change, a planet located near the sun will also change where it appears to rise and set.



Venus approached the western horizon at sunset during different seasons of the year. The picture applies to an observer at 20 degrees N. (Diagram by P. Dunham, Aveni, p, 93.)

Objective

To record the rise and set points of Venus.

Integrated Subjects

Science

Process Skills

Observing, discovering.

National Science Standard

Science as Inquiry.

Procedure

Inferior to Superior Conjunction:

- Remove the sun button located in the Skeleton at the Vernal Equinox position (position 1 on diagram in Activity 15) so that the sun is showing. Explain that you will pretend that Venus is at Inferior Conjunction. Move through one day and ask the students to determine the position of Venus. [Can't see Venus so position cannot be noted.]
- After the Milky Way Dragon and Bird 3 rise, point out the position of Venus along the ecliptic midway between Skeleton and Bat. Explain that Venus is moving around the sun and, after being invisible, has now moved to this position (position 2 on the diagram in Activity 15 which is 12 ° from the sun). Move through one day. When the sun is above the horizon, bring up the lights. As the sun sets, lower the lights. Ask the students when Venus would be visible [just before sunrise]. Using a Post-it™ note, mark on the dome where Venus rose. Can Venus be seen in the evening sky? [No, Venus has set by the time the sun sets.]

- Show the position of Venus at its brightest (near the head of Bird 3, position 3 on the diagram in Activity 15. Position 3 on the cylinder, 39 degrees from the sun, is noted as a red crescent). Again move through one day, bringing up the room lights when the sun is visible. Mark the rise position of Venus. How has the rise point changed?
- Again go through a day, marking the rise point of Venus (position 4 on the diagram). This is as far as Venus will appear east of the sun. (47 degrees. This point is marked in red as VME (Venus Maximum Elongation) on the cylinder near the wing of Bird 3.)
- Move Venus to superior conjunction. (Position 6 on the diagram.) Venus is behind the sun. As you move through a day, can Venus be seen? [No, the planet is behind the sun and so is not visible.]
- Now move Venus so it is to the left of the sun on the dome and go though one day (position 7 on the diagram). When can Venus be seen now? [In the evening sky near the sun.] Mark its set point using a Post-it™ note.
- Continue moving Venus toward inferior conjunction (positions 8 – 10 on the diagram) and placing a Post-it™ note on the dome where the planet sets.
- Have the students describe the movement of Venus as seen from earth. Have the students describe or draw what is actually happening as Venus orbits the sun.

Note

This activity does not take into consideration that the earth is also moving around the sun. In actuality, the sun would seem to change position among the stars as both Earth and Venus move around our star.

MATERIALS

- STARLAB Portable Planetarium
- Maya Cylinder

Activity 18: The Milky Way Dragon

Introduction

The Milky Way is the name of the galaxy to which the sun and its solar system belong. From earth it appears as a thin band of light because it is made up of the combined light from the stars located in the plane of our galaxy. It is brightest in the summer because we are looking towards the center of the galaxy. The Milky Way intersects the Celestial Equator at about a 60-degree angle. At dusk, during the Maya dry season, the Milky Way arches high above the horizon. During the wet season the Milky Way skims the horizon.

To the Maya, the Milky Way was a great celestial reptile which extended across the sky. His body represented the sky, from which the other sky deities, the stars, were suspended. His body bears the symbols of the sun, moon, Venus, and other celestial bodies. This beast had two heads.

The front head, to the left, signifies the summer solstice when the sun, when located in the Milky Way, is near the Pleiades. This head faced east and was associated with the rising sun, the Morning Star (Venus) and life. The rear head (on the right) marked the place where the Milky Way crossed the ecliptic in Scorpius or Sagittarius at the time the sun was at the Winter Solstice. The head facing west, symbolized the setting sun, the evening Star (Venus) and death. It was especially significant when a planet crossed the Milky Way as it traveled along the ecliptic. Maya glyphs show that Maya kings carried a representation of the Milky Way god in their arms, known as the double-headed serpent bar.

To the modern Quiche Maya, the Milky Way has two separate designations. The part that appears to be uniformly white is called the saqi b'e or the white road. The area in Cygnus and Lyra, where the stars are divided into two segments separated from each other by a dark region (the Great Rift), is known as xib'alb'a b'e, the underworld road (Aveni 1992). The dead entered the sky through the Great Rift.

A relationship between the Milky Way and the Moon is found in this story from the modern Kekchi Maya of Guatemala. According to the myth, the Sun tries to steal the Moon from her elderly father by covering the Moon with a turtle shell. The old man hits the Sun with a pellet from his blowgun, and the sun drops the Moon into the sea where she is smashed into many pieces. Small fish gather the pieces of the moon and patch them together with their silvery scales. They form a net and lift the Moon back into the sky. The fish remained in the sky and become the Milky Way.

Altar 41, Copan (Henderson)

Objective

To hypothesize about the Milky Way glyphs and drawings.

Integrated Subjects

Art • Science

Process Skills

Observing, describing, and hypothesizing.

National Science Standard

Physical Science — Position and motion of objects.

