

# WELCOME TO Ancient Astronomy

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# Lectures on the Web

- <http://voyager.deanza.edu/~howardp>
- Available on-line Monday October 11

- Mrs. Copernicus was a great inspiration to her husband:

"Copernicus, when are you going to come to terms with the fact that the world does not revolve around you?"

# Course Topics

- Astronomy Basics
- Archaeology Basics
- Cosmologies of ancient cultures
- Paleolithic “Astronomy”
  - Marshack theory
  - Lascaux Cave
- Neolithic “Astronomy”
  - Durrington Walls
  - Newgrange
  - Avebury
  - Stonehenge

# Course Overview Cont.

- Astronomy in Mesopotamia
  - MUL.APIN
  - Enuma Anu Enlil
  - Cosmology
  - Mesopotamian “Astrolabes”
- Astronomy in Ancient Egypt

# Course Overview Cont.

- Hellenistic/Greek Astronomy
  - Seleucid Period
  - Aristotle
  - Eratosthenes
- Ptolemaic Period
  - Ptolemy

# Course Overview Cont.

- Astronomy in India
- Astronomy of the Maya
- Astronomy of NA Indian Peoples
- Ancient Navigation
- Origins of the calendar
- Let's get Sirius for a moment

# Index Cards

- What topics, sites, cultures you would to see covered
- What topics you would like emphasized
- Why you are interested in ancient astronomy
- What short courses you are interested in having us offer in the future
- What evenings are best for you



# Tonight's Topics

- Naked eye astronomy
- Scientific method
- Magnitudes and Measurement
- Archaeology Methods and Theory
- Paleolithic astronomy
- Abri Blanchard
- Lunar Phases
- Lascaux Cave
- Coordinate Systems

# Eyesight

- Natural eye sensitivity
  - You are born with this, some people having much more acute eyesight than others;
  - Age and color of the eyes
- Age
  - The older you become, the less acute your vision can be
- Eye Fatigue
- Position of the eye
  - In relation to what it is being viewed
- Dark adaptation
  - The eye becomes considerably more sensitive to subtle light variations when totally dilated and equalized to its dark surroundings
- Eye defect and disease
  - Everyone has some degree of defect in our eyes

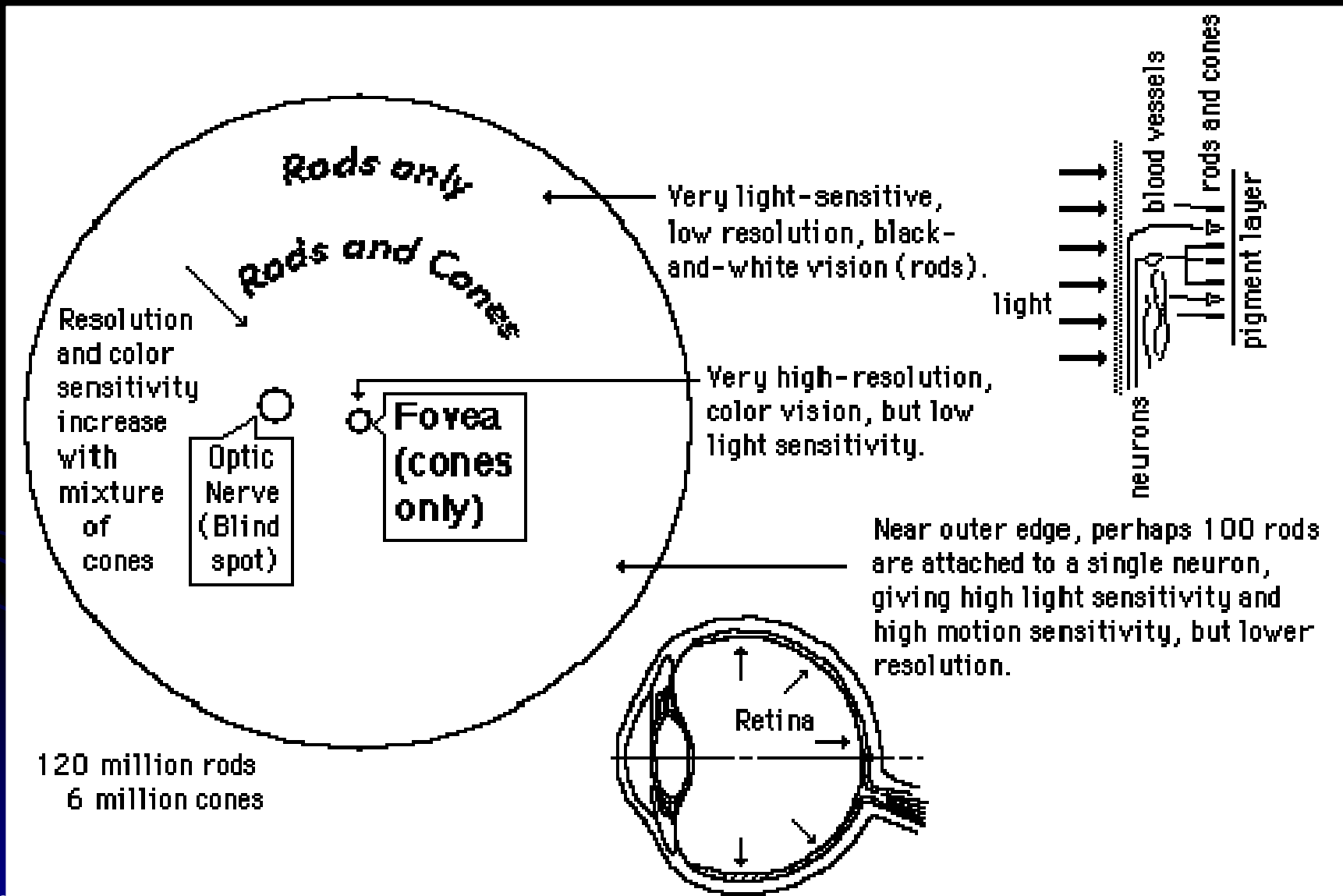
# The Naked Eye

- **Cones**

- Lower sensitivity, specialized for day vision

- **Rods**

- High sensitivity, specialized for night vision
  - More photopigment , captures more light
- High amplification, single photon detection
  - Saturate in daylight
- Low temporal resolution:
  - Slow response, long integration time
- More sensitive to scattered light
- More rods in the peripheral areas
- Do not see **RED**



# Eye Resolution

- 90 million to 120 million receptors (pixels)
- Not all cones and rods are active at any given time

# Eye Resolution Cont.

- Captain William Henry Smyth's *Bedford Catalog* of 1850 lists stars as he saw them in England.
  - "The number of stars seen by the naked eye at once is seldom much above a thousand; though from their scintillation and the indistinct manner in which they are viewed, they appear to be almost infinite. Indeed, albeit the keen glances of experience might do more, the whole number that can generally be perceived by the naked eye, taking both hemispheres, is not greatly above three thousand, from the first to the sixth magnitudes."

<i>Starname</i>	<i>Magn</i>	<i>Constellation</i>	<i>Northern visibility</i>
1. Sirius, ( <i>Tayammisinte</i> )	-0.3	Brightest star, Canis Minor (Lakota Animal-tail)	Visible above 50° north lat. Found to be rise-marked on Medicine Wheel cairns, summer's end dawn.
2. Canopus	0.1	Argo (keel); southern hemisphere most brilliant	Far south, never rises above 37°N latitude
3. Alpha Centauri	0.2	Centaur	Never rises north of 29°N
4. Rigel, ( <i>Tayamnitichuhu</i> )	0.3	Orion (Lakota Animal, outer rib)	On Zodiac -- good Northern visibility. Found to be rise-marked on Medicine Wheel cairns
5. Arcturus, ( <i>Itkob u</i> )	0.3	Boötes (There are several Lakota names for this bright star, this one means "going toward")	Northern sky, good Northern visibility
6. Capella	0.3	Auriga, (Lakota Racetrack, north marker)	Northern sky, good Northern visibility
7. Vega	0.3	Lyra	Northern sky, good Northern visibility
8. Procyon	0.4	Canis Minor, Lakota Racetrack	Near Zodiac, good Northern visibility
9. Achernar	0.4	S. end of Eridanus, the River	Never rises north of 36°N
10. Betelgeuse ( <i>Tayamnitichuhu</i> )	0.7	Orion, Lakota Animal inner rib	Zodiac, good Northern visibility
11. Antares	0.7	Scorpio	Zodiac (S. of ecliptic), good Northern visibility
12. Acrux	1.0	Southern Cross	Never rises north of 30°N
13. Pollux, Castor	1.1	Gemini, (Lakota Mató Tipila)	Zodiac, good Northern visibility
14. Aldebaran	1.2	Taurus, (Lakota Animal neck)	Zodiac, good Northern visibility. Found to be rise-marked on Medicine wheel ciarns (solstice dawn)
15. Beta Centauri	1.2	Centaur	Never rises north of 32°N
16. Altair	1.3	Aquila	Northern sky, good Northern visibility
17. Fomalhaut	1.3	Pisces Australianus	Most southerly star visible to 50°N. Found to be rise-marked on Medicine Wheel cairns

