Astronomy and Cosmologies

week 1, Spring 2013, Chamberlain & Zita

- *Introduction*
- *Registration*
- *Solar motion*
- *Workshop: Solar motion demonstrator*
- *Looking ahead*

Introductions

- *Faculty*
- *Program*
- *Website and Moodle*
- *Covenant, etc.*
- *Meet each other – you will form teams next Tuesday*

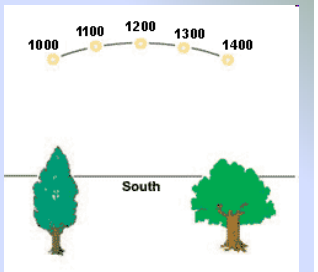
Bookmark Astro & Cosmo homepage:

http://academic.evergreen.edu/curricular/astro/2013/

- Browse links together
- Note faculty contact info
- Moodle next week

- Registration
- Waitlist

Why does the Sun appear to move in the sky as it does?



http://www.seed.slb.com/labcontent.aspx?id=11434

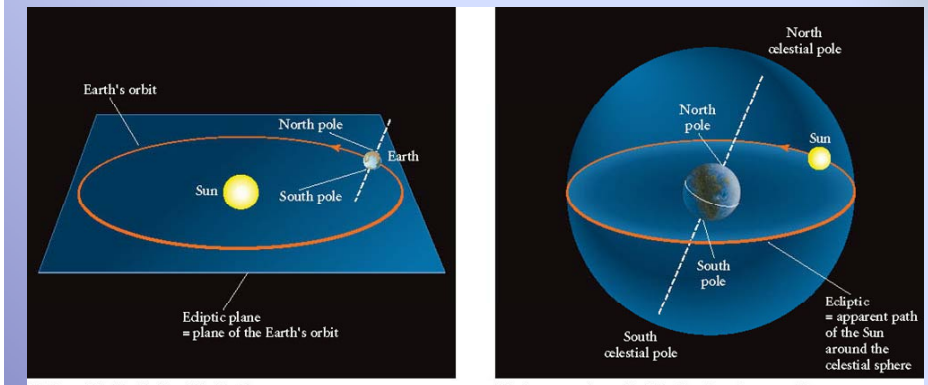
First, consider your observations: how does the Sun appear to move?

What do the Sun's motions depend on?

Can we induce a general rule, based on our observations?

What is the Sun's greatest altitude α at a given latitude θ, on a given day?

Heliocentric reality, but we still use geocentric language



(a) In reality the Earth orbits the Sun once a year

(b) It appears to us that the Sun travels around the celestial sphere once a year

Individually, make predictions:

Where does the Sun rise in the morning, in Olympia?

Where does it set in the evening?

Does the Sun ever shine on the north side of your house?

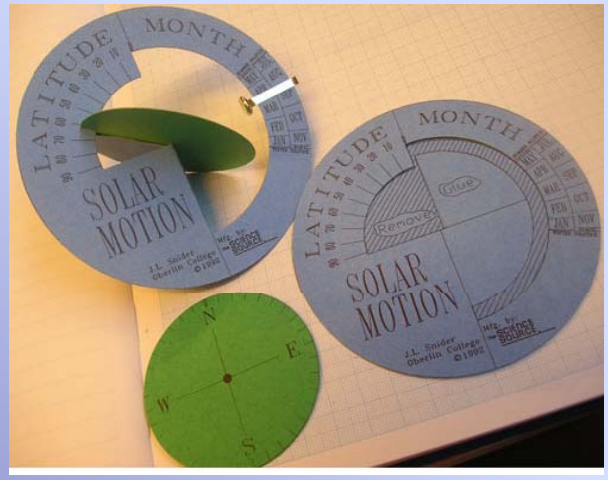
Where was the Sun at noon today?

How high in the sky was the Sun at noon? (straight up at the top of the sky? halfway up at 45 degrees? Somewhere else)

Does the height of the noontime sun change with seasons?