Procedure

- Using the STARLAB set for 20 degrees north, show the Milky Way. Have the students describe the appearance of the Milky Way. Move through one night. How does the appearance change?
- How is the Milky Way similar to the Maya Cosmic Tree, which connected the sky to the underworld below the earth? (See Activity 22: The North Star.) How are the two different? [The Milky Way begins at the horizon, traverses the sky, and then sinks into the horizon. Sometimes the Milky Way is very near the horizon, but at other times it is high in the sky. A tree is small to begin with, but grows into a large object, until it eventually dies. A tree was probably the largest natural object visible to the Maya. The Milky Way was thought of as a path, but would a tree be considered a path?]
- The Big Dipper parrot (Seven Macaw) is shown in the World Tree in Figure 1. (See Activity 23.) Does the Big Dipper touch the Milky Way? [No.] Why might the Maya draw the Big Dipper in the Tree? [We don't know. This might reflect the motion of the Dipper around the Pole Star.]
- Look closely at the picture of the Milky Way Dragon on the previous page. One head on the dragon represents life, and the other death. Look at the animal's paws. Which way is the dragon facing? To the right or to the left? [Left.] Can you tell which head represents life, and which represents death? [Maybe the head emerging from the dragon's mouth is life.]
- In Figure 2, what seems to be the relationship of the tree to the dragon? [The tree is emerging from the mouth of the dragon.]

The Maya also thought that the Milky Way was a world tree that connected their heaven with the underworld of the earth. The Big Dipper is pictured as a bird located among the branches of the tree in this Late Classic funerary vase from Guatemala (Figure 1) (Krupp).

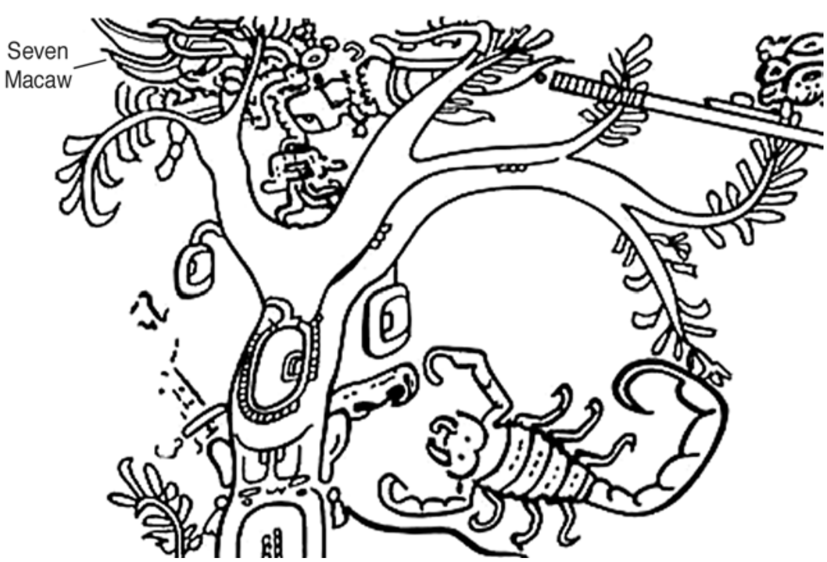


Figure 1

A drawing in the Popol Vuh shows the world tree and the Milky Way dragon:

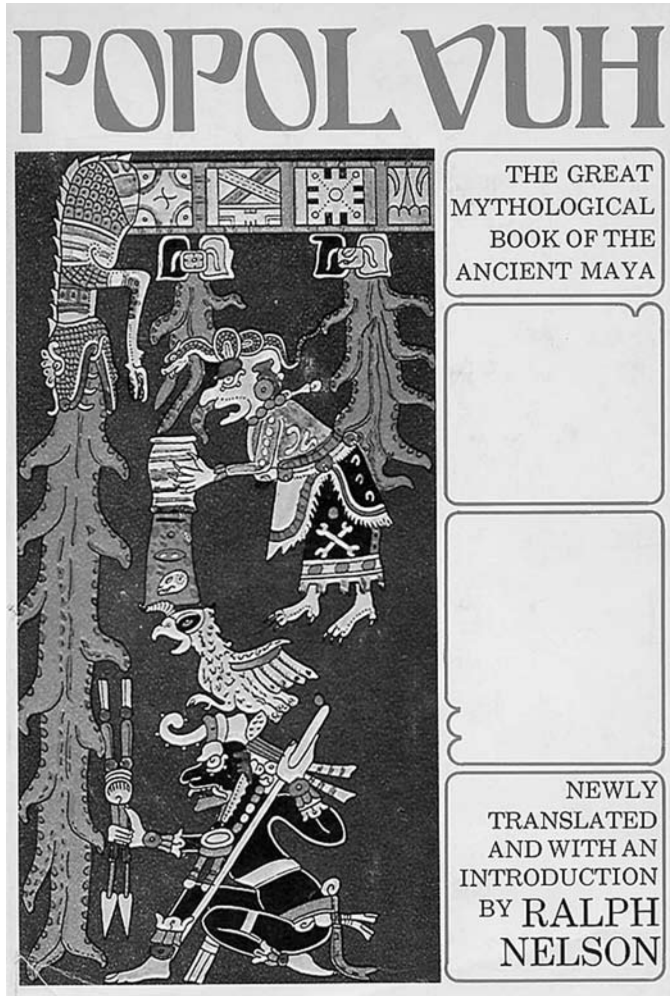


Figure 2

Figure 2 shows the Moon Goddess pouring water, and Venus as the god holding the spears. A skyband is found on the back of the dragon, and the world tree pours out from his mouth.

