Archaeoastronomy

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Looking Back in Astronomical Time

The smallest, faintest points on the images are galaxies which are so far away that we see them as they were, billions of years ago. We are looking back in time.

This structure had deep astronomical significance, thousands of years ago. How can we understand what that signiificance was?

Introducing Your Presenter

… not an archaeologist

Astronomy

What Does the Term Mean to You? To Others?

- New discoveries about the universe; space exploration; cosmology etc.
- The night sky; constellations and stars.
- How the motion of the sun and sky produces day and night, seasons, north and south.
- How the position and motion of the sun, moon, planets and stars might affect you (but don't).
- Astronomical basis of your religion, its calendar, festivals, alignment of churches and burials.

A Matter of **Definition**

- Astronomy is now defined as the study of the universe
- “Archaeoastronomy” implies that societies observed the sky to study the universe. But their motivations were more diverse!
- Archaeoastronomy is the study of how people in the past have used and understood phenomena in the sky, and what role the sky played in their culture (wikipedia/Sinclair)

Introducing the Topic

The name is still debated...

Primitive spelling bees

The Sky as a Cultural Resource

- Light by day and night
- Time of day: sunrise, noon, sunset
- Time of year: seasons, planting, hunting
- Calendar: for practical and ritual purposes
- Navigation on land and sea
- Spirituality, ritual, religion, its calendar
- Explanation of the present; prediction of the future: astrology
- Creation and other cultural stories in the sky

The Sky and Civilization

Chichen Itza: Cesar Ramirez

Great Pyramid: Paul James Cowie

- Every advanced civilization has used the sky as a clock, calendar, and compass, for practical and ceremonial purposes
- Astronomy is part of the technology and culture of these civilizations; should be studied as such

The Wise Men and the Elephant

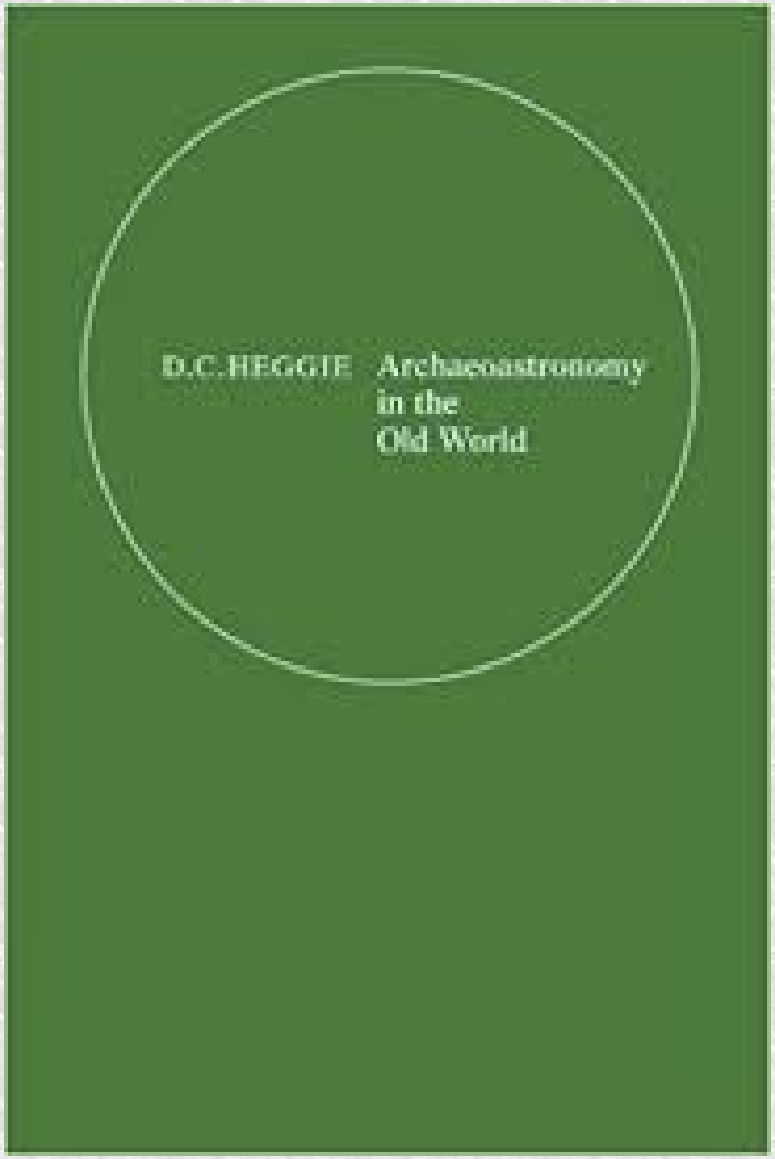
An ancient and widespread legend, reminding us that we need as much (and as varied) information as possible

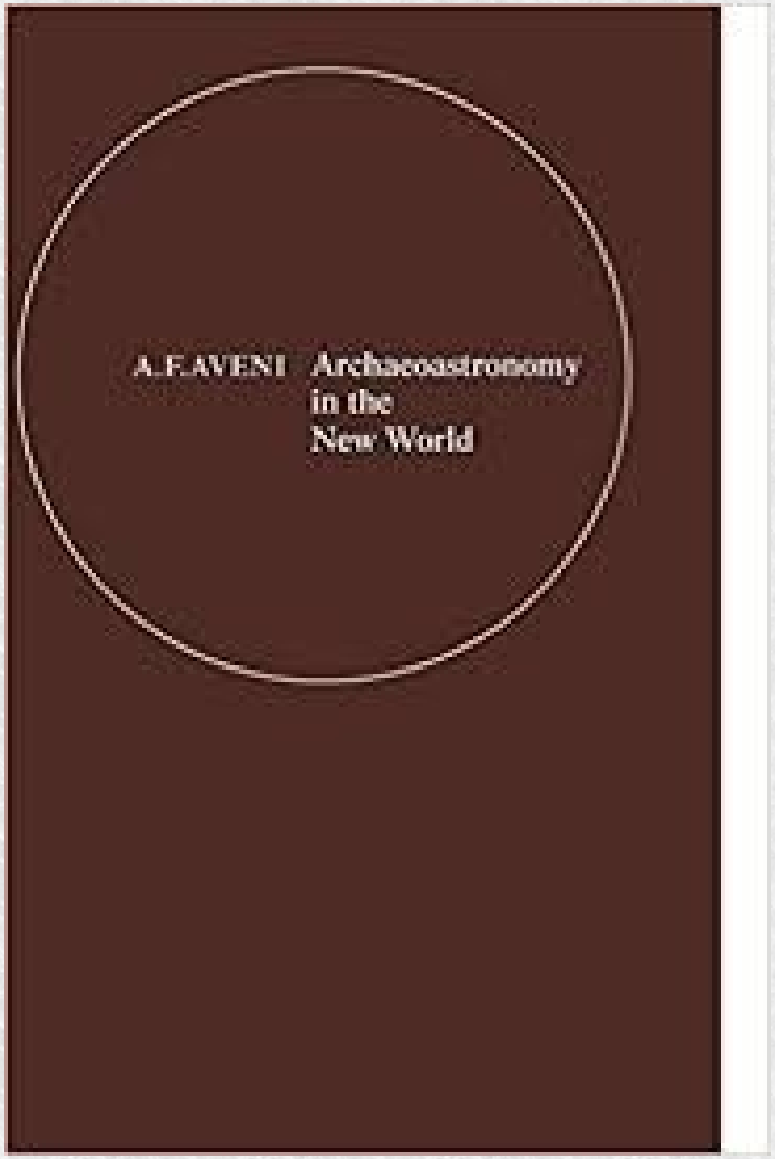
Methodology

The challenge (and interest) is in the methods used to glean information; interdisciplinary!

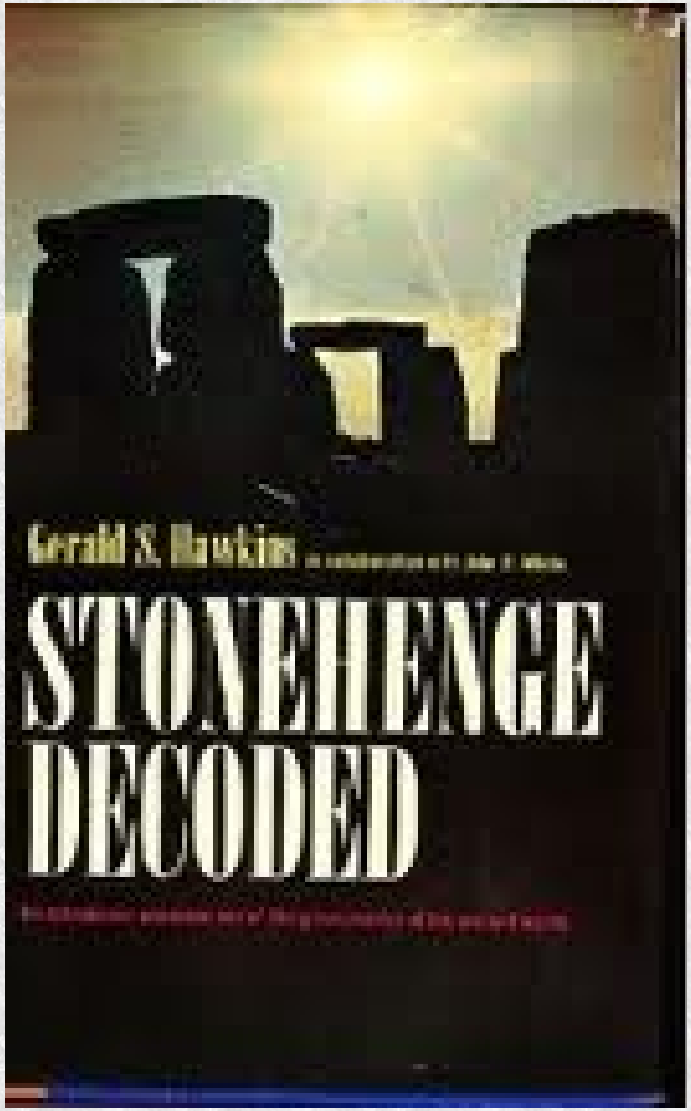
- **Archaeology**; material culture; artifacts
- **Anthropology/ethnology**; oral history; traditions; reports of colonizers
- **Present-day practices** by pre-technological cultures – numerous but declining
- **History** (of science, and history generally)
- **Astronomy** – observation, interpretation
- **Statistics and probability**

Green Archaeoastronomy and Brown Archaeoastronomy





Caveat!