# Magnitudes and Measurements

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# Metric System

- **Length**

- meter (m) ~39 inches
- kilometer (km) = 1000 m 0.6 miles

- **Mass**

- gram (gm) ~ 1 Advil Tablet
- kilogram (kg) = 1000 gm = 2.2 lbs.  
10<sup>3</sup> gm

- **Volume**

- m<sup>3</sup>
- cm<sup>3</sup> = 10<sup>-6</sup> m<sup>3</sup> ~ size of a sugar cube

- **Time**

- second (s)

# Magnitudes

- Diameter of the Earth: ~12,756,272m
- Radius of the Earth (Equator):  
~6,378,136m
- Billion:  $10^9$  1,000,000,000
- Trillion:  $10^{12}$  1,000,000,000,000

# Magnitudes Cont.

- AU (Astronomical Unit):  $149,600 \times 10^6 \text{m}$
- Velocity of light:  $299,792,458 \text{m/sec}$ 
  - $186,282.4 \text{ miles/sec}$
- 1 Light Year:  $9,454,254,955,488,000 \text{m}$ 
  - $9.4545 \times 10^{15}$
  - $63,200 \text{AU}$

# Scale

- **Population of US ~294,000,000**
- **Number of cells in human body**
  - ~ 100 trillion
  - $10^{14}$
- **Number of stars in our galaxy – Milky Way**
  - ~100 billion
- **Annual federal budget**
  - ~ \$1 trillion (\$1,926,000,000,000)
  - $10^{12}$
  - **US Debt \$7,384,000,000,000**
    - ~\$25,000/person (294,000,000)
  - ~ number of stars in 10 galaxies

# Scientific Method

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# Scientific Method

- Aristotle
- 1637 René Descartes
  - "Discours de la Méthode"
- The subject of a scientific experiment must to be:
  - Observable
  - Reproducible
- Observations may be made with the unaided eye, a microscope, a telescope, a voltmeter, or any other apparatus suitable for detecting the desired phenomenon.

# Scientific Method

- The invention of the telescope in 1608 made it possible for Galileo to discover the moons of Jupiter the following year
    - Other scientists confirmed Galileo's observations and the course of astronomy was changed.
  - Some observations that were not able to withstand tests of objectivity were the canals of Mars reported by astronomer Percival Lowell.
    - Lowell claimed to be able to see a network of canals in Mars that he attributed to intelligent life in that planet.
    - Bigger telescopes and satellite missions to Mars failed to confirm the existence of canals.
    - This was a case where the observations could not be independently verified or reproduced, and the hypothesis about intelligent life was unjustified by the observations.
  - Lowell did accurately predict the existence of the planet Pluto in 1905 based on perturbations in the orbits of Uranus and Neptune.
    - Good example of deductive logic
    - The application of the theory of gravitation to the known planets predicted that they should be in a different position from where they were
- If the law of gravitation was not wrong, then something else had to account for the variation. Pluto was discovered 25 years later

# Aristotle

- Aristotle was born in 384 BC, in Stagira, near Macedonia
- Student of Plato
- Possibly first to use scientific method
  - Unfortunately not exclusively
  - Logic



# Scientific Revolutions

- Thomas Kuhn

- The Copernican Revolution
- The Structure of Scientific Revolutions

- Paradigm

- "In the absence of a paradigm or some candidate for paradigm, all the facts that could possibly pertain to the development of a given science are likely to seem equally relevant"
- A set of accepted notions based on received knowledge

# Cosmology

- “It is the theory that let’s us see ...” – Einstein

O crassa ingenia. O coecos coeli spectatores.

Oh thick wits. Oh blind watchers of the sky.

Tycho Brahe (1573)

# Cosmology Cont.

- Cosmology is the study of the origin, current state, and future of our Universe
- Cosmology as paradigm
  - Aristotle's geocentric 'paradigm'
  - Copernicus' heliocentric 'paradigm'
  - Big Bang 'paradigm'
  - Steady-state 'paradigm'
- Stephen Hawking

# Archaeology Methods and Theory

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# Archaeology FAQ

**Q: What is an archaeologist?**

**A: An archaeologist is a person whose career lies in ruins.**

# Paradigm

- Data gathering stage
- No mature paradigm yet
- Archaeology today is about where astronomy was in Tycho's time
- Moving fast into Kepler's period
  - Taking the observations and coming up with testable hypotheses/theories
- Ian Hodder

# Method

- **Theory of stratigraphy**
  - The oldest layer was put on first and is at the bottom
  - The newest layer is at the top
  - Miners since at least Roman times
- **Nicolaus Steno in 1669 described two basic geologic principles**
  - Sedimentary rocks are laid down in a horizontal manner
  - Younger rock units were deposited on top of older rock units
- **James Hutton in 1795**
- **Charles Lyell in the early 1800s**

# Stratigraphy Cont.

- Thomas Jefferson
- Thomas Huxley
- Charles Darwin





# Context Context Context

- **Matrix**

- The physical material within which artifacts or other archaeological remains are embedded or supported
- In a stratified site the strata/layer

- **Provenience**

- The horizontal and vertical position of archaeological remains within the matrix, with reference to an external datum point
- Location in 3D space

- **Association**

- The co-occurrence of archaeological materials, usually within the same matrix

# Context

- Where an object/artifact has been found
- An object's physical location
  - Country
  - Archaeological site
  - Field
  - Square
  - Locus
  - Layer/Stratum