(How) Does the height of the noontime sun depend on your latitude?

Make your solar motion demonstrator



***Then investigate your questions**, and explore:*
what else can you find out about solar motion?

Test your hypotheses & note key points and surprises

Sunrise is usually NE or SE, not due east

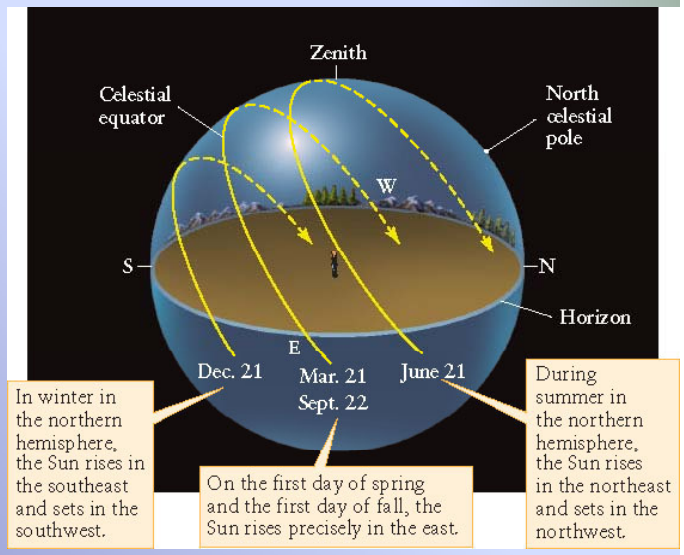
Sunrise and sunset are due E and W only at Equinox
(and on those dates, day and night are equally long at every latitude)

The north side of a house in Olympia *can* get sunshine in the morning and evening, all summer.

The Sun is never directly overhead in Olympia – only in the tropics, and only one or two days a year.

The path of the Sun depends on your **latitude**
The rising/setting locations depend on the **time of year**

Day length and temperature change more at the poles.
You can find the length of the day with your model.



ejz1

Q&A

Q: How does path of the Sun depend on your **longitude?**
A: It doesn't – longitude simply fixes the **timing** of sunrise.

Q. Would patterns be reversed in the S. hemisphere? Yes.

Q: What are the different poles on Earth?
A: Spin axis points at the North Star (for a few hundred more years.) The Magnetic axis is offset, and wanders slowly.

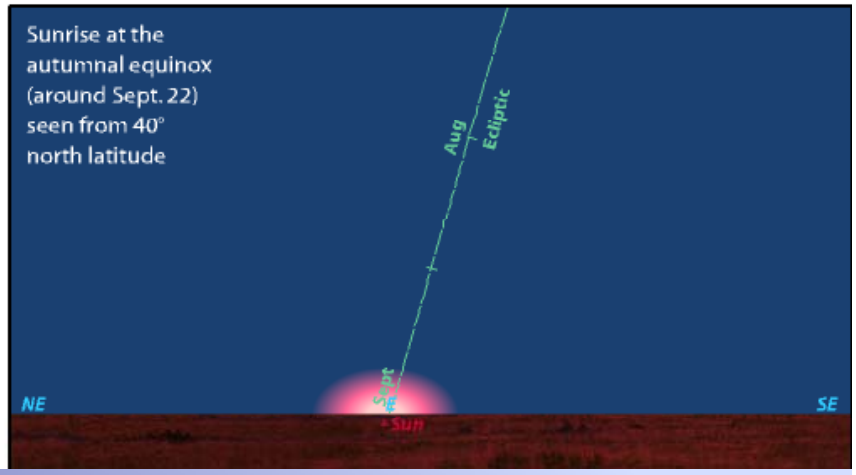
Q: What would the seasons be like if Earth's tilt was different?
A: More tilt → greater seasonal differences

Q: How does the angle affect the brightness of sunlight?
A: Steeper angle → dimmer sunlight.

