

Astronomy 100
The Solar System
Tuesday, Wednesday, Thursday

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MIKE DOUGHERTY
FRIDAY 12PM - 1PM
Trick & Treat

PROFESSIONAL
INTERNATIONAL
2009
SAN DIEGO COMIC-CON 2009

Thomas
Burton
LONDON, NE
COMIC CON
INTERNATIONAL
2009

Course

- **Course Website:**

- <http://blogs.umass.edu/astron100-tburbine/>

- **Textbook:**

- **Pathways to Astronomy (2nd Edition)** by Stephen Schneider and Thomas Arny.

- **You also will need a calculator that you will bring to class.**

All presentations

- Will be online before class
- You do not have to copy down every word I write

Goals of the Class

- To learn about the Universe, the forces acting within it, and life throughout the galaxy and universe:
 - What the ancients knew about the sky
 - Gravity
 - Energy
 - The planets
 - The Sun
 - Stars
 - Galaxies
 - The Universe
 - The fate of the Universe
 - Life on other planets

Class Structure

- 9-10 am – Lecture
- 10-11 am – Laboratory
- 11am-noon – Movie/Discussion/Presentations/Quizzes

How can I tell if you have learned something?

- You can answer questions correctly on a quiz or you do an excellent presentation

Grading

- 25% – Quiz every Thursday
 - Take top 5 scores
- 25% - Laboratories/Exercises
 - Take top 10 scores
- 25% - 5 Presentations (Start 2nd week of class)
- 25% - Homework
 - Take top 10 scores

Grading

- A (92.50 – 100)
- A- (89.50 – 92.49)
- B+ (87.50 – 89.49)
- B (82.50 – 87.49)
- B- (79.50 – 82.49)
- C+ (77.50 – 79.49)
- C (72.50 – 77.49)
- C- (69.50 – 72.49)
- D+ (67.50 – 69.49)
- D (59.50 – 67.49)
- F (below 59.49)

Late work

- Homework is due at the beginning of class that it is assigned for
- Laboratories can only be made up for valid excuses
- A missed HW can only be made up by writing a 10 page paper on a solar system subject of my choosing

Homework #1

- Find an article concerning a topic concerning Astronomy and write about why you found it interesting.
- Include the name of the article and where it was published.
- Due June 9th

Virtual office hours

- You can IM me at tomburbine on AOL

- Student: and who are u? lol
Student: u gotta answer cuz i asked first both times
tomburbine: why r u Iming me
Student: cuz u added my sn for some reason so i wana know why
tomburbine: sn?
Student: screen name?
Student: lol
tomburbine: no I didnt
Student: ok..
tomburbine: do u live in massachusetts?
Student: do u?
tomburbine: do u live in cambridge?
Student: no
tomburbine: is it snowing?
Student: yea
tomburbine: do u have a xnga?
Student: no joke who the f**k are ya?
Student: yes i do live in MA
tomburbine: i never heard of u until u Imed me
Student: then how the h**l did u know i lived in MA?

- Student: and yes i do go to umass
tomburbine: r u in astronomy 100
Student: how do u know all this?
tomburbine: because I am the professor
Student: OHHHHH OOOPS!
tomburbine: i think u must have added me
Student: omg lol
tomburbine: and then forgot who I was
Student: ya i did
Student: sorry for all that
tomburbine: my name is my screen name
tomburbine: seem familar now
Student: didnt mean to use language but it happened
tomburbine: no problem
tomburbine: funny
Student: heh
tomburbine: i actually dont know who u r
Student: good thing we got an exta 2 days for the hw
tomburbine: yes
tomburbine: u can Im me anytime
tomburbine: and
Student: ill tell ya if u promiss not to fail me
tomburbine: I cant add my name to ur aim
tomburbine: only u can
tomburbine: i am fine not knowing
Student: ok
Student: well i have to go ill cya on thursday. take care
tomburbine: bye!

Review #1

- This man is OFF the wall. He's hilarious. I honestly look forward to this class like no other. He mumbles sometimes, but he is SO funny. Also, his brilliance is obvious. Take this guy's classes!

Review #2

- This class sucks. He doesn't teach anything. the powerpoints are indecipherable. the formulas don't make any sense. The tests are hard, and he sucks.

Review #3

- Like what everyone else said. Pretty straightforward teacher, you do need to study for the exams though if you want a good grade. Drops lowest test and a couple lowest HW's. He is funny at times.

Now

- We take a short quiz

Mnemonics

- **My Very Eager Mother Just Served Us Nachos**
- **My Very Eager Mother Just Served Us Nine Pizzas**
- **Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto**

Things we will discuss today:

What is a planet?

Why is there a discussion on the number of planets in the solar system?

Seasons

Eclipses

What is a planet?

- Complicated definition - “A celestial body orbiting a star or stellar remnant that is massive enough to be rounded by its own gravity, is not massive enough to cause thermonuclear fusion, and has cleared its neighboring region of planetesimals.”
- **Simpler definition - A “large” object that orbits a star and shines primarily by reflecting light from its star.**

Planets

- Ancients called them “Wandering Stars”
- Stars remain motionless in relation to each other
- Planets shift their positions relative to the stars



<http://apod.nasa.gov/apod/ap060419.html>

star cluster - Messier 35 (M35)

Moon

- Natural satellite that orbits around a planet



How many planets are
there now in the Solar System?

Number?

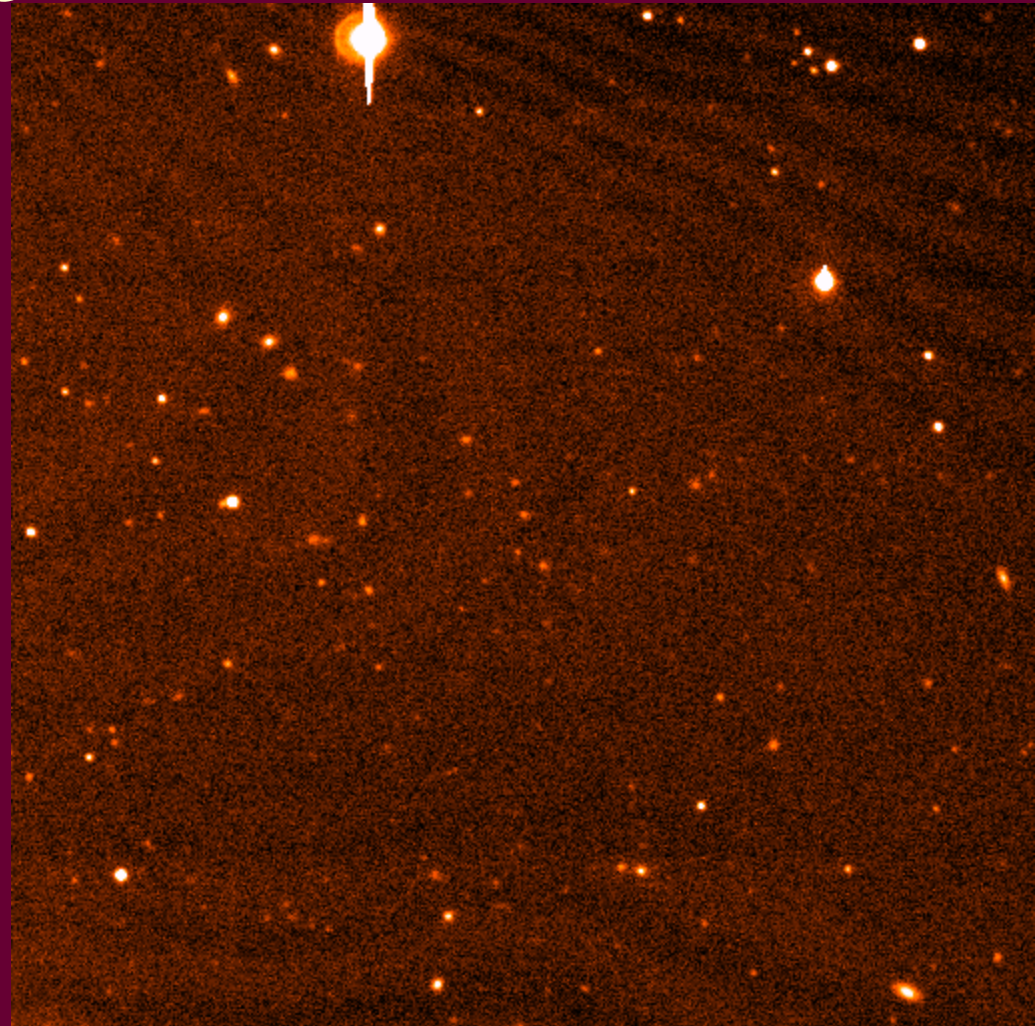
- 8?
- 9?
- 11?
- 12?
- Tens?
- Hundreds?