# Paleolithic

## Sky Watchers

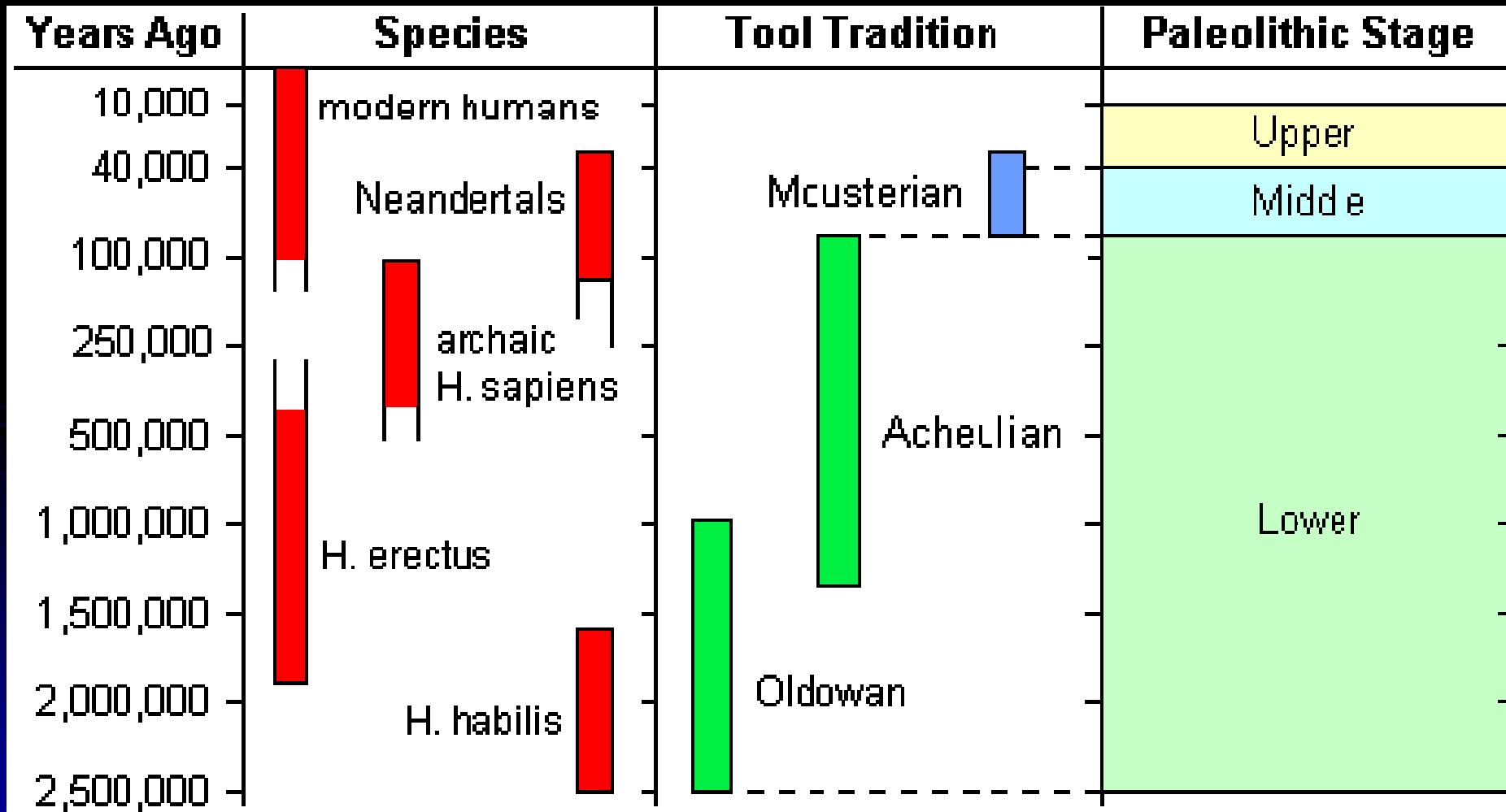
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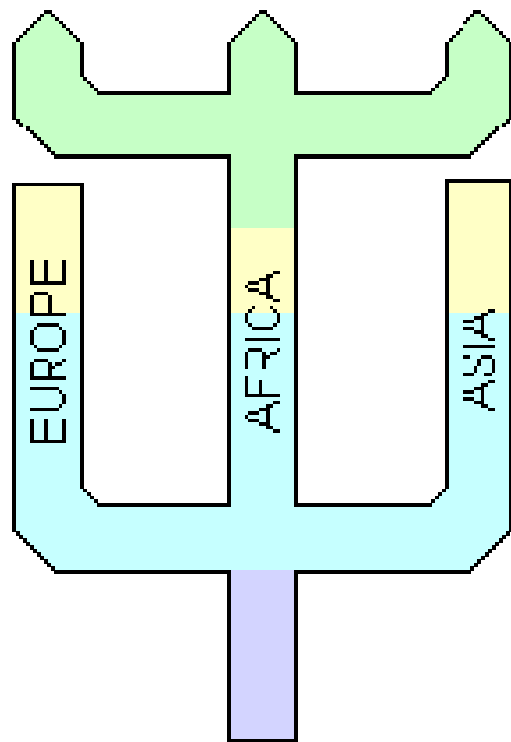
# Paleolithic

- Paleo – old
- Lithic – stone
- ~17,000 BP
  - $C_{14}$  date from wall pigments
- Early Magdalenian

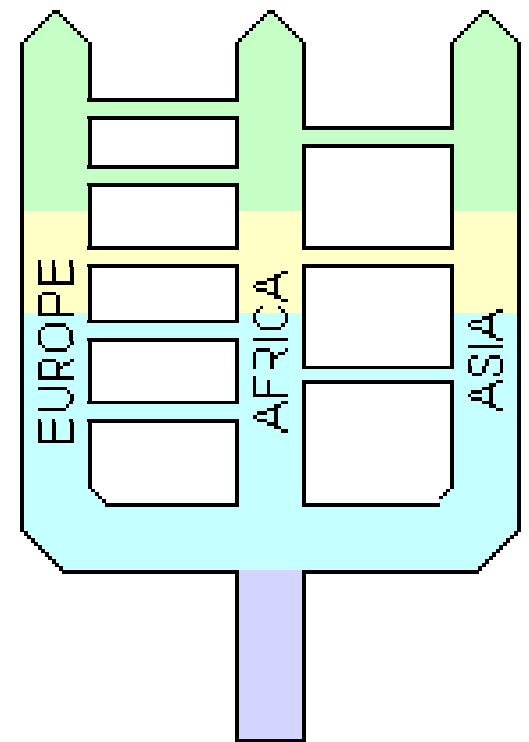
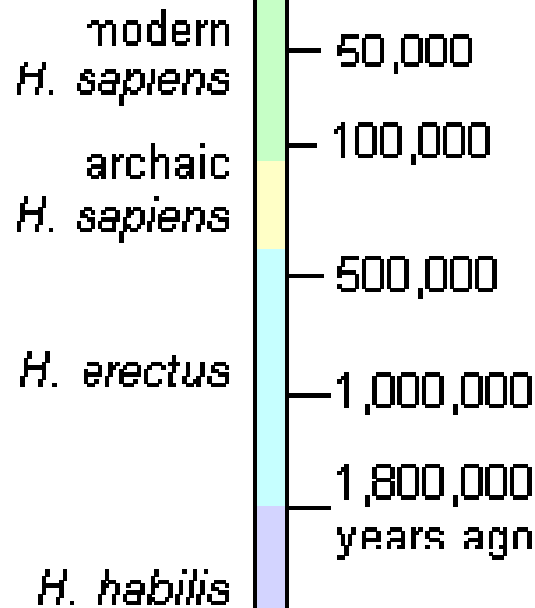
# Paleolithic Stages



# Homo Sapiens Sapiens



Replacement Model



Regional Continuity Model

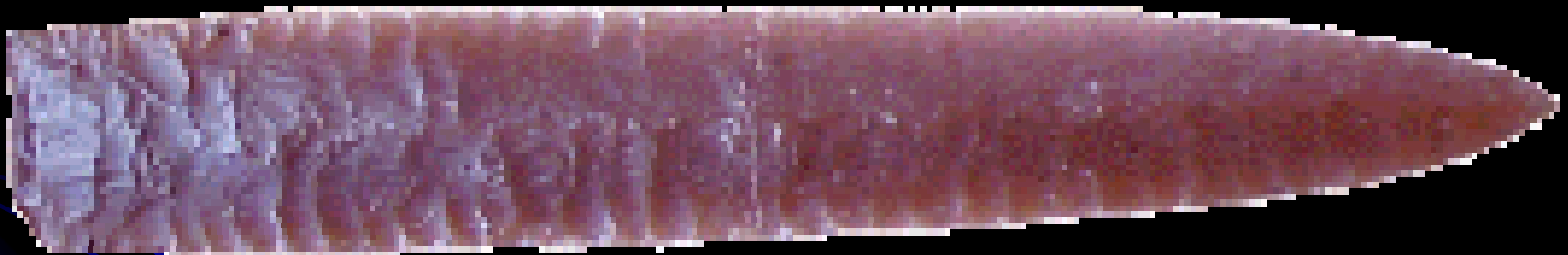
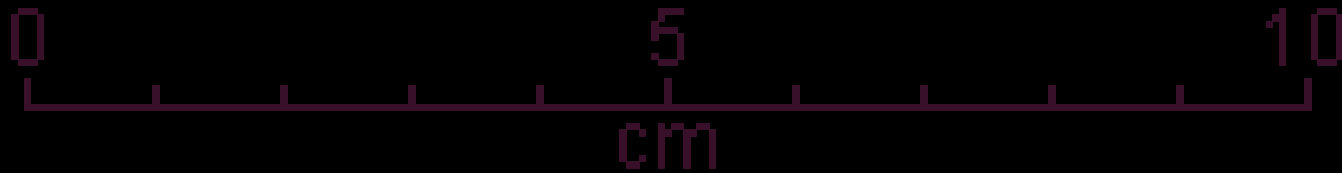
# Paleolithic Cultures

Paleolithic Stage of Development	Beginning (years ago)	Cultural Tradition
Upper Paleolithic	17,000	Magdalenian
	21,000	Solutrean
	27,000	Gravettian
	33,000	Aurignacian/Chatelperronian
Middle Paleolithic	75,000	Mousterian
Lower Paleolithic	* 700,000+ ?	Acheulian

\* The Acheulian Tradition began by at least 1.4 million years ago in Africa.

