

WELCOME TO Ancient Astronomy Lecture II

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Lectures on the Web

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

Next Week

- Mesopotamian astronomy and cosmology
- Origins of the calendar
- Mayan astronomy and cosmology
- Hellenistic and Roman Period astronomy
 - Aristotle
 - Aristarchus and Seleucus of Babylonia
 - Eratosthenes
 - Ptolemy
- Polynesian wayfarers and ancient celestial navigation

Tonight

- Lascaux
 - Pleiades
 - Taurus
- Celestial sphere
 - Relative coordinates
- Stonehenge and Neolithic Britain
- What is a constellation
- Planetary, solar and lunar movements

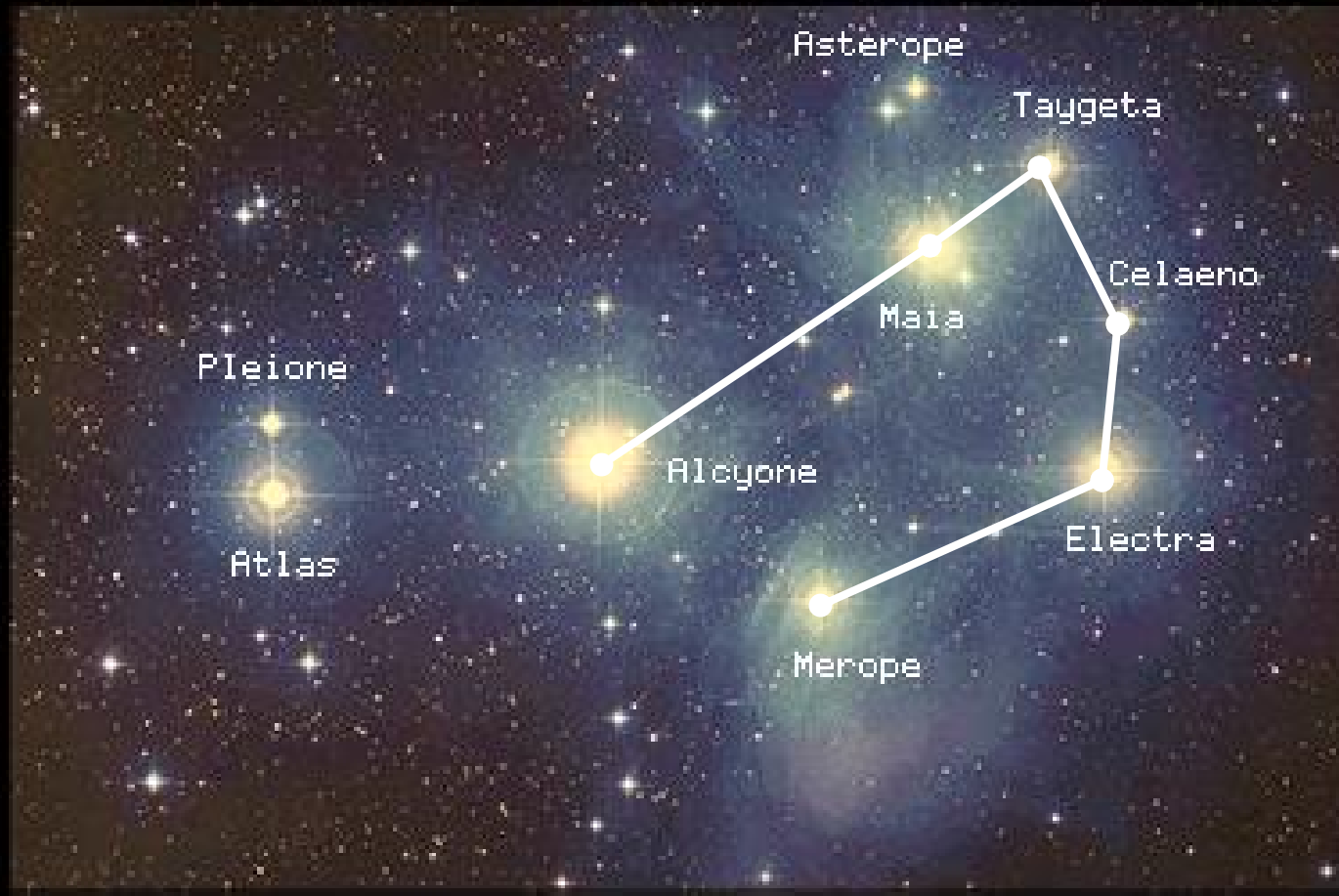
Replay

- How human vision works
- Timelines
- Paleolithic skywatchers
 - Abri Blanchard
 - Bone implement with “lunar phases”
 - Lascaux Cave
 - Paintings
- Pleiades

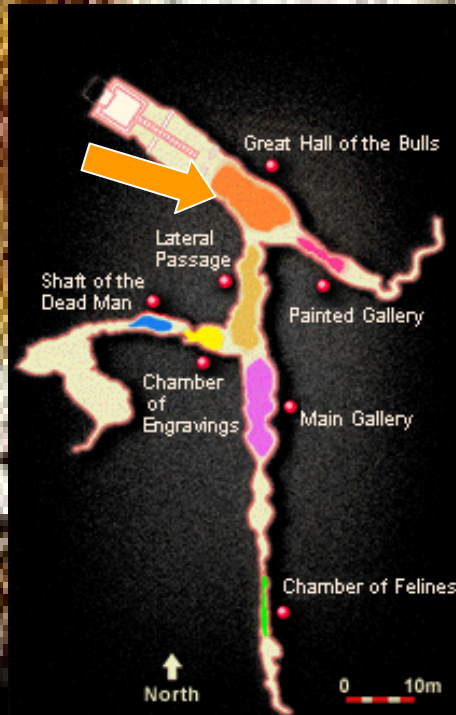
Lascaux Redux

Pleiades and Taurus

Pleiades



Great Hall of the Bulls



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
- 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.

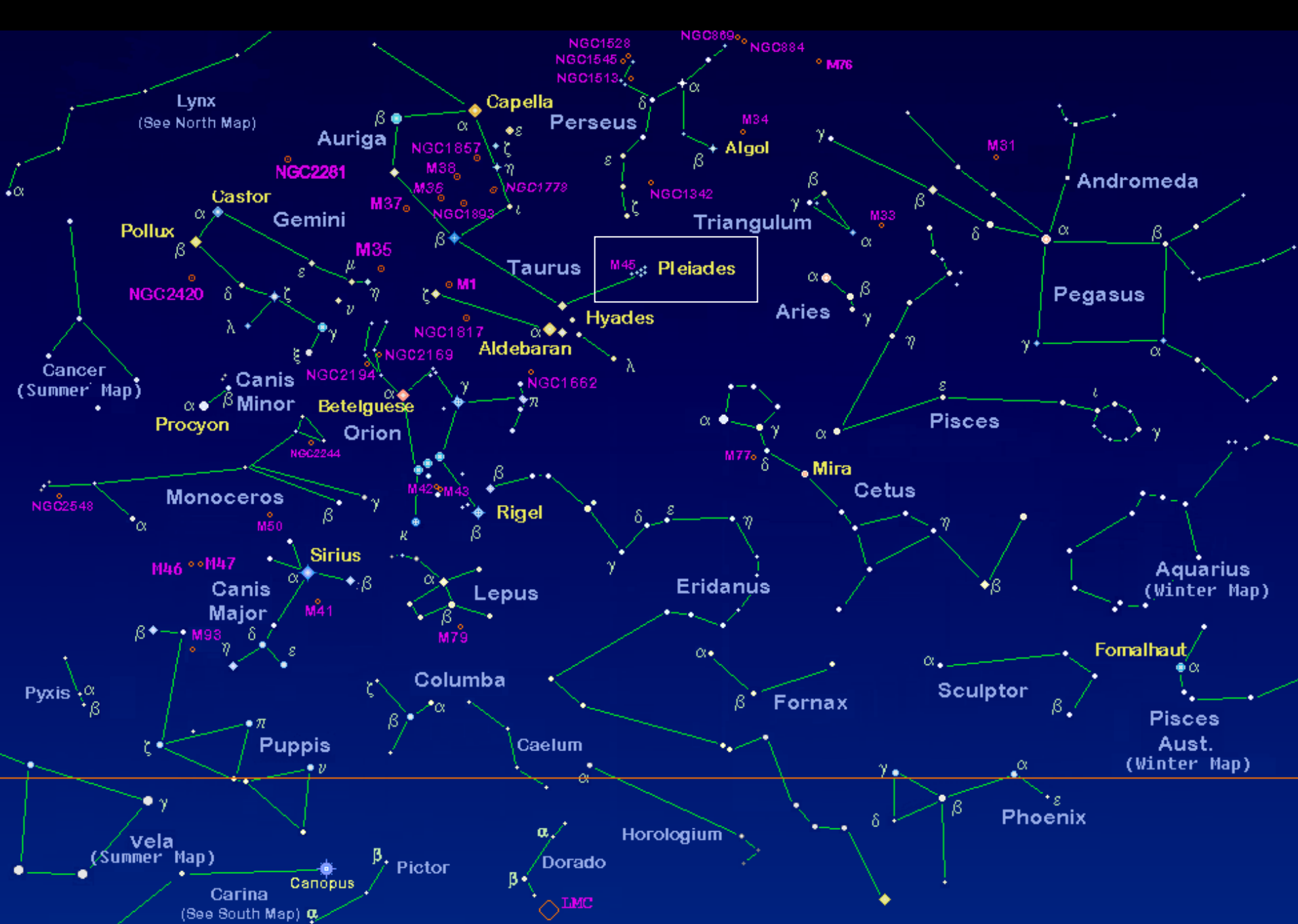
- Pleione and Æthra were Oceanids
 - Daughters of Oceanus and Tethys
 - Titans who ruled the outer seas before being replaced by Poseidon
- Atlas ('he who dares' or 'suffers')
 - From the Indo-European *tel-*, *tla-*, 'to lift, support, bear')
 - Titan who led their war against the Olympian gods
 - Condemned 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)^{1x}

The Pleiades Cont.

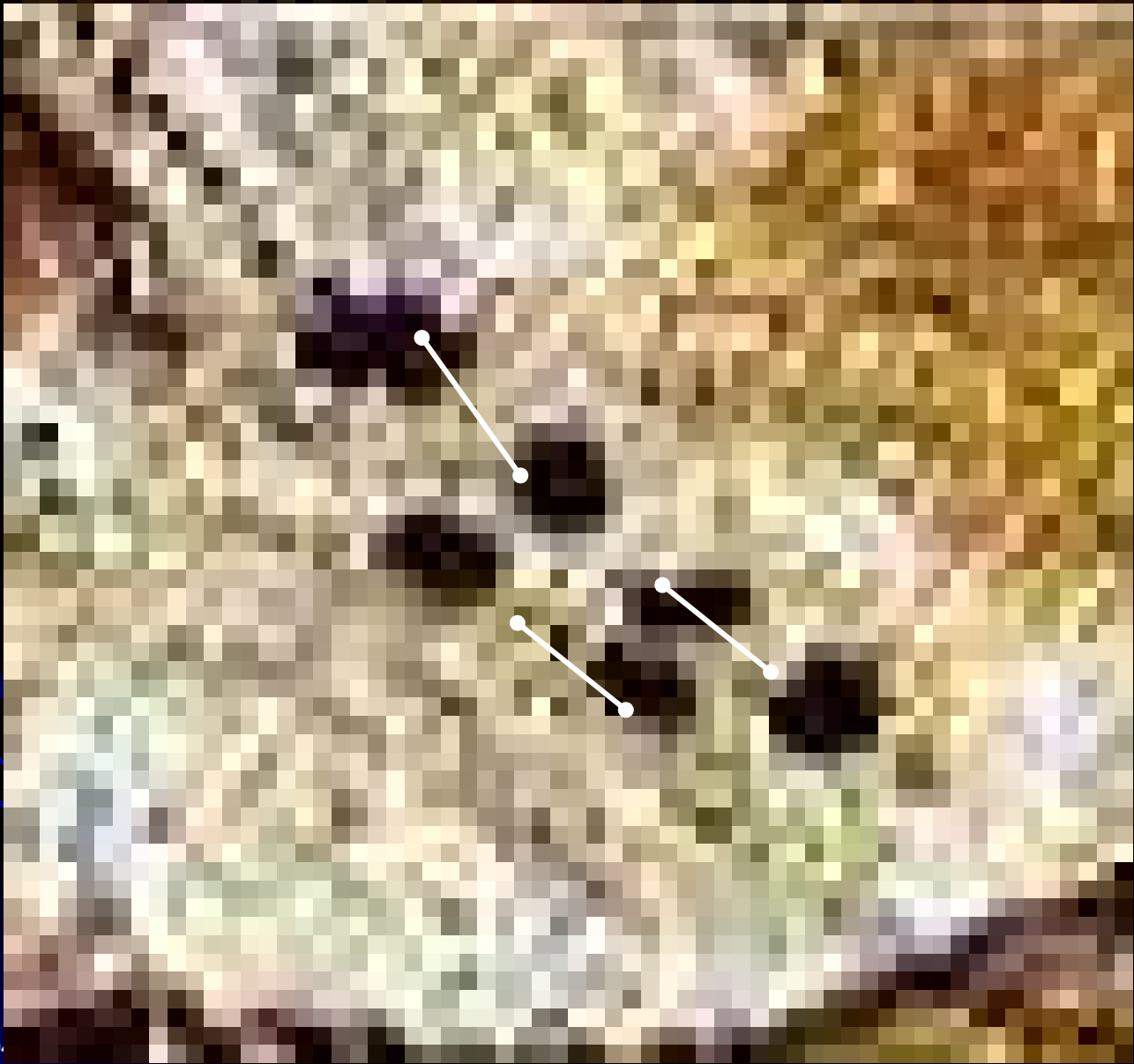
- The brightest Pleiad is only of magnitude 3
- In 1899 Richard Hinkley Allen, a Yale astronomer
 - "Only 6 are visible to the average observer, and whoever can see 7 can readily see at least 2 more"
- So there are, 5, 6, 7, 9, 14 Pleiades (all naked eye counts given by various observers)
- In less famous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



Winter

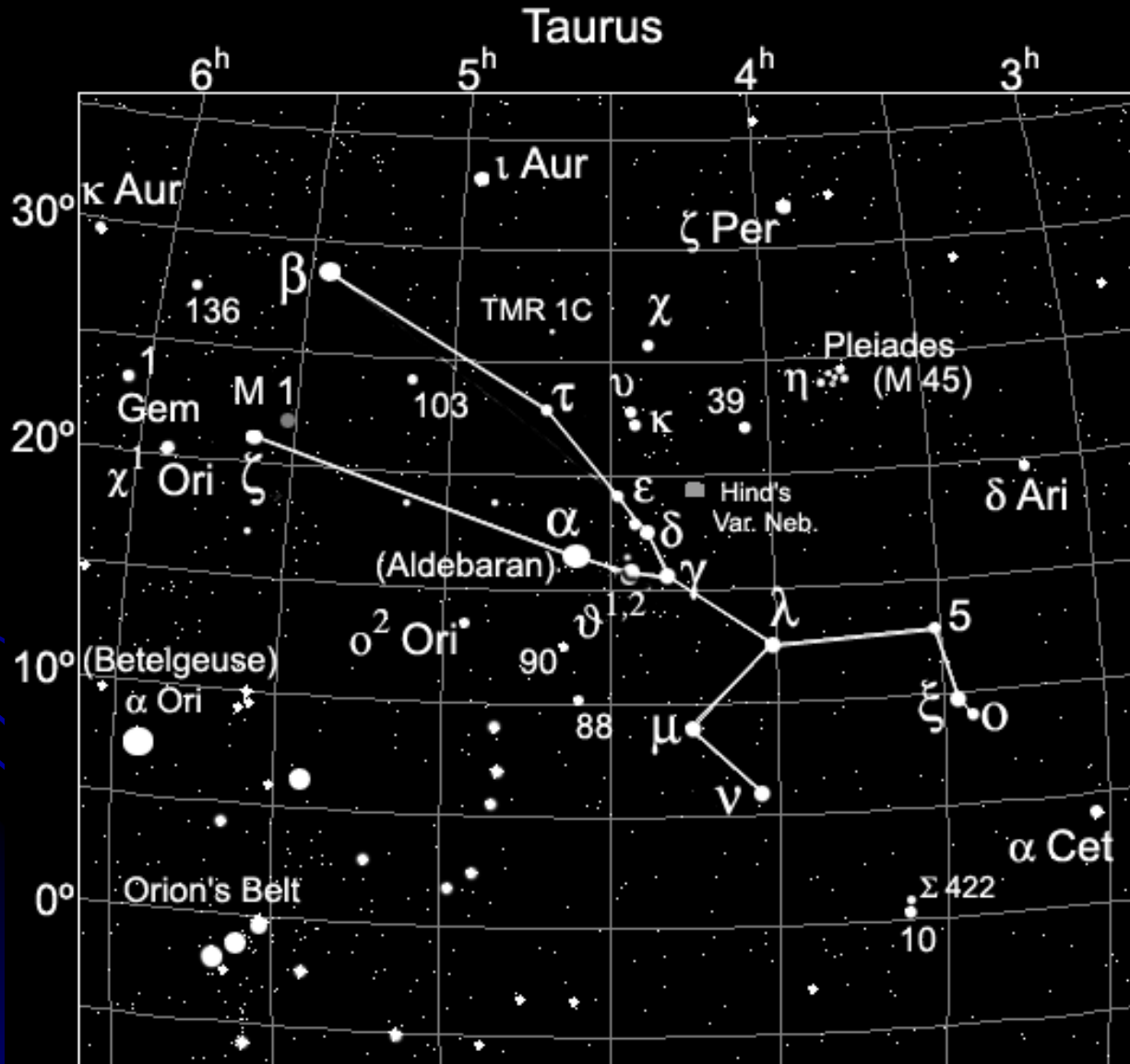
Pleiades Cont.



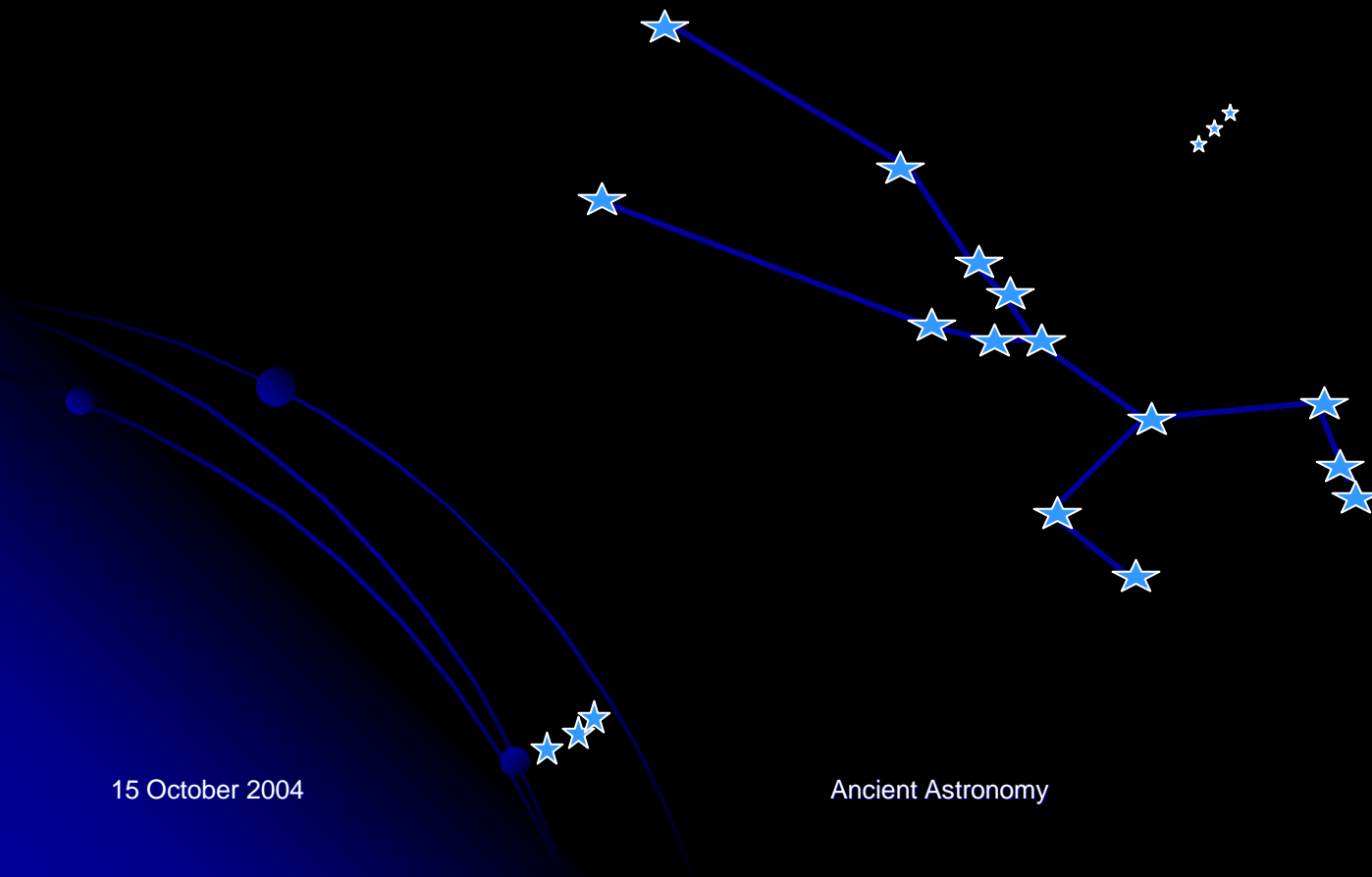


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Taurus

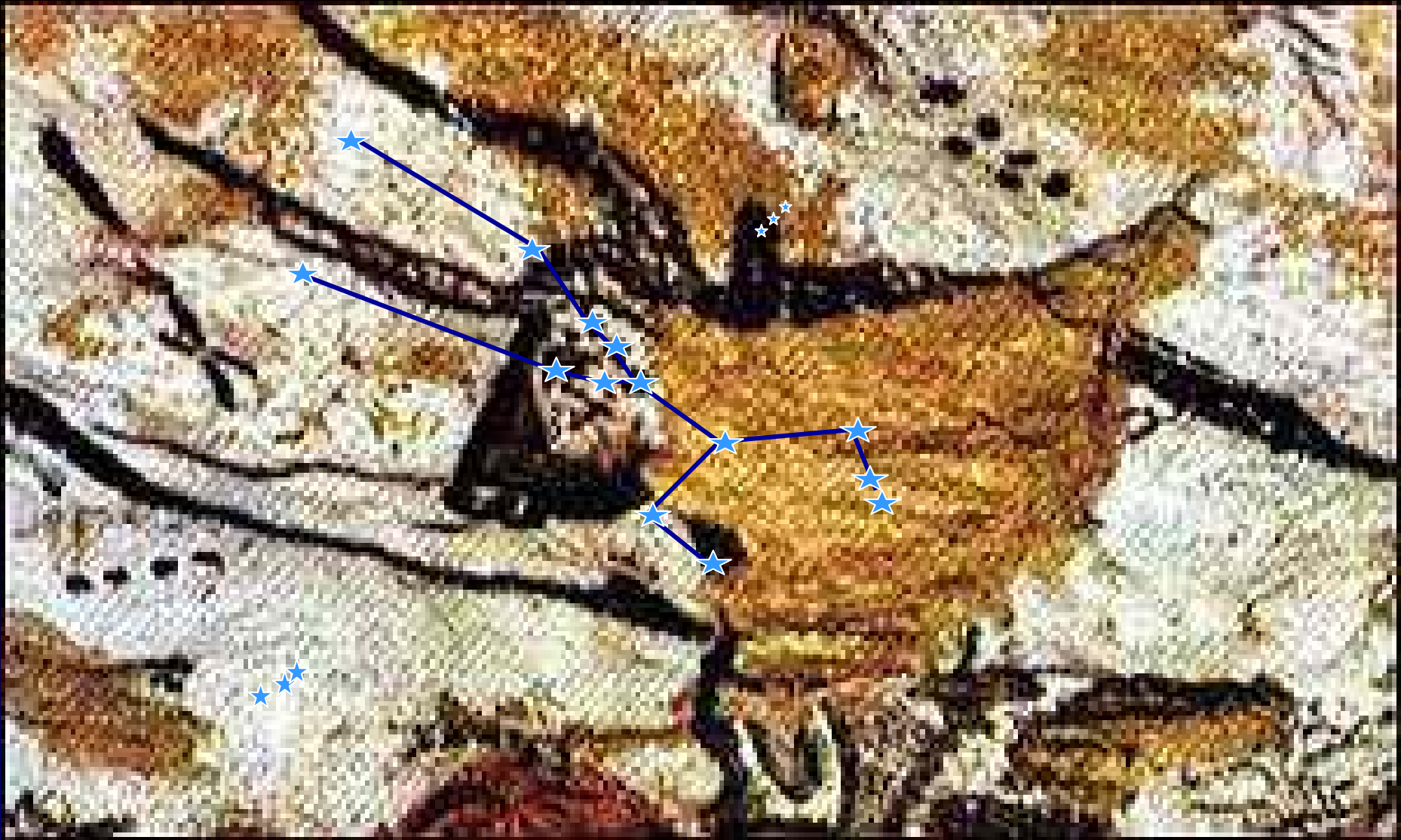


Taurus



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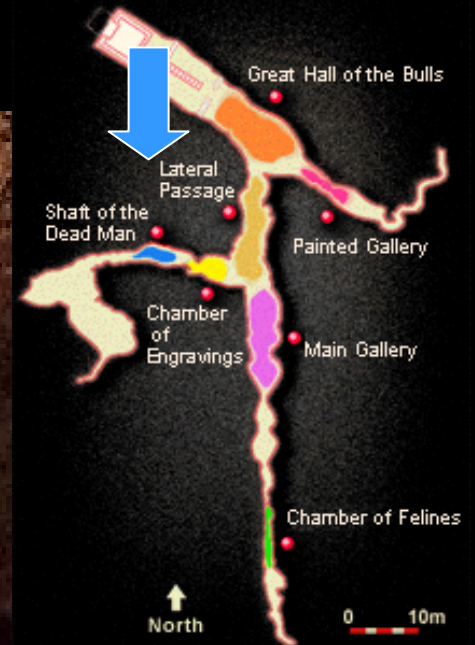
Ancient Astronomy