Activity 19: Stars

Introduction

The Maya used the stars to tell time at night, and to herald the time of the year for rituals and for agricultural purposes.

Mayan dictionaries contain a number of metaphorical names for stars. For example the term "Ek" may refer to a star, or to the spots of a deer or jaguar. A jaguar skin was a symbol for a starry sky. See Figure 1. Early dictionaries also compared the rising of a star to the sprouting of a plant.

Stars are the "eyes of the night" in Madrid Codex, where an astronomer seems to be observing the sky (Figure 2). Here one of his eyes seems to be stretched out from its socket.

Concentric rings can also signify stars, or water, depending on how the glyph is used (Figure 2). Another star glyph resembles the letter M or W around two rings, and seems to represent very bright stars, or planets (Figure 3).

Birds placed on skybands (see next page) may also represent individual stars.

Objective

To recognize star images in Maya art.

Integrated Subjects

Art • Language Arts • Science

Process Skills

Pattern recognition.

National Fine Art Standard

Students should be able to have an informed acquaintance with exemplary works of art from a variety of cultures and historical periods.

National Science Standard

History of Science.

Procedure

* Figure 4 shows the skyband found at Chichen Itza.

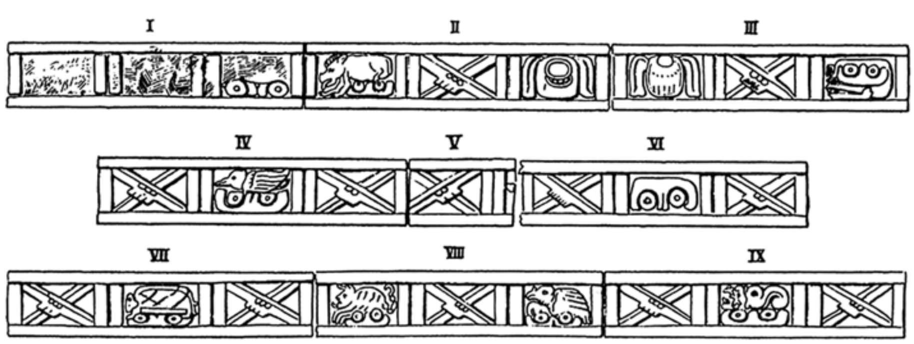


Figure 4

Figure 1

Figure 2

Figure 3

What markings on the glyph in Figure 4 show that this image has something to do with the sky? [The "W" or "M" glyph with the two circles, the "X" Conjunction glyphs, and the Moon symbol which is the 6th glyph from the left on the top band.]

- How do you know that this turtle glyph (Figure 5) is associated with the night sky? [The star glyph to the left of the turtle.]

Figure 5

Activity 20: The Maya Zodiac

Introduction

The evidence for a thirteen member Maya zodiac comes from several sources. One source is a set of celestial figures found on pages 23 and 24 of the Postclassic Paris Codex. These figures each has its jaws clamped around the sun symbol.

Part of the zodiac is carved on a lintel on the eastern facade of the east wing of the Nunnery building in Chichen Itza. Several constellations are also painted on a mural in Room 2 of the Palace of Bonampak in eastern Chiapas. In most cases, the Chichen Itza carvings are used along the STARLAB ecliptic.

Objective

To locate the Maya constellations along the ecliptic (see next page).

Integrated Subjects

Science • Geography

Process Skills

Pattern recognition.

National Geography Standard

Standard 6: How culture and experience influence people's perception of time and space.

National Science Standard

Unifying Concepts — Systems and organization.

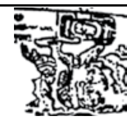
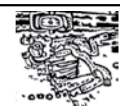
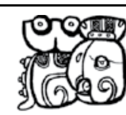
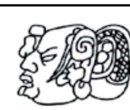
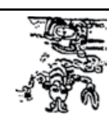
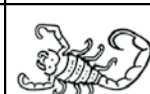
Procedure

- Set the STARLAB latitude to 20 degrees North, the latitude of the Maya civilization.
- Locate each of the Maya zodiacal constellations along the ecliptic.
- How do the birds differ from each other?
- Why would the Maya have constellations such as a turtle and rattlesnake in their zodiac, rather than a lion such as Leo?
- Look for the constellation of the rattlesnake and imagine the head of the snake in Perseus and the rattles on the tail in the Pleiades. Draw the rattlesnake as you see it.