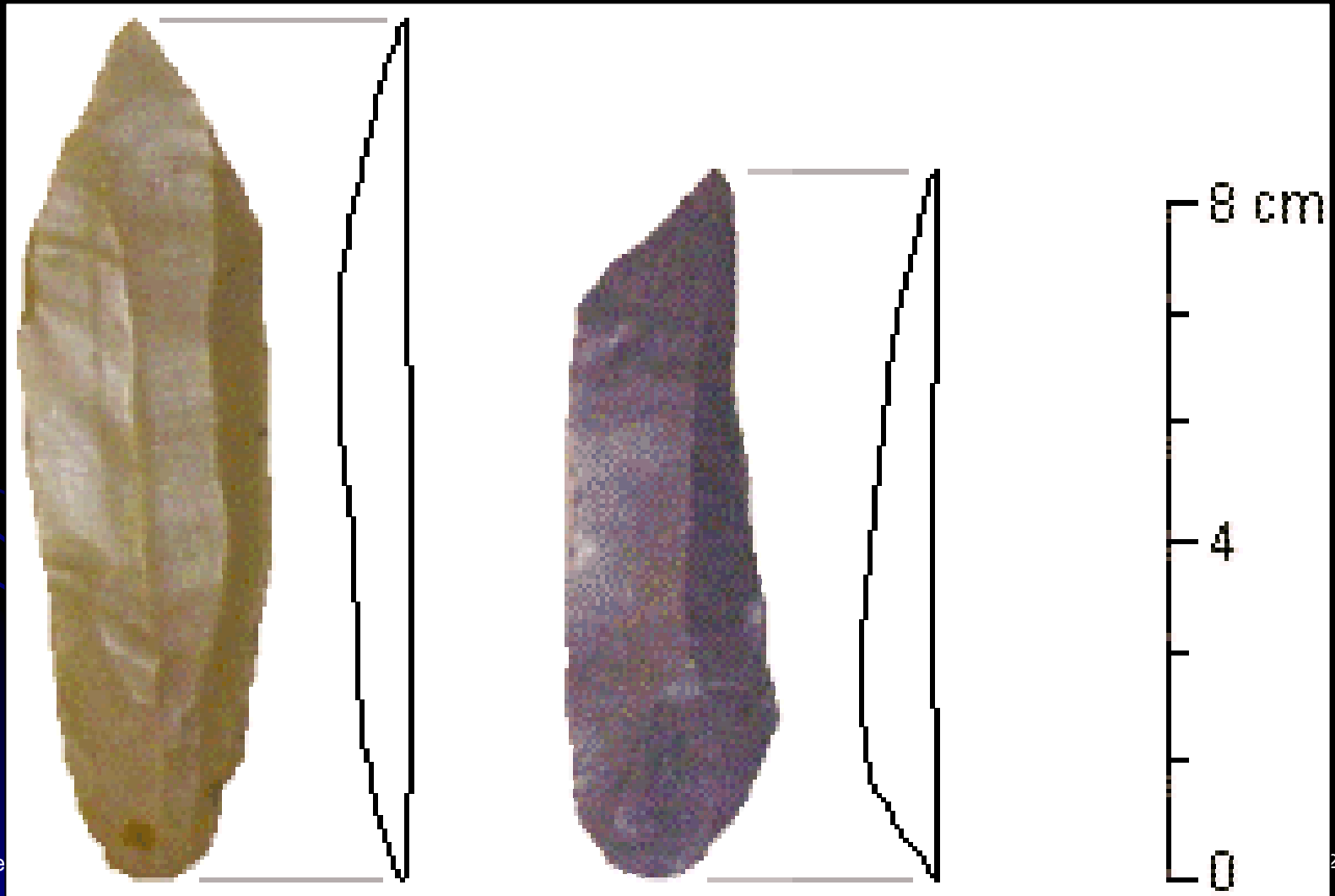


# Upper Paleolithic Tools



small, uniform flake scars  
produced by pressure flaking

# Flake Tools



# Aurignacian Blade



# Aubri Blanchard

## Alexander Marshack

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# Early Upper Paleolithic

- Aurignacian
- ~30,000 BP



possible sequence of  
moon phase changes  
over 2 months

# Aurigacian

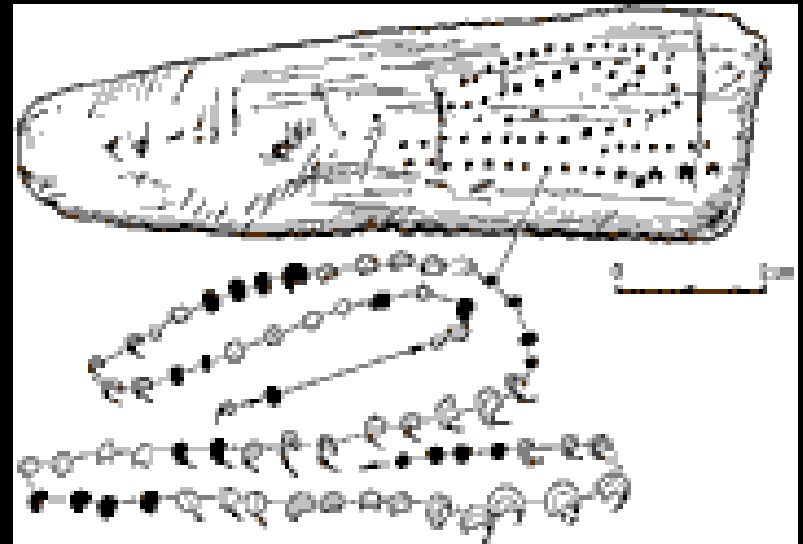
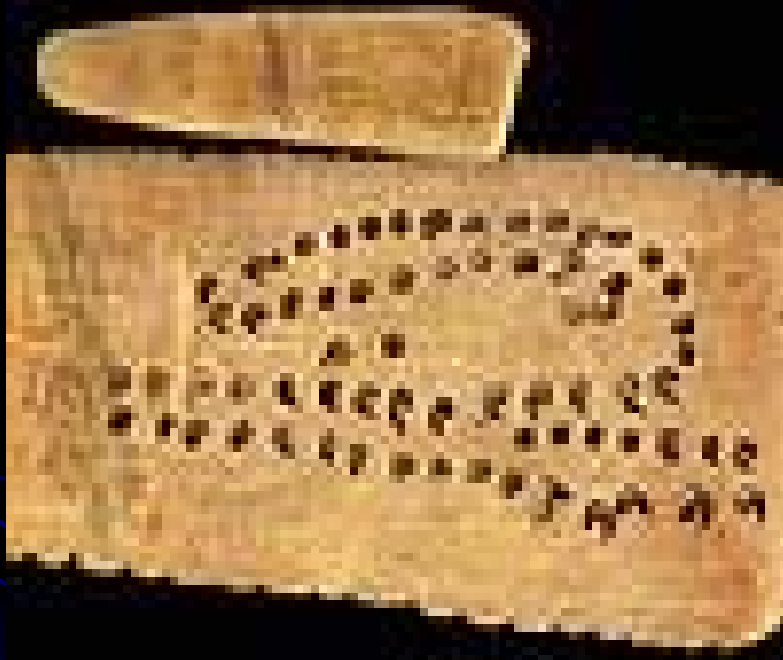