Souvenir Press

- *"A field with academic work of high quality at one end, but uncontrolled speculation bordering on lunacy at the other"* (Ruggles)
- Beware extreme pseudoscientific websites and interpretations!
- ... and experts within narrow disciplines

Historical Bias

- Most of us were schooled in Western, Judaeo-Christian history; **we must not impose our thought patterns on other cultures!**
- We were less exposed to non-Western history and culture ...
- ... especially in non-English languages
- We often consider pre-technological civilizations as “primitive”
- Many indigenous languages and cultures are being lost
- Certainly true in Canada; their traditions, including their astronomy, may be lost forever

Earth – Our Common Home

NASA

- Life has developed on our planet for 4 billion years
- We share our planet with billions of other people, and countless other living organisms
- We all have a cosmic origin, and a common history – one world, one sky!

The Inspiring Beauty and Wonder of a Clear, Dark Sky Transcend Cultural Boundaries

Richard Payne

The Sky Clock

The Sky Compass

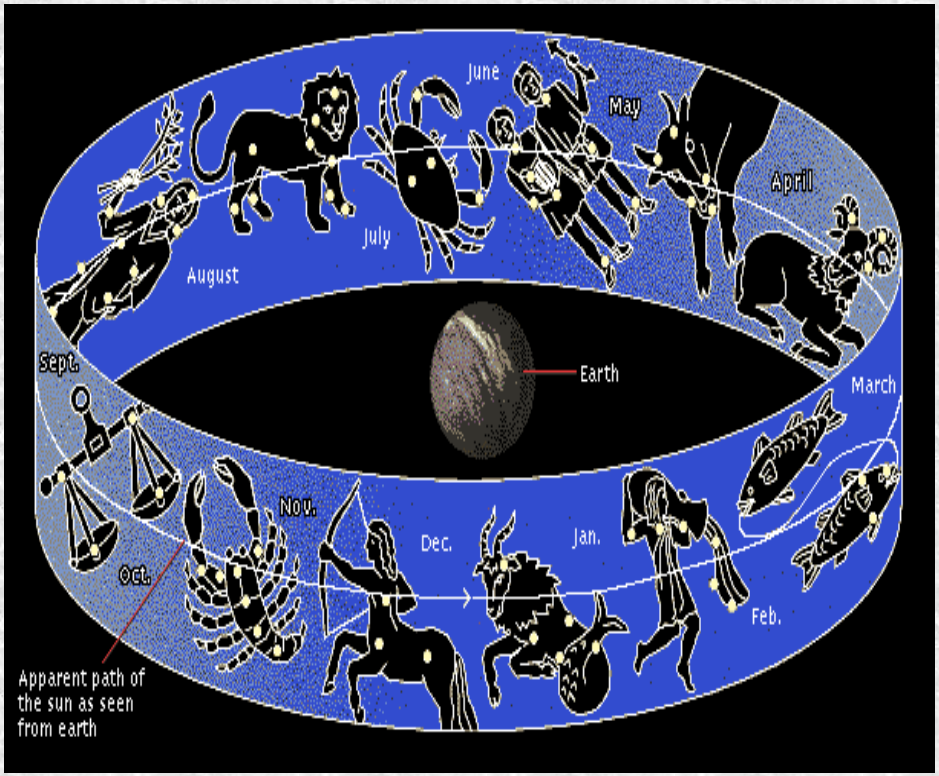
- The earth's rotation axis defines directions on earth: the north and south poles and equator, and their projections on the sky – the celestial poles and equator
- And the sun is due south or north when highest in the sky at noon

Polynesian Astronomy

US Postal Service

- Polynesians needed to be able to navigate long sea voyages
- They used knowledge of ocean currents, clouds, nature, and the night and day sky, including the rising and setting points of equatorial stars and other observations to do this
- Their knowledge and traditions were handed down through generations