MATERIALS

- STARLAB Portable Planetarium
- Maya Cylinder

The Maya Zodiac

Maya Constellation	Chichen Itza Lintel Glyph	Paris Codex Glyph	Bonampek Mural	Other	Western Zodiacal Constellation	Solar Conjunction at A.D.O.
Bird 3					Capricornus	January
Bat					Aquarius	February
Skeleton					Pisces	March
Jaguar					Aries	April
Rattlesnake					Pleiades in Taurus	April–Mid May
Turtle					Orion	May– Mid June
Bird 2 Muan Bird (Owl)					Gemini	June
Frog					Cancer	July
Peccary					Leo	August
? (Moon Goddess)?					Virgo	September
Bird 1					Libra	October
Scorpion					Scorpius	November
Fish-snake					Sagittarius	December

Activity 21: The Pleiades

Introduction

The Pleiades are an open star cluster that contains about 400 individual stars which are gravitationally linked to each other. Although this group is often called "the Seven Sisters," only six of the stars are bright, and can easily be seen at night. A darker sky will show more stars. The group's size is such that a full moon completely covers it.

Maya people observed the Pleiades to regulate their agricultural calendars. When the Pleiades reached the tops of the trees at dawn, the Lacandon Maya know this is the time to burn their fields. Among the Quiche Maya, the time to plant high-altitude maize is determined by observing when the Pleiades set with the sun in March. Low altitude maize is planted when the Pleiades are in conjunction with the sun in May. The Pleiades have been associated with the rainy season for thousands of years. In Yucatan, the Pleiades are said to rise at dawn on June 13, at the time that the heavy rains are to begin.

The Quiche refer to both the Pleiades and the Hyades as a "handful" (motz) because the Pleiades represent a handful of maize kernels, and the Hyades are a handful of beans. The setting of these two asterisms corresponds to the time these two crops are sown. In Yucatan, the rattle of a rattlesnake represents the Pleiades. The head of the rattlesnake is in the constellation of Perseus. The Pleiades were important calendar stars at the time of the Spanish conquest. Both dawn and dusk observations were important in certain Maya Classic inscriptions, and also in the orientation of buildings. The Pleiades mark the front head of the Milky Way Cosmic Monster.

Objective

To observe the motion of the Pleiades at night.

Integrated Subjects

Science

Process Skills

Observation, compare and contrast.

National Science Standard

Physical Science — position of objects.

Procedure

- Mark North, South, East, and West on the STARLAB dome by writing N, S, E, and W on separate Post-it™ notes and placing them in the correct position on the dome.
- Set the STARLAB to your home latitude. Find the Pleiades star cluster (in the shoulder of Taurus the Bull). Move in daily motion, and describe how far the Pleiades rise from due east? The Pleiades rise about how high above the horizon? The Pleiades set how far from due west?
- Set the STARLAB to 20 degrees north latitude. Using daily motion, describe the motions of the Pleiades. The Pleiades rise how far from due east? The Pleiades rise how high above the horizon? The Pleiades set how far from due west?
- Compare and contrast the motions of the Pleiades at your home latitude with the motions of the star group at 20 degrees north.

MATERIALS

- STARLAB Portable Planetarium
- Maya Cylinder

MATERIALS

- Diagram of the earth's precession circle

Activity 22: The North Star of the Maya

Introduction

The earth has three motions: rotation, revolution, and precession. While rotation gives us day and night, revolution around the sun causes the constellations to change each season, and precession changes the orientation of the constellations and also changes our North Star.

Precession is caused by wobbling of the earth on its axis, once every 26,000 years. The effect of precession is that each century the North Celestial Pole changes its location slightly among the stars. The change is so small that we don't notice it our lifetime. But, the Maya watched the sky for more than 1500 years and would have seen the change.

During the time of the Classic Maya there was no bright star at the North Celestial Pole. This dark area was called Wak-Chan-Ki, the 'Raised-up-Sky Heart'. This is where the top of the Cosmic Tree hits the heavens.

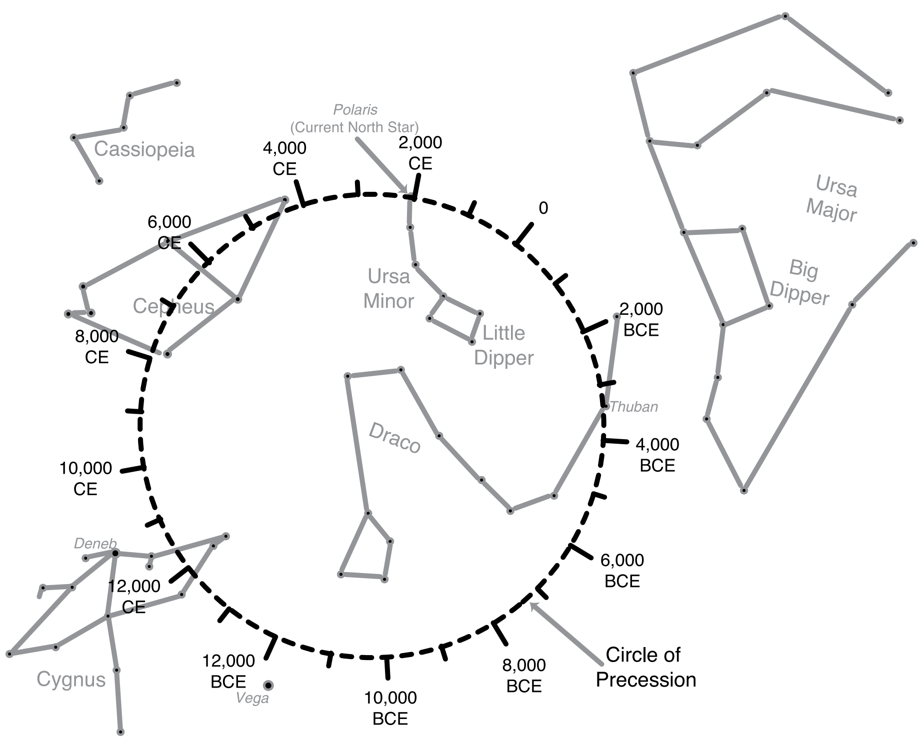
Currently Polaris is the North Star. Its Maya name was 'Xaman Ek', and was sometimes associated with the rain god who brought welcomed winter storms. This star was also called 'Guiding Star'. Because the other stars seemed to revolve around Polaris, it seemed to be a beacon, especially to merchants and mariners.