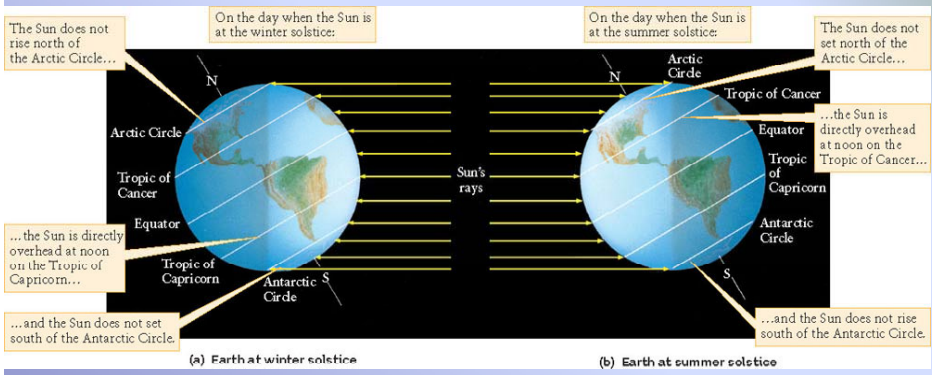
Slide 10

ejz1 ezita, 4/8/2009

Knowing the Heavens : 2.6 Sun's Path Across the Sky



Using planetarium software, ***explore the Sun's rising/setting angle and location****. How does it depend on latitude and month?*



Sun at its highest point

Latitude=θ	location	max alt.=α	relation
____	Equator	____	____
____	Tropics	____	____
____	N pole	____	____
____	Olympia		____

Fill in what you know, from solar motion wkshp.

Can you generalize a rule to find the maximum altitude α at a given latitude θ?

Find a relation between latitude θ and max. altitude α_{max}

Latitude=θ	*location*	α_{max}
0°	*Equator*	90 + 23.5 =90 – ***0*** + 23.5
23.5°	*Tropics*	90 = 90 – ***23.5*** + 23.5
90°	*N pole*	23.5 = 90 – ***90*** + 23.5
47 °	*Olympia*	___ = 90 – ***47*** + 23.5

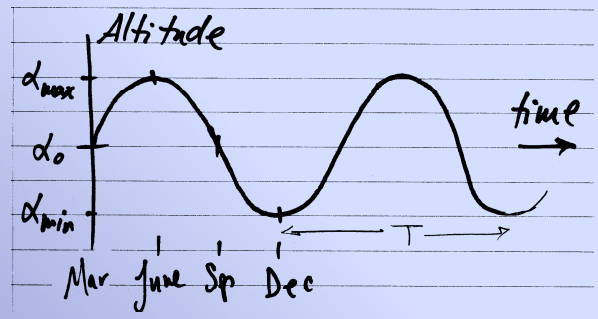
Does this rule work in general? $\alpha_{max} = 90 - \theta + 23.5$

Sun at its lowest point

latitude θ	location	α_{min}	relation
0	Equator	90 - 23.5 = 90 – ***0*** - 23.5	
23.5	Tropics	90 –2*23.5= 90–***23.5*** - 23.5	
90	N pole	-23.5 = 90 – ***90*** - 23.5	
47	Olympia	___ = 90 – ***47*** - 23.5	

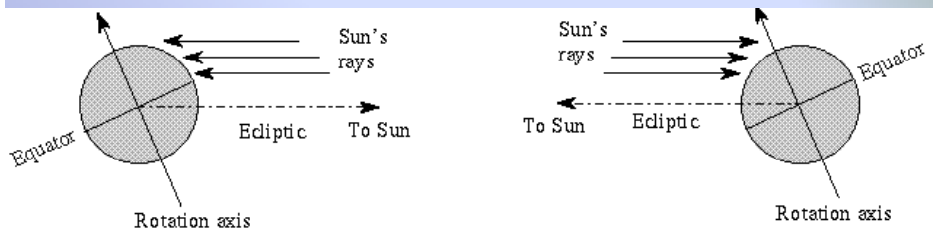
Does this rule work? $\alpha_{min} = 90 - \theta + 23.5$