Why was there a discussion on
how many planets exist in
our solar system?

136199 Eris was discovered

- In 2005, an object a little larger than Pluto was announced to have been discovered
- Originally called 2003 UB313
- Also Eris was found to have a moon called Dysnomia

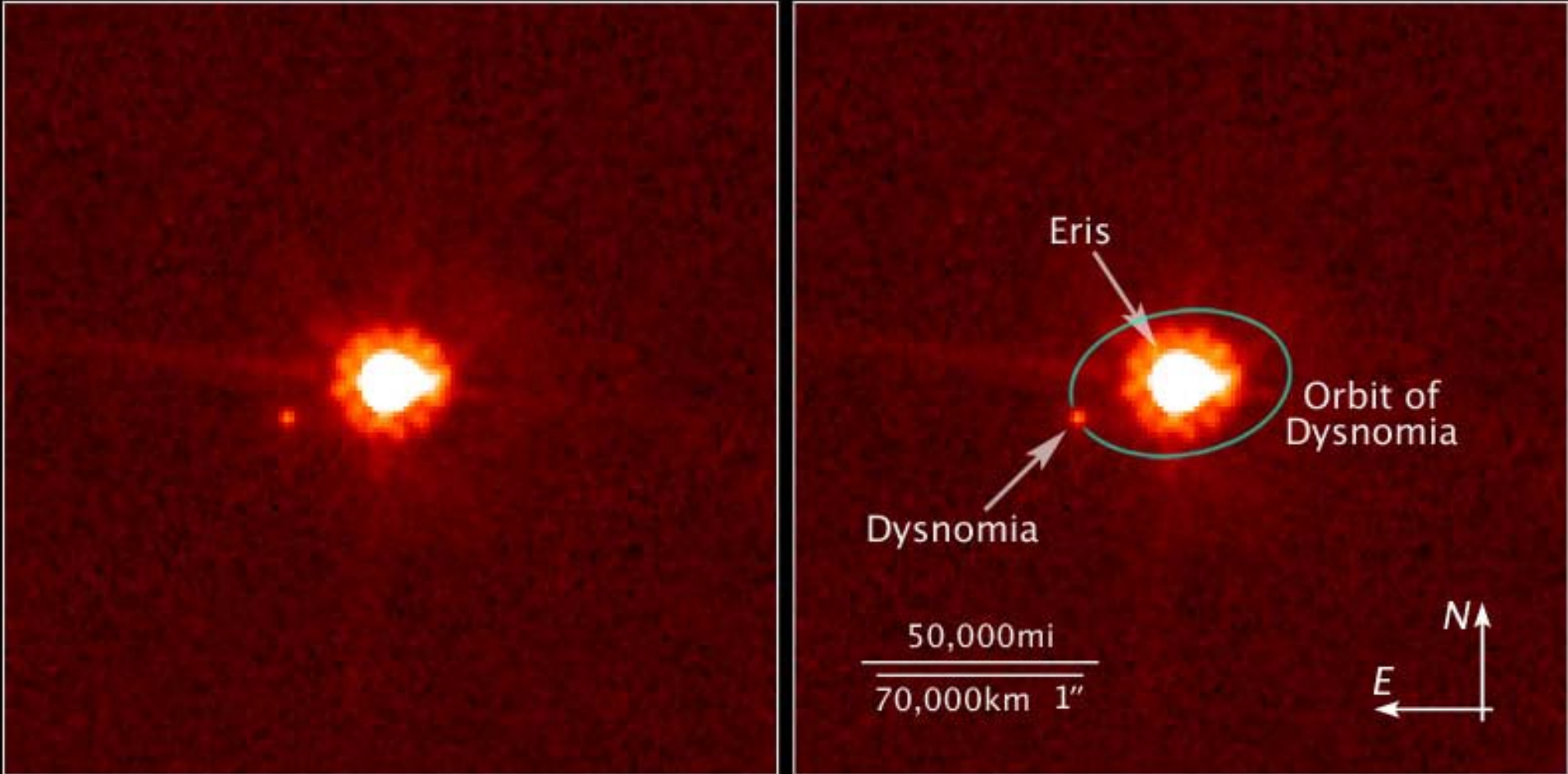
Three frames over three hours.