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Ancient Astronomy

The Pleiades or Poop

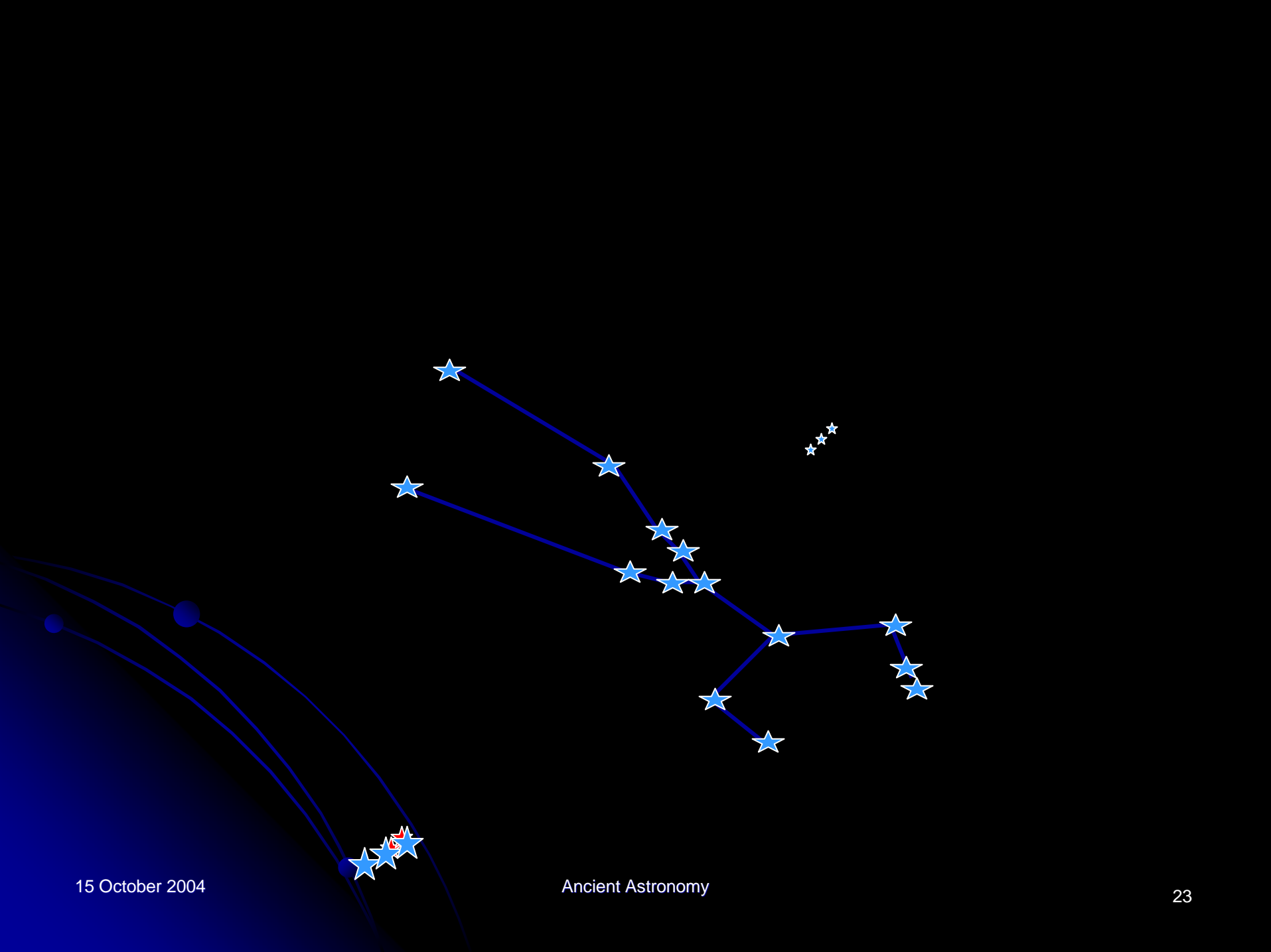


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Shaft of the Dead Man

Ancient Astronomy

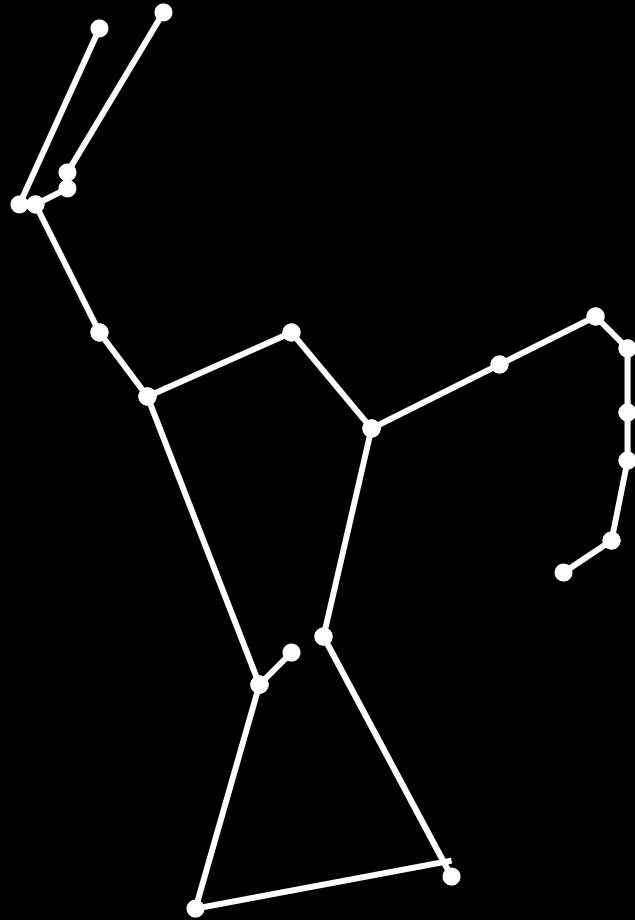




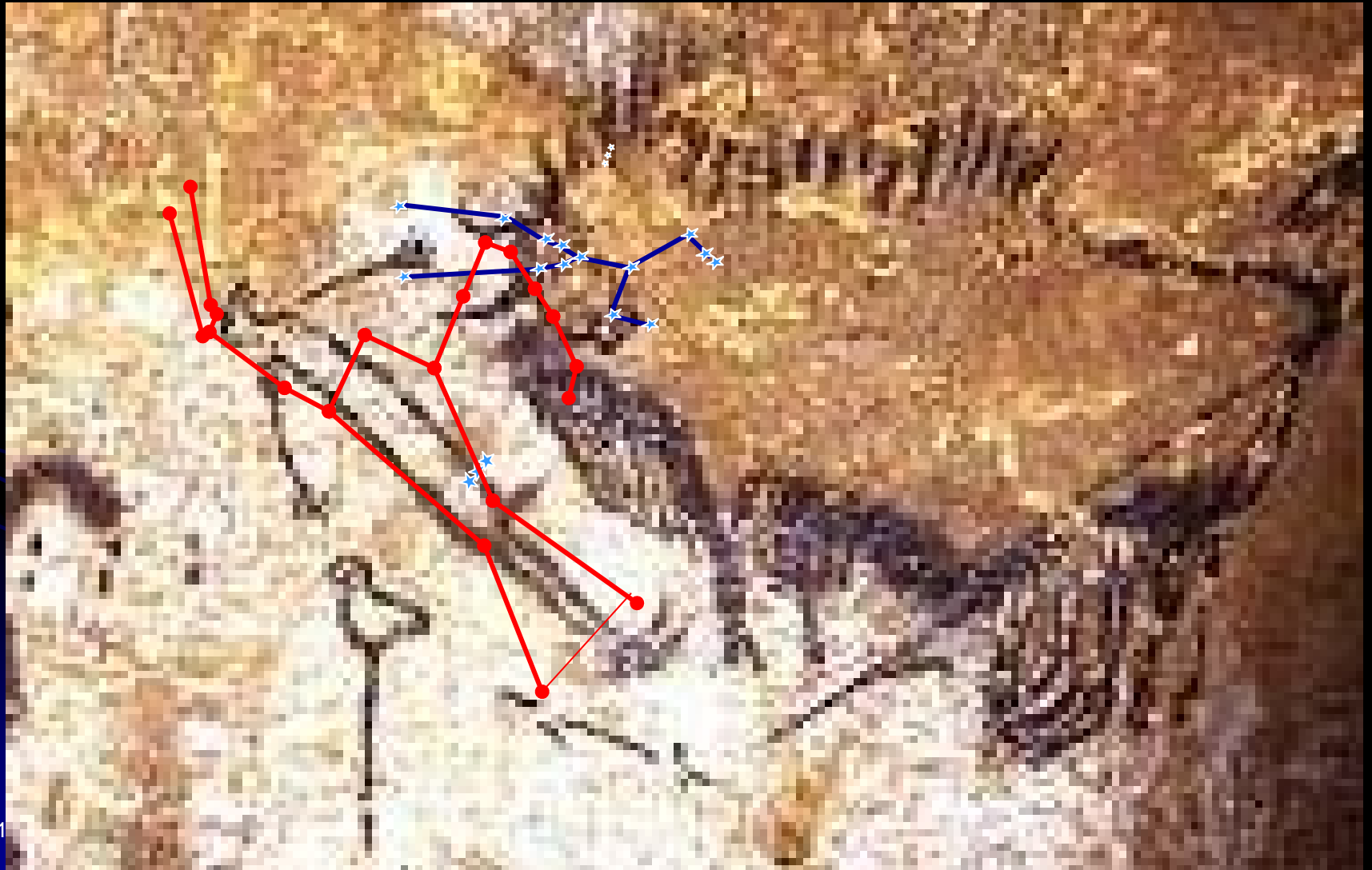
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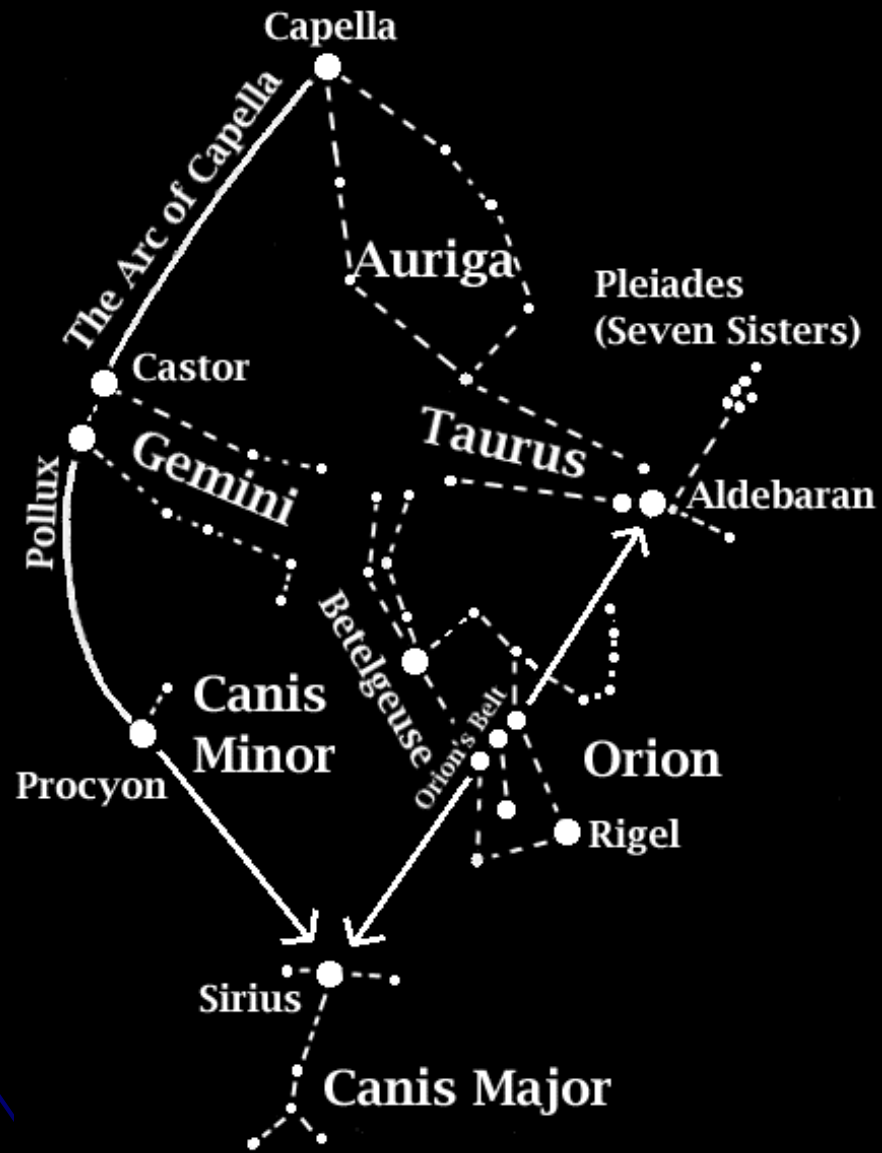
Ancient Astronomy

Orion



Orion and Taurus

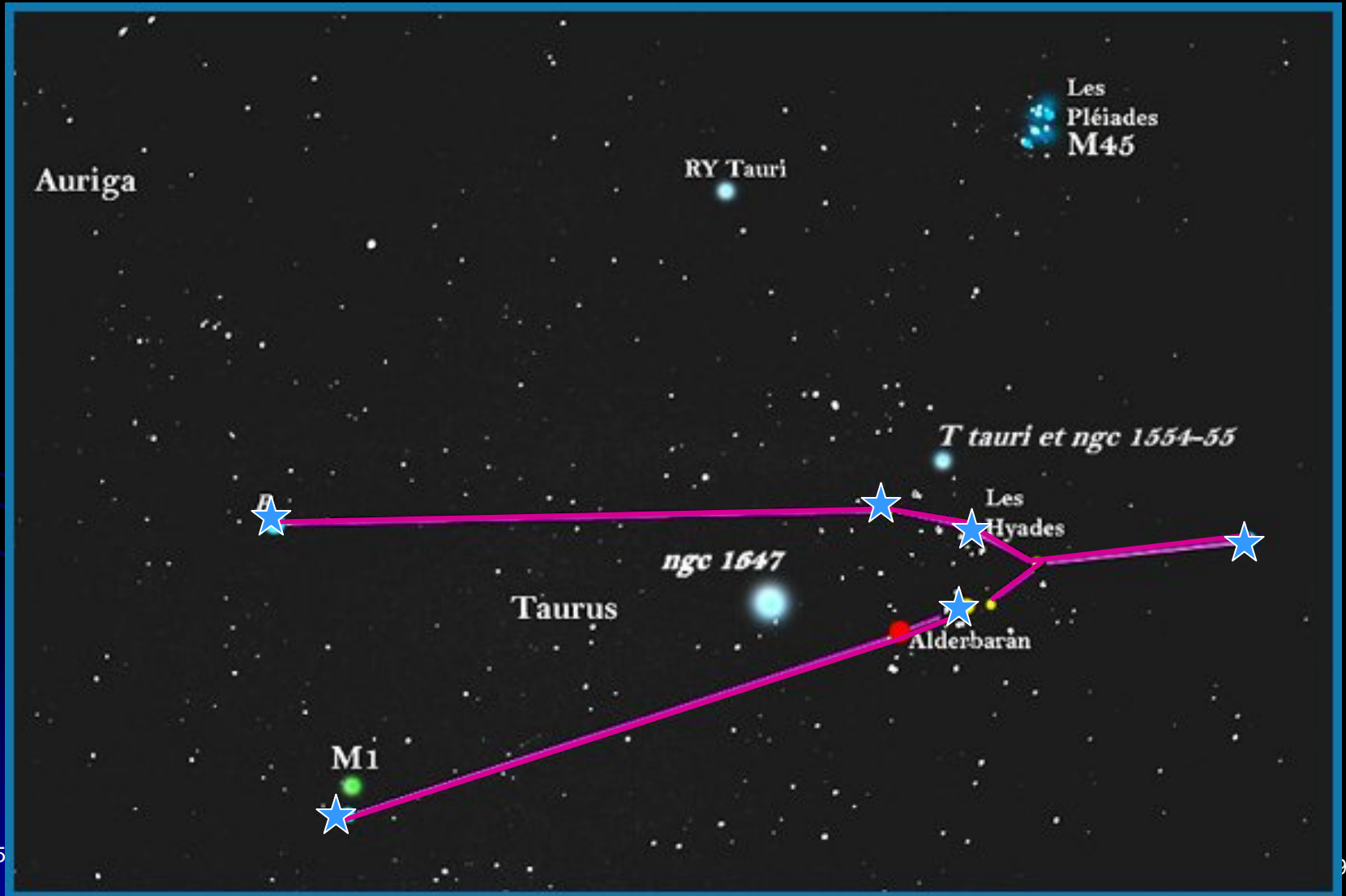




Hall of the Bulls - Pleiades



Taurus



Coordinate Systems

Coordinate Systems

Geographic

- Every point on the surface of the earth has a latitude and a longitude associated with it.
- GPS systems are based on latitude and longitude
- This building is at:

Coordinate Systems

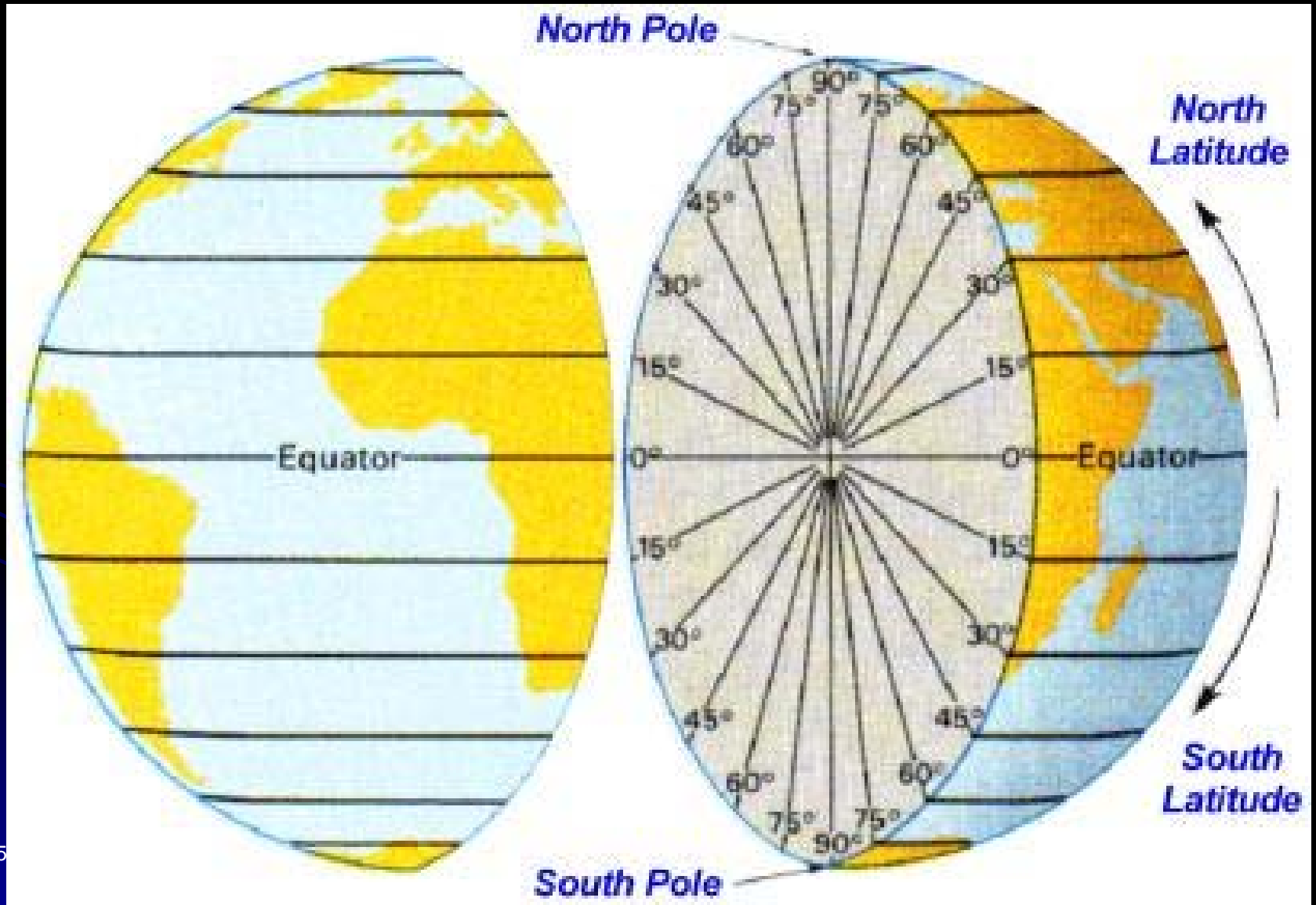
Geographic - Latitude

- **Latitude**

- Lines circling the earth East – West
- Parallels
- 0° - Equator



Latitude



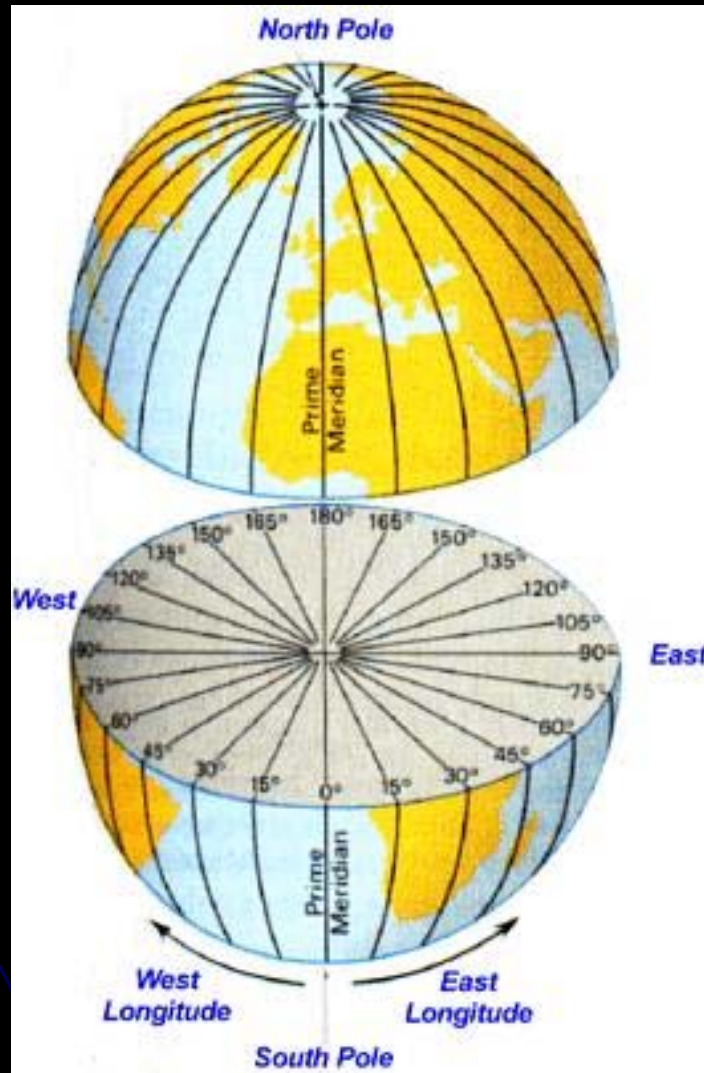
Coordinate Systems

Geographic - Longitude

- Longitude
 - Lines circling the earth North – South
 - Meridian Lines
 - 0° - Greenwich UK (Prime Meridian)