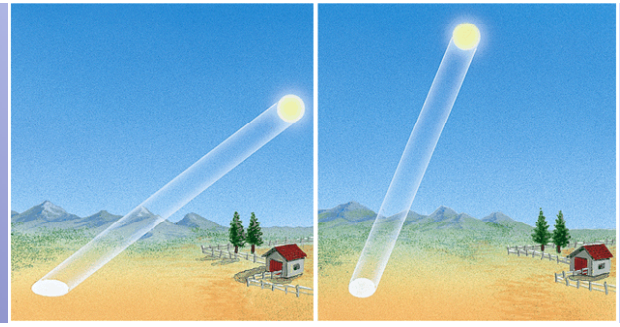
Solar altitude varies through the year

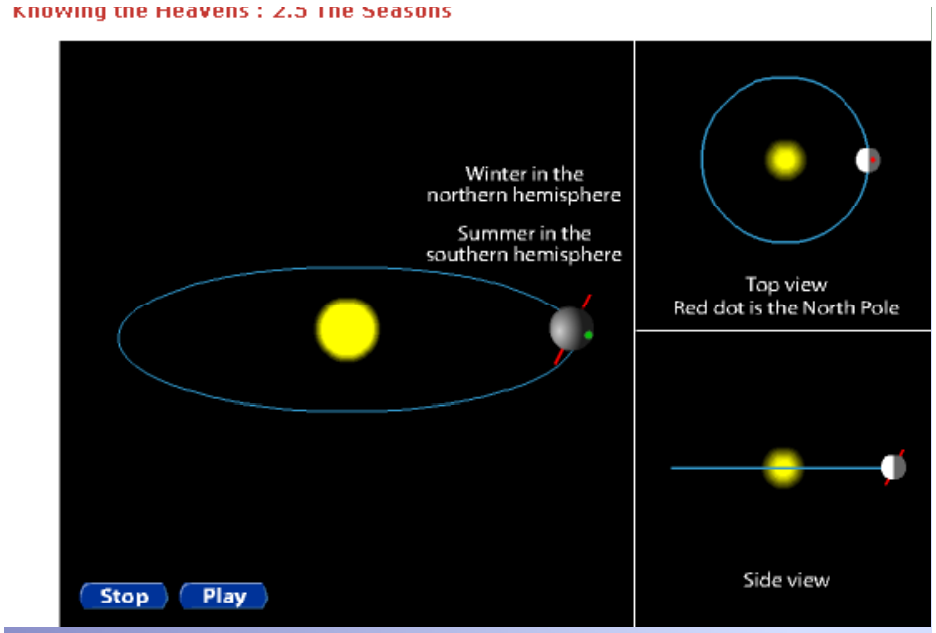


Altitude$(\theta,t) = \alpha_0 + A \sin(\omega t)$
where t = day number (time),
$A = \alpha_{max} - \alpha_0$, and average altitude $\alpha_0 = (\alpha_{max} + \alpha_{min})/2$
period of oscillations T = 365 days
angular frequency $\omega = 2\pi/T$

Reasons for the Seasons







Earth is a tiny bit *closer* to the Sun in *January* than in June!