Hubble Space Telescope

Dwarf Planet Eris and Satellite Dysnomia • August 30, 2006

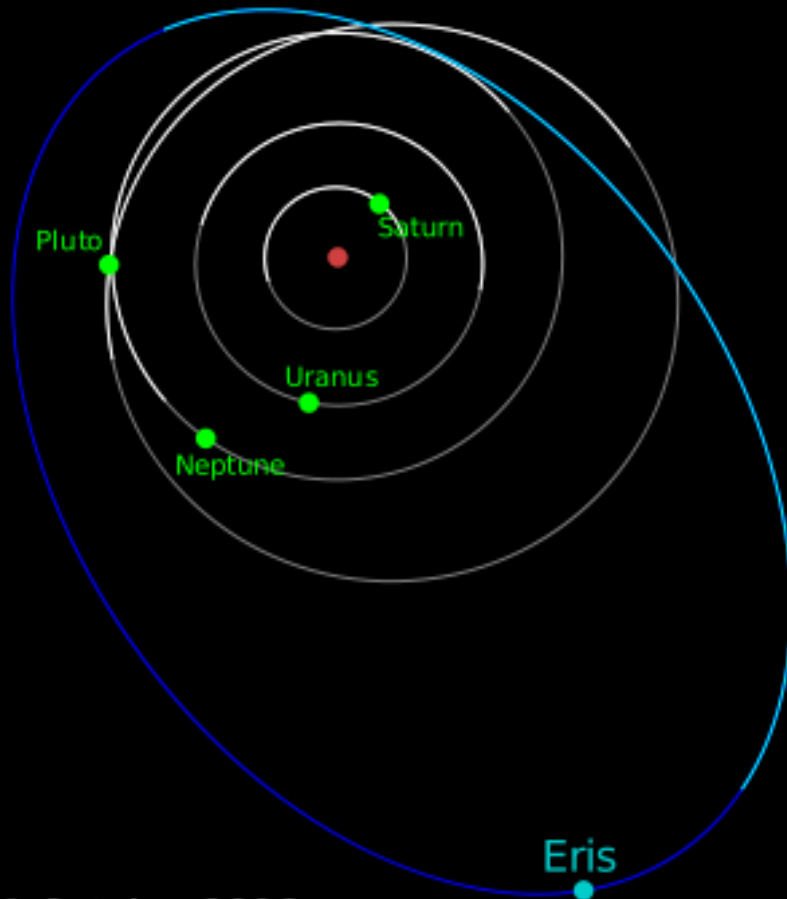
HST • ACS/HRC



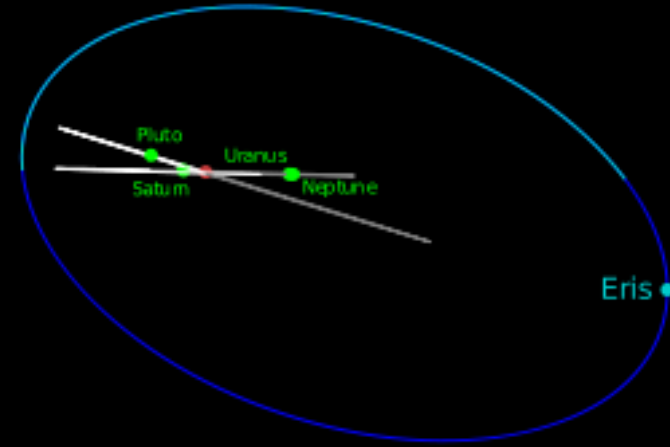
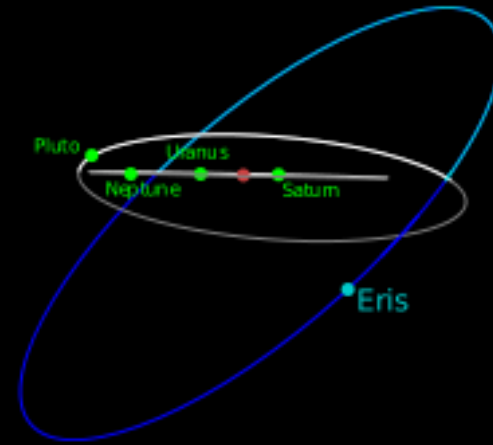
NASA, ESA, and M. Brown (California Institute of Technology)

STScI-PRC07-24

http://www.planetary.org/explore/topics/trans_neptunian_objects/eris.html



11 October 2006



Orbit of Eris (136199 Eris)

Perihelion: 37.77 AU

Aphelion: 97.56 AU

Orbital period: 557 years

Eccentricity: 0.44

Inclination: 44°

What were the original “unofficial”
names for Eris and Dysnomia

original “unofficial” names for Eris and Dysnomia

- “Xena” and “Gabrielle”
- But there are rules:



<http://www.blog.speculist.com/archives/Xena%20&%20Gabrielle.jpg>

Rules

- Couldn't call it Persephone (wife of Pluto)
 - Already an asteroid named after Persephone
- International Astronomical Union (IAU) regulations require a name from creation mythology for objects with orbital stability beyond Neptune's orbit
 - goddess Eris, goddess of strife and discord
 - Dysnomia is daughter of Eris
 - English translation of "Dysnomia" is "lawlessness," like Lucy Lawless

Why is it important that Eris has a Moon?

Why is it important that Eris has a Moon?

- The moon allows you to calculate Eris' mass
- Eris is 27% more massive than Pluto
- Size of Eris is harder to determine but is approximately 2397 km (±100 km)
(Pluto is 2306 km in diameter)

Meeting that decided new planet definition

- Astronomy 2006 - IAU XXVIth General Assembly
- IAU is the International Astronomical Union
- Prague
- August 14-25, 2006
- About 2,400 astronomers attended the meeting

Initial Proposal

- *"A planet is a celestial body that
(a) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and
(b) is in orbit around a star, and is neither a star nor a satellite of a planet."*

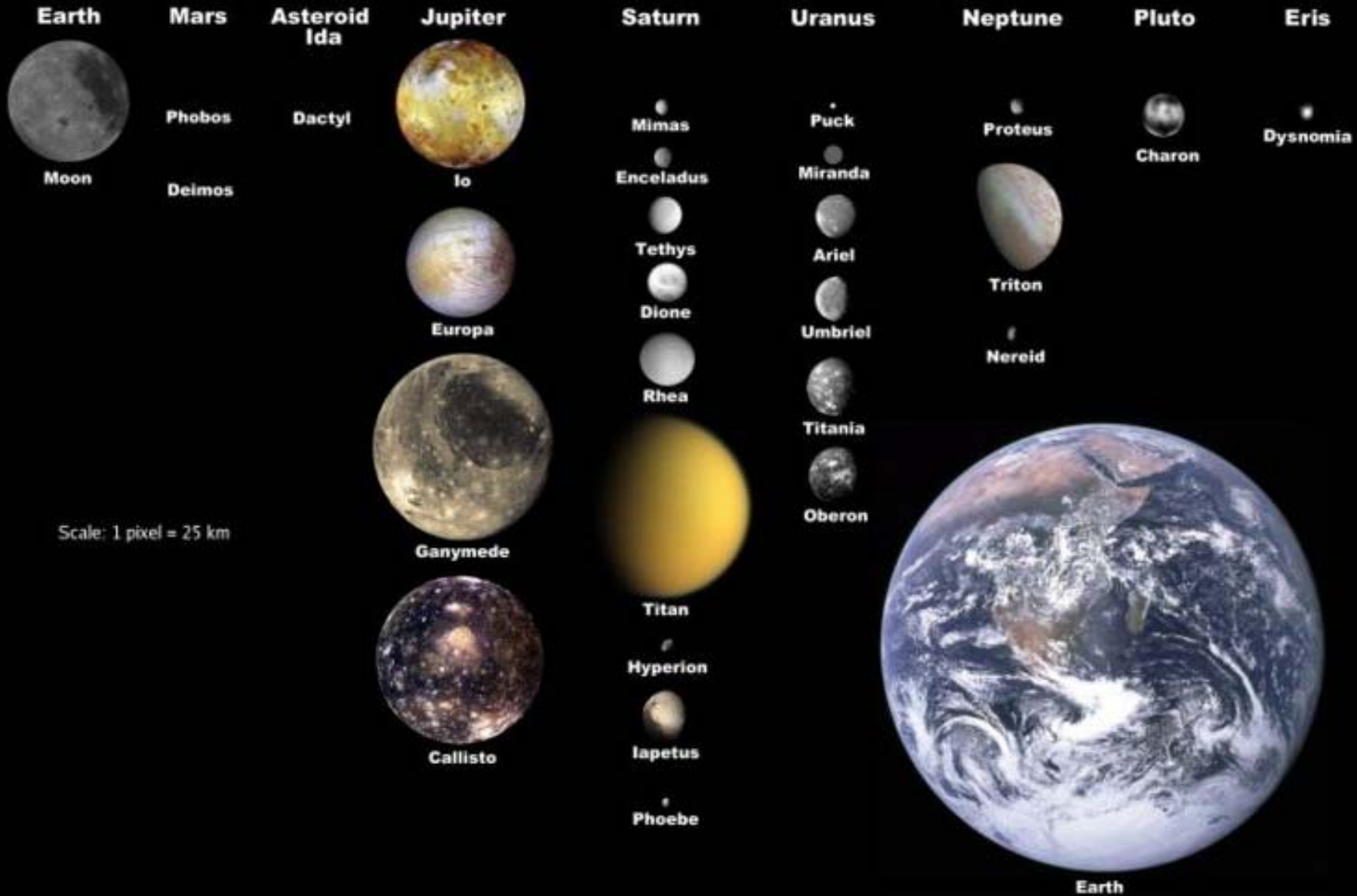
What would then qualify as a planet?