Longitude



True

- True North and South
- Magnetic North and South are different
 - What you see on your car compass is magnetic North

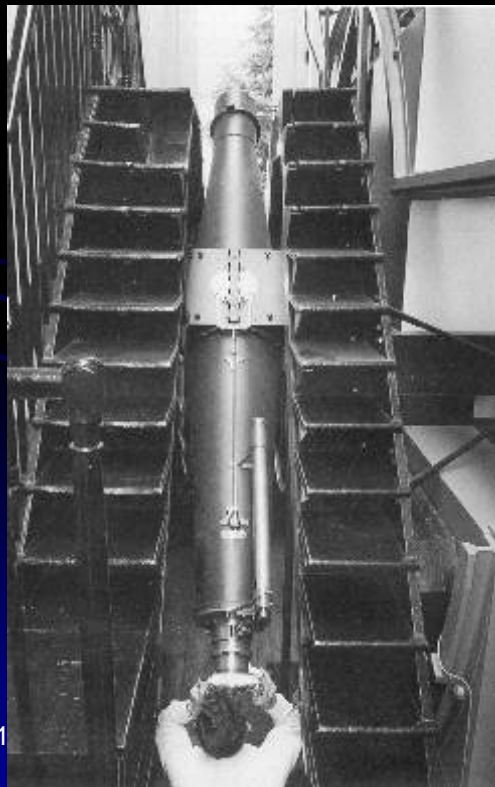
Longitude

Prime Meridian

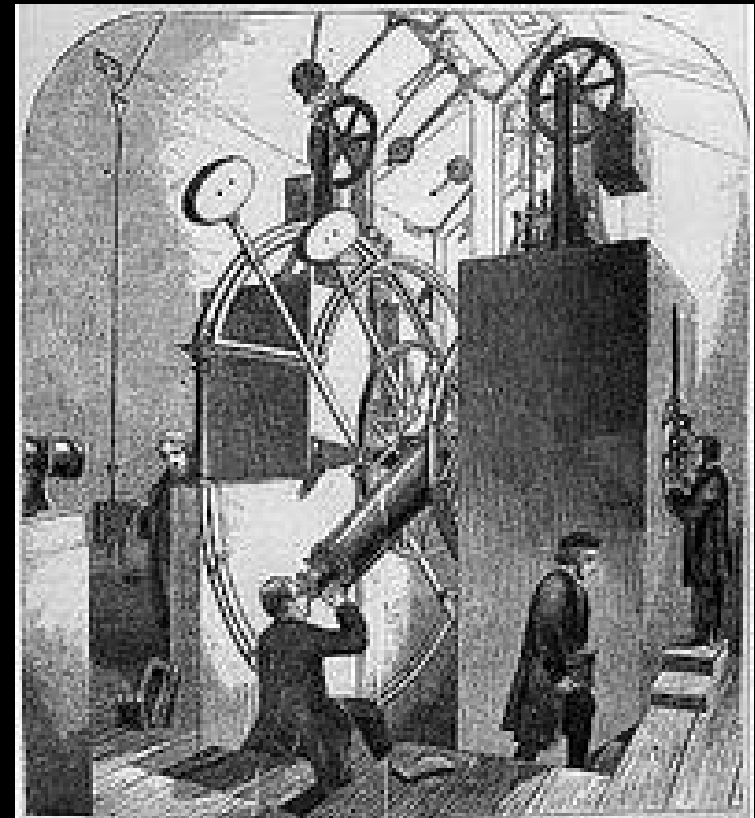
- **0° longitude is defined as:**
 - Optical axis of the Airy Circle Transit Telescope
 - Old Royal Greenwich Observatory
 - The Prime Meridian

Transit Telescope

- Also an astronomical instrument
 - Airy Circle Transit Telescope
 - Telescope that can only be moved along a meridian



Ancient Astronomy



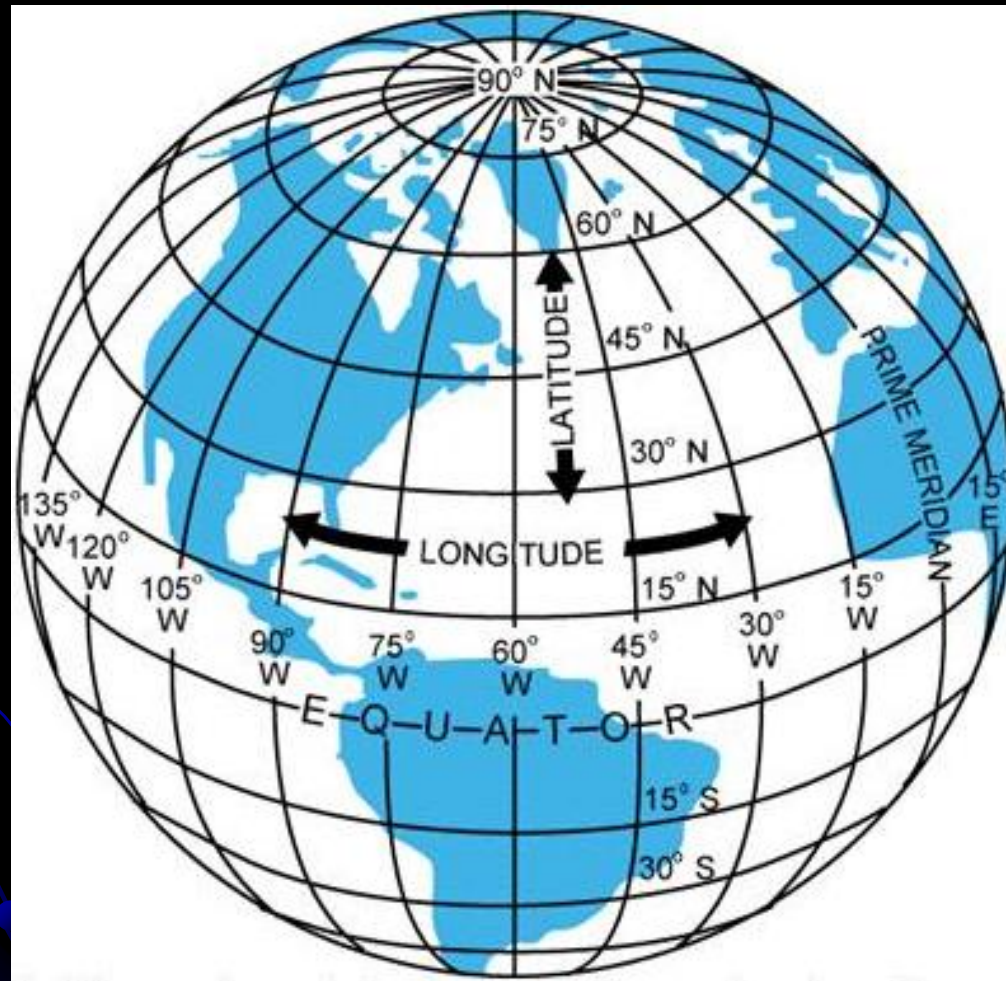


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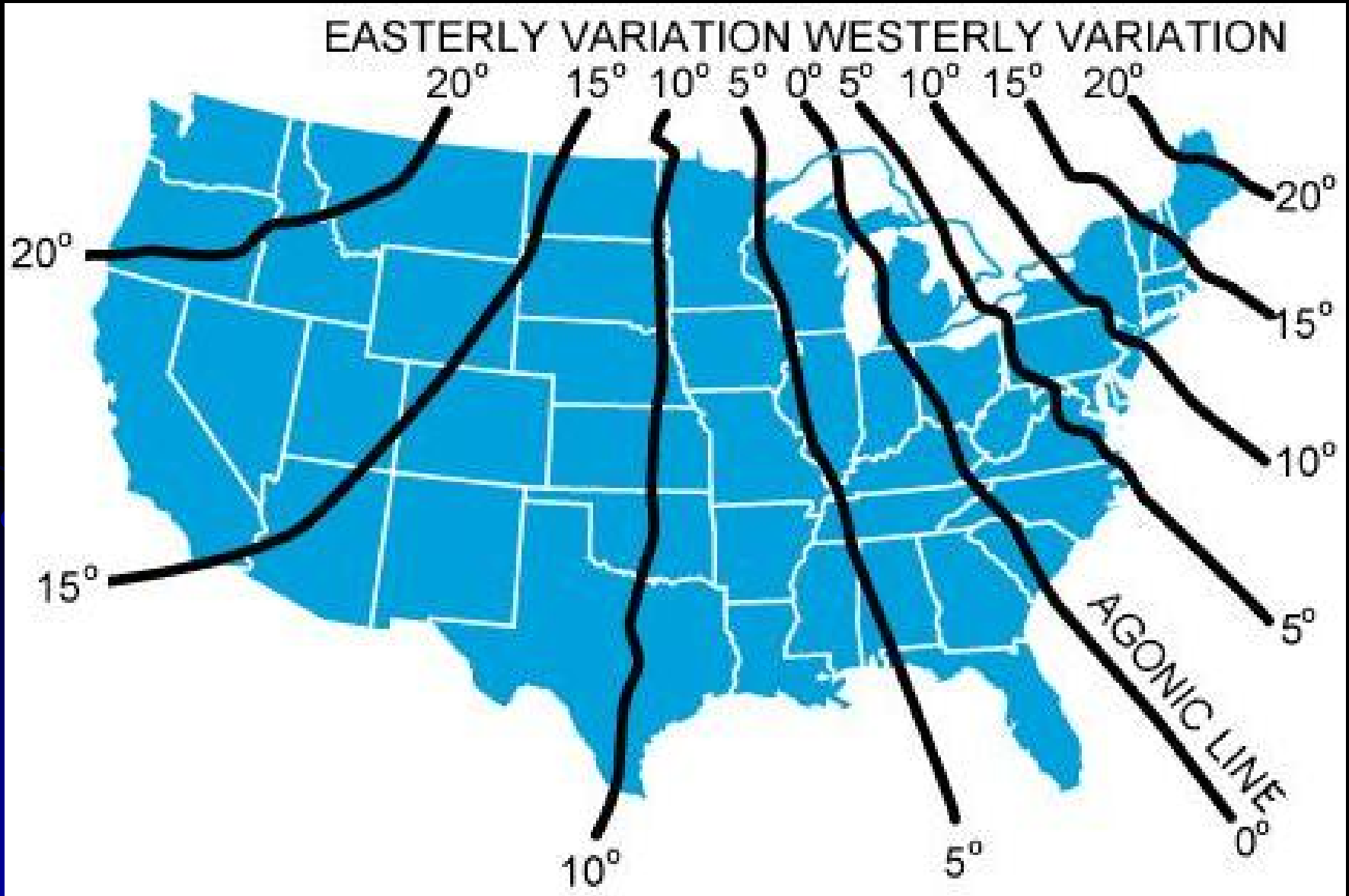
Latitude and Longitude



Longitude and Latitude True



Isogonic – Agonic Lines



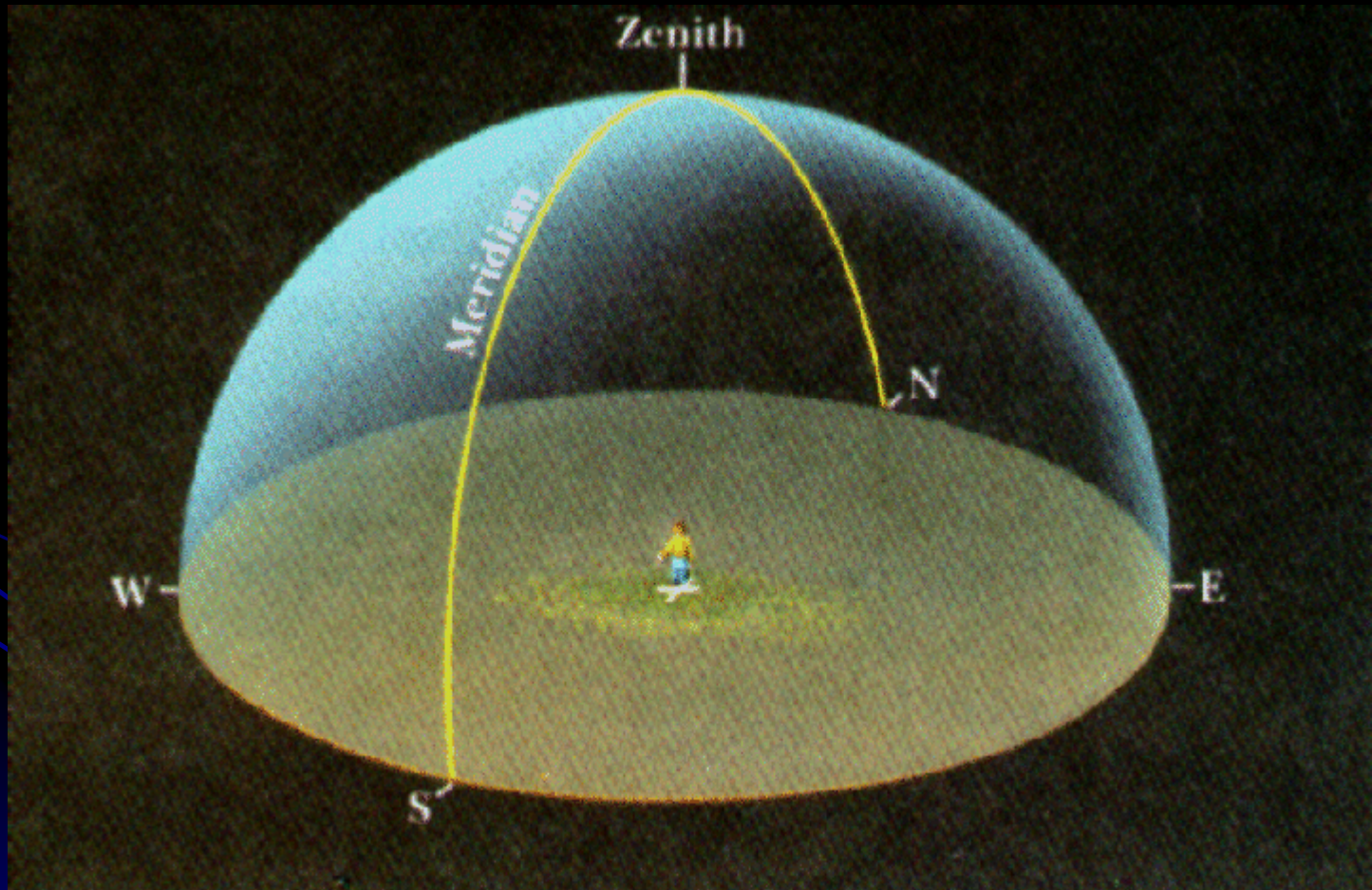
Celestial Coordinate Systems

Relative System

Celestial Sphere

- Standing on the Earth
 - Appear to be at the center of a plateau
 - Sky looks like a huge dome
 - A hemisphere
 - Covered with stars
 - Horizon is our equator
 - The zenith point (our north pole) is directly above our head
 - The nadir point (our south pole)

Zenith and Meridian

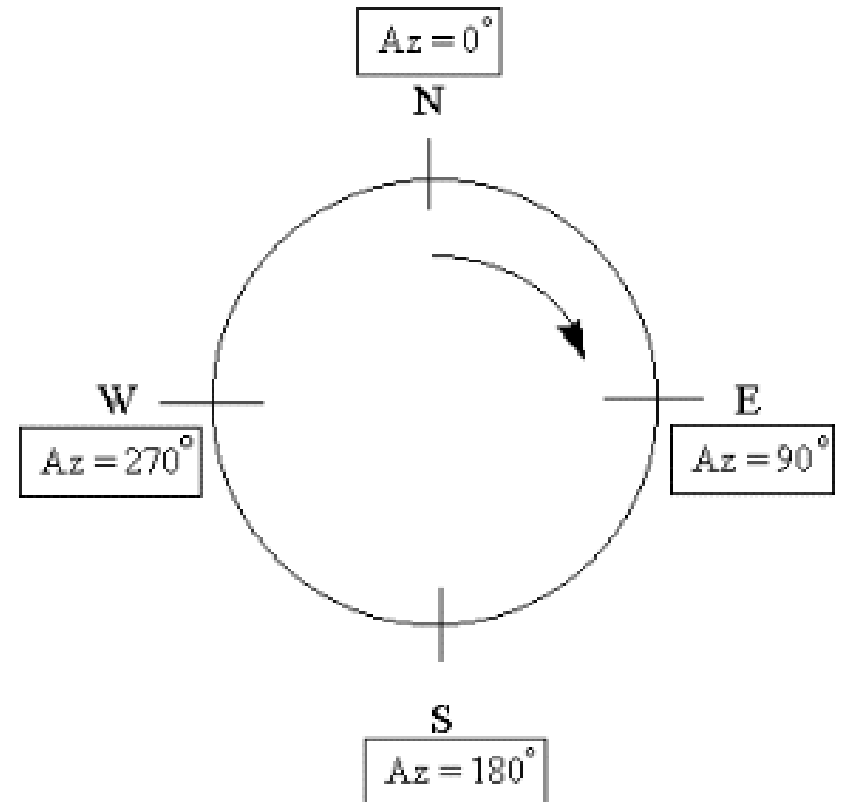
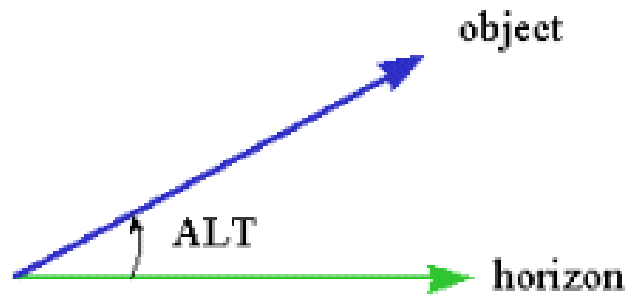


Celestial Coordinates

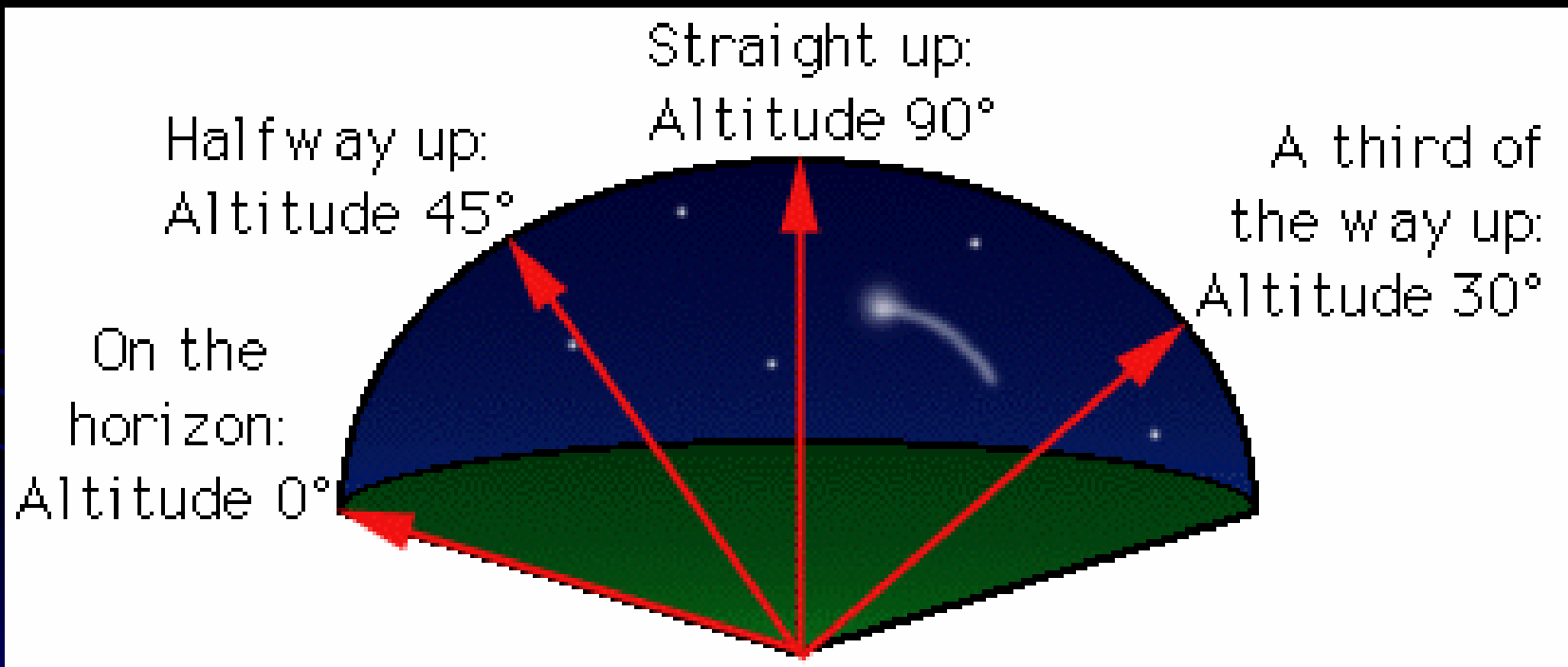
Altitude

- Assigning a position/location
 - Determine “latitude” = ALTITUDE
 - Elevation above the horizon in degrees 0° to 90°
 - If an object is below the horizon it has a negative value
- The Altitude of an object is the distance appears to be above the horizon.
- The angle is measured up from the closest point on the horizon

Altitude



Altitude Cont.