# Blanchard Bone Cont.



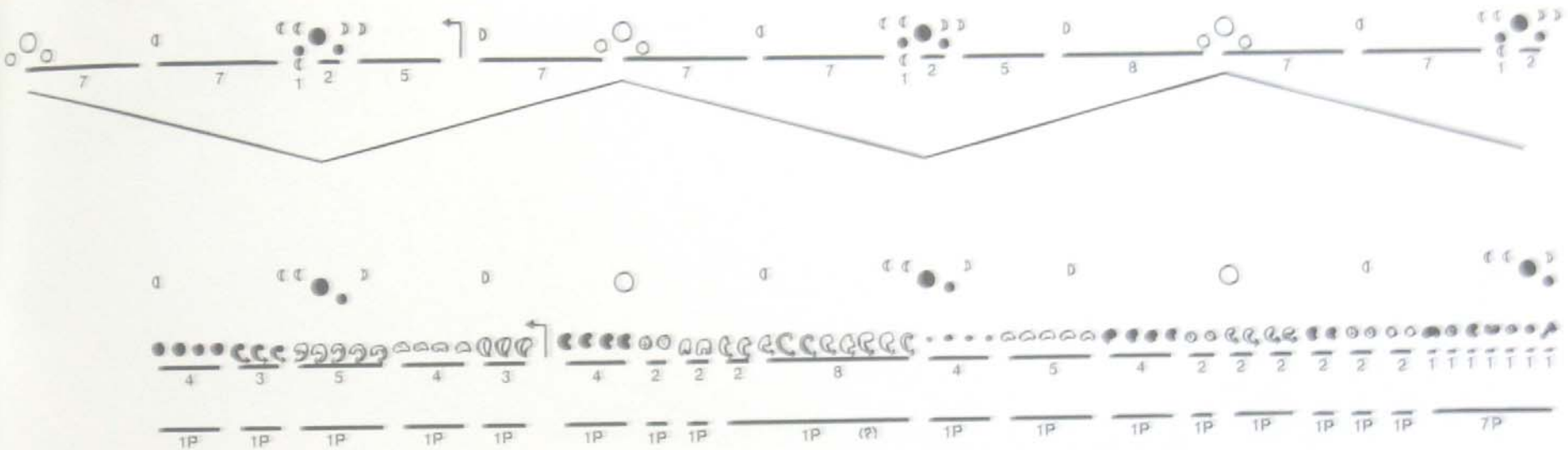


# Abri Blanchard Bone



# Interpretation

- Lunar model and bone
- 3 months
- Begins day of last crescent
- Ends on day of invisibility



# Abri Blanchard Bone Cont.

- Obverse
  - 63 marks made by ~40 points
- Reverse
  - ~40 marks
- 172 Total Marks
  - Close to six months
  - $29.5 * 6 = 177$

# Lunar Phases

Or, It doesn't phase me.

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# Lunar FAQ

**Q: What is more useful: the sun or the moon?**

**A: The moon, because the moon shines at night when you want the light, whereas the sun shines during the day when you don't need it.**

# Lunar Phases

- Lunar cycle
  - 29.5 days to complete one cycle
    - New Moon to new Moon
- Waxing Moon
  - Moon “grows”
- Waning Moon
  - Moon “shrinks”
- Gibbous
  - Humpback
  - More than half but not all of the disk illuminated

# Lunar Phases Waxing

- **New Moon**
  - Not visible
- **4 Days**
  - Waxing Crescent
- **7 Days**
  - First Quarter
  - Rises at noon
  - Sets at midnight
- **10 Days**
  - Waxing gibbous
- **14 Days**
  - Full Moon



# Lunar Phases Waning

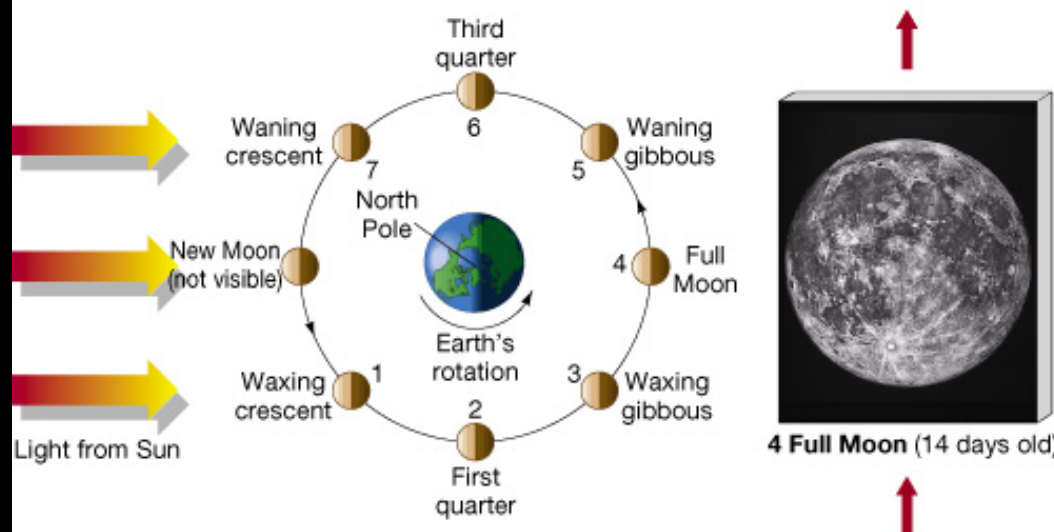
- **19 Days**
  - Waning gibbous
- **22 Days**
  - Third quarter
  - Rises at midnight and sets at Noon
- **25 Days**
  - Waning crescent







7 Waning crescent (26 days old) 6 Third quarter (22 days old) 5 Waning gibbous (18 days old)



1 Waxing crescent (4 days old) 2 First quarter (7 days old) 3 Waxing gibbous (10 days old)



# Grotte Lascaux

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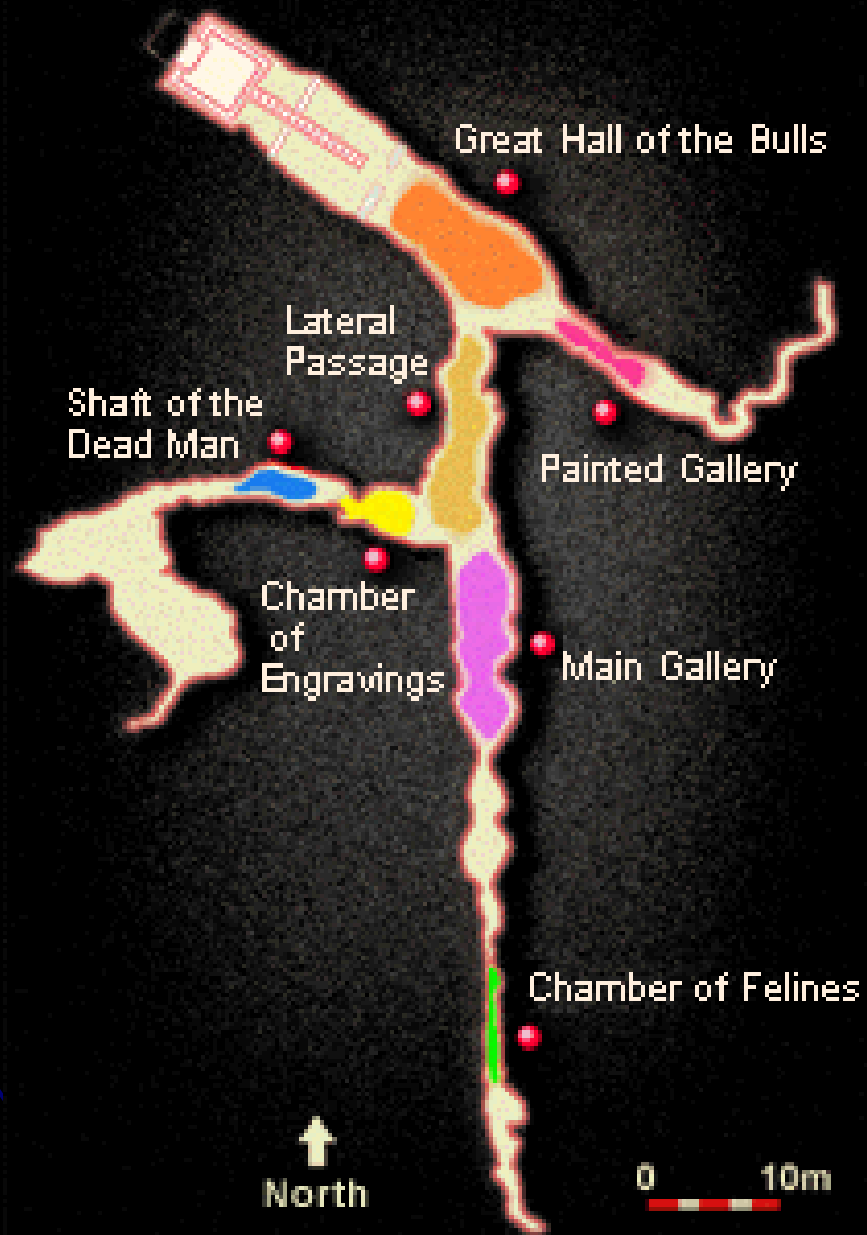
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# Lascaux