- Pluto and at least three other bodies would be considered planets
 - 1 Ceres (an asteroid)
 - 136199 Eris – slightly bigger than Pluto
 - Charon
- What is Charon?

Charon

- Charon is the largest moon of Pluto
- 240 natural satellites in the solar system
- 166 orbiting the eight planets

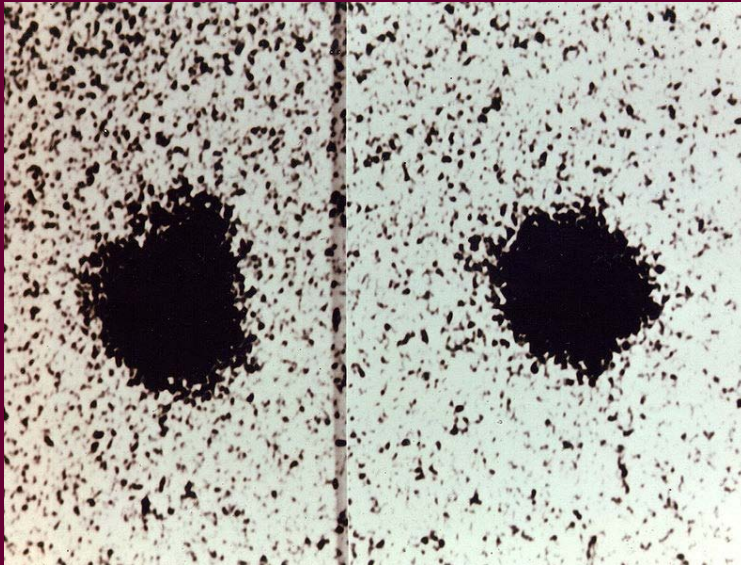
Selected Moons of the Solar System, with Earth for Scale



Charon

- Charon is half the diameter of Pluto
- Center of mass of this system is outside Pluto
- Double planet system

1978



1996 – Hubble Space Telescope



2006

- The IAU now defines "**planet**" as a celestial body that:
 - (a) is in orbit around the Sun,
 - (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and
 - (c) has cleared the neighborhood around its orbit.

~400 people voted



<http://www.nature.com/nature/journal/v442/n7106/images/442965a-i1.0.jpg>



http://www.plutoisaplanet.com/index_files/image004.jpg

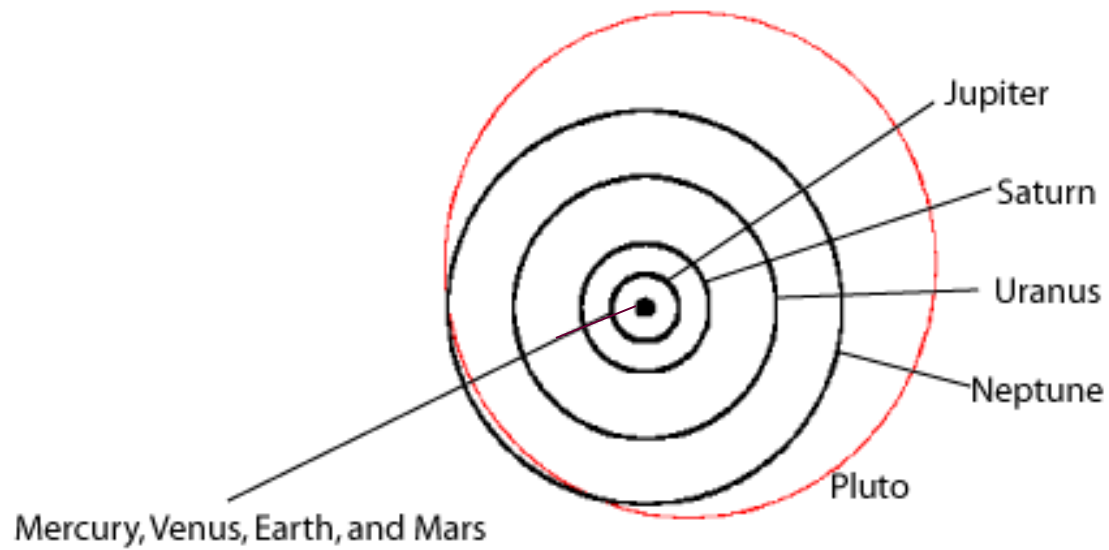
- A "dwarf planet" is a celestial body that
 - (a) is in orbit around the Sun,
 - (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (**nearly round**) shape,
 - (c) has not cleared the neighborhood around its orbit, and
 - (d) is not a satellite.
- All other objects except satellites orbiting the Sun shall be referred to collectively as "Small Solar-System Bodies".