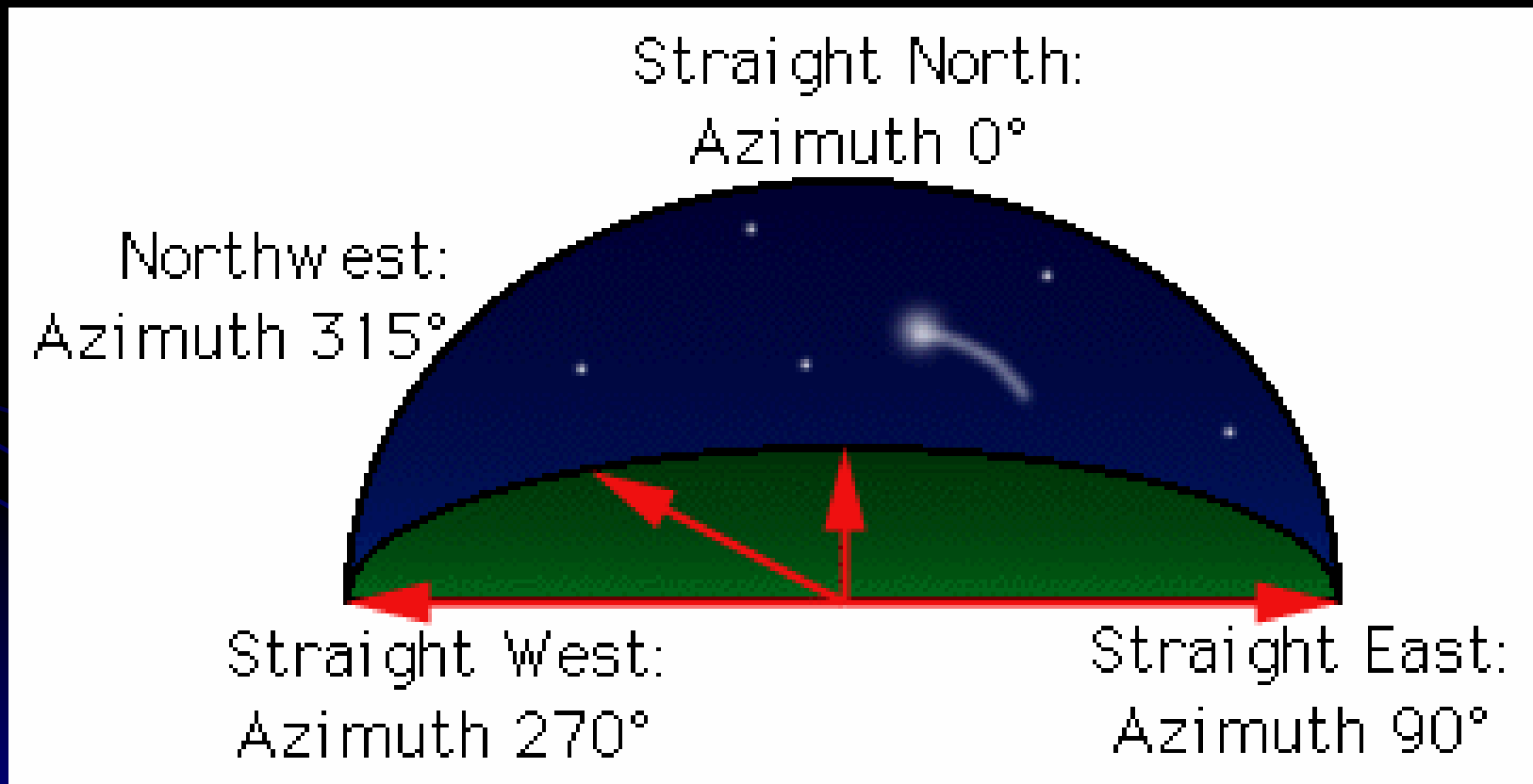


Celestial Coordinates

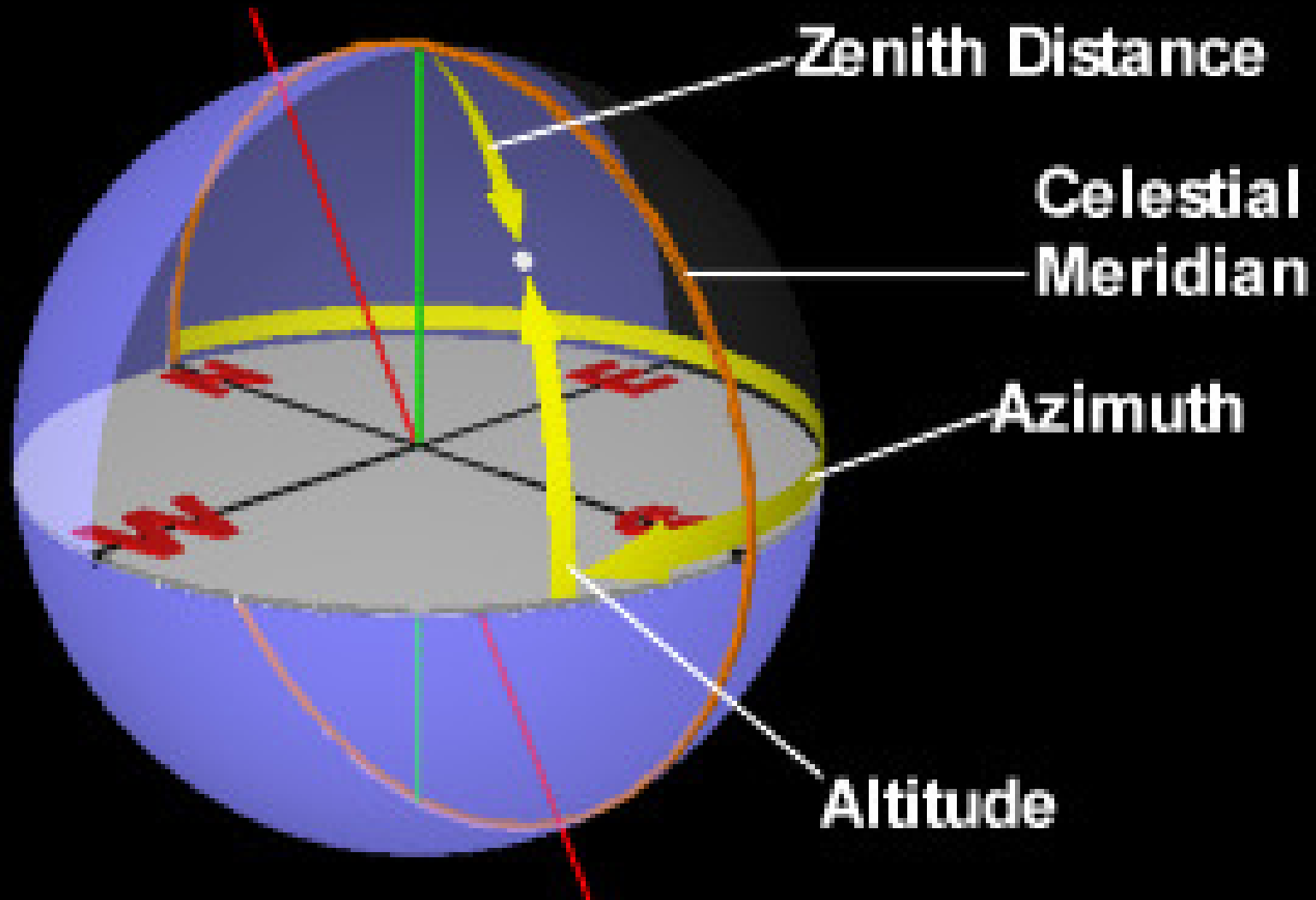
Azimuth

- The **azimuth** of an object is the angular distance along the horizon to the location of the object.
- Measured in degrees $0^{\circ} - 360^{\circ}$
- By convention, azimuth is measured from north towards the east along the horizon
 - Clockwise (right) from north point on the horizon
 - Due north is 0° (and 360°)
 - South 180°
 - East 90°
 - West 270°
- **Generally accepted definition**

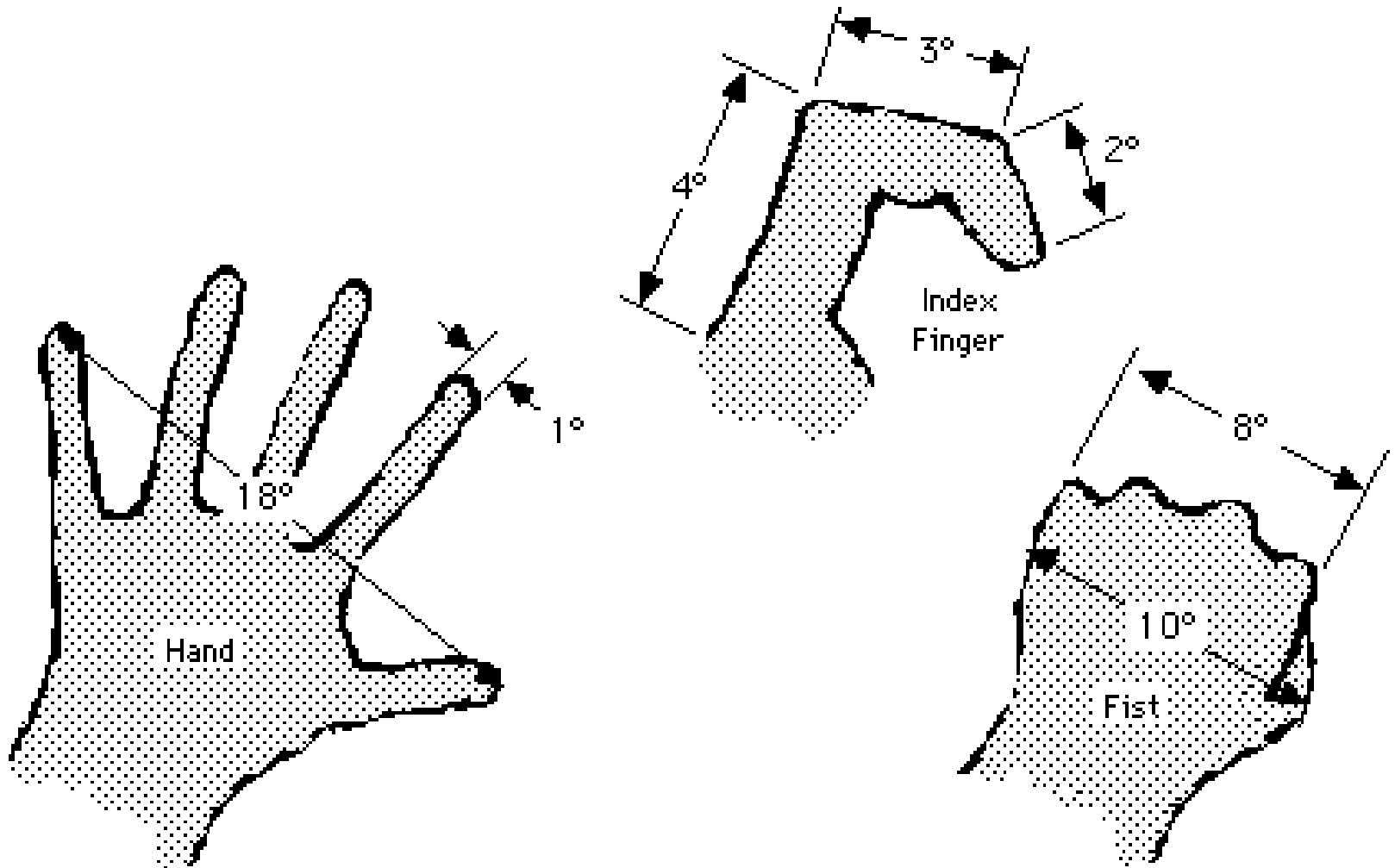
Azimuth



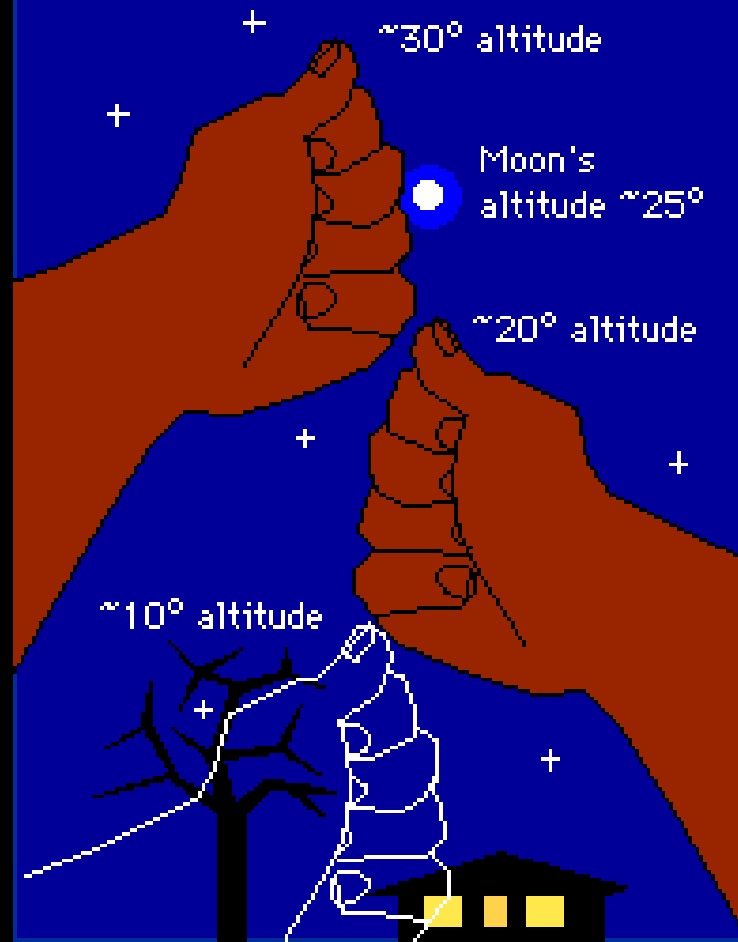
Azimuth and Altitude



Rules of Thumb and Fist and Finger



Measuring altitude with fists at arm's length.



Bring one eye in six inches from the screen for correct scale!

Measuring Azimuth

Measuring Azimuth in Michigan

and other places with north-south east-west street grids



Azimuth and Altitude

- We use altitude and azimuth to describe the location of an object in the sky *as viewed from a particular location at a particular time.*
- Used in celestial navigation

Upside

- Useful for determining location on the surface of the Earth
- Can be used to determine the size of the Earth – Eratosthenes

Problems

- Object's altitude and azimuth change over time
- Only one half the meridian is observable from the surface of the Earth
- Not a practical system for recording observations

Henge World

Astronomy in Neolithic Britain Stonehenge

Henge

- Humpbacked
- Structure
 - External bank
 - Internal ditch
 - Circular shape
 - One or multiple entrances
- Original structures were wooden
 - Used as living structures from ~3500 BCE

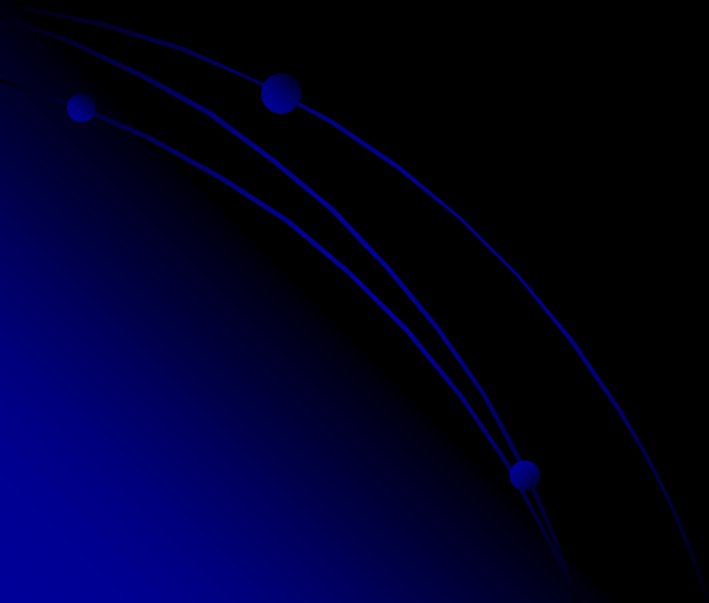
Timeframe

- Mesolithic – Middle Stone Age
- The Mesolithic in Britain has two periods
 - Early (9,700 - 8,700 BP)
 - Late (8,700 - 5,300 BP)
- ~8,000 BCE Britain becomes an island
- Subsistence and mobile lifestyle
 - Hunting
 - Fishing
 - Gathering

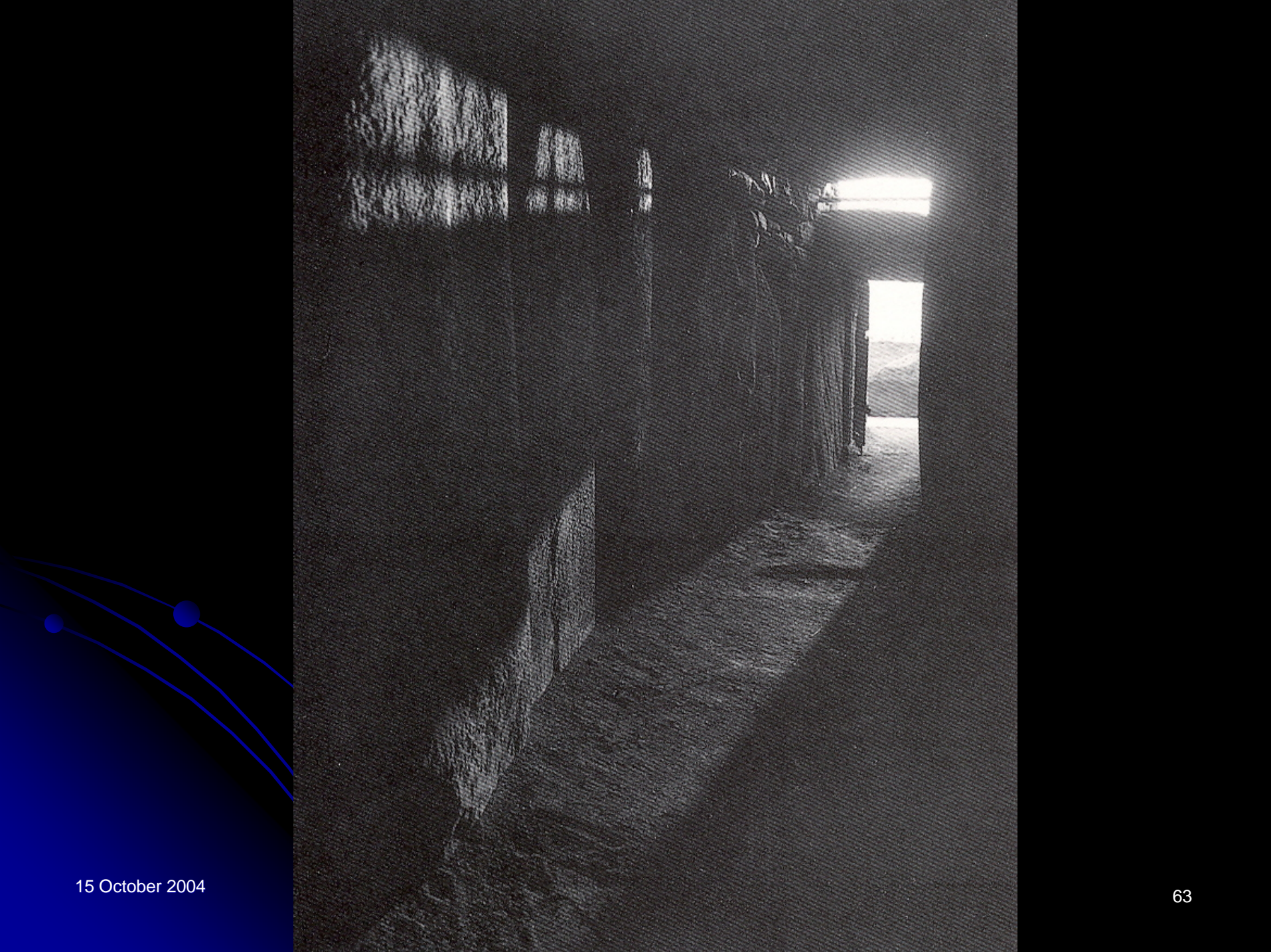
The Neolithic

- ~4,000 BCE – Introduction of farming
 - Causewayed enclosures
 - Southern England
 - Robin Hood's Ball
 - Earthen long tombs
 - Britain and Ireland
 - Megalithic long tombs
 - Britain and Ireland
 - Simple round-bottomed pottery

Newgrange

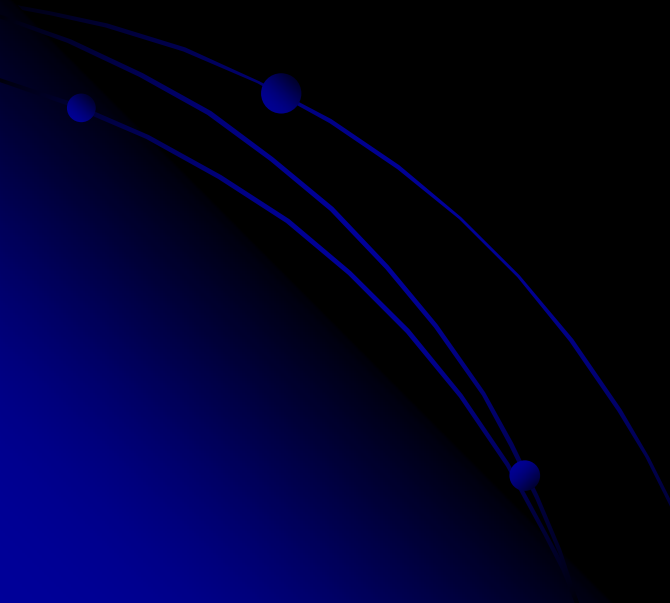


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Stonehenge



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Stonehenge ?

“Every age has the Stonehenge it desires
and deserves.”