Advanced Q&A

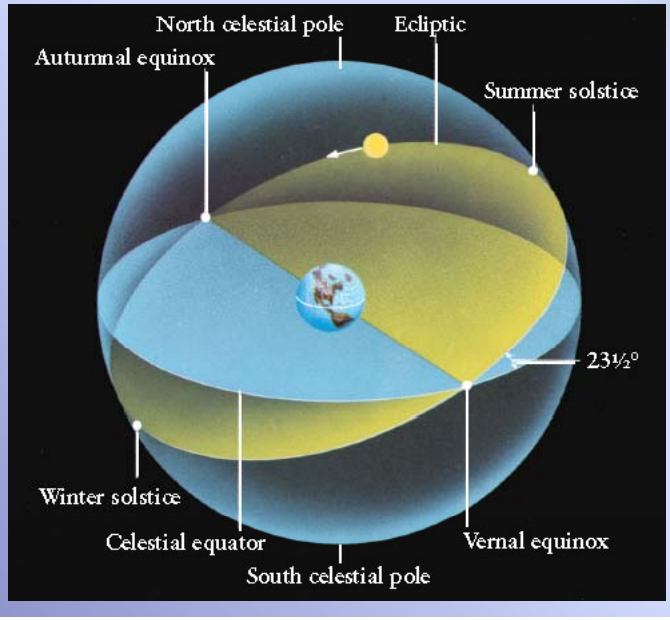
Q: Why are June and December so small on your model?
A: The Sun's apparent position on the horizon is changing more slowly from day to day. Solstice = "solar stand still"

Q: Does the speed of the orbit vary?
A: Yes, Earth goes slightly faster when it is closer to the Sun.

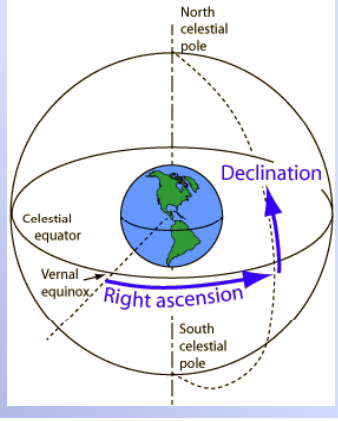
Q: Do the Sun's rays get more intense when the Sun's magnetic field flips?
A: Yes, by 0.1% - magnetic storms during solar polar reversals cause the Sun to emit energetic flares (radiation) and coronal mass ejections (matter), delivering extra energy to Earth.

Q: What makes the tilt of the Earth change? A: Nutation.
A: When has it happened in the past? A: Every ~ 41 ky.

Equator, Ecliptic, Equinoxes



Right Ascension & Declination



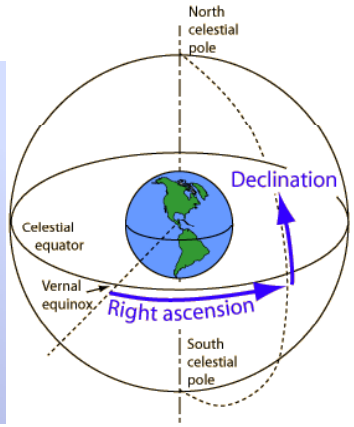
10. The declination of the Sun on the first day of summer is

- a. 23.5E north.
- b. 0E.
- c. variable, depending on the year.

How much do the stars move per hour?

13. What is the angle, measured in degrees, between one star of right ascension = 8^{hr}, declination = 0E and another star of right ascension = 11^{hr}, declination = 0E?

- a. 3°
- b. 45°
- c. 180°



Answers:

10: (a) 23.5 degrees is the Sun's highest declination, equal to the current tilt between the ecliptic (the Sun's path) and the celestial equator

13: There are 24 hr of RA around the Earth.