Problems

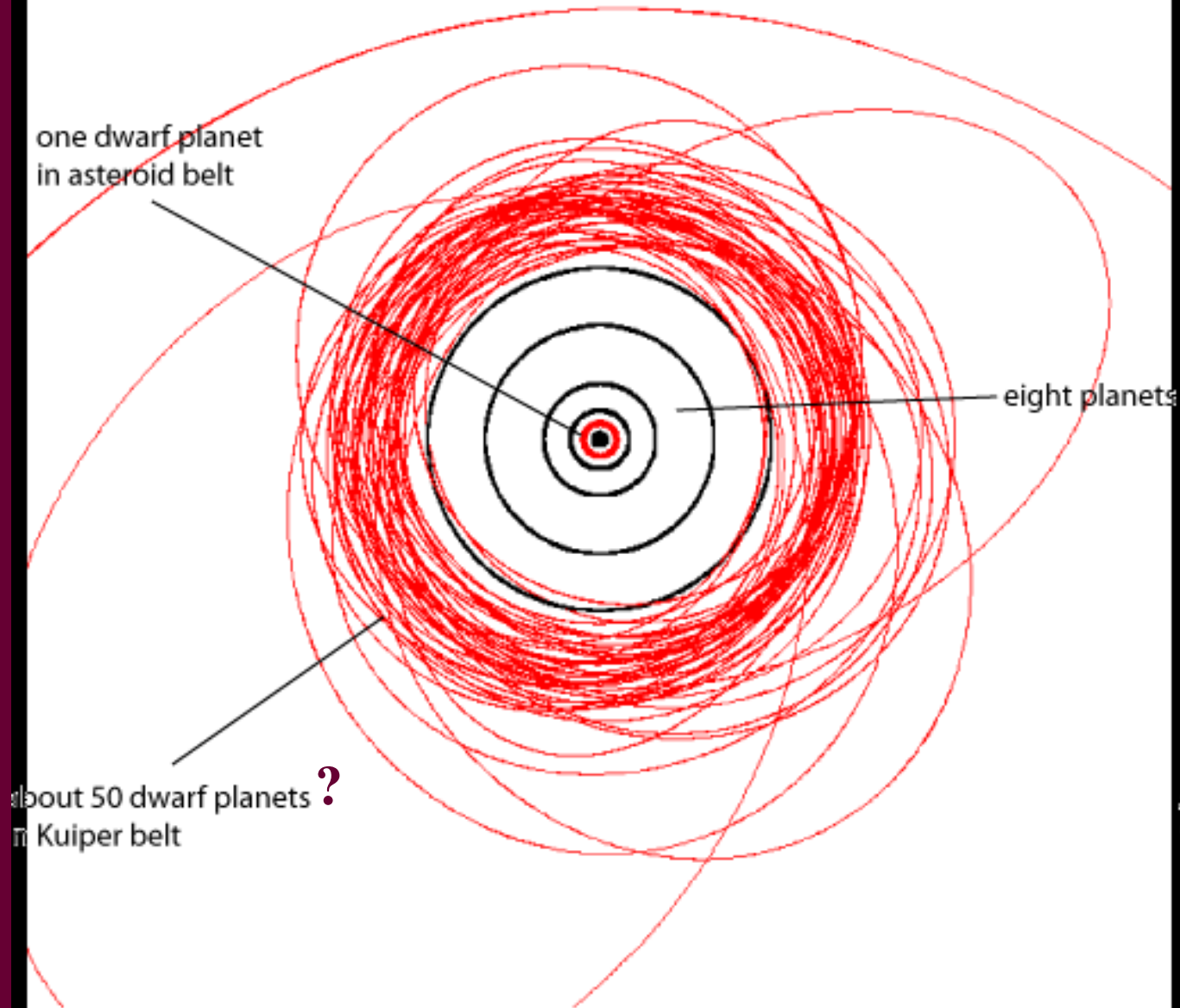
- “Any definition that allows a planet in one location but not another is unworkable. Take Earth. Move it to Pluto’s orbit, and it will be instantly disqualified as a planet.” (Allan Stern)
- What does clear the neighborhood really mean?
 - Earth, Mars, Jupiter and Neptune all have asteroids as neighbors (in similar orbits)

- Five bodies which fulfill the first three conditions but not the fourth (**Charon**) are now classified as dwarf planets:
 - Ceres, Pluto, 136199 Eris, 136472 Makemake, and 136108 Haumea

The old solar system



The new solar system



How many planets are known to exist
outside the solar system?

How many planets are known to exist outside the solar system?

- There have been more than three hundred planets (424 as of yesterday) discovered orbiting other stars to date.

Does it really matter what is a planet
and what isn't?

- up to 1500 - seven (Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn) - Geocentric model
- 1550 - six (with Earth, without Moon and Sun) - Heliocentric model
- 1781 - seven (with Uranus)
- 1807 - eleven (with Ceres, Pallas, Juno and Vesta)
- 1845 - twelve (with Astraea)
- 1846 - thirteen (with Neptune)
- 1851 - eight (without the asteroids)
- 1930 - nine (with Pluto)
- 2006 - eight (without Pluto)
 - From wikipedia

What is a star?

What is a star?

- A large glowing ball of gas that generates heat and light through nuclear fusion in its core
- Stars manufacture high-mass elements (carbon, nitrogen, oxygen, iron, etc.)

Metric System

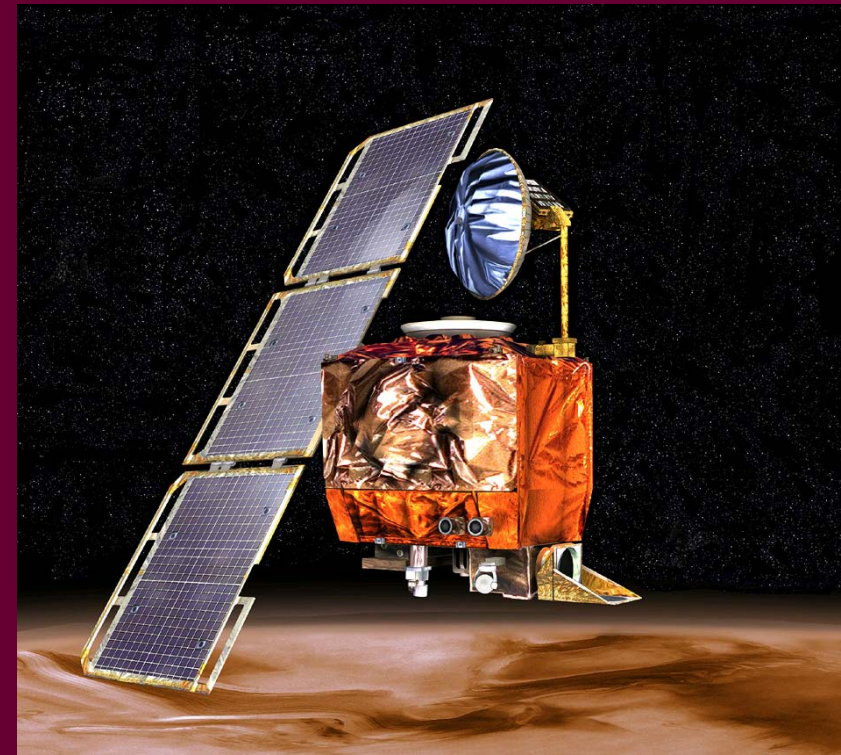
- Any system of measurement needs three fundamental units
 - Length - meter
 - Mass - kilogram
 - Time - second

Things you need to know because we will use the metric system

- one kilometer is $\frac{5}{8}$ of a mile
- one meter is approximately a yard or 3 feet
- 1 kg (**mass**) is equivalent to 2.2 pounds (**force**) on Earth
- We will use the metric system in this class
- Does anybody remember the Mars Climate Orbiter?

Mars Climate Orbiter

- Software calculated forces for the thrusters in English units (pounds).
- People controlling the spacecraft thought the calculated forces were in Newtons (metric). (One English pound of force equals 4.45 Newtons.)
- Changes made to the spacecraft's trajectory were actually 4.45 times greater than what the JPL navigation team believed.
- The spacecraft missed its intended 140 - 150 km altitude above Mars during orbit insertion, instead entering the Martian atmosphere at about 57 km.
- The spacecraft was destroyed