- <http://www.culture.gouv.fr/culture/arcnat/lascaux/en/>
- Cave discovered in 1940 by some boys playing
- Dated to ~17,000BCE or ~15,000BCE

# Lascaux France





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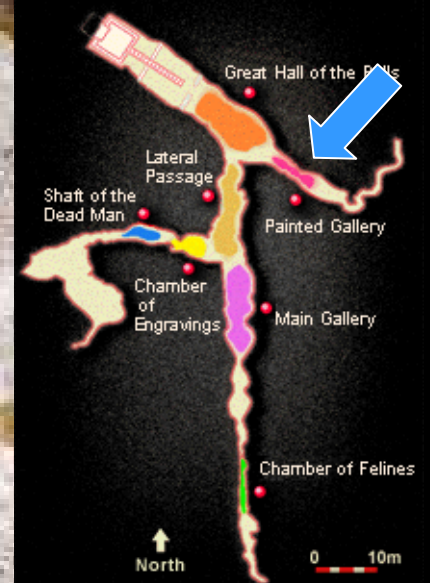








# More Lunar Phases???



Painted Gallery



# Lunar Phases???



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Painted Gallery

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66

# The Pleiades???



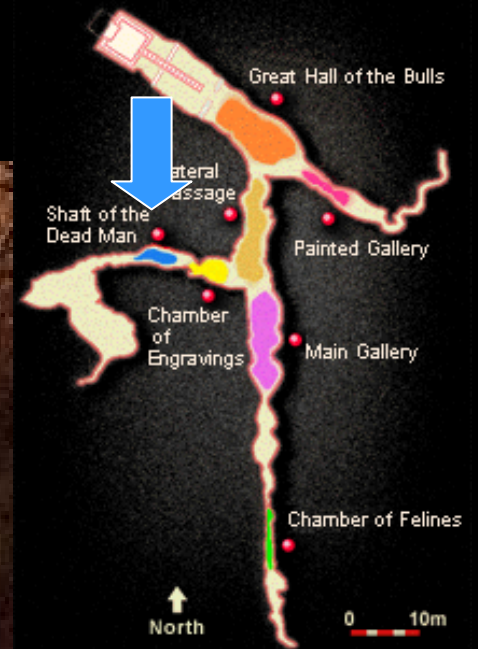
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Great Hall of the Bulls

# The Pleiades???



# The Pleiades or Ponn



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Shaft of the Dead Man

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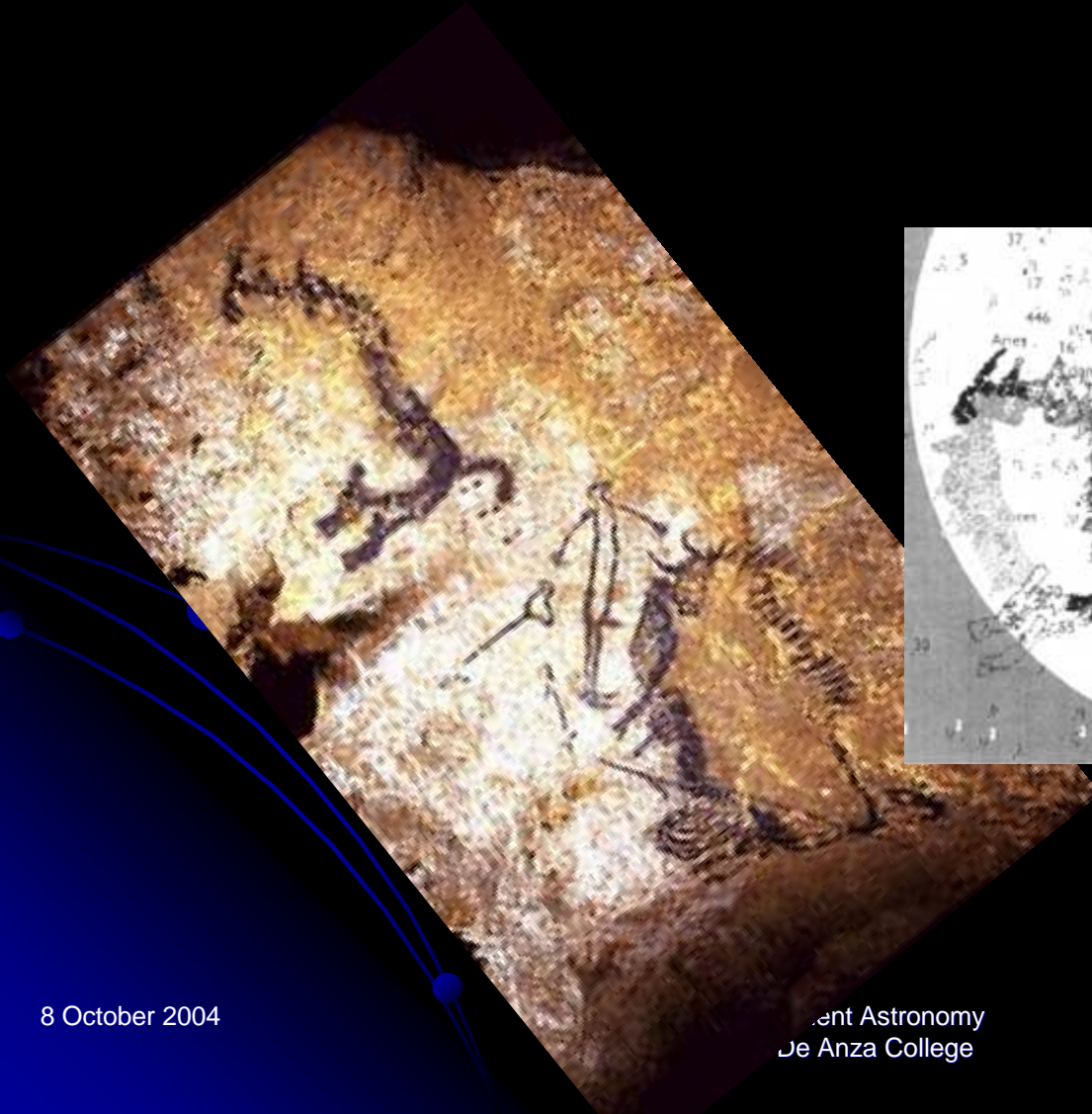