Jacquetta Hawkes

Mesolithic ~8000 BCE

- Three post holes
 - Possibly for a timber structure

Phase 1

~3000 - ~2900 BCE

Age	date BC	culture	metals used	main artifacts
EBA	2700-2100	early beaker	copper + tin	flat axes, halberds
	2100-1900	late beaker	same	knives, tanged spearheads
	1900-1500	urn	copper + tin	
MBA	1500-1300		copper, tin	palstaves, socketed spearheads
	1300-1200			rapiers
	1200-1000	early urnfield		
LBA	1000 - 900	late urnfield		socketed axes, palstaves
	900 - 700			leaf-shaped swords
	700 - 600	Hallstatt C	bronze, iron	iron swords



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Phase 1

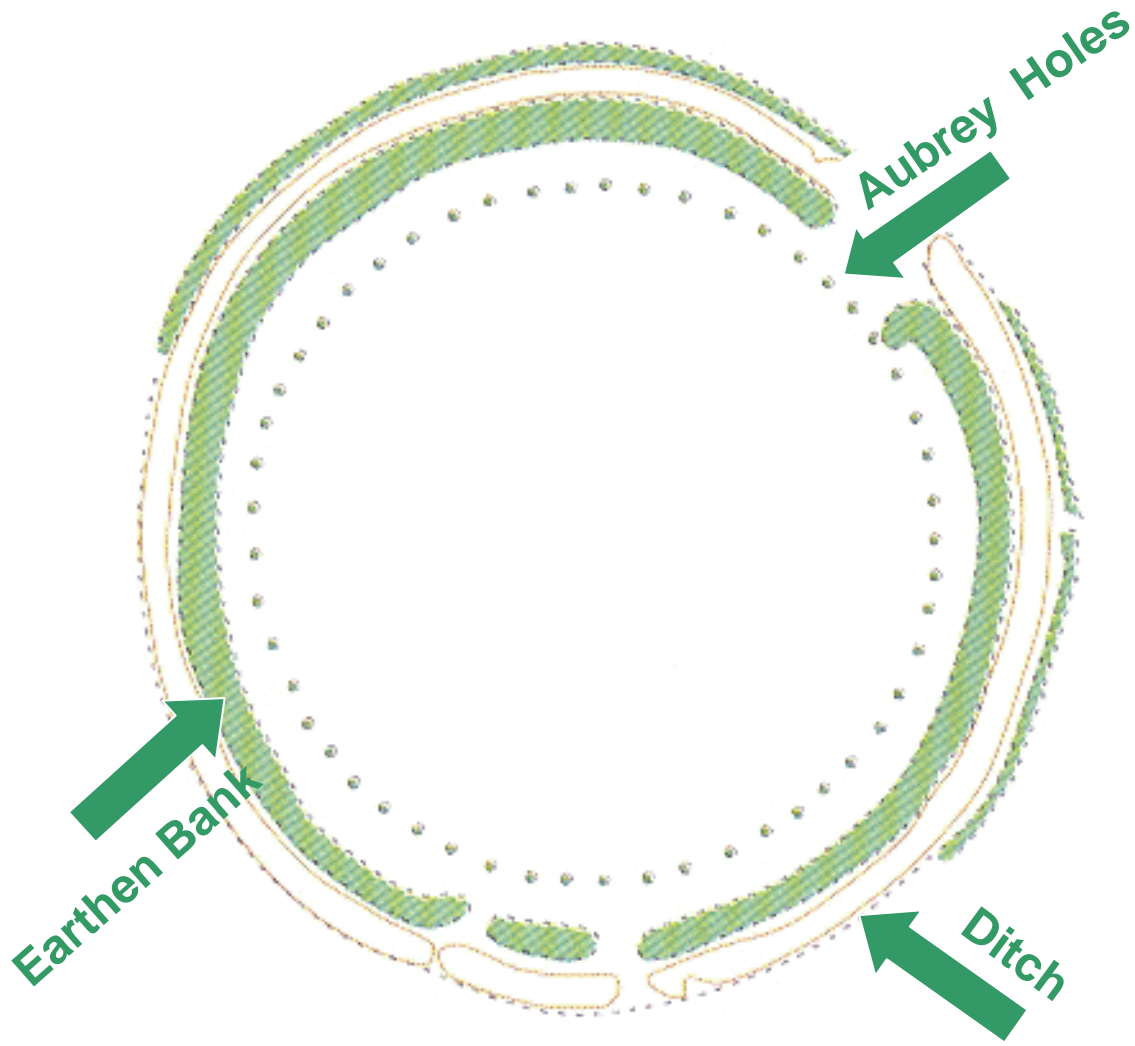
- Constructed ~3,000 – ~2,900 BCE
- Short use (several hundred years)
- Possible timber building
- Ditch and earthen bank
 - Radiocarbon date of ~3000
 - 3015-2935 cal BCE
- Possibly a Late Neolithic enclosed cemetery

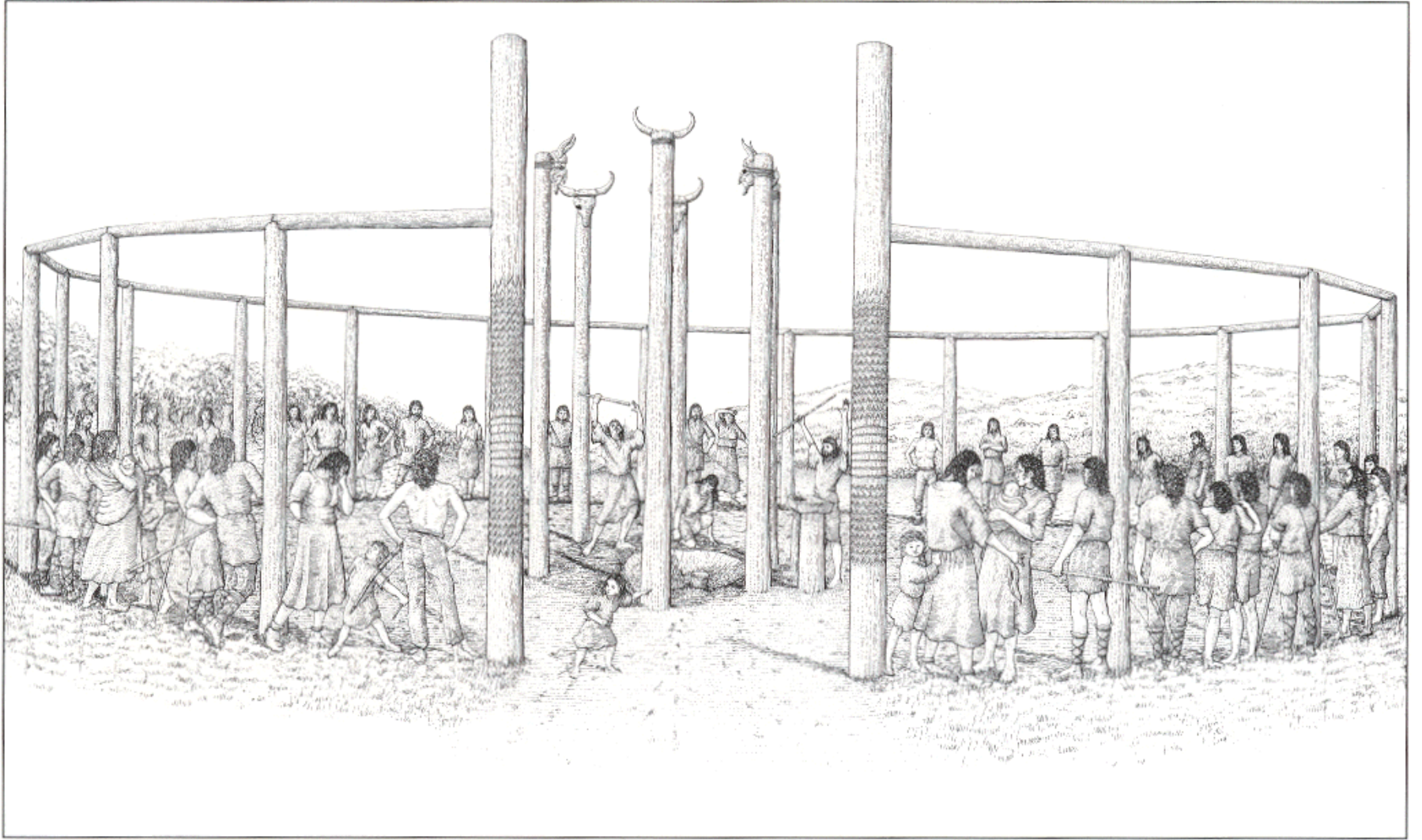
Phase 1 Cont.

- Site was overgrown for an time
- No evidence of sarsen or blue stones
- Aubrey holes and Stations Stone
 - 56 holes
 - Uncertain dating
 - Center is same as center of the ditch and bank
 - Likely held timber posts

Phase 1

~3000 - ~2900





Phase 1 Cont.

- Not a true henge
- Not a true causeway enclosure
- Actual usage still uncertain

Earliest Peoples

- Windmill Hill Culture
- Typically lived in causewayed camps
- Rings of concentric ditches with “causeways”/banks between them
 - Causeway is a bad term
 - Some were only centimeters wide
- Used shovels made of cattle shoulder blades and antlers

Windmill Hill People Cont.

- Communal timber roundhouses
 - Wattle and daub (twigs with mud or clay)
- Cone shaped thatched roof
- Housed small extended families
- Durrington Walls
 - Multiple dwellings
 - Surrounded by ditch-and-bank ~415m in diameter

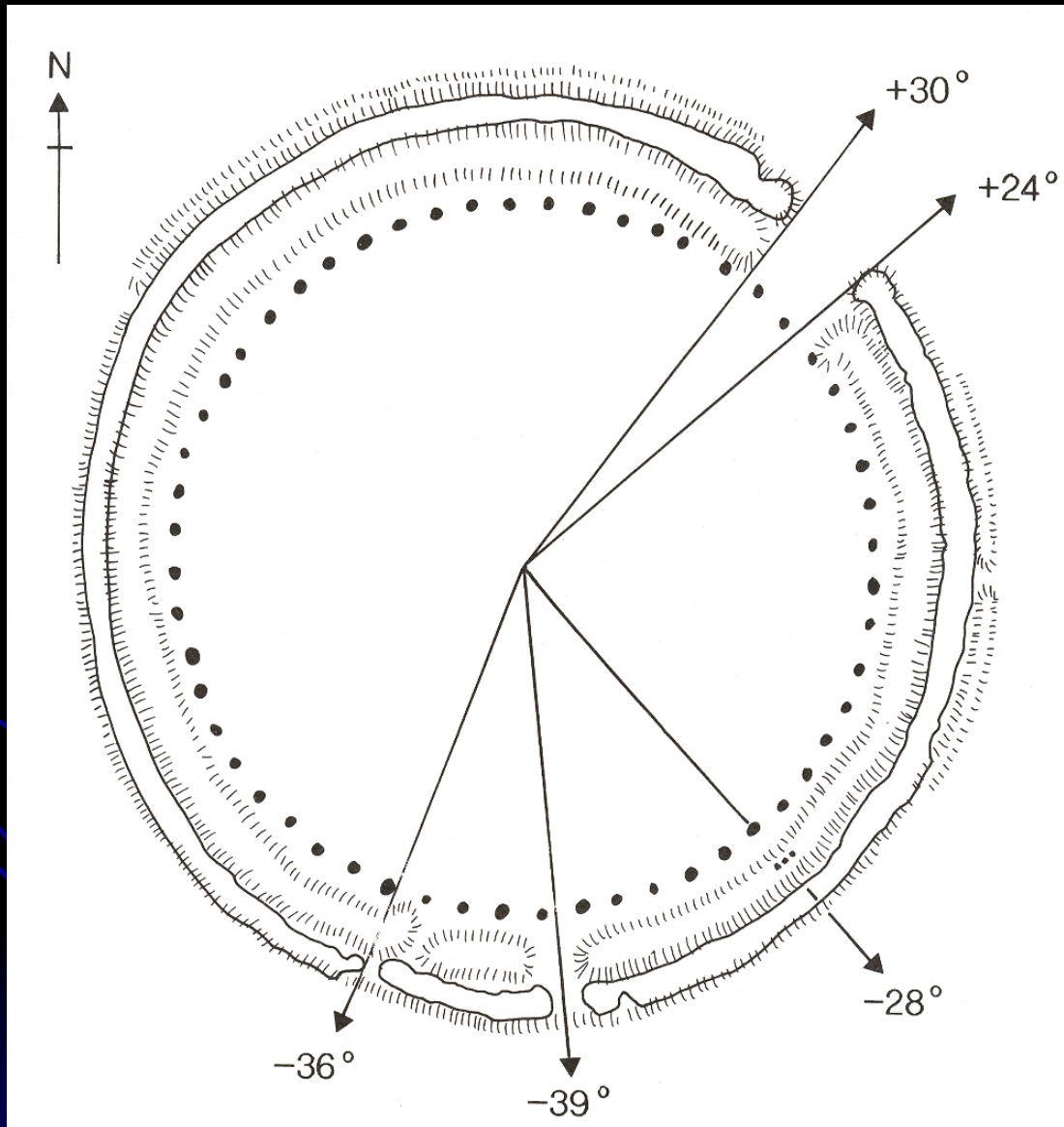
Phase 1 Cont.

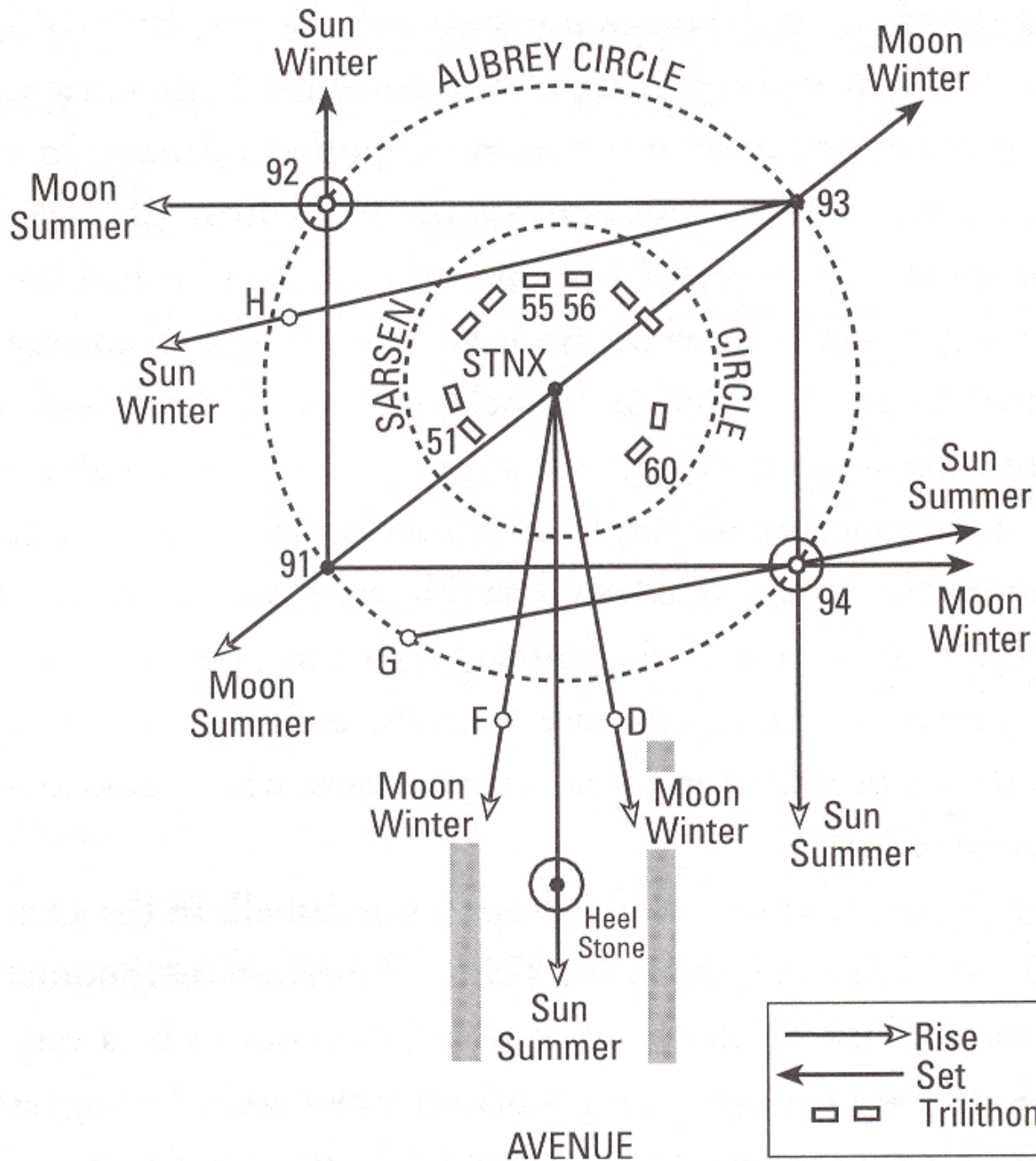
- Built in Meldon Bridge period
- Continued into the Mount Pleasant period
- Burial in ditch typical Beaker burial goods

Sightlines

Lunar and Solar Phenomena

Phase 1 "Sightlines"





Astronomical Alignments

- Nada
- None of the proposed “sightlines” align with any lunar or solar phenomena

Phase 2

2900 -2400 BCE

Phase 2

- ~2900 -2550 or 2400 BCE
- Modified in line with other “henges”
 - Durrington Walls
 - Woodhenge
 - Coneybury
- New settlements within 1km
 - More surrounding land under cultivation

Phase 2 Cont.

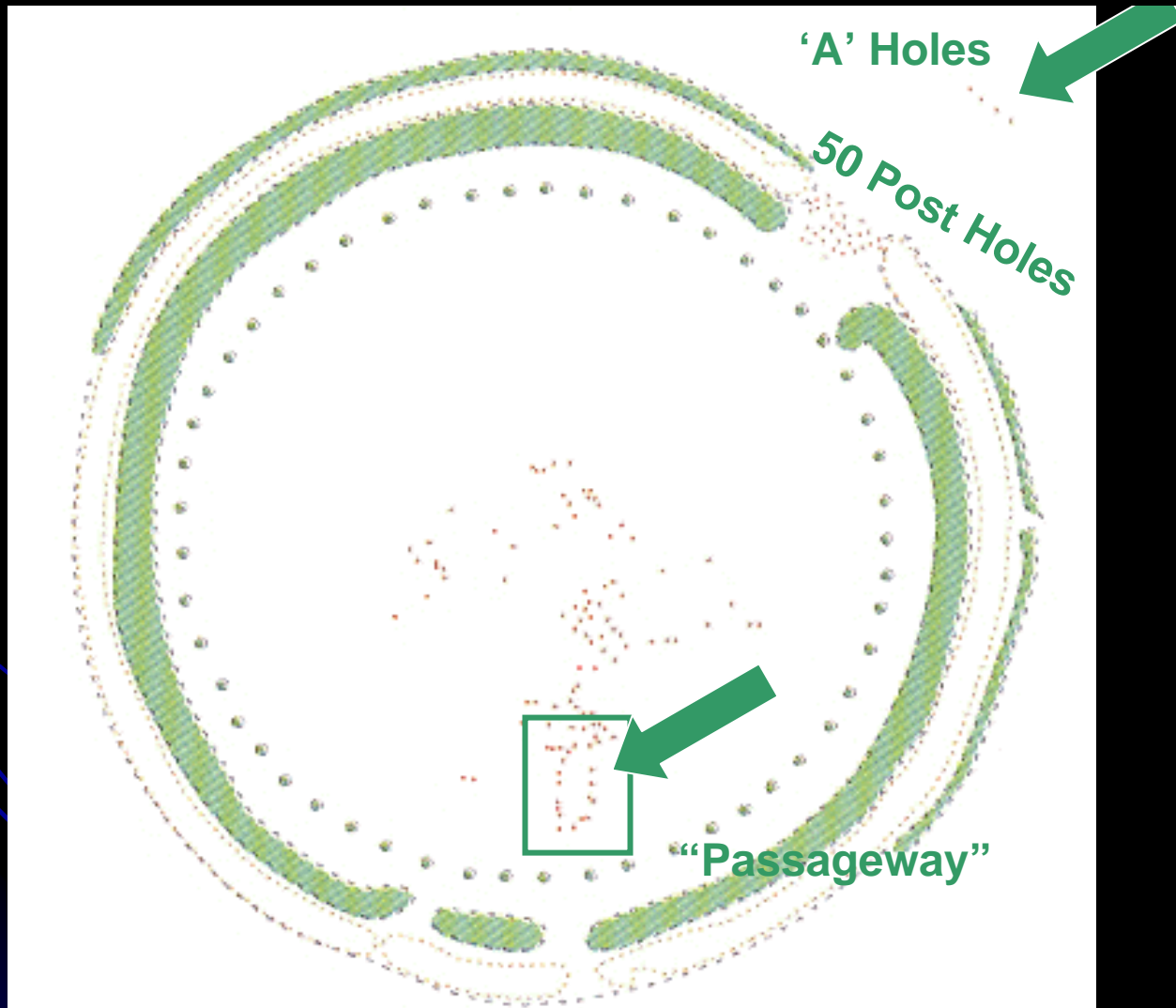
- Aubrey hole timber posts removed
- A number of cremation burials cut into previously filled-in Aubrey holes
 - At least 52 found so far

Phase 2 Cont.

- A number of timber structures in the central area
- “Passageway” leading from southern entrance
- ~50 postholes in a grid
- 4 ‘A’ holes across axis 20m outside the NE entrance
- 113 post-holes known in the interior area

Phase 2

~2900 - ~2550 BCE



Phase 2 Alignments

- Again we do not find any definite alignments/sightlines

Phase 3

~2550 - ~1600 BCE

Phase 3

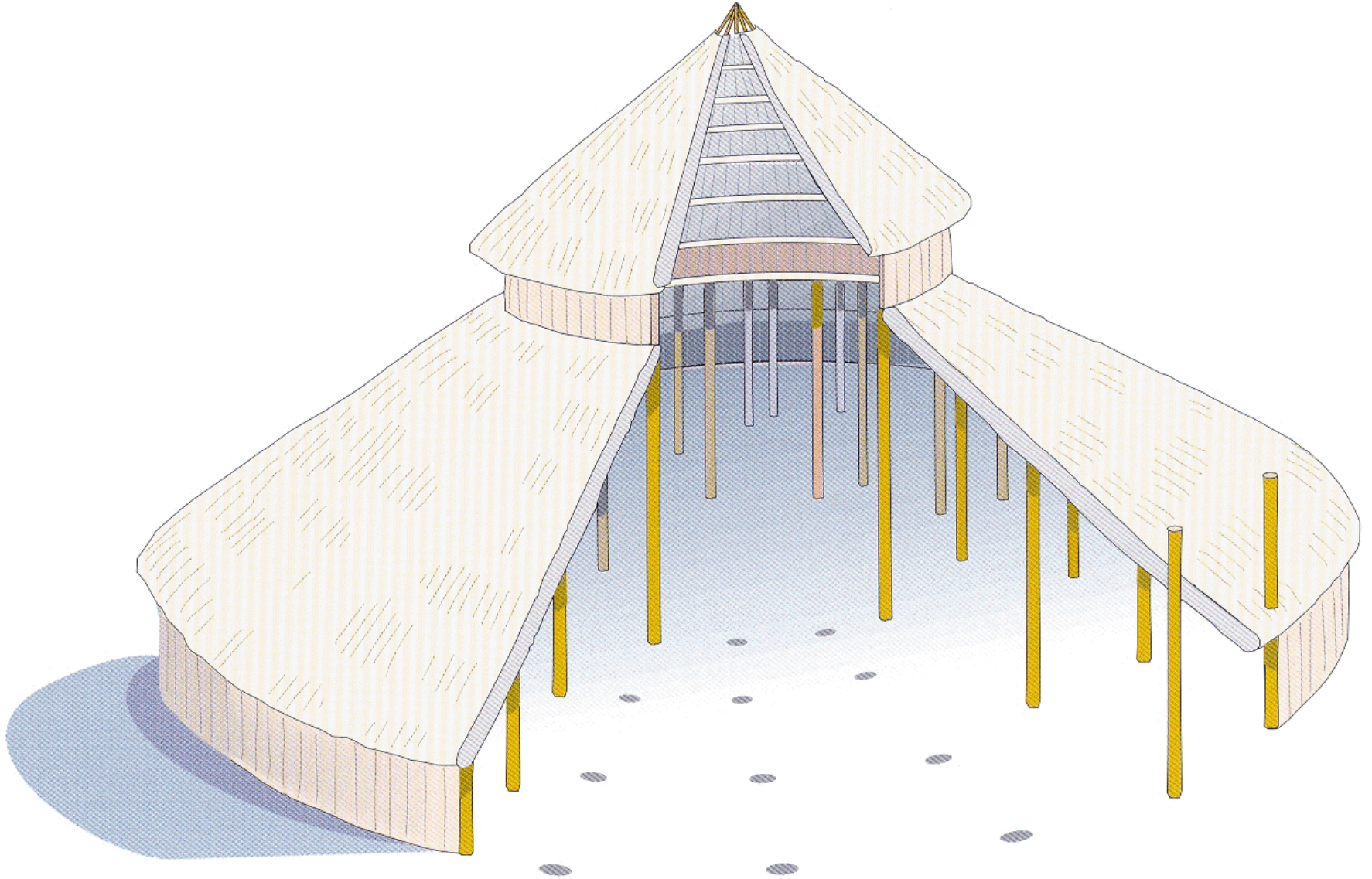
~2550 - ~1600 BCE

- Increasing farming in surrounding area
 - Permanent field systems
 - Farmsteads
 - Settlements
- Organized labor
- Many modifications during this period

Woodhenge

- ~2300 BCE
- ~44 m in diameter
- Communal living area
- Possibly used for worship
- Center may have held poles (totems?)
- Three year old child buried in center
 - Possible sacrifice
- Ditch and bank