Laboratory

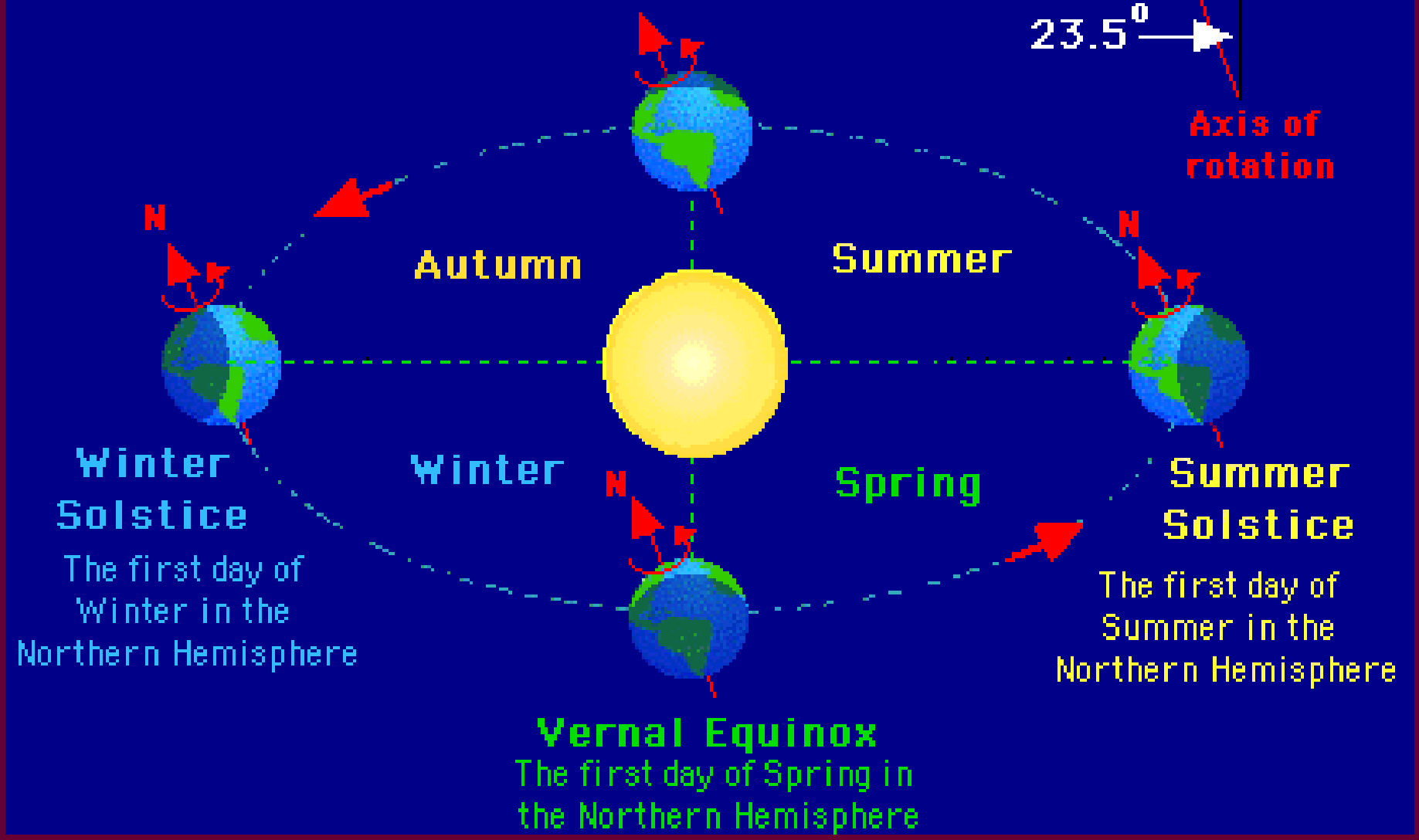
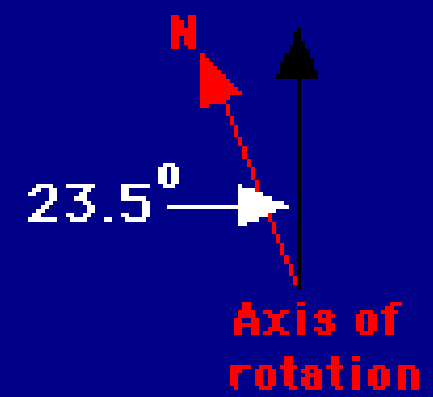
- Scientific Notation

Seasons

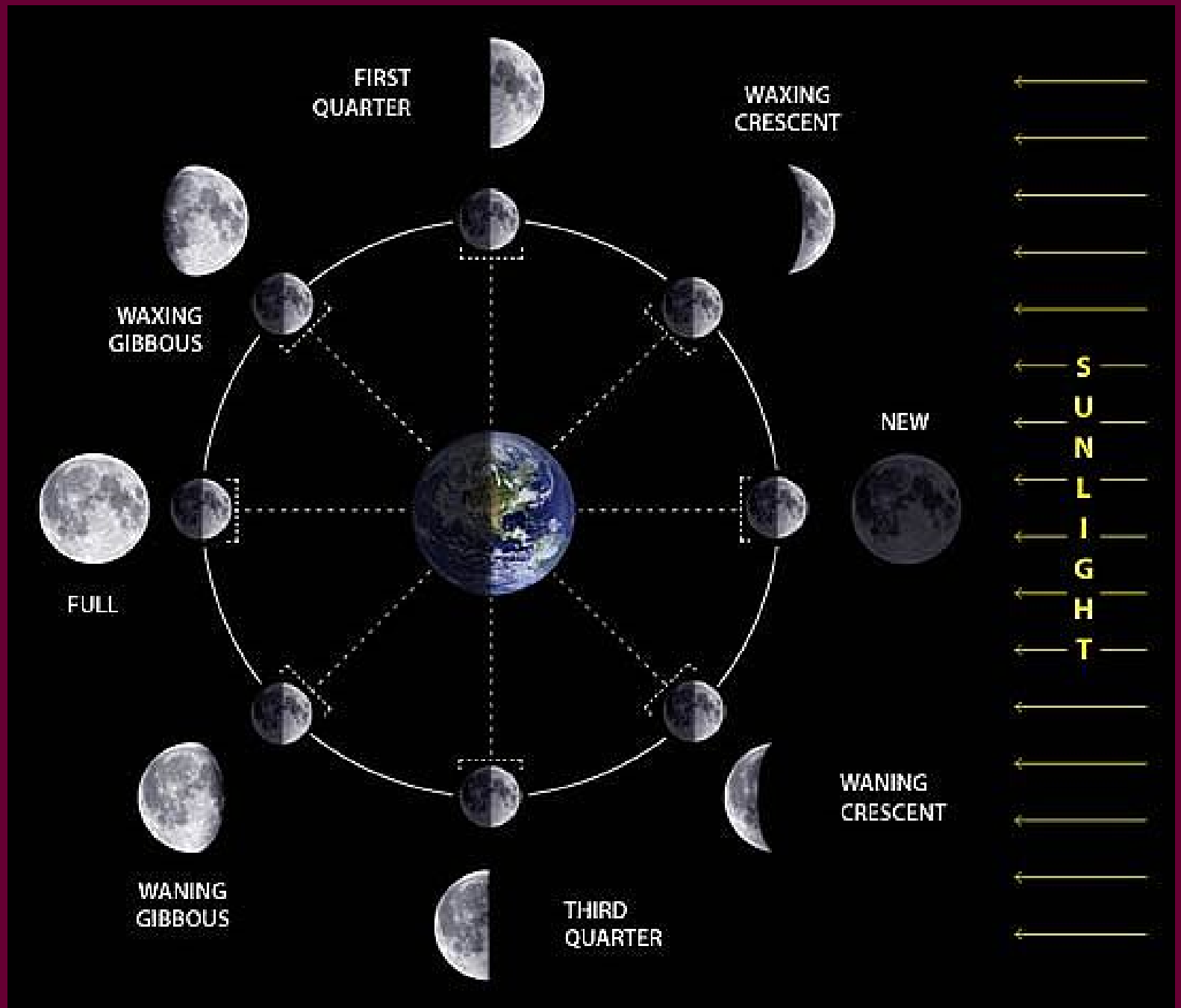
- <http://www.learner.org/resources/series28.html>