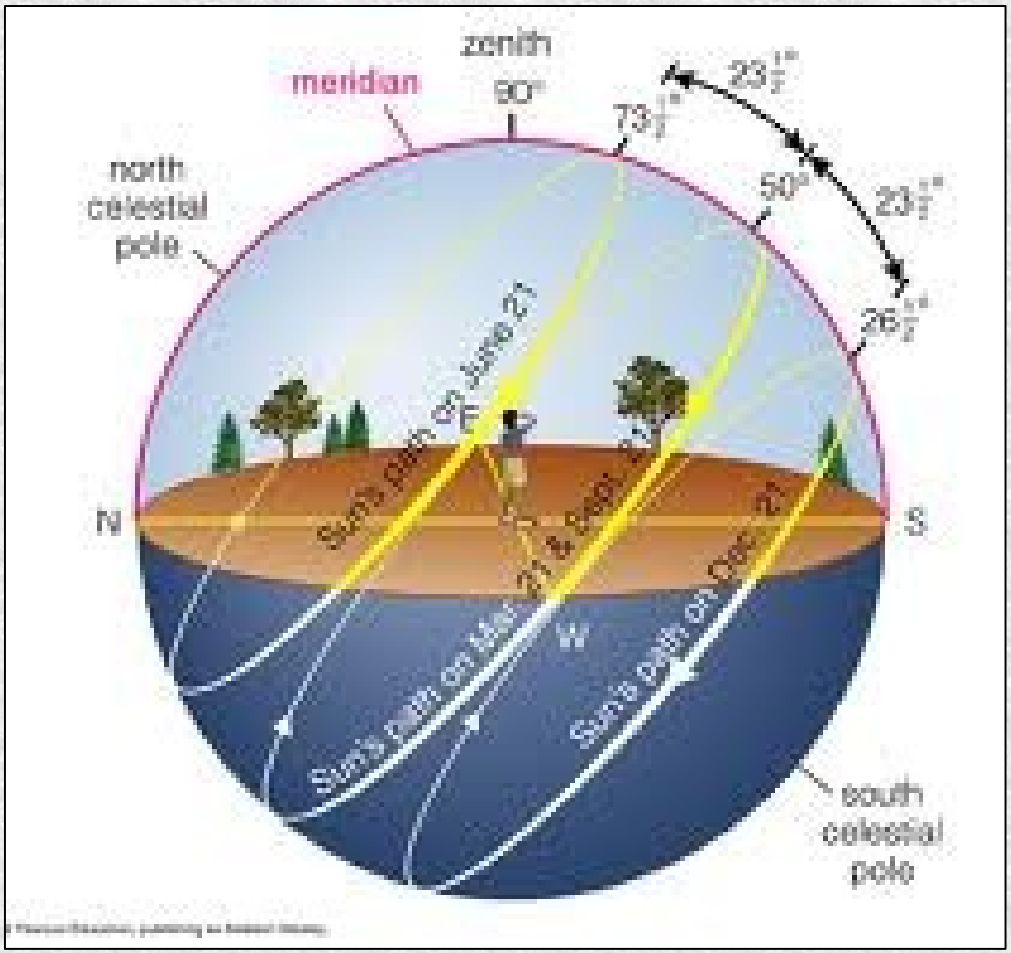
The Sky Calendar



dailygalaxy.com

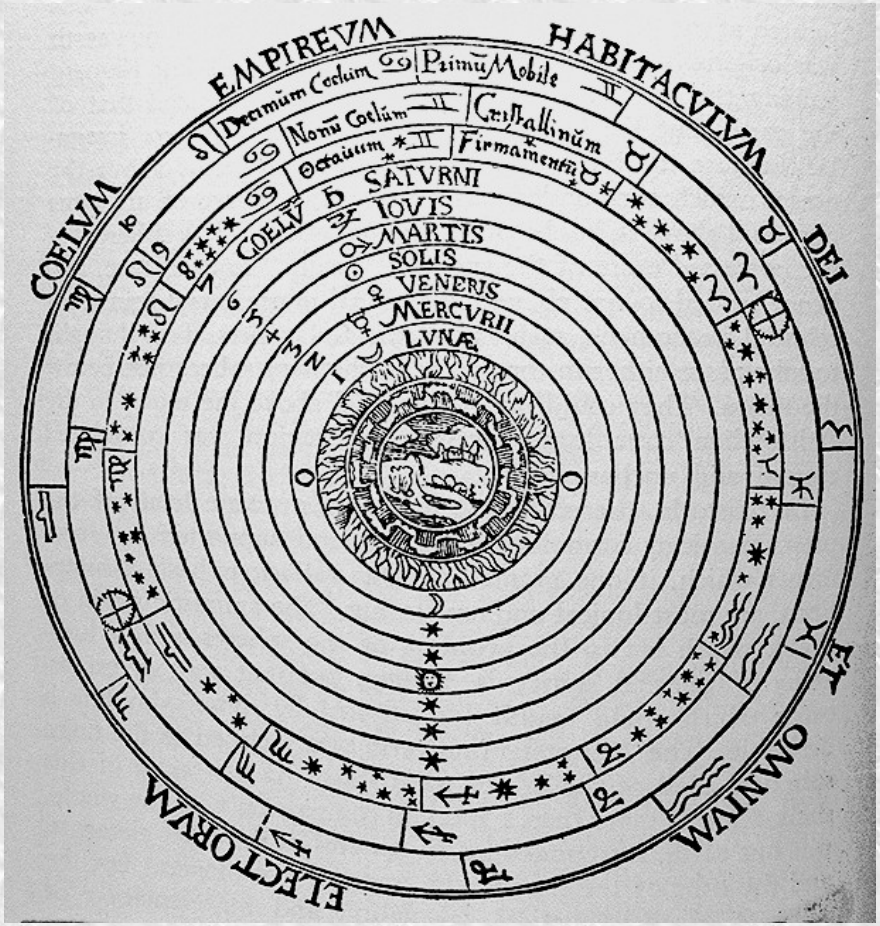
- As a result of the earth's revolution around the sun, the constellations visible in the night sky change during the year, and can be used to keep track of, and predict the seasons

The sun's daily path and the Seasons



- As a result of the tilt of the earth's axis, the sun moves north and south during the year
- This affects the number of hours of daylight, and the height of the noonday sun; this causes the seasonal changes in temperature
- It also affects the position of sunrise and sunset

Myth and Cosmology



Were the cosmologies of “primitive” societies really inferior to Aristotle's earth, water, air, fire?

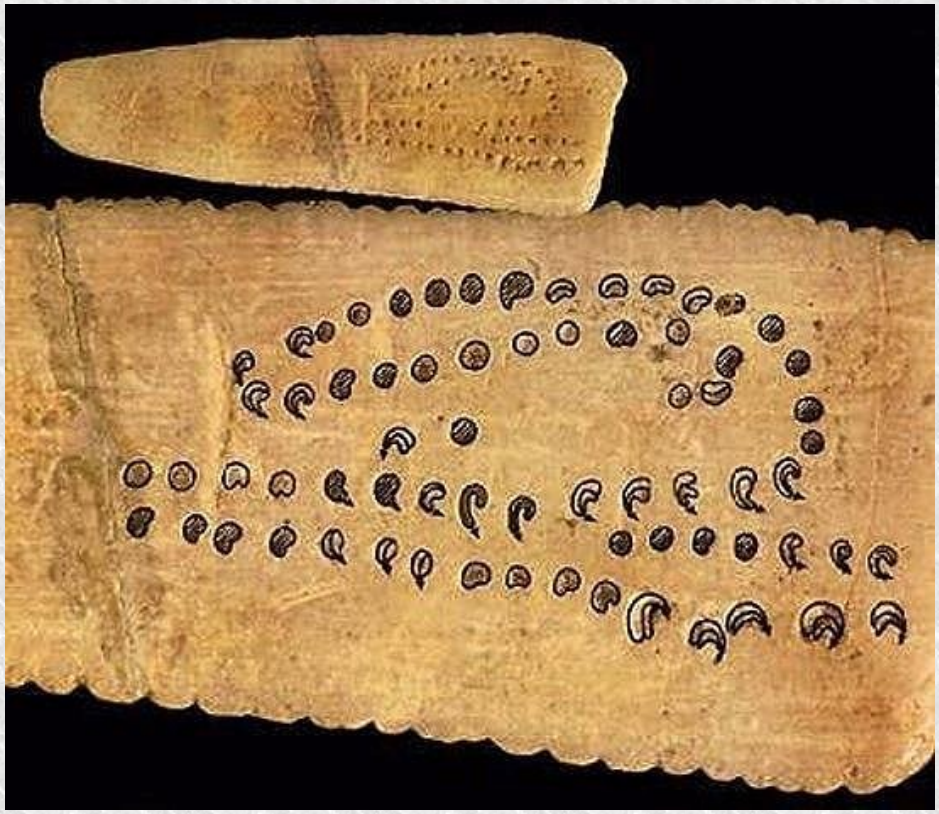
… which leads to **astrology**

How Old is Astronomy?
The Sky and Non-Human Species

wikipedia.org

- Many species – birds, butterflies, turtles -- undertake lengthy migrations
- There is evidence that they use the earth's magnetic field, the sun, and perhaps stars
- Is this purposeful?
- Is this the first “astronomy”?

The Beginning of Human "Astronomy"



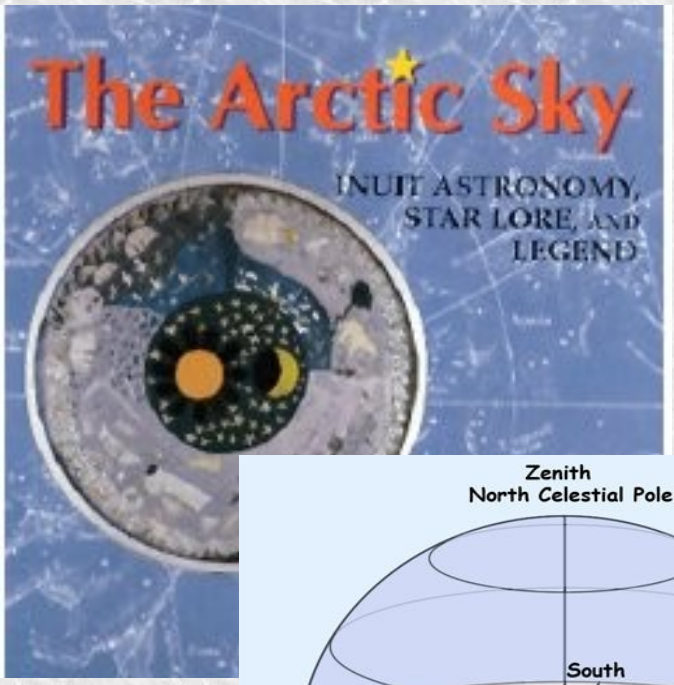
After Marshak (1970)

- This may be a moon calendar, carved on a bone, 30,000 years ago
- Over 70,000 years ago, humans in Africa may have used observation of moon phases to determine when to catch shellfish
- And the moon provides light for night activities

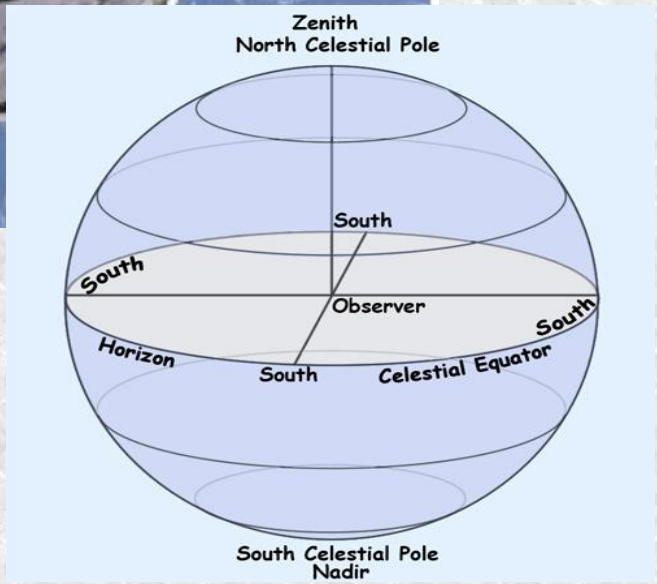
Astronomy and Cave Art?

- Lascaux Cave, France (ca. 16,500 BCE): these patterns have been interpreted as stars
- Interesting, plausible, but unproven: but the artists are not around to confirm it

Effect of Latitude: Inuit Astronomy



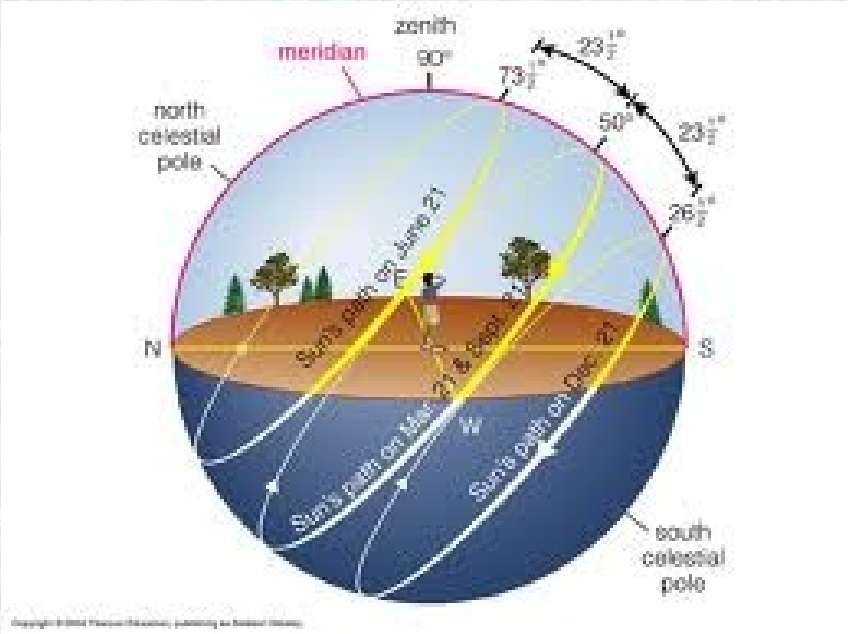
Royal Ontario Museum



Professor C. Seligman

- At high Arctic latitudes, the sky moves more parallel to the horizon; rising and setting are less apparent
- The sun is below the horizon for many weeks in winter, and above the horizon for many weeks in summer (“midnight sun”)
- The Inuit used the day and night sky, and other observations of the environment, for practical and ceremonial purposes