Objective

To determine which star was the North Star during Maya times.

Integrated Subjects

Science



Process Skills

Interpretation

National Science Standard

Earth and Space Science — Changes in the sky.

Procedure

- Using the diagram of the earth's precession and the chart at the end of the activity, determine the star nearest to the North Celestial Pole, the North Star at the time.

  During the 1500 years that the Maya observed the sky, what other stars might have been used as the North Star? [None except Polaris — the North Celestial Pole was in an area of darkness.]

Important Maya Events	Approximate Date	North Star
Spanish Conquest	1697	
Maya Civil War	1441	
Itzas rebuild Chichen Itza	10th Century	
Dresden Codex Measurements	Early Seventh Century	
Beginning of the Classic Period	AD 300	

MATERIALS

- STARLAB Portable Planetarium
- Maya Cylinder

Activity 23: Seven Macaw (the Big Dipper)

Introduction

At the latitude of the Maya, the Big Dipper is not circumpolar, but dips below the horizon for part of each night. To the Maya, the Dipper is a parrot named "Seven Macaw" who has long tail feathers, similar to the shape of the handle of the Big Dipper. The seven probably refers to the number of bright stars in the asterism. His wife is Chimalmat or "shield," which is the Little Dipper.

According to the Popol Vuh, Seven Macaw thinks of himself as being very important because the light from his stars guides people to their destination. He makes some very boastful claims. The twin heroes of the Popul Vuh decide to teach the Seven Macaw a lesson.

The twins discover that Seven Macaw is a creature of habit. He flies into the Word Tree each day to eat its fruit. When the bird is in the tree, one of the twins, who is named Hunahpu, aims his blowgun at the parrot to knock Seven Macaw to the ground. The dart breaks open Seven Macaw's beak, and knocks him out of the tree. (See Figure 1.)

When the Big Dipper rose at dusk, this was the sign of the dry season. When the Big Dipper descended below the horizon at dusk, this foretold of the hurricane season.

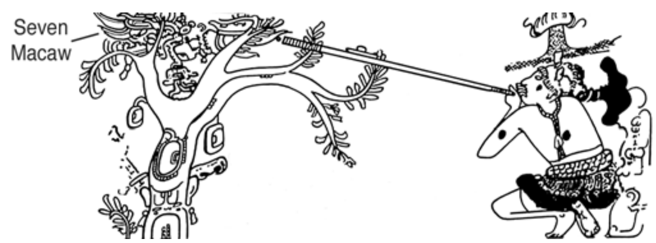


Figure 1

Integrated Subjects

English • Science

Process Skills

Observing, interpreting.

National Science Standard

Science as a Human Endeavor.

Procedure

- Set the STARLAB for your own latitude and watch the motion of the Big Dipper throughout one night.
- Move in latitude to 20 degrees north. In the STARLAB, watch the motions of the Big Dipper. It will rise in the northeast, make an arc until it crosses the meridian, and then move toward the northwest until it sets.
- How does the motion of the Big Dipper change as you move in latitude from your home latitude to 20 degrees north?

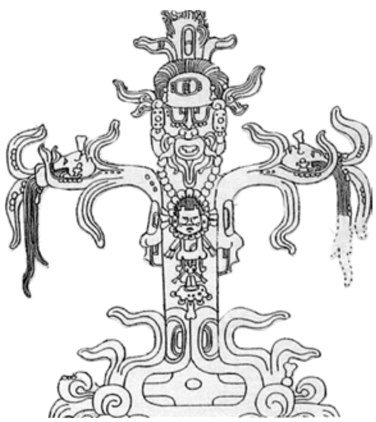
- How is the motion of the Dipper similar to the story of Seven Macaw? [The star group rises in the NE just as the bird flies into the tree. After passing the meridian, the Dipper stars fall to the horizon.]
- Move the STARLAB sky to a July sky (Cygnus is rising in the east).