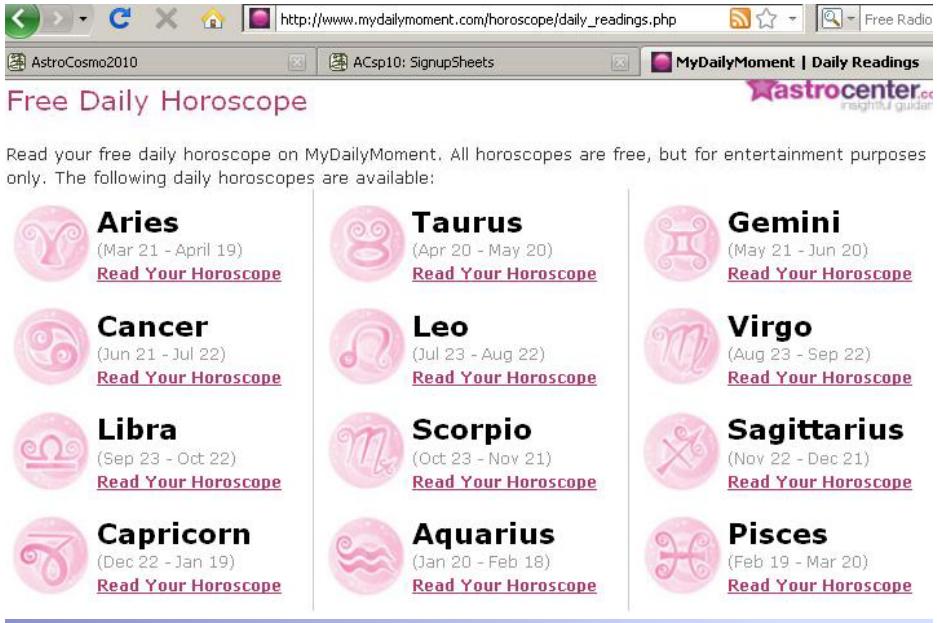
The full circle is 360 degrees.

360/24 = 15 degrees per hour

If there are 3 hr of RA between two stars, then there are 3*15=45 degrees between them. (b)

break time…

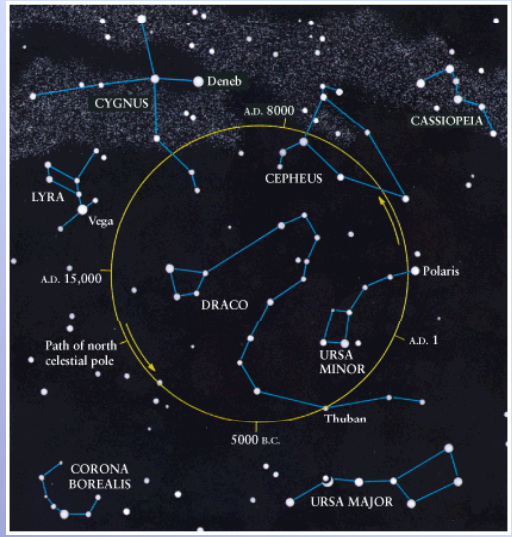
…then we'll talk about the Zodiac…



Does your horoscope fit you?

- If so, let's do a horoscope workshop
- If not, let's investigate precession of the equinoxes now.

Precession of equinoxes→ your sign has changed



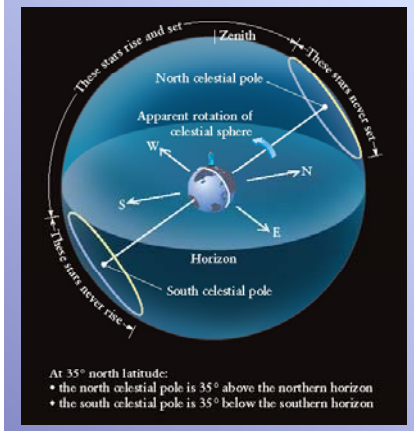
and we aren't usually lucky enough to have a "North Star"