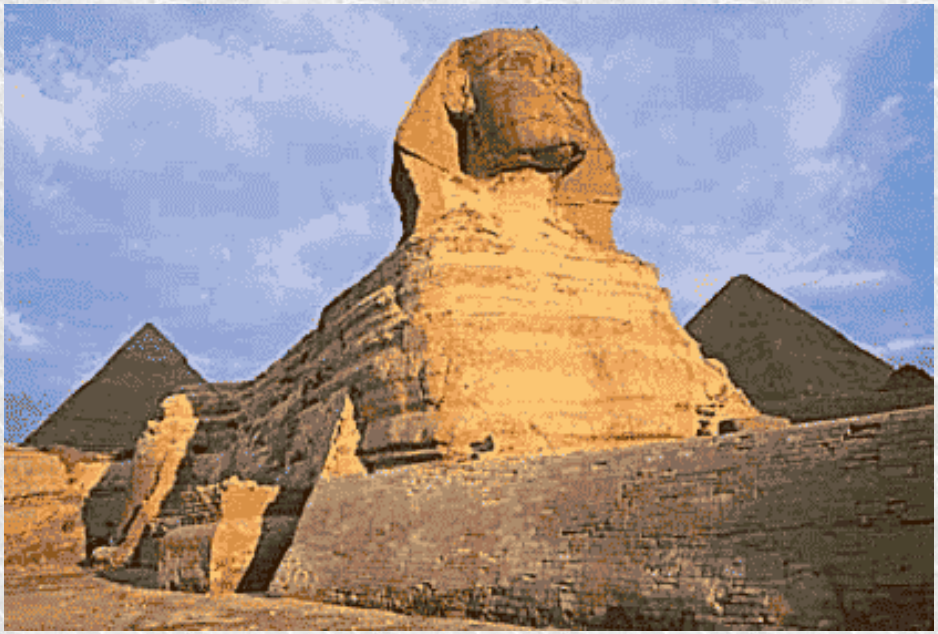
Seasons and Sunrises/sets



Stonehenge: British Tourist Board

- Sunrise and sunset points move northward and southward during the year
- Early astronomers could determine the time of year (seasons) by observing the rising or setting point of the sun on the horizon
- This was done in many parts of the earth

The Sky and the Afterlife



Egyptian Tourist Board

- E.g. Sphinx of Giza ca. 2500 BC
- Associated with sun deity and its relation to afterlife; the sky as a “window on the supernatural”
- Heaven ~ heaven
- Orientation?
- As usual, lots of wilder theories

Newgrange ca. 3300-2900 BC

www.newsfile.ie

- Passage burial chamber in eastern Ireland
- Sunlight penetrates passage on the winter solstice through a purpose-built (?) shaft
- Evidence: **alignment; evidence of purpose; other examples of aligned structures**

Stonehenge

- Built ca. 3100-1600 BC
- Required great effort, but not advanced technology
- Many astronomical alignments, some firm, but others dubious
- **Most likely used at winter solstice as a shrine for the dead, for rituals attended by thousands**

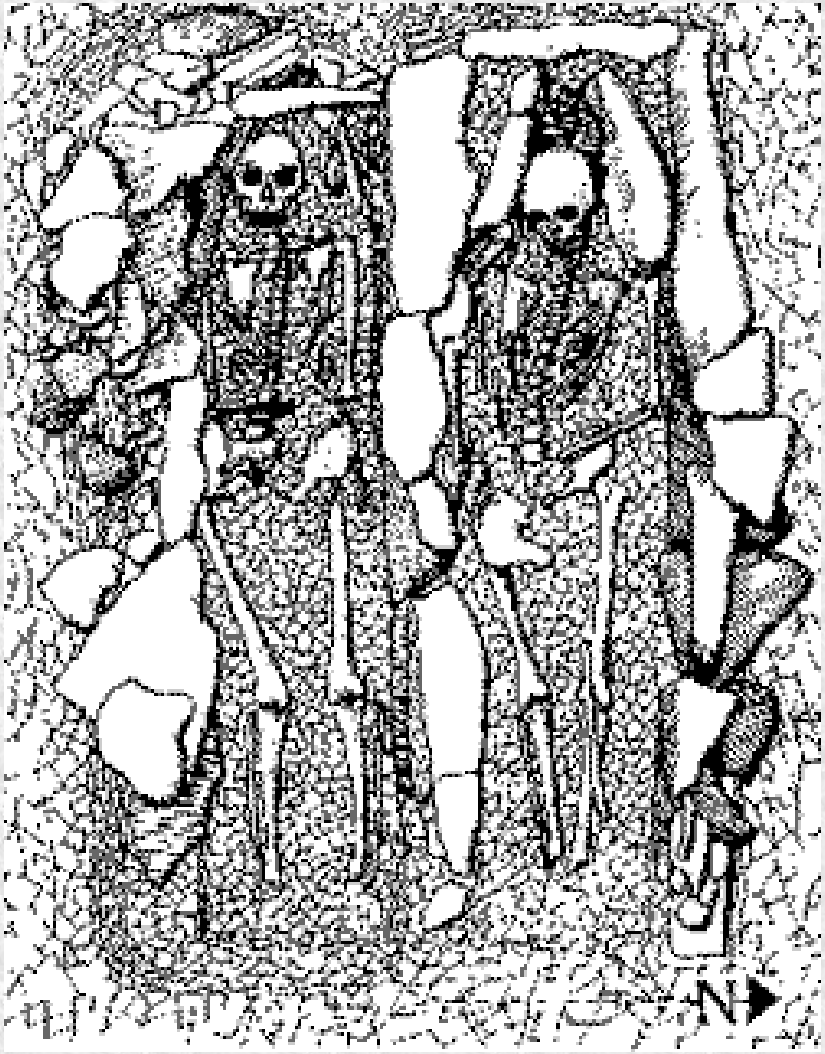
Other Megalithic Structures

widely distributed in Europe

wikipedia.org

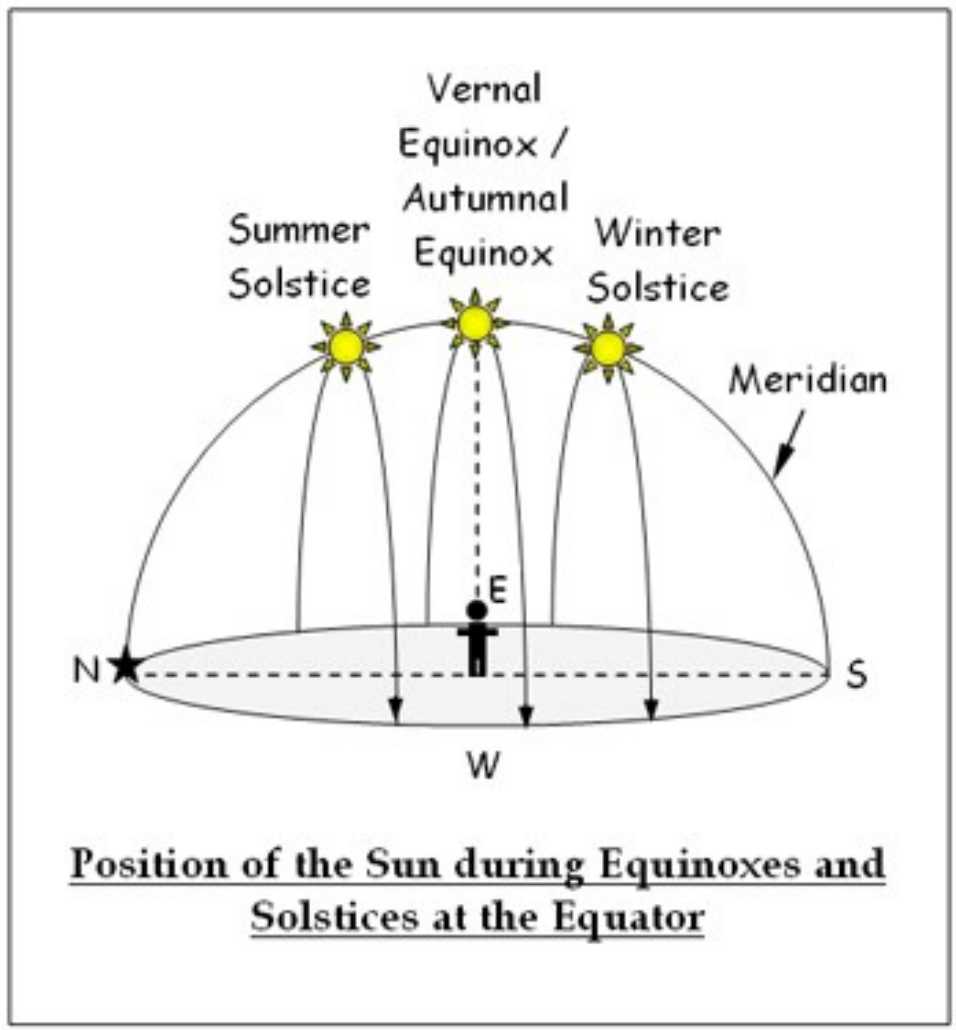
- These include numerous stone circles, and structures (probably) aligned to observe the sun's rising or setting point on the horizon
- At left: Auglish, Londonderry, studied by Alexander Thom