  There may be a weather reason why Seven Macaw has to be shot and pushed out of the tree. According to the story (Krupp, 1991), Seven Macaw offended the god called 'Hurricane', who brings the rains of July. When Seven Macaw is not in the sky, the rains can fall. Why is the Big Dipper not visible in July? [Because the Big Dipper is above the horizon during the day and so it is not visible. During the early hours of the night the Big Dipper is below the horizon.]
- Some modern Maya picture the Big Dipper as a car with a tail. What part of the Big Dipper is the 'tail'? [The handle.] The Quiche Maya call these stars paq' ab', and picture the two Dippers as spoons or ladles. What part of the spoon is the handle? [The handle of the Dippers.]

Activity 24: The Northern Cross

MATERIALS

- STARLAB Portable Planetarium with projector set for 20 degrees north or a star chart for 20 degrees



Introduction

The Northern Cross is part of the Greek constellation known as Cygnus the Swan. The tail of the swan is the top of the cross, and the wings of the swan form the cross-piece. To the Maya, the Northern Cross was a maize plant which is similar to the plant we call corn.

Maize made up most of the diet of the Maya. Other foods in the diet included beans, squash, peppers, chocolate, and tobacco, but 80% was maize. The Maya book, the Popul Vuh, describes the creation of the first humans by the Corn God from the combination of maize planted in soil, which was then nourished by water.

The mythmakers saw a striking resemblance between the human head, and an ear of corn. The maize ears were known as "little skulls." For this reason Maya nobility elongated the heads of their babies by binding them between carved pieces of wood, and arranged their hair to resemble corn tassels.

Architectural alignments to the rising points of the sun and Venus helped to determine the agricultural calendar of the Maya, and buildings were designed to observe the skies. Currently, the official planting season by Quiche Maya for maize begins with the full moon of March when the brush in the fields are burned. The ashes were then spread on the fields as a fertilizer and the maize crop is planted during the full moon of April before the rainy season begins. Weeding is always done on a full moon. Harvest occurs in November, at the beginning of the dry season.

The planting of maize, for the Chorti Maya people, began on May 4, the day after the Day of the Holy Cross, which was the most important festival date of the year. Maize takes 260 days to mature, which may have led to the 260 day Maya calendar. The identity between maize and humans is reinforced because it takes maize 9 months to mature, just as it takes 9 months for a human fetus to mature.

The Temple of the Foliated Cross at Palenque is aligned toward the setting point of Deneb, and thus seems to be dedicated to the Northern Cross.

Objective

To determine if the motions of the Northern Cross could have influenced the planting schedule of the Maya.

Integrated Subjects

Science • Biology • Geography

Process Skills

Problemsolving

National Geography Standard 15

How physical systems affect human systems.

National Science Standard

Unifying Concept — Systems and organization.

Procedure

The Maya usually observed the skies when the morning star was rising, the sun was rising, or the sun was setting.

- Using a star chart or STARLAB, place the sun in a 6 AM sunrise position for early March. The sun would be located among the stars of the Bat (Aquarius). Where is the Northern Cross? [Midway between the horizon and the zenith.]

  Is the Northern Cross visible in the evening sky? Assume that the sun sets about 6 PM. [The Northern Cross has already set in the west.]

- Find the location of the Northern Cross just before sunrise in early April. The sun is in the constellation of the Jaguar (Pisces). Where is the Northern Cross asterism located now? [Near the meridian.]

  Is the asterism visible at sunset? [No, its sets about mid-afternoon.]

- Find the location of the Northern Cross at sunrise (6 AM) and also at sunset (6 PM) on the Day of the Holy Cross, (sun in the rattlesnake on May 3). [At sunrise it would be crossing the meridian and would set below the horizon at about noon.]

- How could the motions of the Northern Cross be used to tell Maya farmers when to burn their fields, when to plant, and when the rainy season was to begin? [At dawn in March, the maize plant is upsidedown in the northeast sky. In April, the plant is sideways and almost overhead. In May, the plant is lower in the sky than it was in April. At harvest, the plant is just rising.]

Activity 25: The Thieves Crosses

Introduction

The thieves crosses or the thieves daggers, are called Repib' al elaq' omab' to the Quiche Maya. This is a modern constellation. Apparently there are two or three "crosses" in the night sky at the same time, which watch over thieves when they prowl at night.

According to the Modern Quiche Maya, when a person is about to commit a crime such as robbery, it is necessary to get the protection of these stars because this brings luck. The potential thief secures two bananas and goes out to the country at midnight where he offers the bananas to the constellation, and makes a speech to the constellations so that money will be attracted to him. When his neighbors see him with two bananas, they know robbery is on his mind. (Remington).

Objective

To find the two "Thieves Crosses."

Integrated Subject

Science

Process Skills

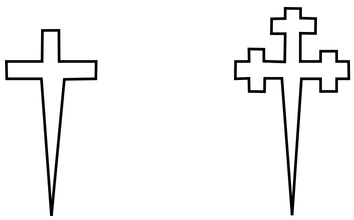
Observing, interpreting

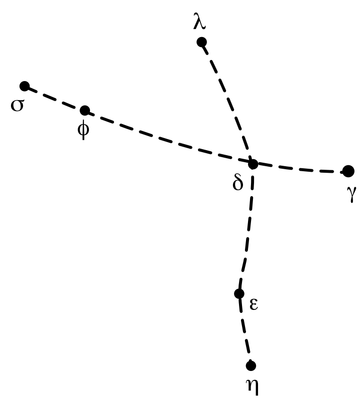
National Science Standard

Earth and Space Science — Objects in the Sky.