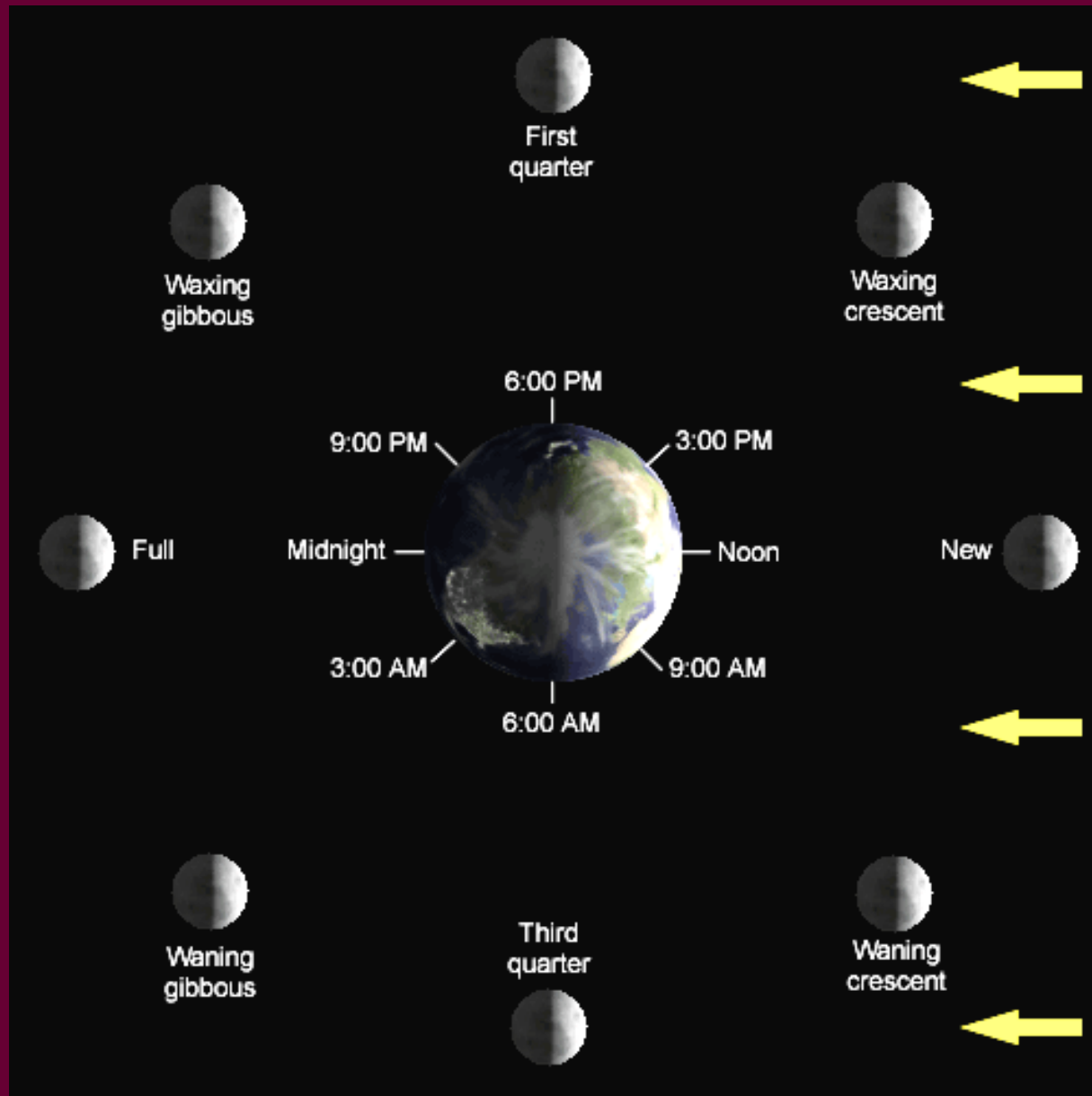
Earth's Seasons

Autumnal Equinox
The first day of Autumn in the Northern Hemisphere



Phases of the Moon- 29.53 day cycle

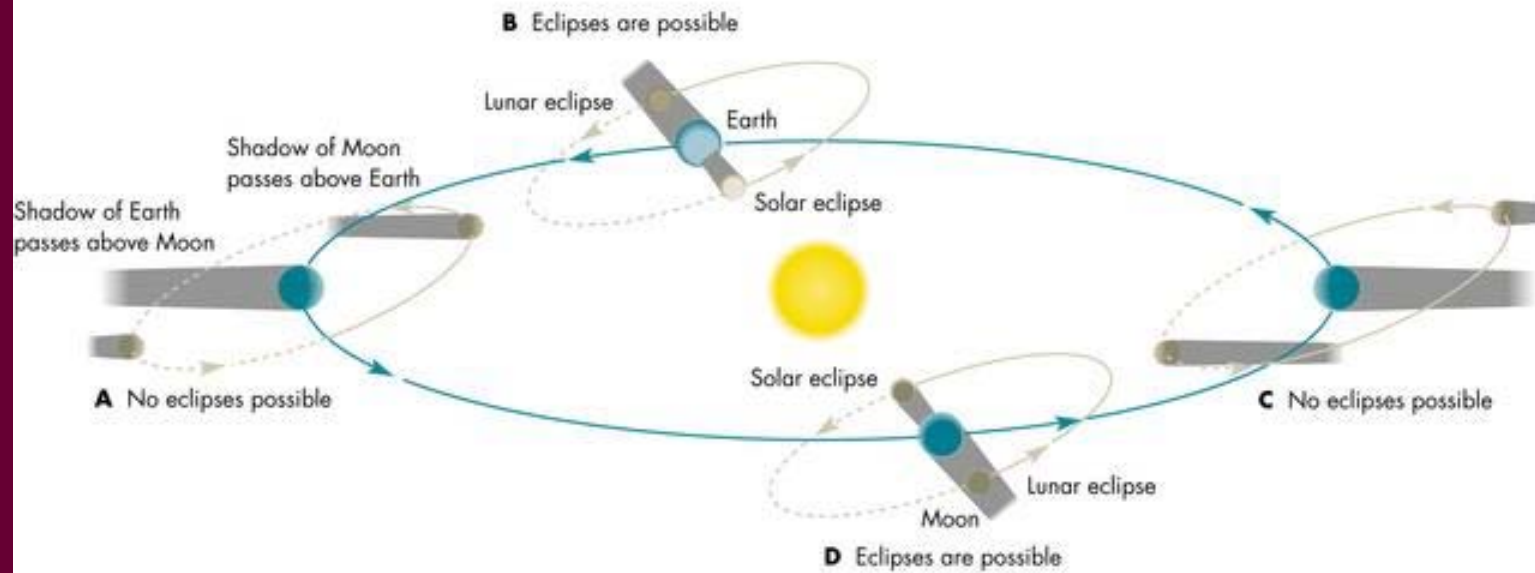




<http://en.wikipedia.org/wiki/File:Lunar-Phase-Diagram.png>

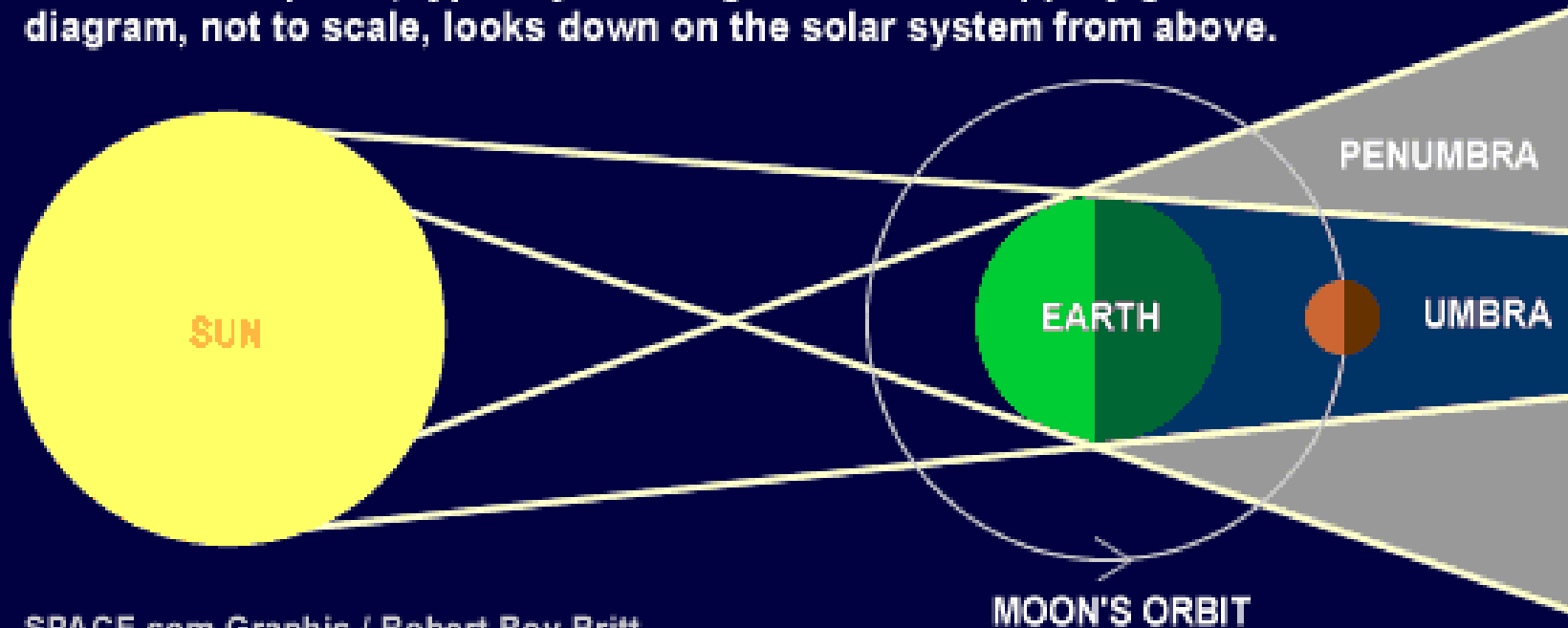
Eclipses

Moon is tilted at an angle of 5 degrees to Earth's orbit



Anatomy of a Lunar Eclipse

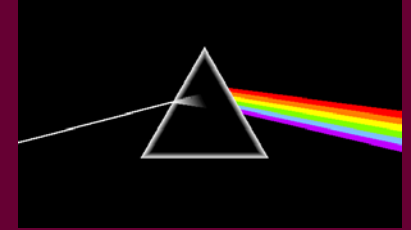