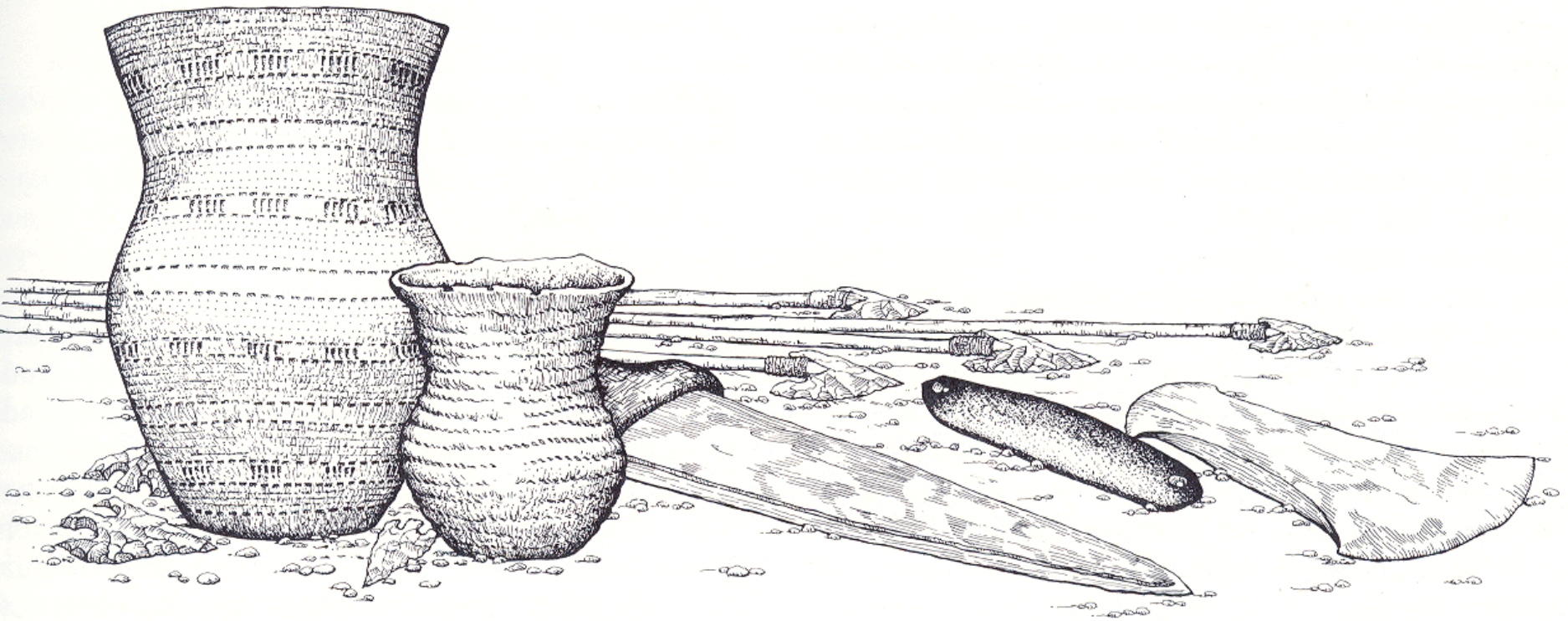
Woodhenge



Beaker Culture

- Last causewayed enclosures, long barrows and long chambered cairns were built by 2500 BCE
 - Possibly changes in spiritual beliefs or social organization
- Emergence of Beaker Culture
- Appears to have originated in Europe and migrated to Britain about mid-2nd millennium BCE

Beaker Funeral Goods



Phase 3

Construction Phases

- Five phases
- 3i
 - Dumbbell-shaped stone-holes (Q and R Holes)
 - In pairs of bluestones
 - Not a circle but an flattened arc



A diagram showing a blue arc on a dark blue background. The arc is labeled '3a' and has several grey dots along its length, representing station stones. The arc is flattened, curving downwards from left to right.

3a

Station stones

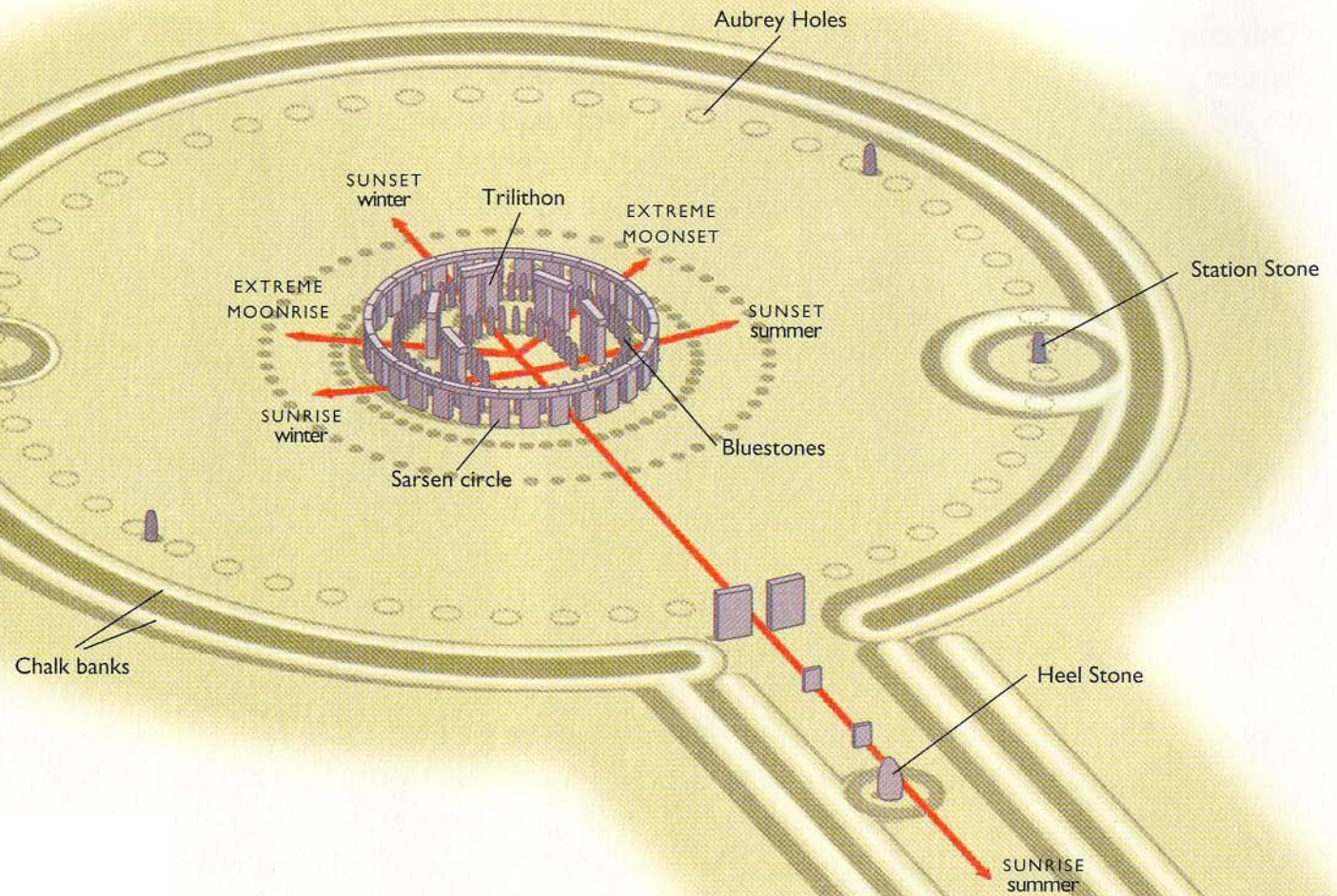
Phase 3 Cont.

- 3ii
 - Sarsen Circle
- 3b
 - Ditch
 - Station Stones surrounded by banks
- 3iii
 - Possibly trilithons of sarsen and bluestones

Jargon

- Sarsen
 - Silicified sandstone boulder
 - Silicon dioxide
 - Derivation of the word is unknown but likely from saracen
 - Has come to be used generally to mean an upright stone used in prehistoric henges and other sites

Final Stage



Outer Sarsen circle

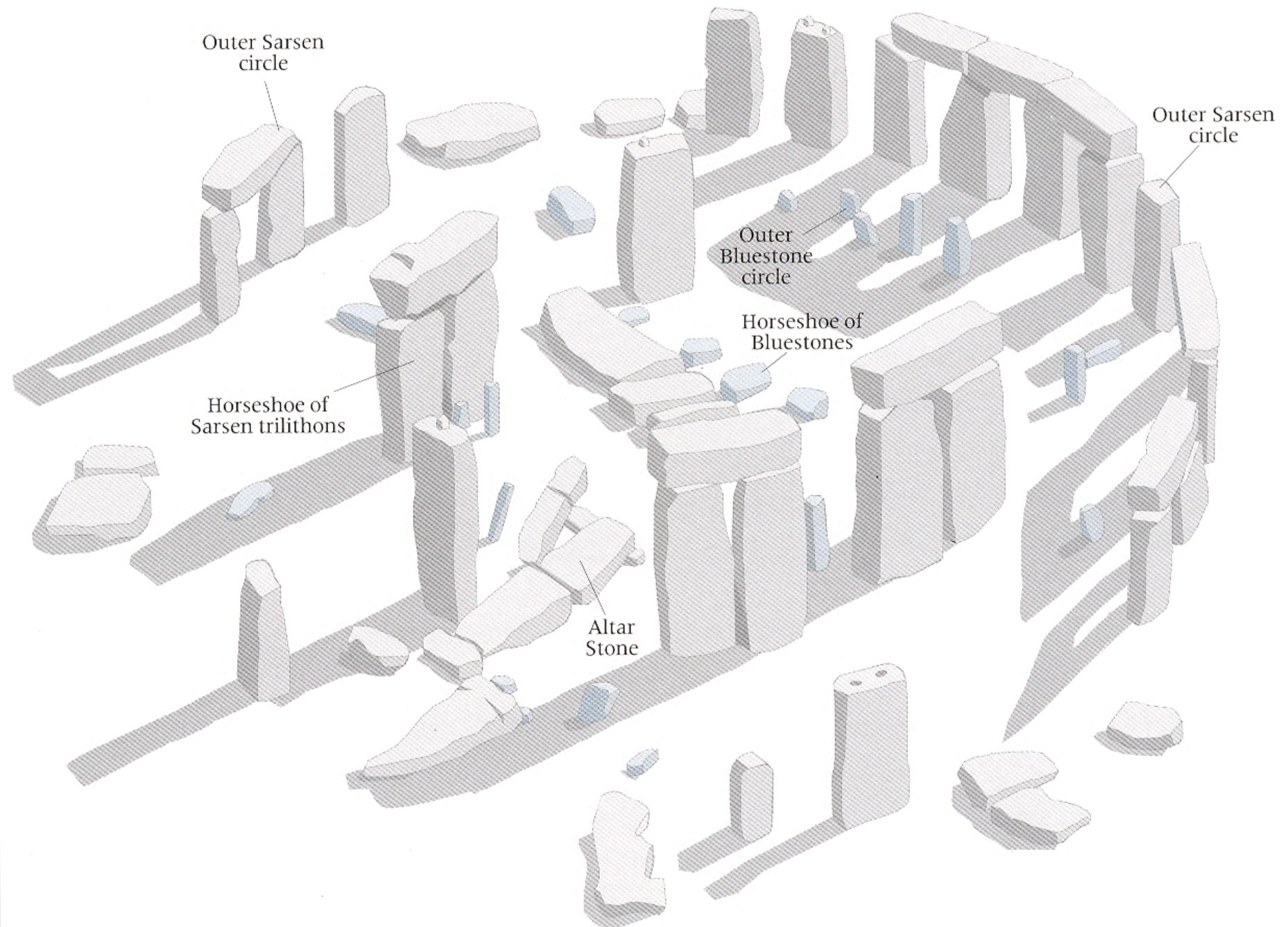
Outer Sarsen circle

Outer Bluestone circle

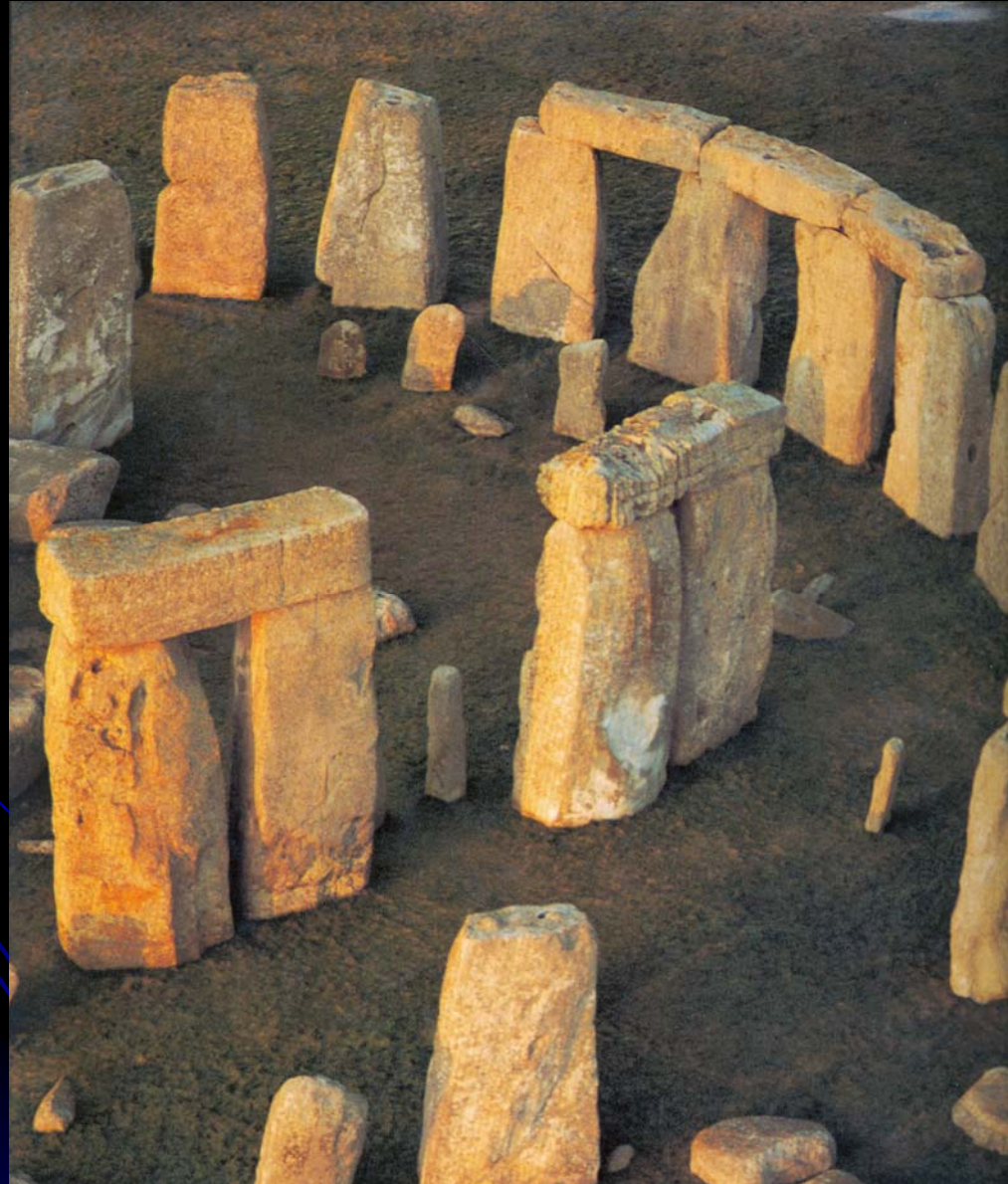
Horseshoe of Bluestones

Horseshoe of Sarsen trilithons

Altar Stone



Sarsen Circle and Trilithons



Trilithons



Bluestones



Phase 3 Sub-phases

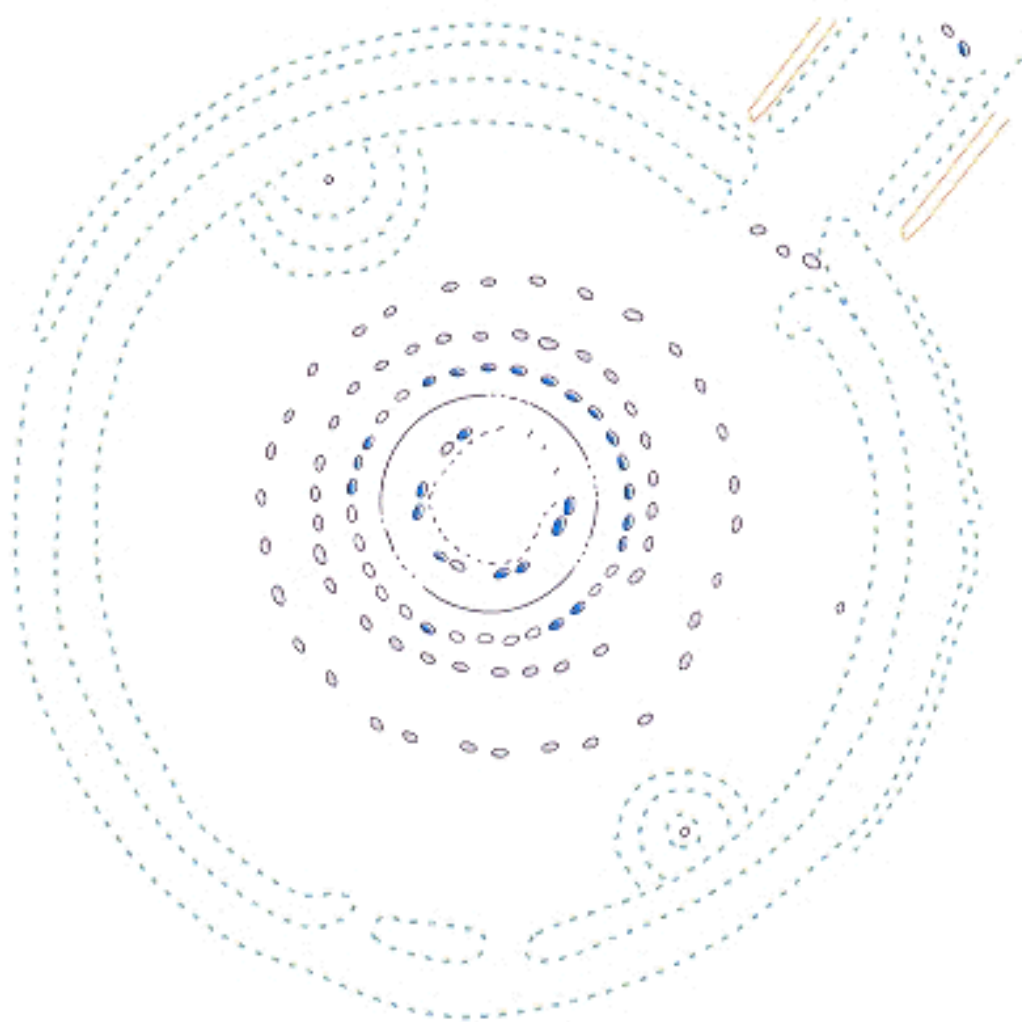
- 3iv -v
 - Bluestones “reorganized” into circle
- 3c
 - Avenue constructed
- 3vi
 - Two concentric circles of pits

Phase 3 Subphases

Sarsen Circle	3ii	2850-2480
Entrance Stone-hole E	3a	2480-2200
Ditch burial	3a	2400-2140
Sarsen Trilithons	3ii	2440-2100
Bluestone Circle	3v	2270-1930
Bluestone Horseshoe	3v	2270-1930
Z Holes	3vi	2030-1750
Y Holes	3vi	1640-1520

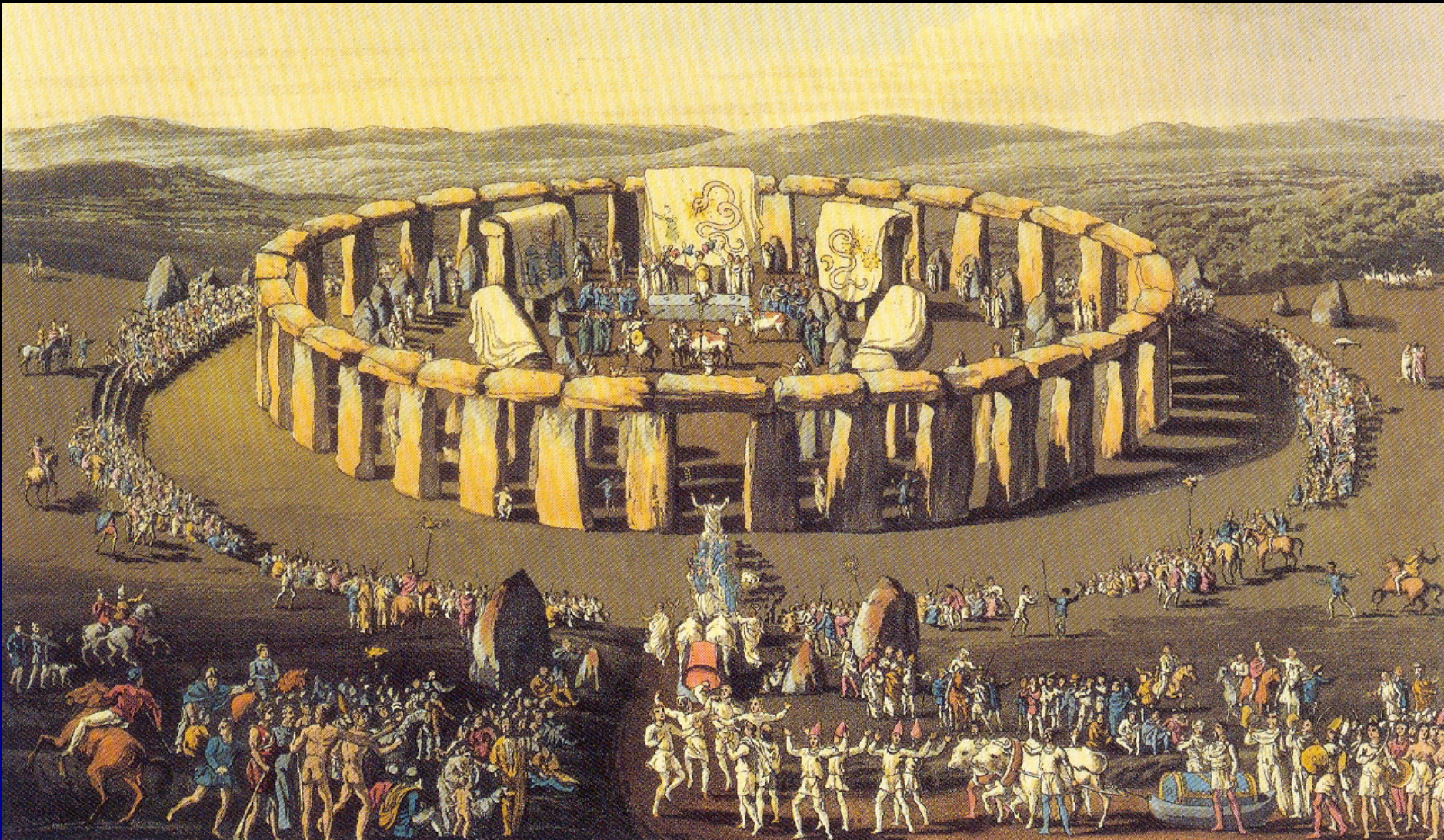
Phase 3

2550–1600 BC



Major Architectural Features

Element	Parts	Dating BCE	Use
Heel Stone and Causeway	1	~2600	June solstice marker
Posts adjacent to causeway	6?	~2700	N. Lunar standstill marker
Aubrey Holes	56	~2900	Eclipse predictor????
Double Bluestone Circle	85	~2550	?
Sarsen Circle	30	~2450	Lunar synodic month
Trilithon Horseshoe	5	~2100	Solstice and lunar standstill
Station Stones	4	~2600	Solstice and lunar standstill
Bluestone Horseshoe	19	~1800	?
Bluestone Circle	59	~1800	?
Y, Z Holes	30, 29	~1800	Lunar synodic month