Alignment of Churches and Burials



- It was a common Christian tradition to align churches east-west
- Burials also
- Based on tradition that, at the Second Coming, Christ would arrive from the east

The Tropics: Mesoamerican Astronomy



- In the tropics, the sun can pass *directly* overhead – a **"zenith passage"**
- This could be observed with a vertical pole, or a deep well or pit
- Significant in Mexico and elsewhere in Mesoamerica

Mayan Astronomy

markmallett.com

- The Mayans were fascinated by time, as measured by both the sun and by appearances of Venus – the second-brightest object in the night sky
- Their rituals were built around cycles of time
- Their calendars were sophisticated and accurate

Mayan Astronomy – The Codices

latinamericanstudies.org

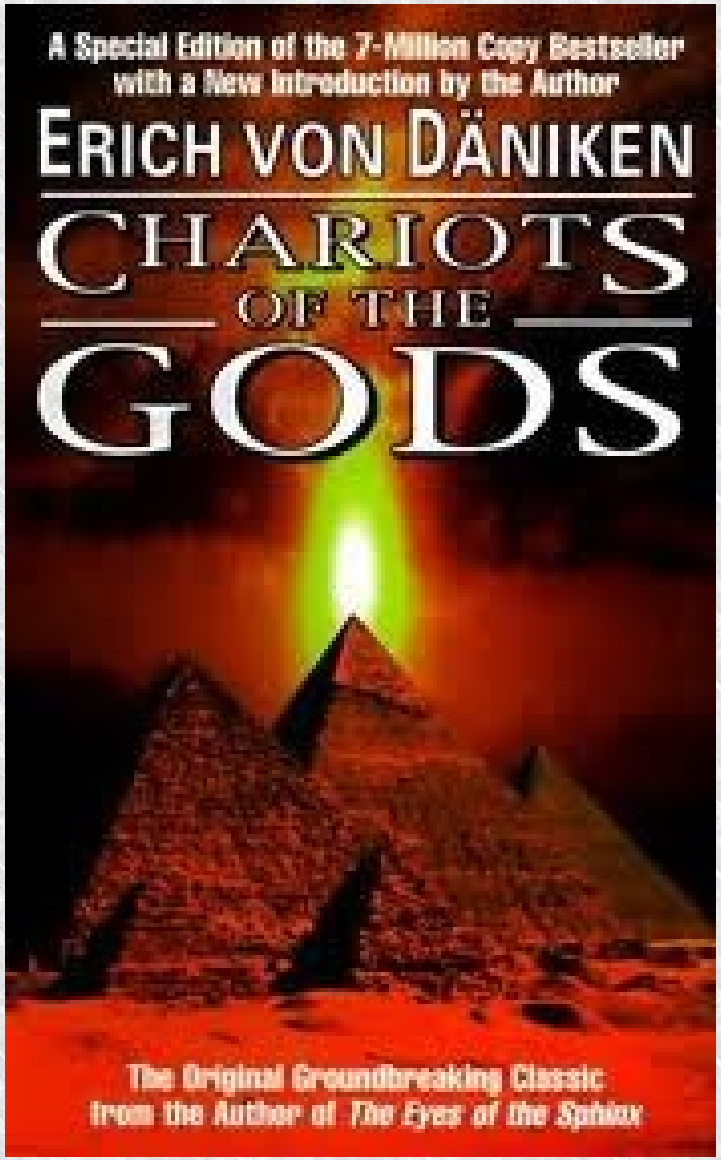
- A few Mayan writings survived the Spanish conquest
- These - -especially the Dresden Codex -- provide details of Mayan astronomy, calendars, and astrological obsession with **Venus**
- No, the world did not come to an end on Dec. 21, 2012!

Nazca (Peru) Astronomy ~ 500 AD

latinamericanstudies.org

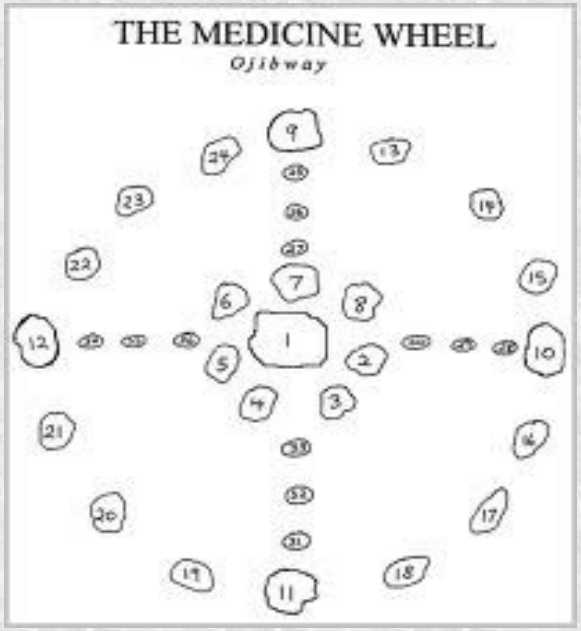
- Lines and other patterns on the desert, made by scraping stones aside
- Wide variety of hypotheses, including alignment and other astronomical significances
- Ethnography suggests ritualistic use, with astronomical and environmental bases

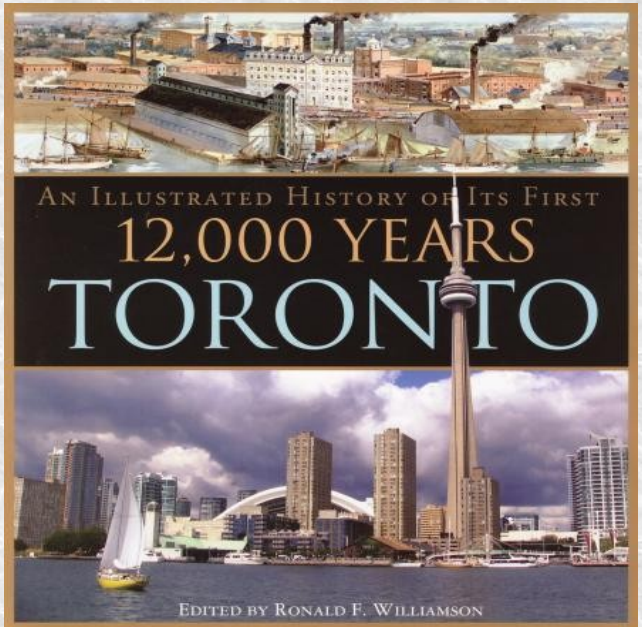
Diversion: Erich von Daniken



- Von Daniken, an accused plagiarizer and convicted embezzler and fraud, wrote breathless books and documentaries which attributed many ancient artifacts to space aliens
- These claims have been well-rebutted
- Pseudoscience sells, rebuttals don't

The Sky & Aboriginal Civilizations





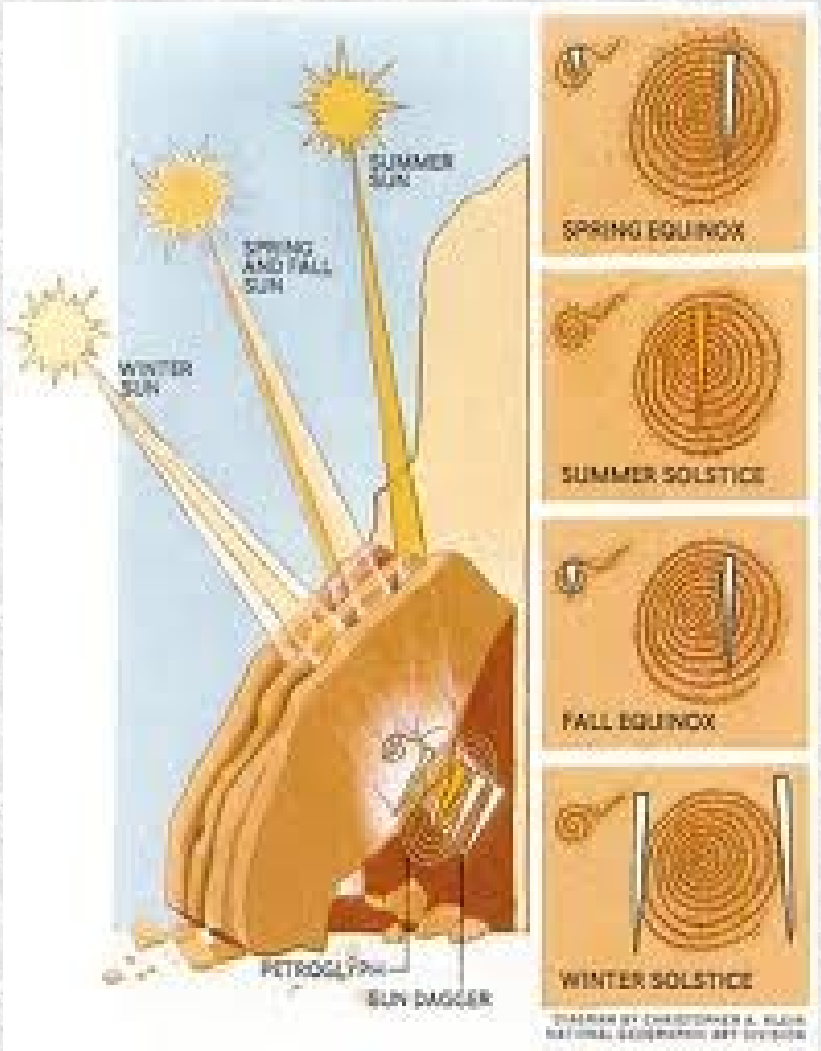
- Aboriginal civilizations, including those in North America, have also used astronomy for practical and ceremonial purposes
- The sky is part of their deep understanding of their environment, as well as part of their spiritual world -- as it is for other civilizations