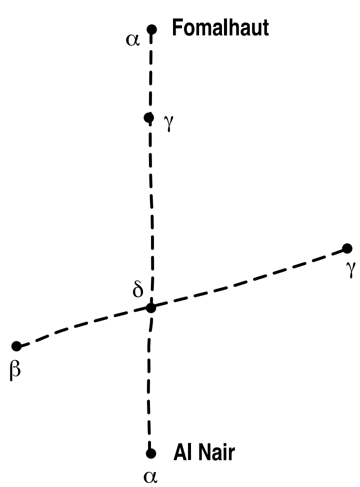
Procedure

- Use the Northern Starfield Cylinder. Set the STARLAB sky for 15 degrees north.
- Move the sky so that the Fish Snake (Sagittarius) is rising.
- Look for patterns in the stars that look like crosses or daggers. Although there are many crosses in the night sky, see if you can find three: Cygnus the Swan, Crux, and the stars of Sagittarius.
- Put the Maya cylinder on the STARLAB projector and compare your crosses to the ones seen by the Maya.





6.7. Possible visualization of Cross B in Sagittarius.



6.8. Possible visualization of Cross C, with Fomalhaut and stars in Grus.

Remington p. 86

Resource Materials for Teachers and Students

Teacher Materials

Websites

Winkler, L. (1995). "Indiana Jones and the Astronomers of Yore" in The Universe in the Classroom*, Summer 1995 or may be found at http://www.aspsky.org/education/tnl/31/31.html. This publication and Website come from the Astronomical Society of the Pacific. It begins with a primer on archaeoastronomy; continues with how geometry is used to measure the azimuth, altitude, and declination of objects in the sky; and includes how to decipher the Maya numbering system.*

Moreno-Corral, M. & Rodriguez, M. A. (Nov/Dec 1995). "Word Beat: Mexico" in Mercury*, 995. This article in* Mercury *magazine, the bi-monthly magazine of the Astronomical Society of the Pacific, and on line at http://astrosociety.org/pubs/mercury/9506/mexico.html, traces the history of astronomy in Mexico from the time of the pre-Columbian peoples to the modern astronomy of today.*

http://www.michielb.nl/maya.html is a nice Website that gives information about the politics and cosmology, the ecliptic, and the concept of the Maya Milky Way.

Books

Harris, J. F. & Stearns, S. K. (1992). Understanding Maya Inscriptions: A Hieroglyph Handbook*. Philadelphia: The University Museum of Archaeology and Anthropology, University of Pennsylvania. A "how to" book that teaches one how to read ancient Maya manuscripts. It contains directions for writing today's date in Maya hieroglyphs, and an assortment of nice glyphs (dance, observe, or complete) and not so nice glyphs (bloodletting, capture, or death) so that a teachers could lead the students in sentence writing in Maya glyphs. The English alphabet is also given in glyph form so that other words may be spelled out. As the preface says:*

"(The book) uses the latest methods of structural analysis, illustrates the traditional techniques for computing Maya calendrics, introduces the currently accepted orthography, provides syllabary and syntax, suggests new readings and presents previous interpretations. In short, (this is) a book to put you on the path of an intellectual adventure who fascination never ends."

A. F. Aveni. (1989). Empires of Time: Calendars, Clocks, and Cultures*. New York: Basic Books, Inc. A great book for those who want to understand how early time was reckoned and how and why calendars were created. Chapter Six deals with the calendars of the New World: the Maya of Central America; the Aztec of Northern Mexico; and the Inca of western South America. Because these cultures developed their ideas about time before European contact, it is possible to study the concept of time keeping and the importance of this in their cultures.*

Fash, W. L. (1991). ***Scribes, Warriors and Kings: The City of Copan and the Ancient Maya****. London: Thames and Hudson, Ltd. This is an easy to read book about all of the aspects of life in Copan, one of the great cities of the Classic Maya. The city was abandoned for nearly a thousand years, until it was rediscovered two centuries ago. According to the book jacket, by deciphering the glyphs and studying new tomb discoveries, we now know about:*

"The blood rituals by which kind and people communed with their ancestors; the sacred ball games played by the city's rulers; and the role of the scribes who have left such detailed records of their times. Copan's spectacular architecture, sculpture, and jade artifacts are fully illustrated in photography and drawings."