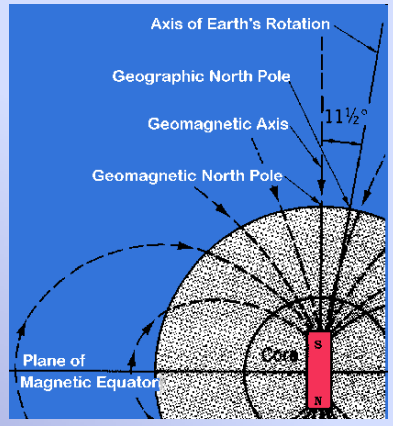
Sign				Constellation[16][17]			
Name	Symbol	Tropical zodiac (2010, UTC)	Sidereal zodiac (Jyotisha) (2010, UTC)[18]	Name	IAU constellation boundaries (2010)	Solar stay	Brightest star
Aries	♈	20 March – 20 April	14 April – 7 May	Aries	19 April – 14 May	25.5 days	Hamal
Taurus	♉	20 April – 21 May	14 May – 7 June	Taurus	14 May – 21 June	38.2 days	Aldebaran
Gemini	♊	21 May – 21 June	14 June – 7 July	Gemini	21 June – 21 July	29.3 days	Pollux
Cancer	♋	21 June – 22 July	14 July – 6 August	Cancer	21 July – 11 August	21.1 days	Al Tarf
Leo	♌	22 July – 23 August	14 August – 7 September	Leo	11 August – 17 September	36.9 days	Regulus
Virgo	♍	23 August – 23 September	13 September – 6 October	Virgo	17 September – 31 October	44.5 days	Spica
Libra	♎	23 September – 23 October	13 October – 7 November	Libra	31 October – 21 November	21.1 days	Zubeneschamali

Sign				Constellation[16][17]			
Name	Symbol	Tropical zodiac (2010, UTC)	Sidereal zodiac (Jyotisha) (2010, UTC)[18]	Name	IAU constellation boundaries (2010)	Solar stay	Brightest star
Scorpio	♏	23 October – 22 November	13 November – 6 December	Scorpius	21 November – 30 November	8.4 days	Antares
Serpentarius	⛎	*n/a*		Ophiuchus	30 November – 18 December	18.4 days	Rasalhague
Sagittarius	♐	22 November – 22 December	13 December – 6 January	Sagittarius	18 December – 21 January	33.6 days	Kaus Australis
Capricorn	♑	22 December – 20 January	13 January – 8 February	Capricornus	21 January – 17 February	27.4 days	Deneb Algedi
Aquarius	♒	20 January – 18 February	12 February – 7 March	Aquarius	17 February – 13 March	23.9 days	Sadalsuud
Pisces	♓	18 February – 20 March	15 March – 8 April	Pisces	13 March – 20 April	37.7 days	Eta Piscium

Why does the axis of Earth's orbit precess?

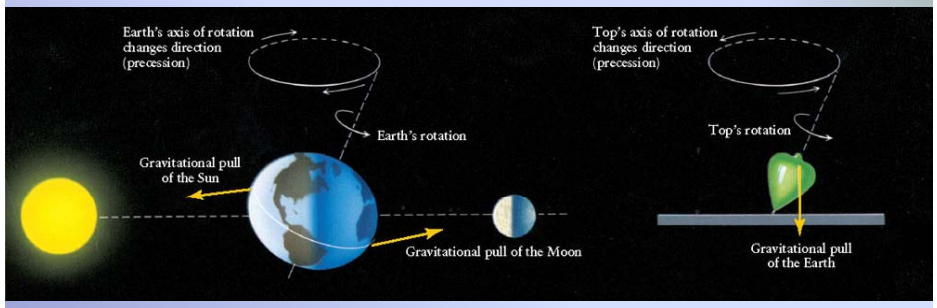
First, distinguish between Earth's
<u>rotation axis</u> and <u>magnetic axis</u>





http://wps.prenhall.com/wps/media/objects/1351/1384326/image/earth_magnetic_axis.gif

Why does the axis of Earth's orbit precess?



1. Fluid Earth bulges out at equator due to rotation
2. Sun and Moon pull gravitationally, causing the axis of rotation to precess about once per 26,000 years.
3. (The axis also nutates a bit – wobbles up and down.)

Looking ahead…

- Read for Thursday
- Bring for Thursday
- …
- …