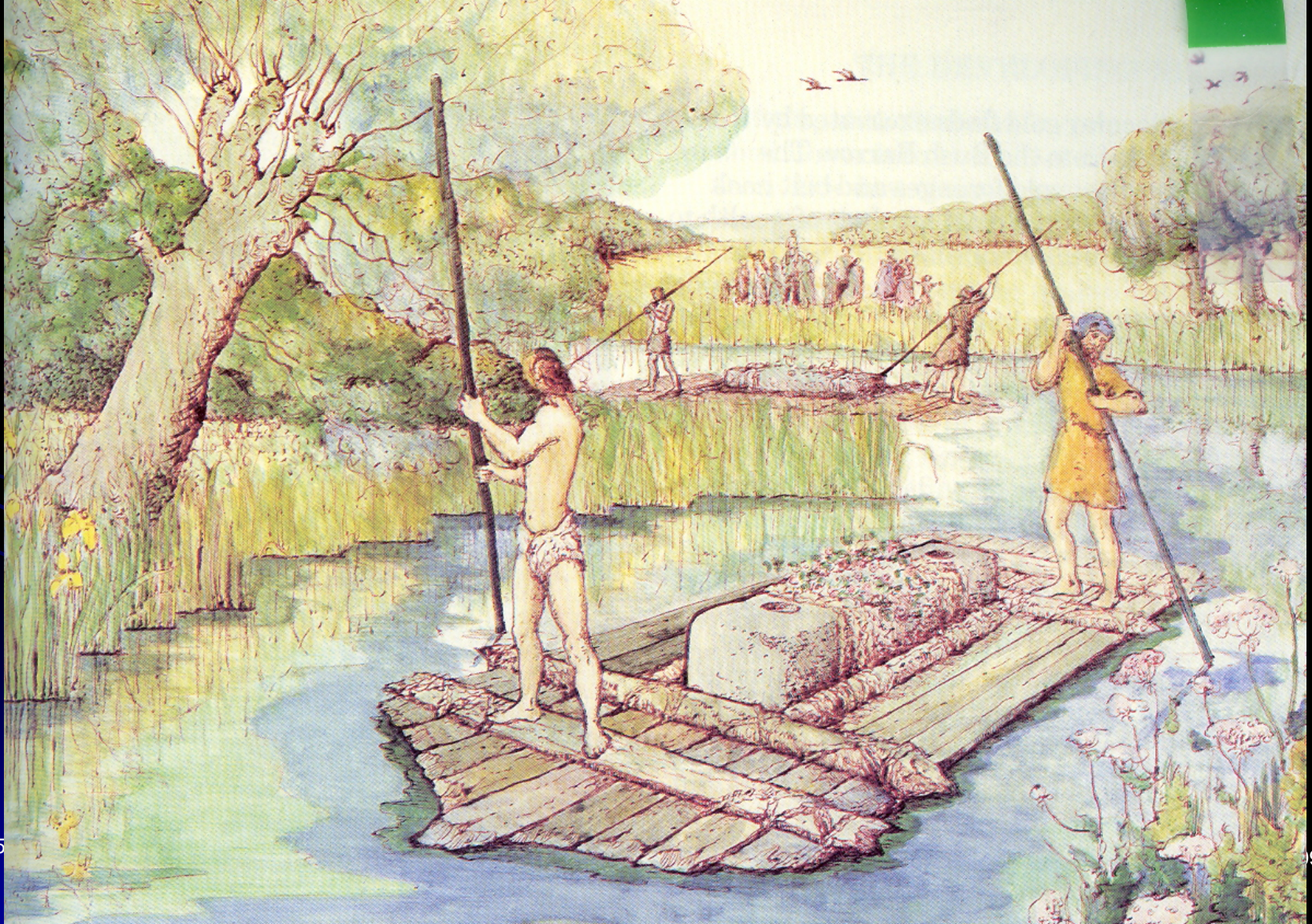


Hod Carriers Union Local 12345

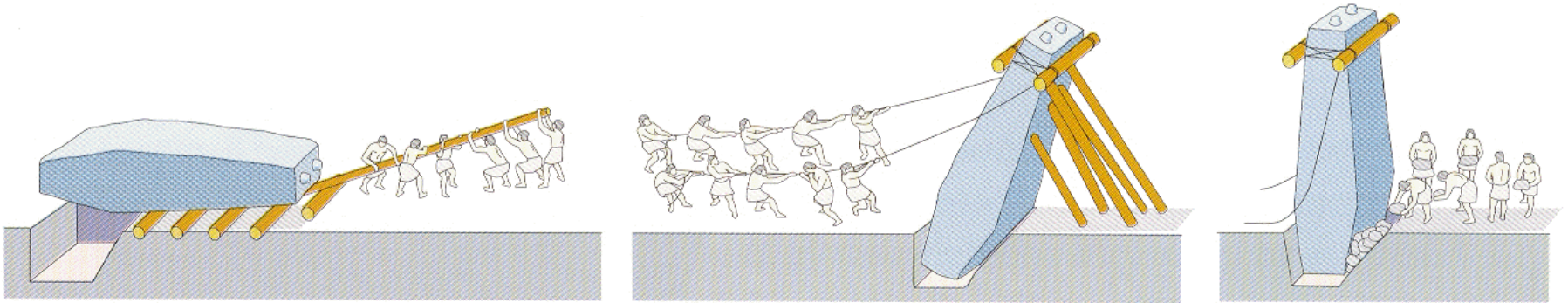


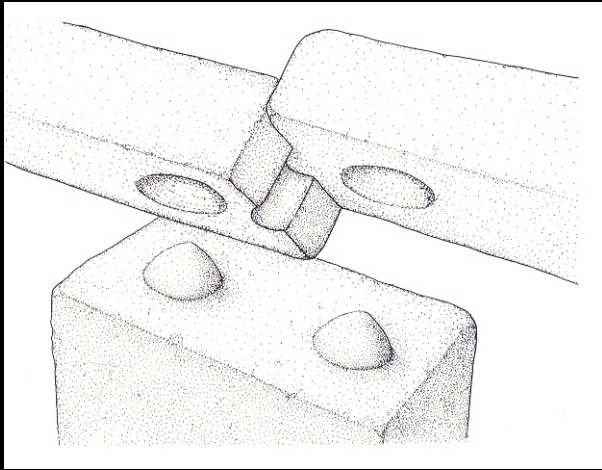
J. Brayne

Pumping Stone



Possible Construction

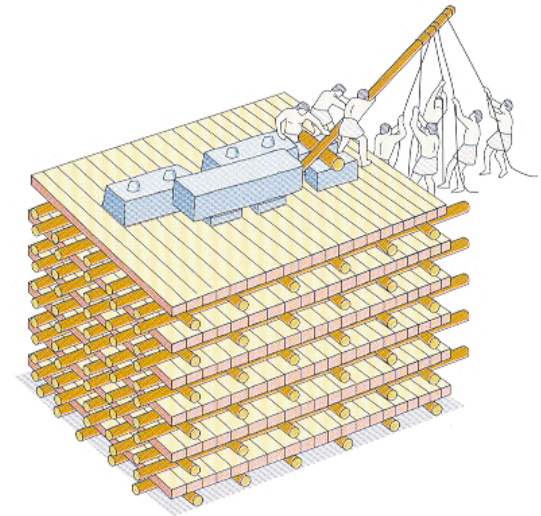
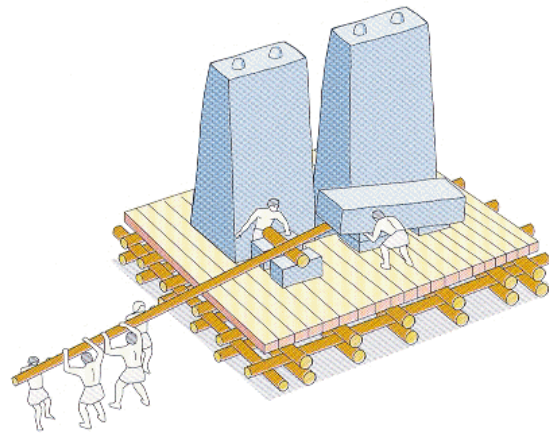
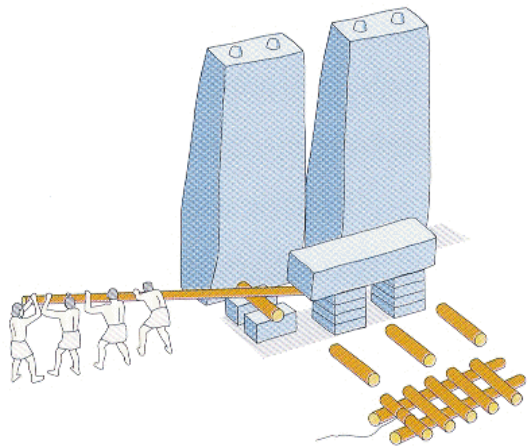




15 October 2004

Ancien

Lintel Placement ??



8000–3100 B.C.

◀ Three holes dug that could have held pine posts to support a wooden structure

2950–2900 B.C.

◀ Construction of a henge, a circular ditch and bank, 490 feet in diameter with a single entrance; inside the ditch 56 pits dug, later known as the Aubrey Holes

2900–2550 B.C.

◀ Stonehenge abandoned

2550–2400 B.C.

◀ New activity at Stonehenge with several wooden buildings constructed

2550–1600 B.C.

◀ Main period of Stonehenge building; in as many as six stages, stones were brought to the site, taken down, and then rebuilt into new patterns

1500 B.C.

◀ Stonehenge abandoned, never to be used again by its builders

Celestial Sphere

Ecliptic Astronomical System
Celestial Coordinates
Absolute System

Celestial Coordinates

- Problem is that altitude and azimuth are relative to the position of the observer
 - Zenith is directly above the head of the observer
 - Nadir is directly under the observer's feet

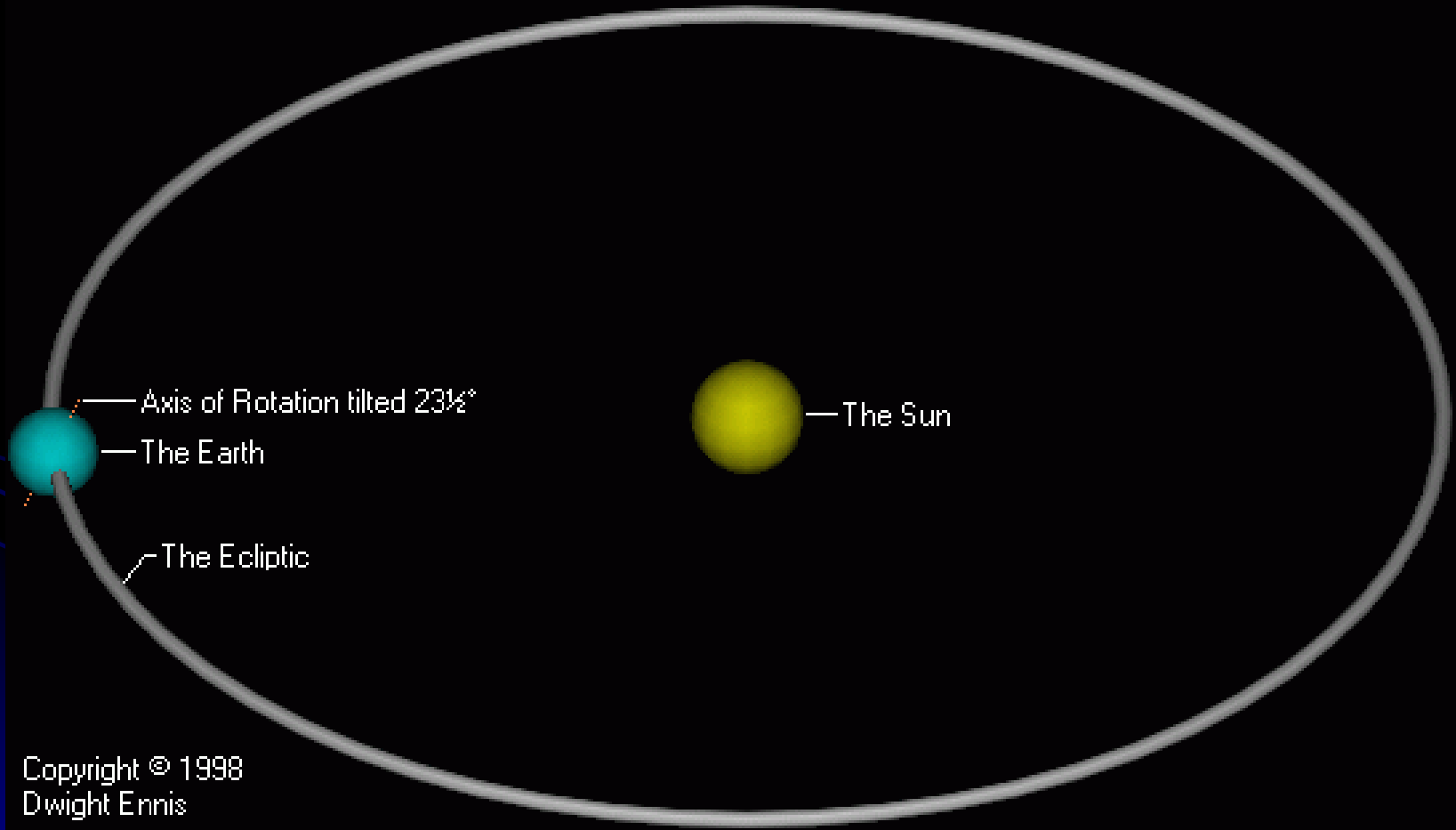
Celestial Coordinates Cont.

- Earth rotates west to east
- Celestial sphere appears to rotate east to west
 - TRANSIT
 - When an object crosses the meridian to the south
 - CULMINATE
 - Reaches its highest altitude
- Sun, Moon, stars, and planets all rise in the east and set in the west