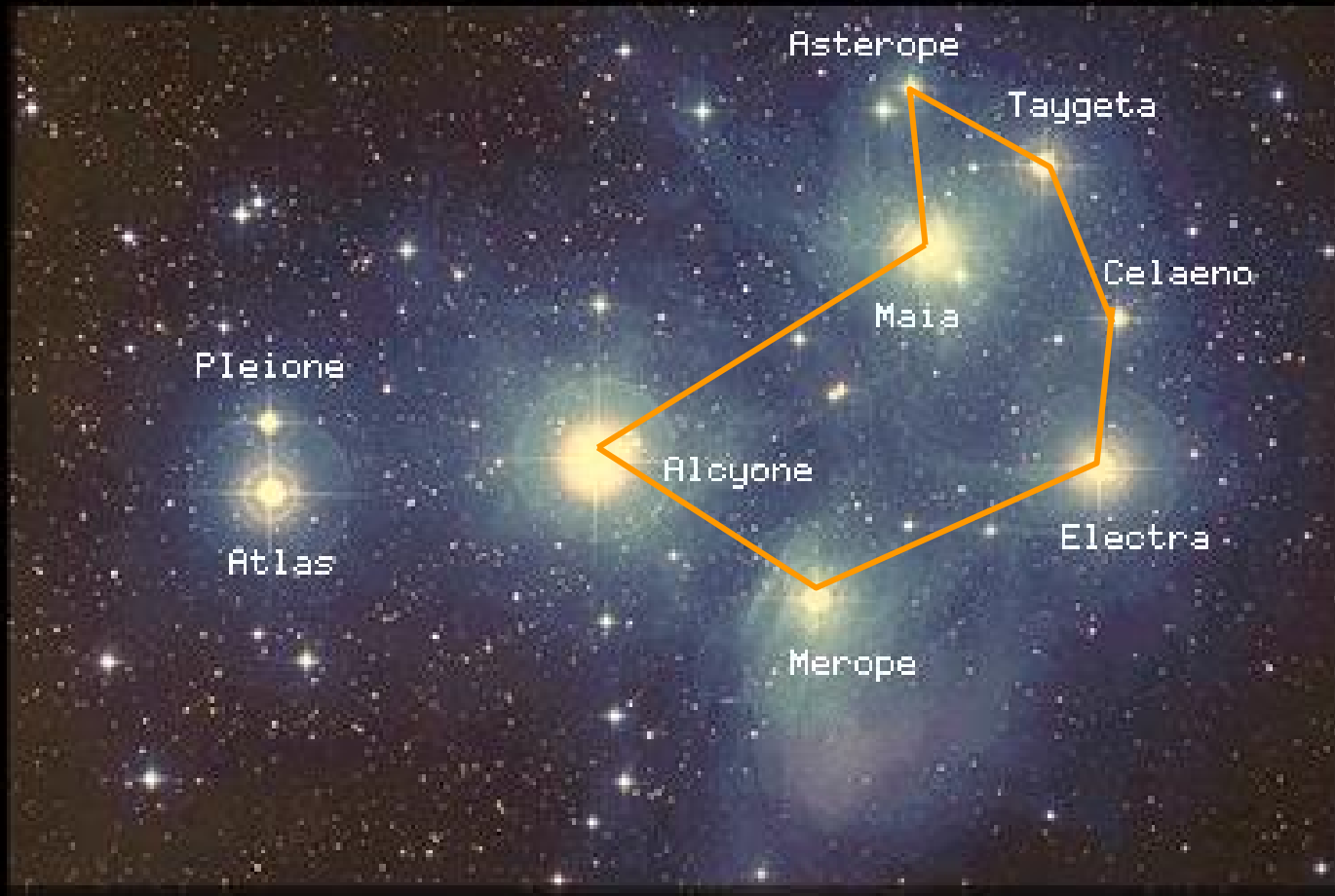
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Michael Rappenglück  
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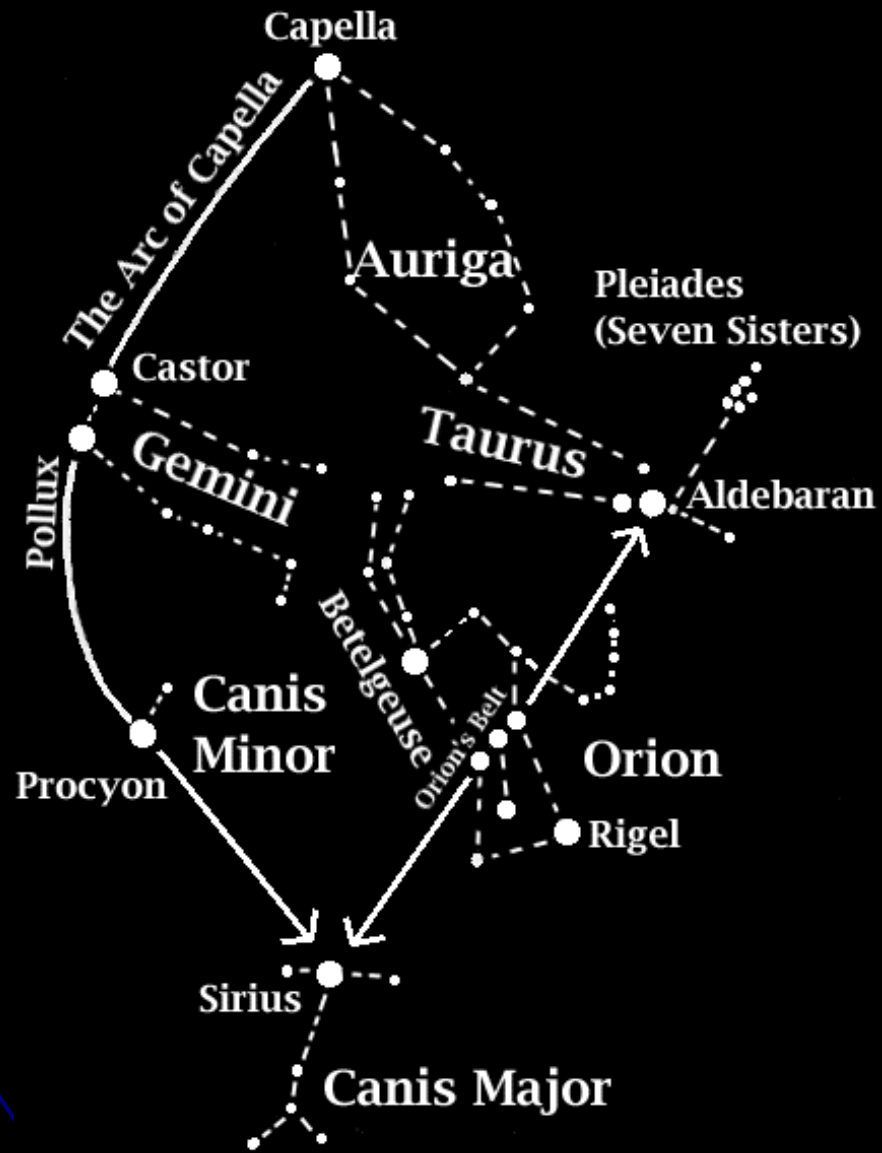
Michael Rappenglück, 1999