Fisher, L. E. (1999). ***Gods and Goddesses of the Ancient Maya****. New York: Holiday House. ISBN 0-8234-1427-2. Artist Fisher illustrates, and briefly discusses twelve of the ancient Maya Gods and Goddesses (Itzama, God of All; Kinich Ahau, God of the Sun; Chac, God of Rain; Yum Kaax, God of Corn; Kukulcan, God of Wind; Ek Chuah, God of War; Xaman Ek, God of the North Star; Ix Xhwl, Goddess of Childbirth, Ix Tab, Goddess of Suicide; Ah Puch, God of Death; Manix, God of Sacrifice; and Bolontiku, God of the Lower World). All of the full-page drawings (8.5" x 11") are in vivid color. A map, pronunciation guide, bibliography and an explanation of Maya numbers are included. Appropriate for elementary students.*

Milbrath, S. (1999). ***Star Gods of the Maya: Astronomy in Art, Folklore, and Calendars****. Austin: University of Texas Press. ISBN 0-292-75226 (paperback), or 0-292-75225-3 (hardback). This reference contains almost all of the Maya astronomical information known at the time of the writing of the book (1999). It provides a clear and easily understood reference to the work completed by scholars concerning Maya astronomy as depicted in their art and monuments. The author, an expert in Maya glyphs, provides general information, as well as the controversies about other researcher's interpretations of the material. The drawings and photographs show almost all of the Maya astronomical glyphs found to date. This is the one reference book to buy.*

Morley, S. G. (1947). ***The Ancient Maya****. Stanford University, CA: Stanford University Press. Dr. Morley traces the history of the Maya over the past five thousand years to the Spanish conquest in A.D. 1697. He discusses how their achievements in astronomy, mathematics, and chronology, were among the greatest in history. According to Time Magazine:*

"this patient, expert, profusely illustrated book is by far the best general survey of the Maya as a whole."

Magazines

Kaufmann, C. (December 2003). "Sistine Chapel of the Early Maya." ***National Geographic Magazine****, Volume 204, No. 6, pp. 72-77. A 2000 year-old painting found on the inside of a pyramid in Guatemala, shows the first known portrayal of the Maya corn god's journey from the underworld to Earth.*

Vesilind, P. (October 2003). "Watery Graves of the Maya." ***National Geographic Magazine****, Volume 204, No. 4, pp. 82-101. Underwater archaeologists have explored 20 or so fresh water pools or cenotes which to the Maya, were the entrance to the underworld. These two capsules record the history of both animal and human habitation of the area.*

Zachowitz, M. (August 2003). "Royal City of the Maya." ***National Geographic Magazine****, Volume 204, No. 2, pp. 96-99. Over 100 graves have* *been recently discovered at Piedras Negras. Gravegoods and carved stelae tell the story of the rise of the city, and its downfall when the king was captured by invaders.*

Inomata, T. (May 2003). "Aquateca: New Revelation of the Maya Elite." National Geographic Magazine*, Volume 203, No. 5, pp. 110-119. About A. D. 800, the last ruler and his family fled the city before an enemy attack, and left their possessions in place. Although fire swept through the enclave, the work of the artists and scribes remain, and tell us how the Maya lived and worked.*

"A New Chapter in Maya History: All-out War, Shifting Alliances, Bloody Sacrifices." (October 2002.) National Geographic Magazine*, Volume 202, No. 4, pp. Geographica. In 2001, a falling tree in the rainforest of Guatemala exposed a stone staircase which, when translated, provides a story about a war in A. D. 625, between two ceremonial centers of Tikal and Dos Pilas. This war may have begun the collapse of the Classic Maya civilization.*

Demarest, A. A. (November 1993). "The Violent Saga of a Maya Kingdom." National Geographic Magazine*, Volume 183, No. 2. pp. 94-111. Recent excavations at Petexbatun have given archaeologists insight into the fall of the Maya civilization. A stela carved in A. D. 731, a newly discovered glyph-covered stairway, and the tomb of the Maya king tell of warfare between Petexbatun, Tikal, and Dos Pilas. As usual, National Geographic does a nice job of combining text, pictures, and diagrams to make the Maya more comprehendible.*

For Children

*Gerson, M. (1995). P*eople of the Corn*. Boston: Little, Brown and Company. ISBN 0-316-30854-4. A delightful picture book with pictures by Carla Golembe drawn in Gouache, an opaque water-based paint. The story is an updated version of the Popul Vuh. In this book, the events have been connected to a more modern world, but the flavor of the ancient text is retained. Appropriate for elementary students.*

Lattimore, D. H. (1985). Why There is no Arguing in Heaven: A Maya Myth*. New York: Harper & Row, Publishers. ISBN 0-06-023717-1. This picture book concisely tells about the Mayan story of creation, as recorded in the Popul Vuh. The drawings are perfect for an elementary school, teacher-led story time. The front and back inside covers show Maya glyphs for simple words, Maya numbers, and Maya month names. In this tale, both the Lizard God and the Moon Goddess argue which god is the greatest, after the Hunab Ku, the first Creator God of the Mayas. There is no arguing in heaven because the Maize God creates humans to worship the Creator God, and thus earned his place next to Hunab Ku.*

Marks, C. False Tongues and Sunday Bread: A Guatemalan and Maya Cookbook*. (1985). New York: Donald I. Fine, Inc. ISBN 1-55611-379-X. Here is a wonderful cookbook that covers Maya meals from appetizers to desserts, and everything in-between. Most recipes use only a few easy-to-find ingredients, and the directions are simple. Upper elementary or middle school students should be able to create a Maya meal.*

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