Star Tracks

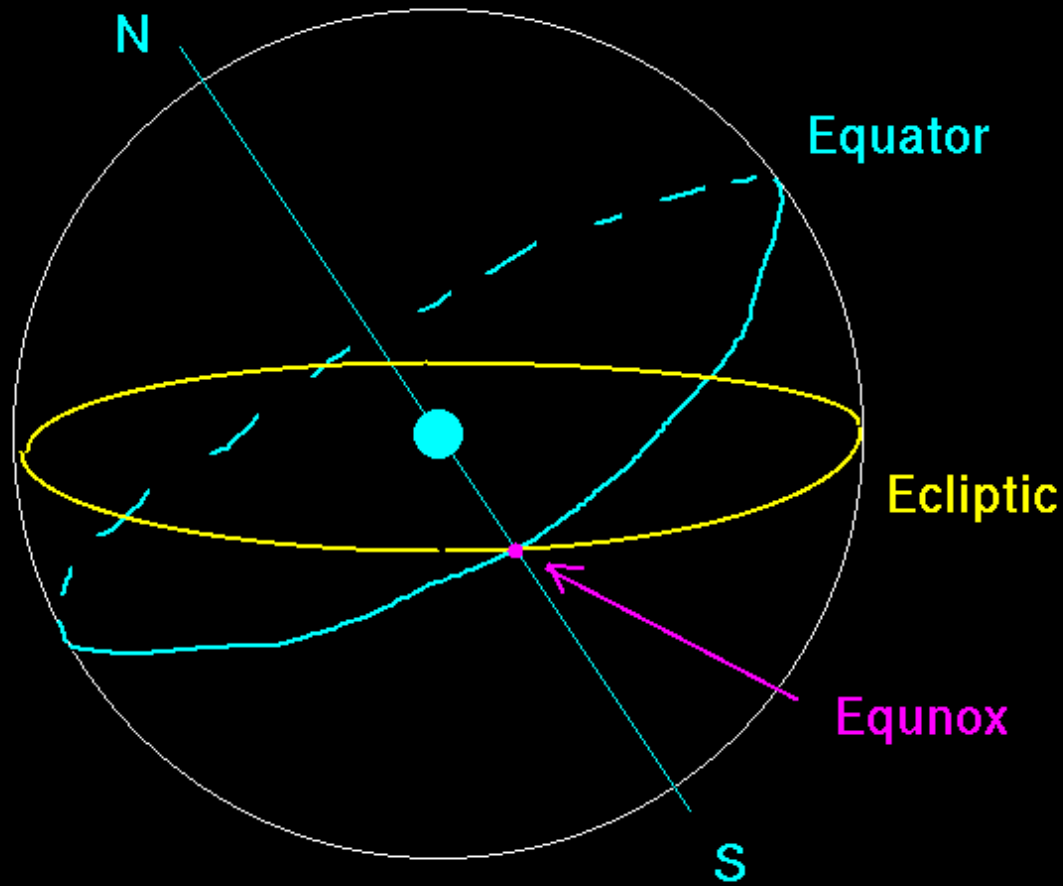


Earth's Orbit The Ecliptic

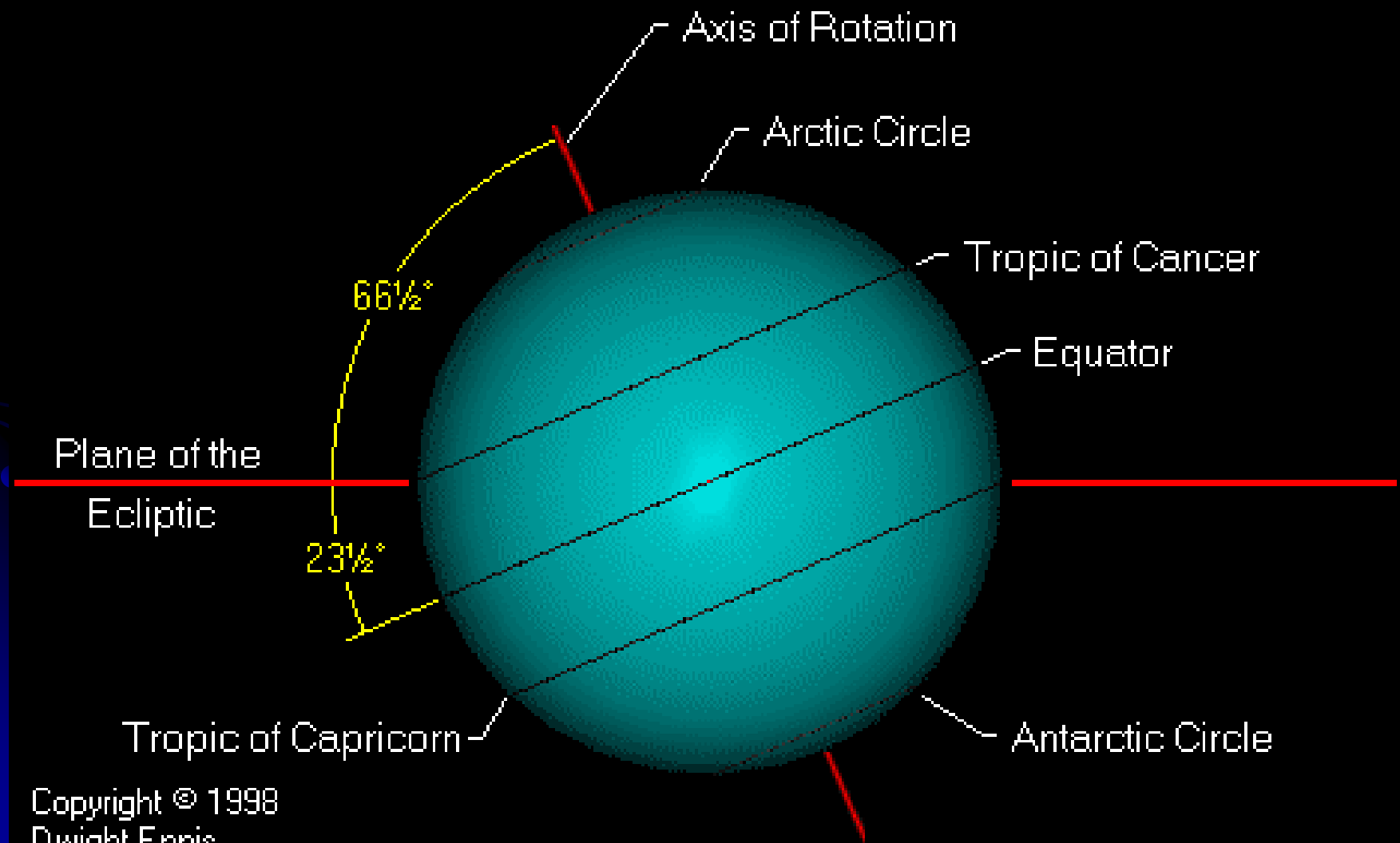


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Ecliptic



Plane of the Ecliptic

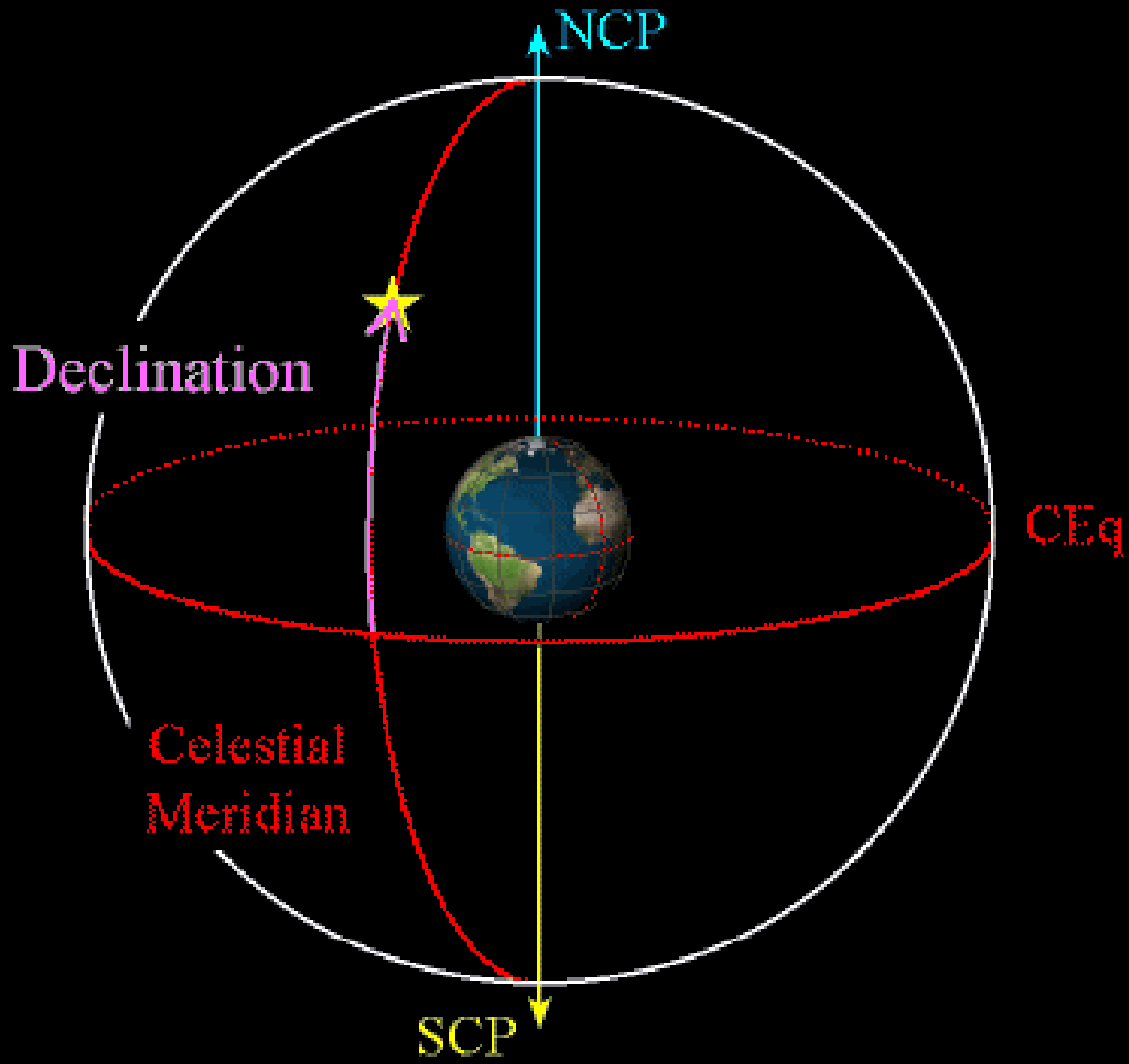


Right Ascension

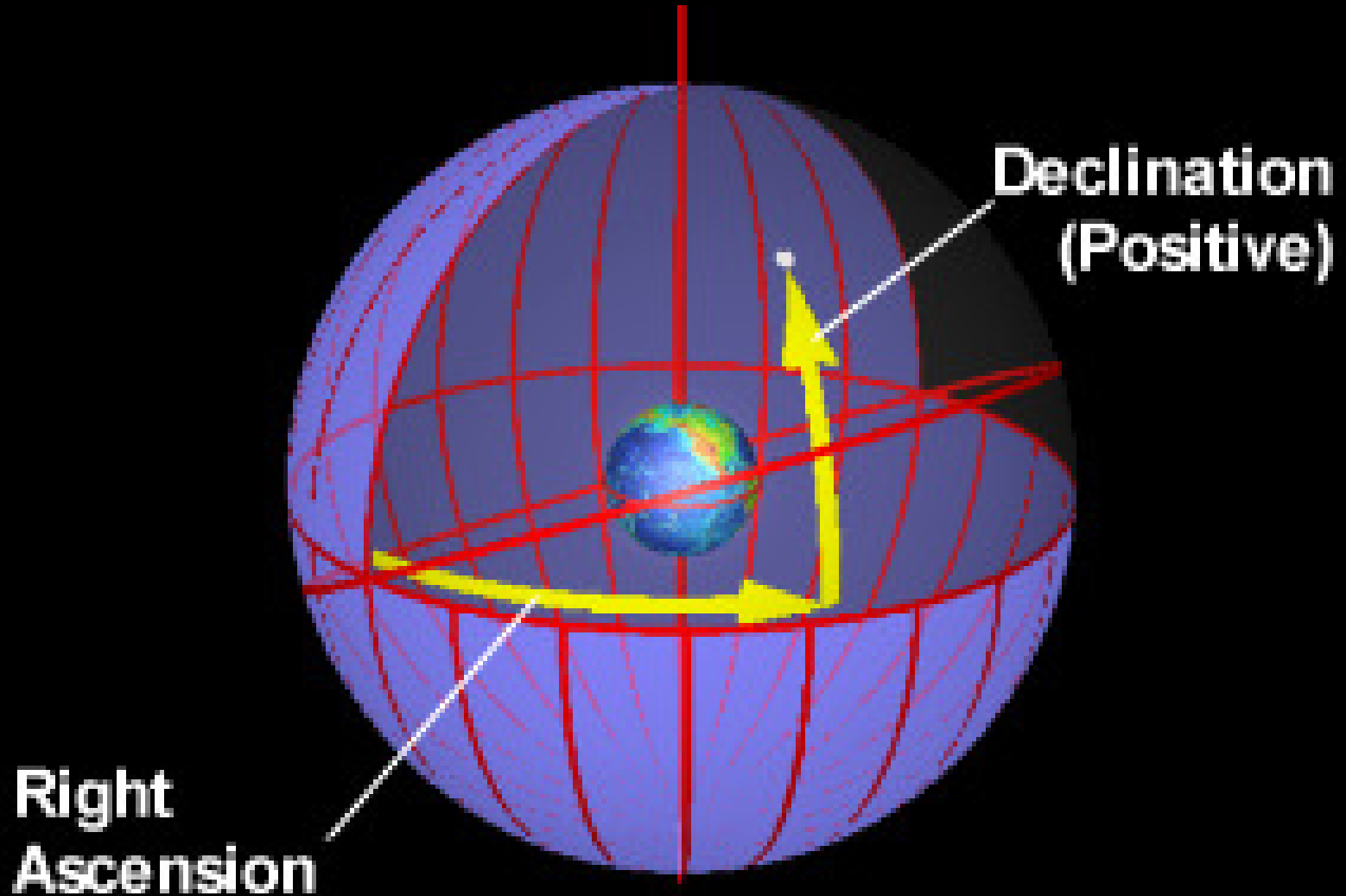
- The equivalent of longitude on earth
- Measured in hours, minutes and seconds to time from the zero line
 - One hour corresponds to 15° (15 degrees)
- Zero Line
 - Ecliptic
- 0^h to 24^h ($h = \text{hour}$)
- Zero Point
 - Point at which the Sun, traveling along the ecliptic, crosses the Celestial Equator from south to north
 - Vernal Equinox (Spring)
 - First Point of Ares
- Like 0° longitude (Greenwich meridian)

Declination

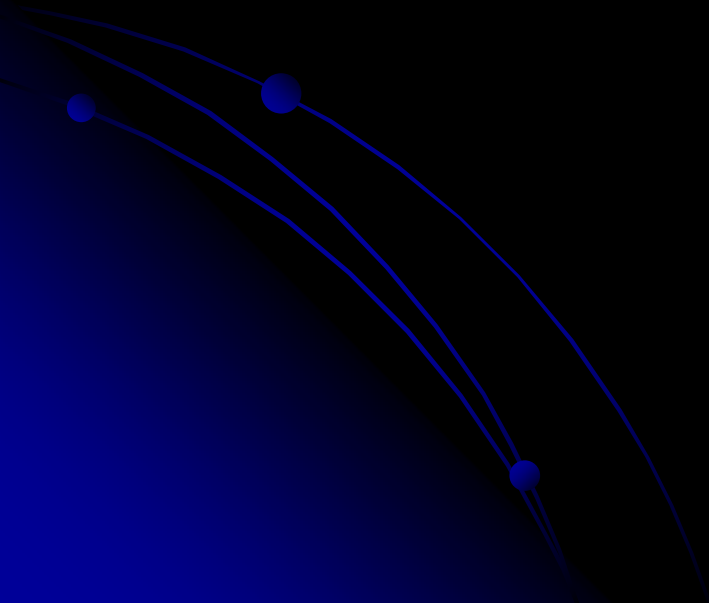
- **DECLINATION** is measured in degrees north or south of the celestial equator
 - Positive declinations are north of the celestial equator
 - North Celestial Pole declination = 90°
 - Negative declinations are south of the equator
 - South Celestial Pole declination = -90°
- **CELESTIAL EQUATOR**
 - On the same plane as the Earth's equator
 - Declination is 0°
- Celestial sphere the movie



Declination and Rt. Ascension



Stonehenge Astronomy



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Celestial Object Visibility

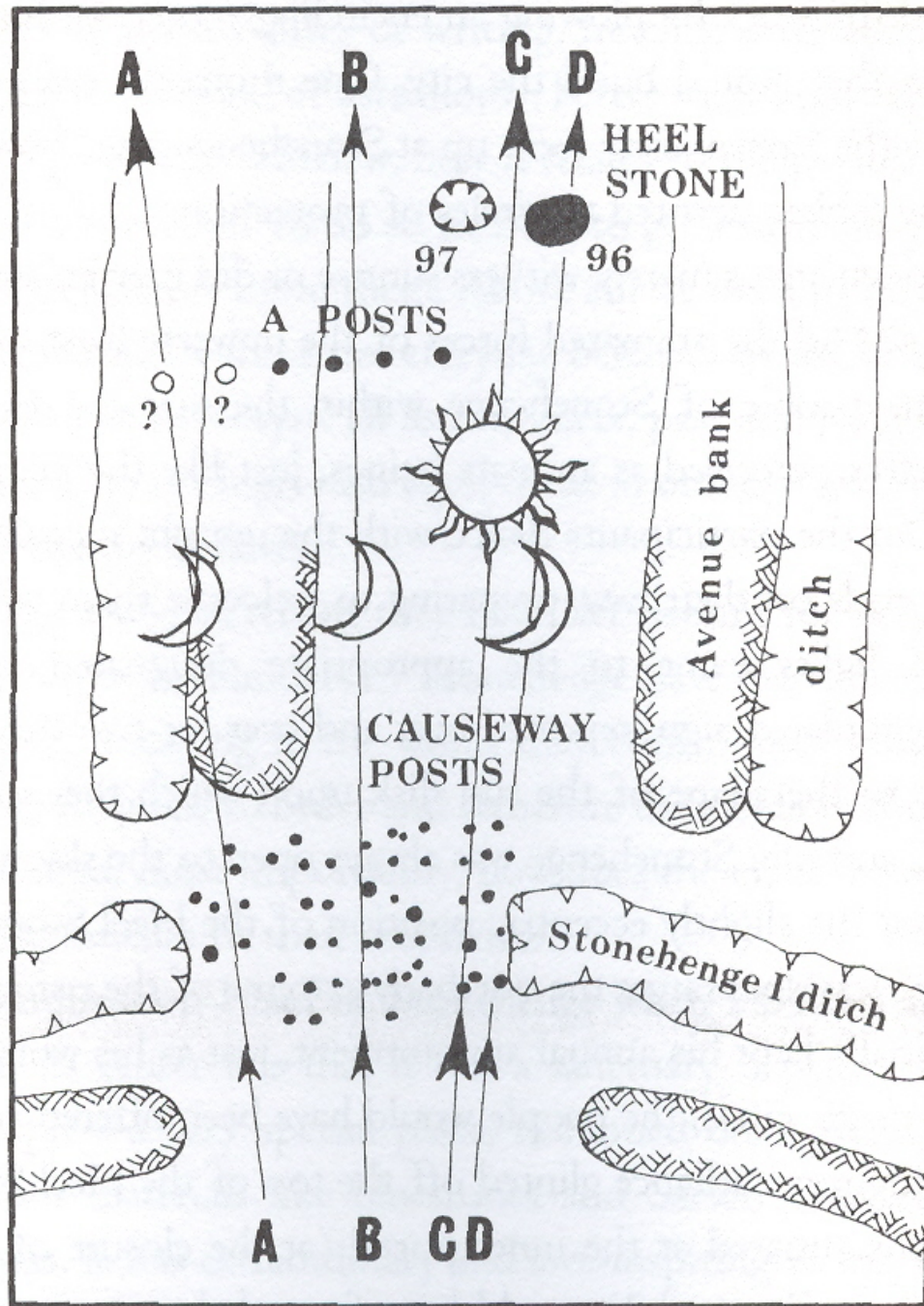
- Latitude $51^{\circ} 2'$
- Celestial object visibility declinations
 - -39° to $+39^{\circ}$
 - Rise and set daily
- Object with high declinations will never set
- Objects with lower declinations
 - Never visible above the horizon

Declinations

4000 – 1500 BCE

Event	Declination
Moon – northern limit	+28°
Sun : June solstice	+24°
Moon – northern minor limit	+18°
Moon – southern minor limit	-20°
Sun – December solstice	-24°
Moon – southern major limit	-30°

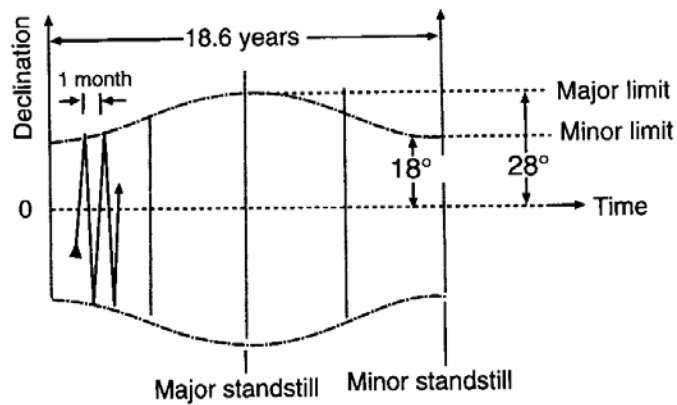
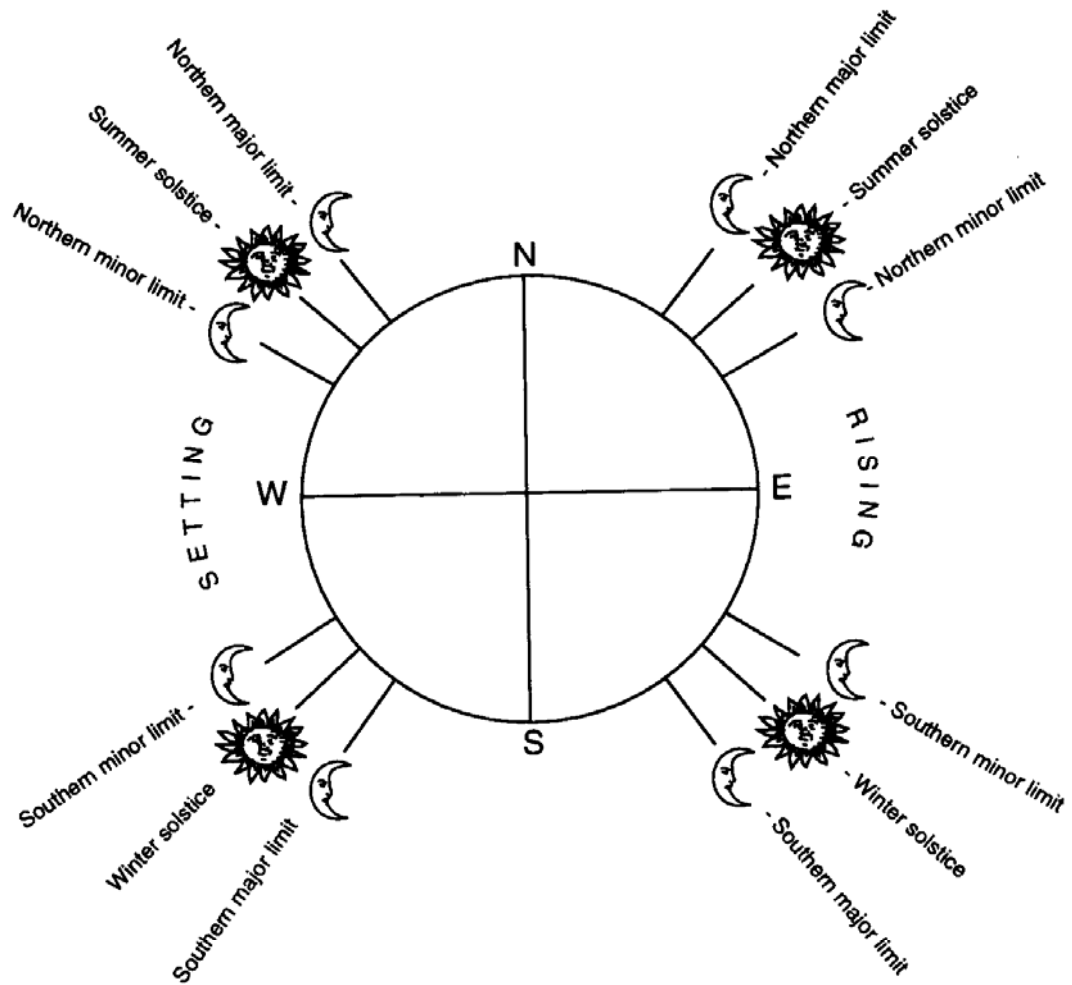




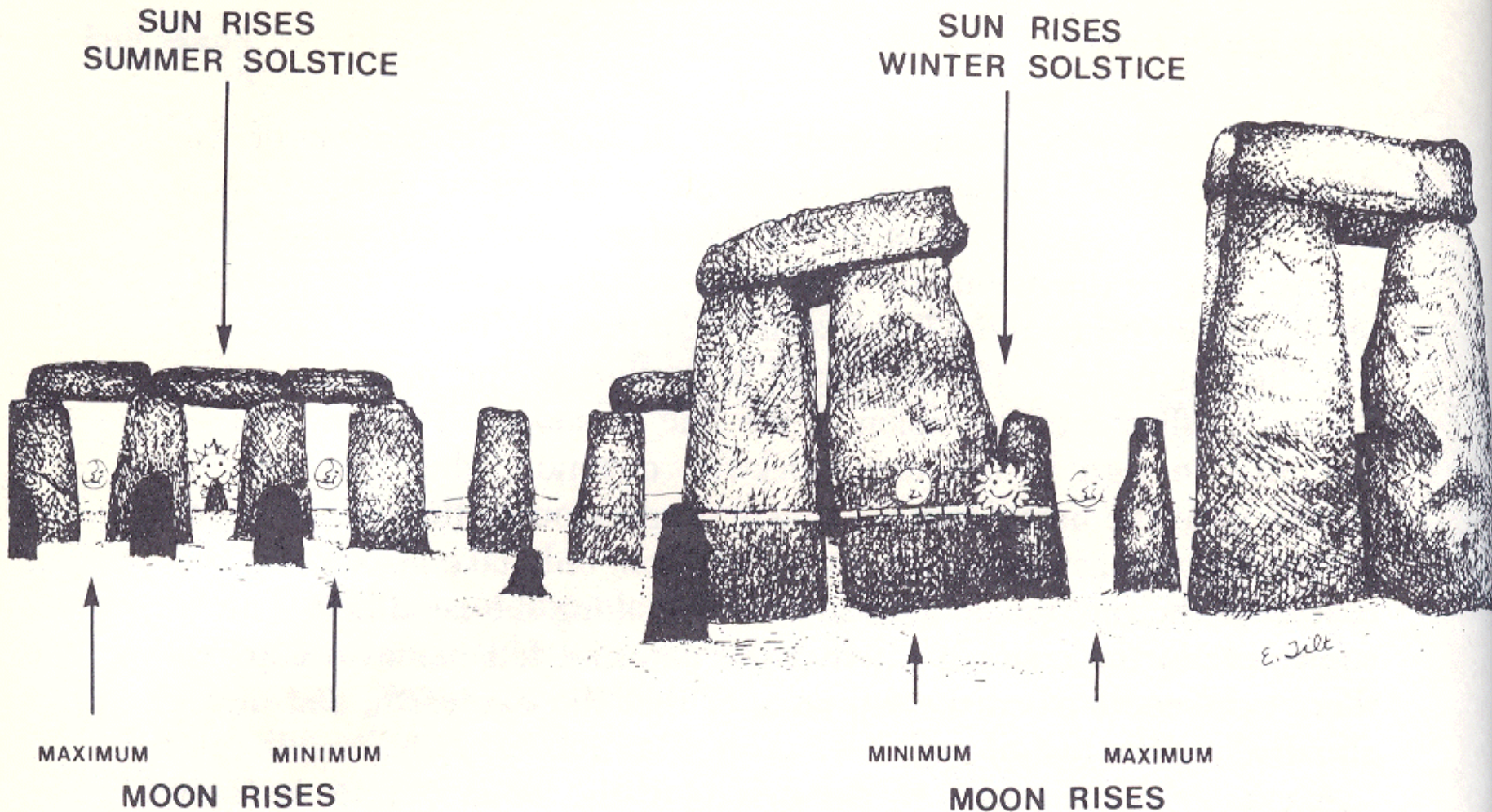
Phase 2

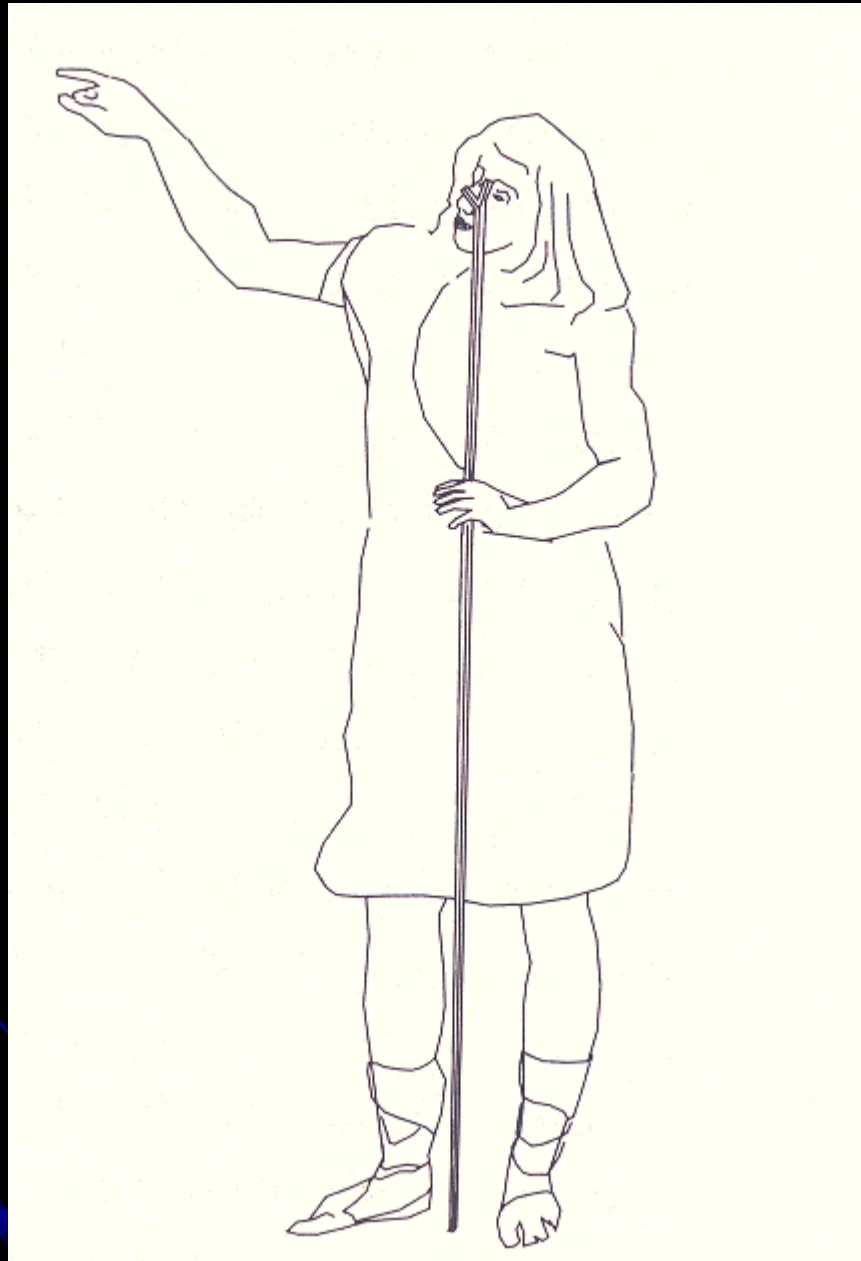
2900–2400 BC





Major Lunar and Solar Events





Conclusions

- **Stonehenge 1**

- The only entrance has a declination of $+27^\circ$
 - Close to lunar northern limit (28°)
- No known alignments or sightlines

- **Stonehenge 2**

- Some lunar alignments have been proposed for the NE entrance posts
 - Unlikely since those posts likely supported structures that would have blocked sightlines

- **Lunar alignments in 1 & 2 are unlikely**

Conclusions Cont.

- Stonehenge 3

- Clear evidence of solar alignments

- “Altar Stone”

- Heel Stone and stone 97 straddle it
- Bracket the midsummer sunrise

- “Altar Stone” may be aligned with midwinter sunset

What we Can Say

- Phase three has definite solar alignments
- No known lunar or celestial alignments in Phases 1 & 2
- Proposed Aubrey Hole lunar eclipse computer is very unlikely
- Thom, Hoyle, Hawkins and others
 - Mostly proven false

Thank You

Next week
Mesopotamia
Maya
Polynesian Wayfarers