Big Horn “Medicine Wheel”

National Park Service

- In Wyoming, one of dozens of such structures in western North America (including Canada)
- Dubious claims of multiple astronomical alignments (“Canada's Stonehenge”)
- Certainly used for rituals (oral history) in which astronomy figured

Sun Dagger



National Park Service

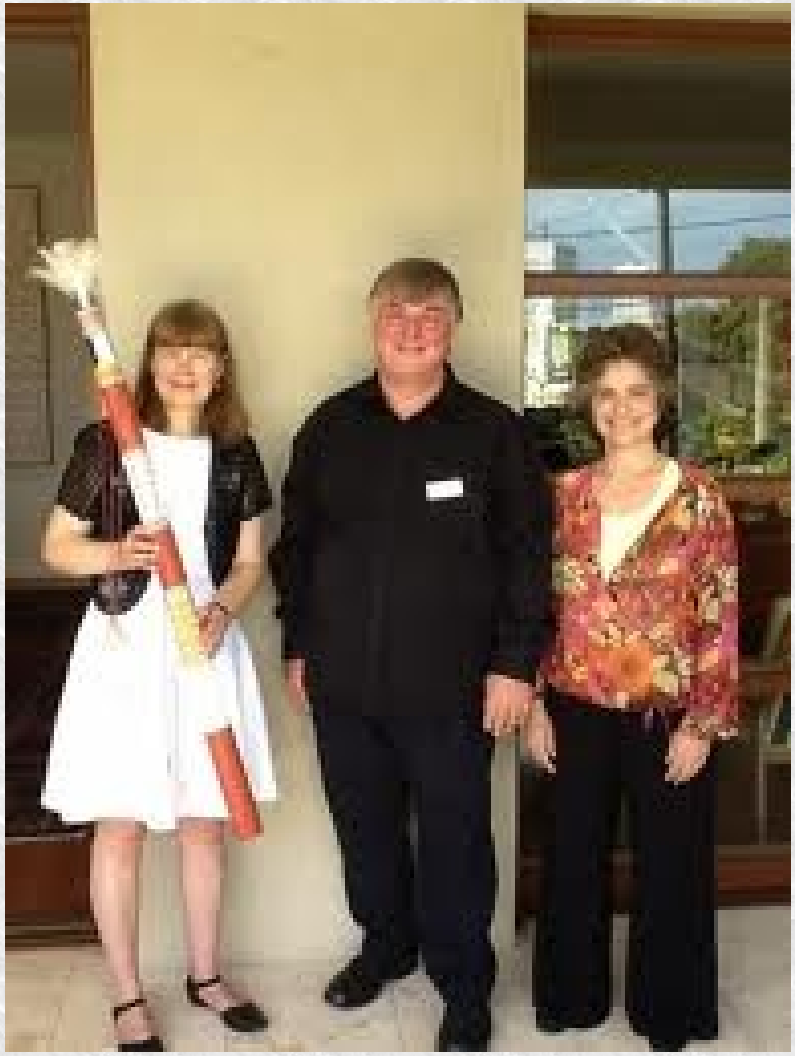
- Chaco Canyon Culture, New Mexico, ca. 900-1150 AD
- **Many astronomical alignments in the area;** the most intriguing is the “Sun Dagger”
- Marks the solstices and equinoxes
- Astronomical significance is not universally accepted

Maori Astronomy: Matariki = Pleiades

Stardome

- What we call the Pleiades figured prominently with Maori season-keeping and navigation; adopted as their new year
- Efforts are being made to establish a national holiday, recognizing this star group

Australian Aboriginal Astronomy



Alison MacKay, Ray Norris, Jeanne Lamon

- 45,000 years of astronomy?
- 270+ languages and cultures (rapidly disappearing)
- At left: Tafelmusik Baroque Orchestra takes The Galileo Project to Australia, and incorporates Aboriginal astronomy
- “Morning star pole”

Constellations: Stories in the Sky

The constelaltion Orion

- The stars form arbitrary patterns which are defined and named differently by different civilizations – according to their location, needs, beliefs, and culture
- We use Graeco-Roman constellations, plus southern constellations named during the industrial revolution – 88 in all

E.g. Chinese Constellations

- These are smaller and more numerous than Western constellations
- Helpful when interpreting observations dating back 2500+ years

The Milky Way

Richard Payne

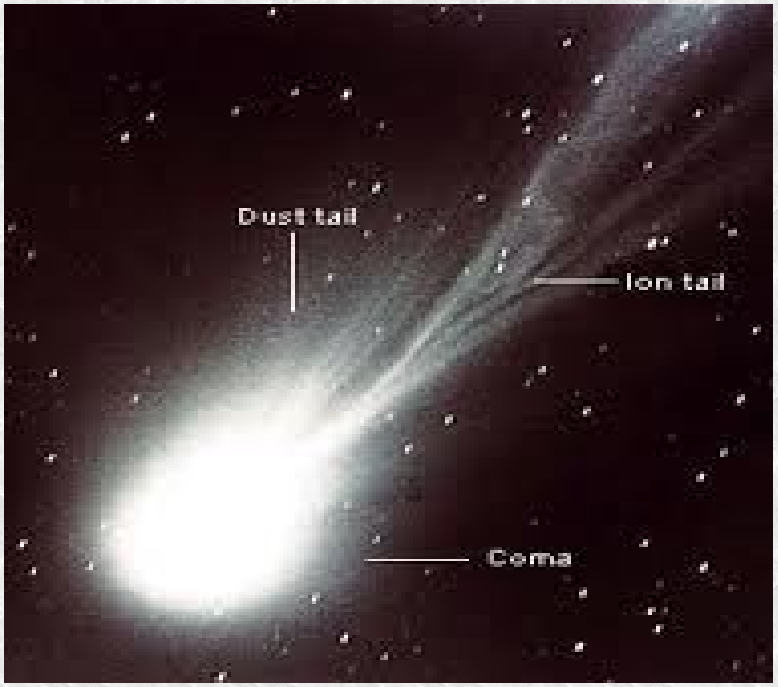
- A faint, hazy band of light across the sky
- Spectacular under a clear, dark sky
- The combined light of billions of stars in the disc of our galaxy
- Each civilization had stories to explain its nature and significance e.g. Milky Way!

Aurora: Northern/Southern Lights

Terence Dickinson

- Shimmering, hazy, all-sky green or blue glow, awesome under a clear, dark sky
- Caused by solar particles, energizing molecules in the upper atmosphere; seen near the magnetic poles – northern Canada and Europe
- Notable in Inuit, Sami culture

Comets



NASA

- Drift slowly across the sky in days, weeks
- Bright ones are quite spectacular
- Iceballs, orbiting and nearing sun, turning to gas; often with long “tails”
- Unpredicted; omens of disaster?

Eclipses of the Moon

wikipedia.org

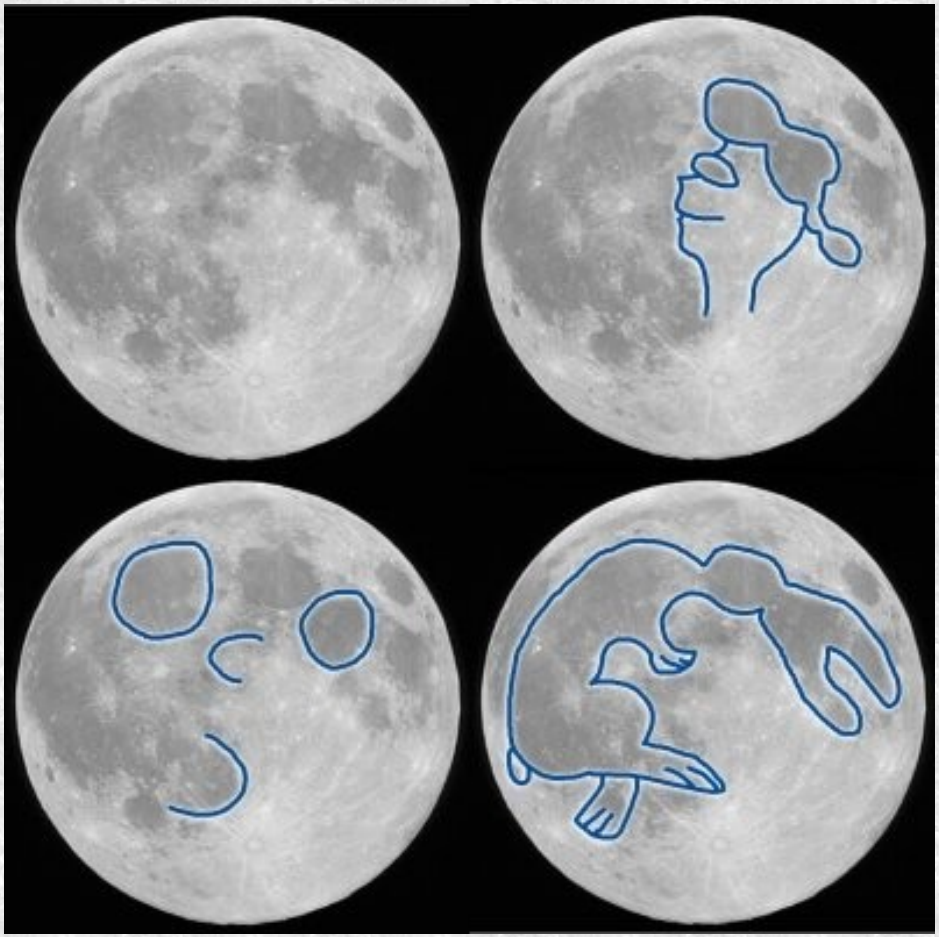
- Occur when moon passes into earth's shadow
- Were eventually predictable, based on observations and calculations
- Rare, but visible over large areas of the earth's surface
- Pale to blood red!