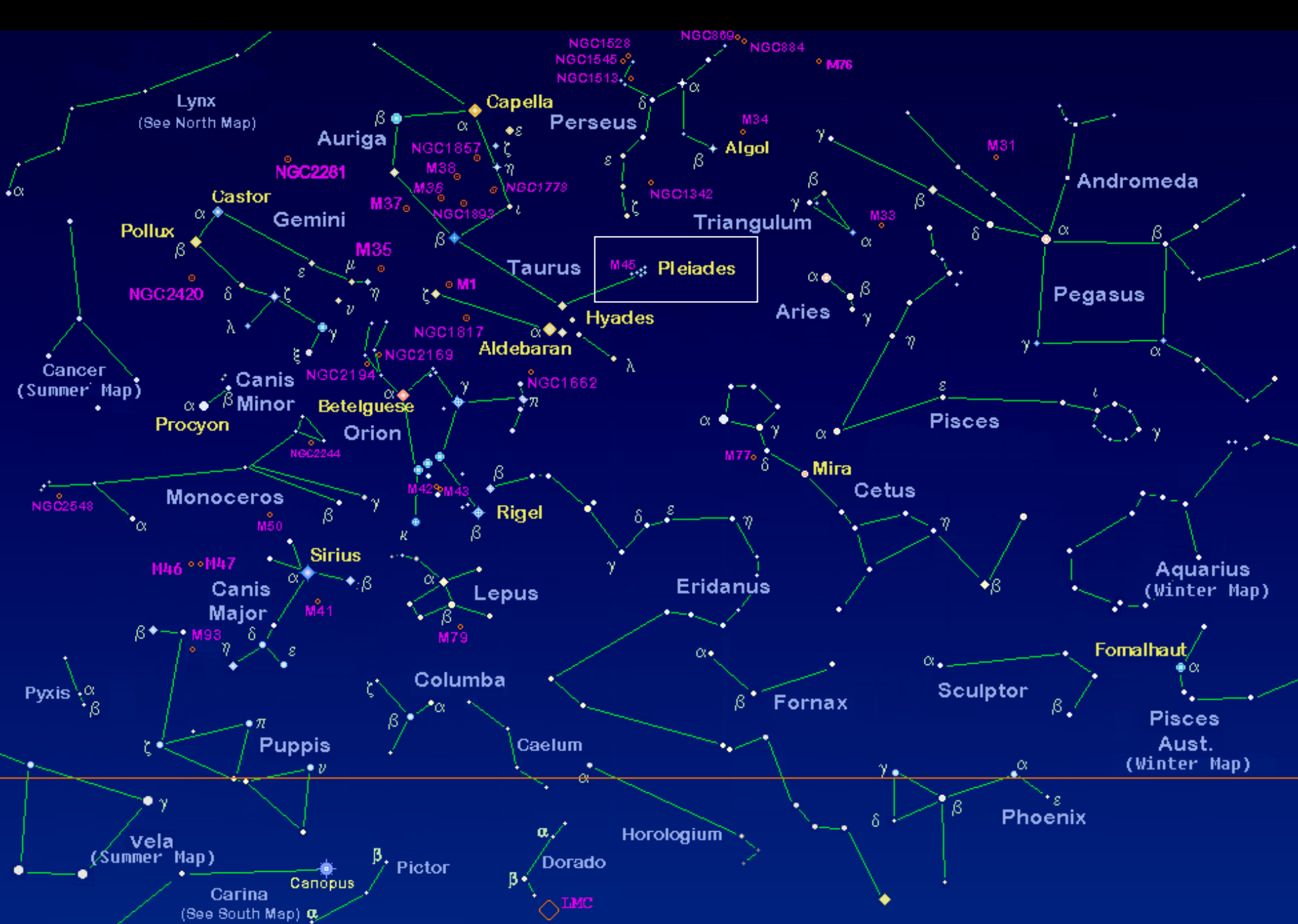


# Pleiades

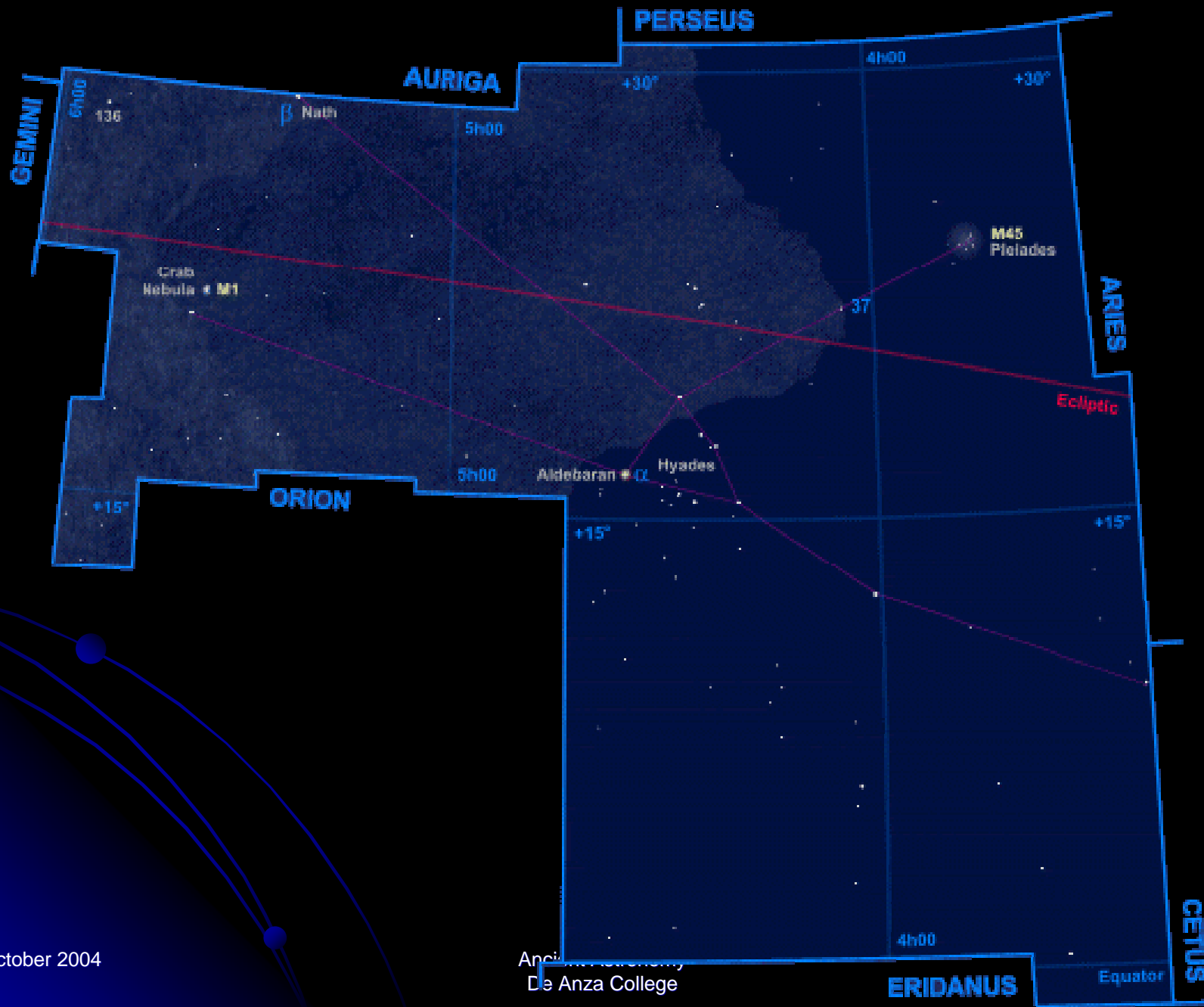








Winter



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# Pleiades

- Not a constellation
- Star cluster – M45 (Messier)
- ~3000 stars
- 7 brightest stars = Seven Sisters = Pleiades
  - From brighter to dimmer:
  - Alcyone (eta Tauri)
  - Electra
  - Maia
  - Merope
  - Taygeta
  - Celaeno
  - Asterope

# Mom and Dad

- Atlas (27 Tauri)
- Pleione (BU Tauri = 28 Tauri), just east of Alcyone
  - The two are often seen as one star
  - Need a clear night to see them as separate stars

# Pleiade(s) – Greek Mythology

- Seven daughters of Atlas and Pleione
- Half-sisters of the Hyades
  - whose mother was *Æthra* ('bright sky'; a
    - different *Æthra* than the mother of Theseus)
- Half-sisters of the Hesperides
  - Daughters of either Night alone, or Atlas and Hesperis ('evening'), or Ceto and Phorcys.

# Possible Meanings

- *plein*, `to sail'
  - Pleione `sailing queen' and her daughters `sailing ones.'
  - The cluster's conjunction with the sun in spring and opposition in fall marked the start and end of the summer sailing season in ancient Greece
- *pleos*, `full', of which the plural is `many', appropriate for a star cluster.
- *peleiades*, `flock of doves', consistent with the sisters' mythological transformation.

# Pleiades Cont.

- **Pleione and Æthra were Oceanids**
  - Daughters of Oceanus and Tethys
    - Titans who ruled the outer seas before being replaced by Poseidon
- **Atlas ('he who dares' or 'suffers')**
  - From the Indo-European *tel-*, *tla-*, 'to lift, support, bear')
  - Titan who led their war against the gods
  - Condemned by Zeus to hold up the heavens on his shoulders.
- **The Pleiades were also nymphs in the train of Artemis, and together with the seven Hyades ('rainmakers' or 'piglets')**



# The Pleiades

- Records of the Pleiades as 7 stars
  - 6000 years ago oldest records(Mesopotamia)
- Other ancient records of them as 6 stars
- Ancient legends about the "missing sister" where she went
- Quite a few people (in good viewing conditions) can see 6
  - Most of people can make out the 4 biggies that form a square just about the right size (a little over 31 angular minutes, half a degree)

# The Pleiades Cont.

- The brightest Pleiad is only of magnitude 3
- In 1899 Richard Hinkley Allen, a Yale astronomer
  - "Only 6 are visible to the average observer, and whoever can see 7 can readily see at least 2 more,"
- So there are, 5, 6, 7, 9, 14 Pleiades (all naked eye counts given by various observers)
- In less famous parts of the sky there can be even more confusion, due to differences in seeing

# Hall of the Bulls - Pleiades



# Thank You

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