Eclipses of the Sun

Total solar eclipse Aug. 21, 2017

- Occur when the moon passes directly between earth and sun
- Very rare; visible only from a narrow strip on the earth
- Utterly spectacular! Day turns into night.

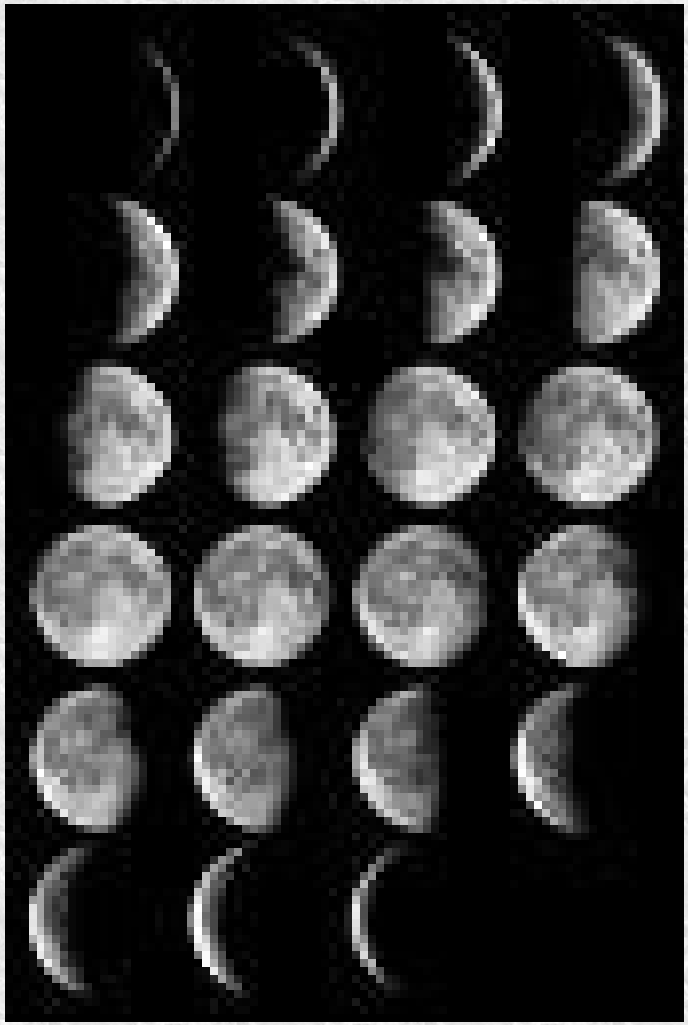
Moon -- Appearance



wikipedia.org

- The moon is the brightest object in the night sky (visible in daytime also)
- Practical: provided light
- Connected with the feminine gender in many cultures (menstrual period?)
- Different cultures/people see different patterns

The Moon -- Motions



Antonio Cidadao

- The moon revolves around the earth; this and its illumination by the sun produce a 29.5-day cycle of phases
- The moon provides light for night-time activities, and also affects the cycle of the tides
- Nowadays, we remember the Harvest Moon, the full moon closest to the autumnal equinox

Calendars Today

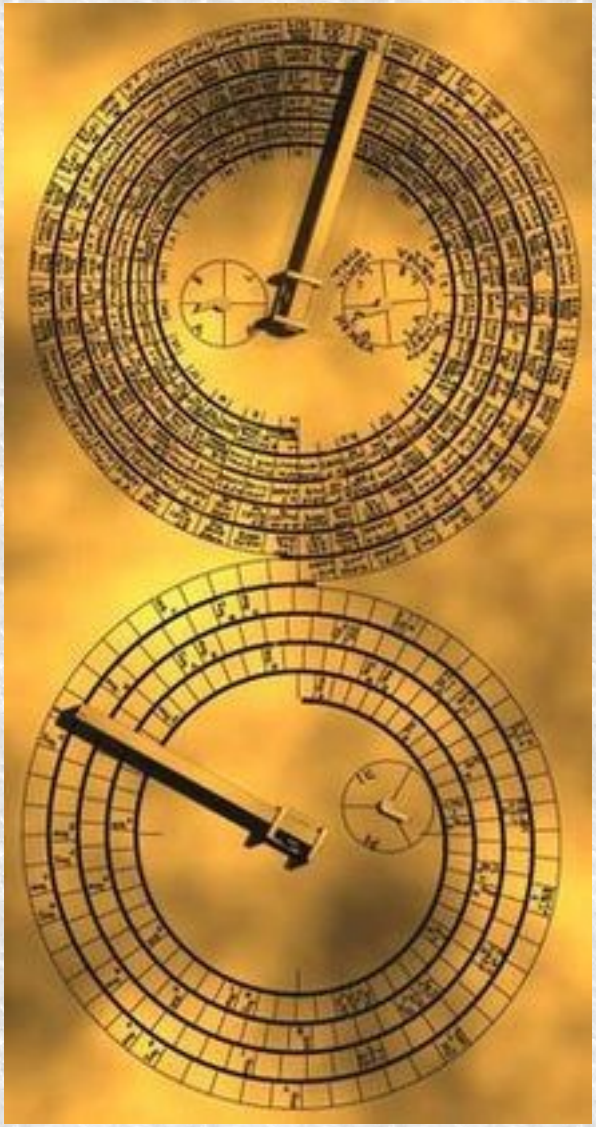
- Problem: the lengths of the day and month (29.53 days) do not divide evenly into the length of the year (365.2422 days)
- The Islamic calendar is based on the moon; the month and year begin with the crescent moon, and the year is 12 “moons” long.
- The Christian calendar (which is used in Canada for civil purposes) is based on the sun: the year begins (approximately) on the first day of northern winter.
- Many Asian calendars are luni-solar; they are based on the sun and moon. The year begins with the new moon, but the year may be 12 or 13 “moons” long, to keep it in step with the solar year.

Antikythera

Artifact, ca. 100 BCE, that speaks for itself

Original

Computer reconstruction of front and back



Early Chinese Astronomy

Beijing Ancient Observatory

- Chinese: 5000 year history of science and technology
- Practical matters of calendars
- Especially interested in unexpected sky events as possible omens
- Courts therefore employed astronomers

In 1054, Chinese astronomers recorded the explosion of the star which produced the Crab Nebula

Indian Astronomy

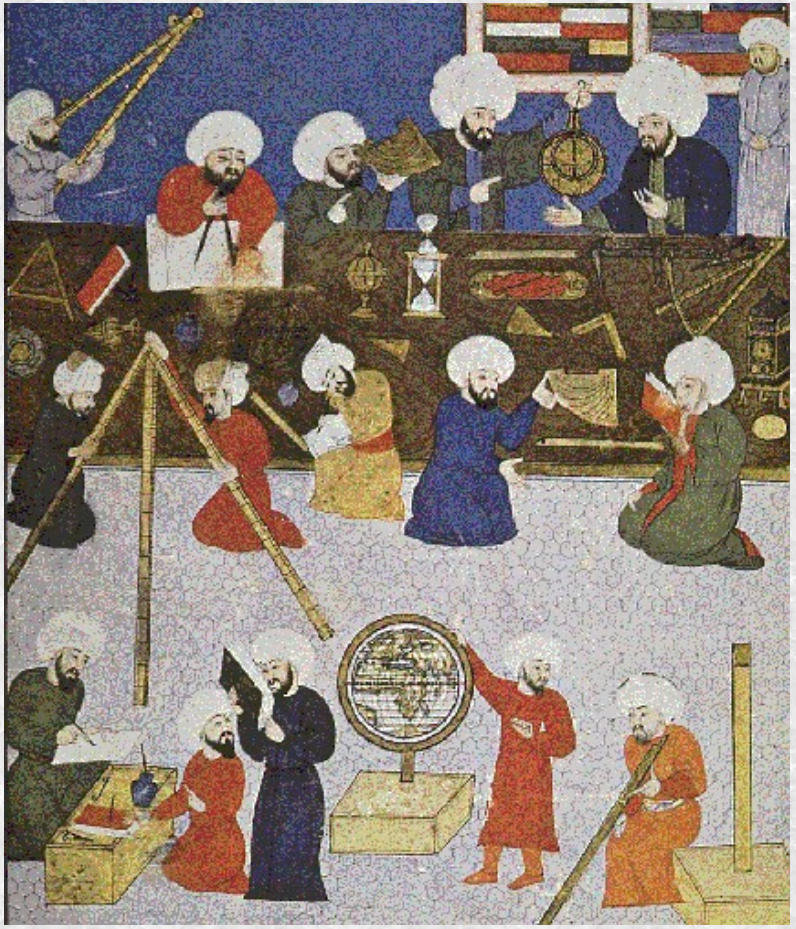
Delhi Tourist Board

IUCAA

- 2000+ years of history; initially astrological
- Arhabhata (bottom left: 476-550 AD) was the foremost astronomer of his time
- Contributions to mathematics; Important contacts with Graeco-Roman world, Islamic world, China
- Great Renaissance observatories (top)

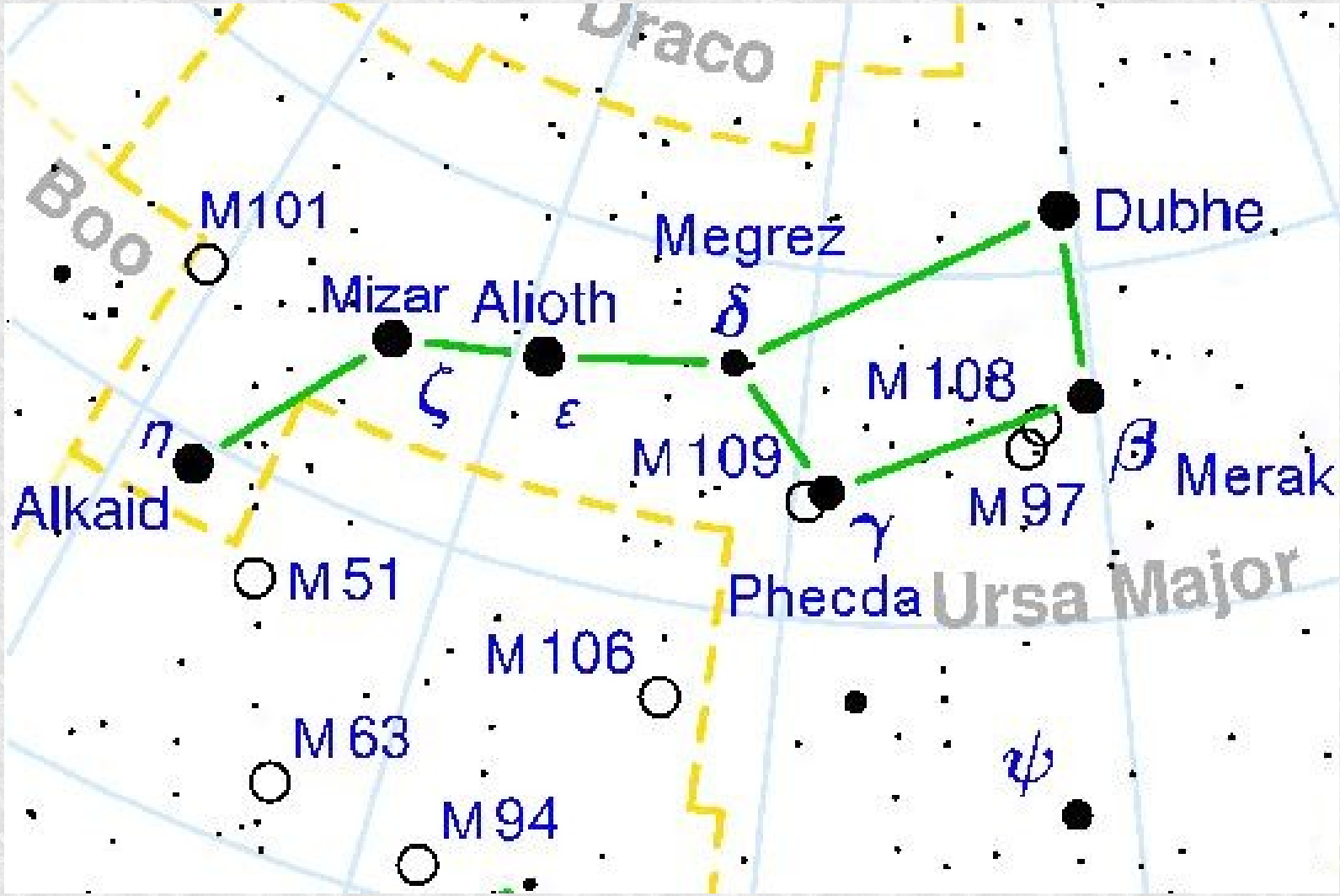
Islamic Astronomy

Ulugh Beg and his observatory in Samarkand

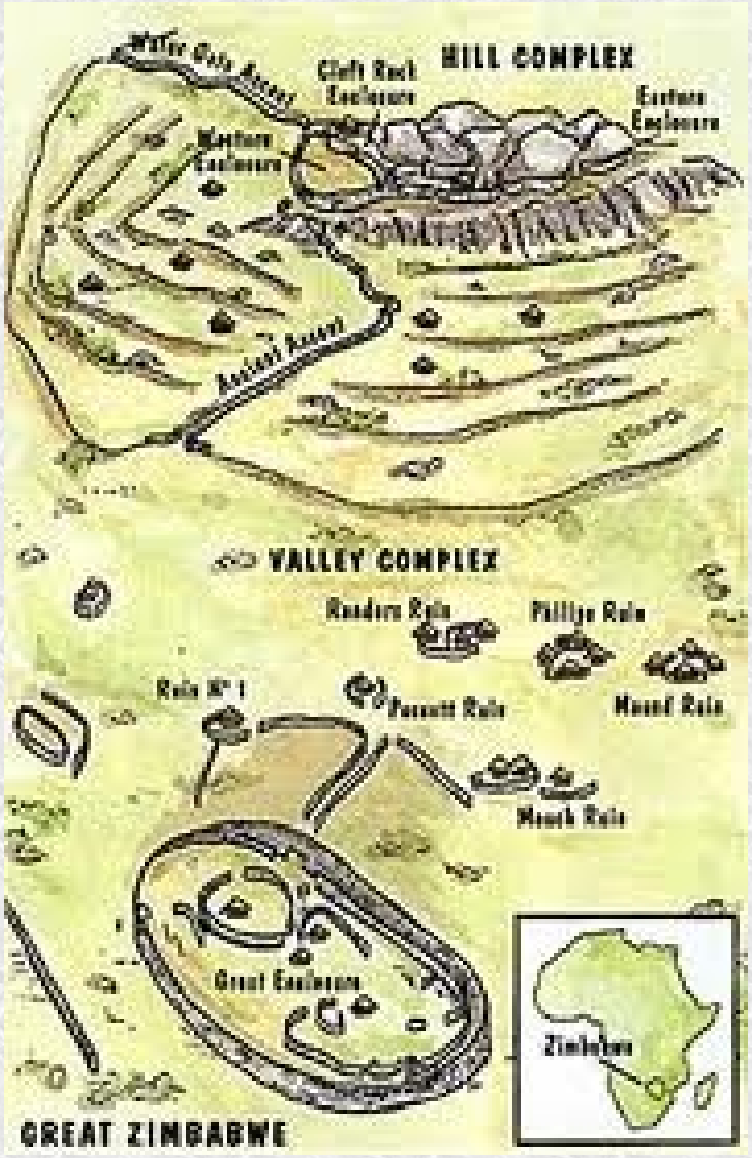


Islamic astronomers preserved existing knowledge, continued oibservations, developed mathematics

Most of the star names that we use today are Arabic



African Astronomy



Breakaway Group Inc.

- As well as the great North African civilizations, there were notable “lost” kingdoms in Saharan and sub-Saharan Africa; much to be done!
- e.g. Timbuktu
- “Great Zimbabwe” in Mali is one (ca. 11th-14th century)
- Some astronomical alignments are possible

And are we so smart today?

Over a third of Americans “believe” in astrology

Over a third of Americans “believe” that space aliens have landed.

Over a third of Americans “believe” in young-Earth creationism

Very few Americans (or Canadians) understand the cause of the seasons.

THE FAR SIDE By GARY LARSON

"Mr. Osborne, may I be excused? My brain is full."

Summary

- Sky-watching pervaded almost every culture, to a greater or lesser extent
- The sky was and is important!
- Many devoted great effort and expense to the observational and/or ritualistic aspects of the sky
- Much of our knowledge is incomplete, or lost completely
- Understanding requires an interdisciplinary approach

Resources

A version of this presentation is on-line:
www. astro.utoronto.ca/~percy/archaeo.pdf

My Education and Outreach webpage:

www. astro.utoronto.ca/~percy/EPOindex.htm

I*nternational Society for Archaeoastronomy and Astronomy in Culture* and various more local organizations

A Crash Course in Astronomy

- Earth, our planet (shines by reflected light) orbits the sun, our star (produces its own energy)
- Earth rotates daily, producing day/night, measures time.
- Earth revolves around the sun each year, producing the annual changes in the visible stars and, because of the tilt of the rotation axis, the seasons.
- The moon, a satellite, orbits Earth once a month
- The sun is one of billions of stars in our Milky Way galaxy, which is one of billions of galaxies in the universe, which is expanding from its birth, 13.7 billion years ago. Our solar system is one of countless billion planetary systems in the universe.