A total lunar eclipse can only occur at Full Moon, when Earth blocks the sunlight normally reflected by the Moon. Some sunlight is bent through Earth's atmosphere, typically allowing the Moon a coppery glow. This diagram, not to scale, looks down on the solar system from above.



SPACE.com Graphic / Robert Roy Britt

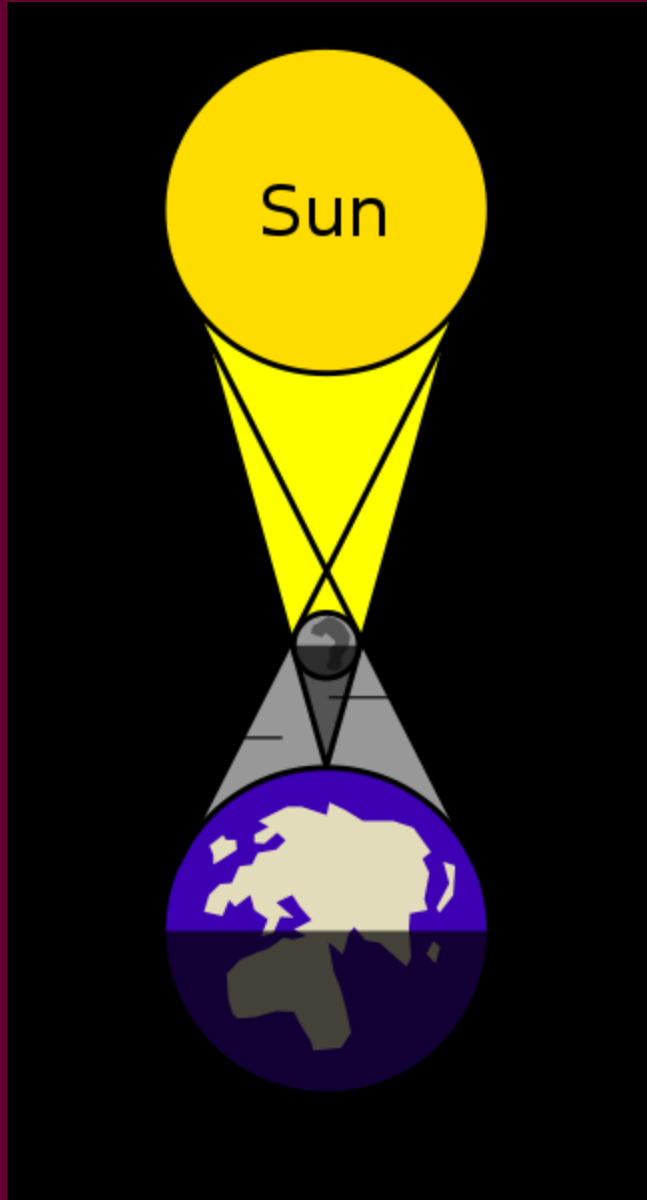
SOURCES: Fred Espenak, NASA; The Moon Book

Color of lunar eclipse

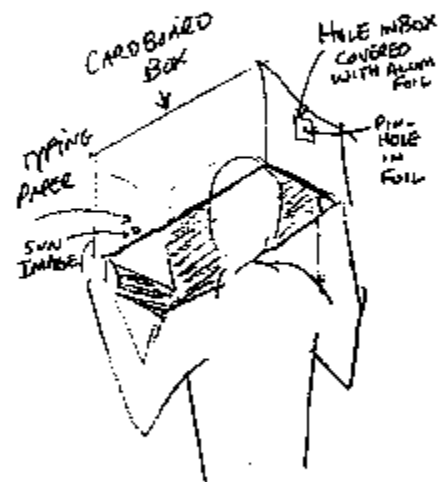
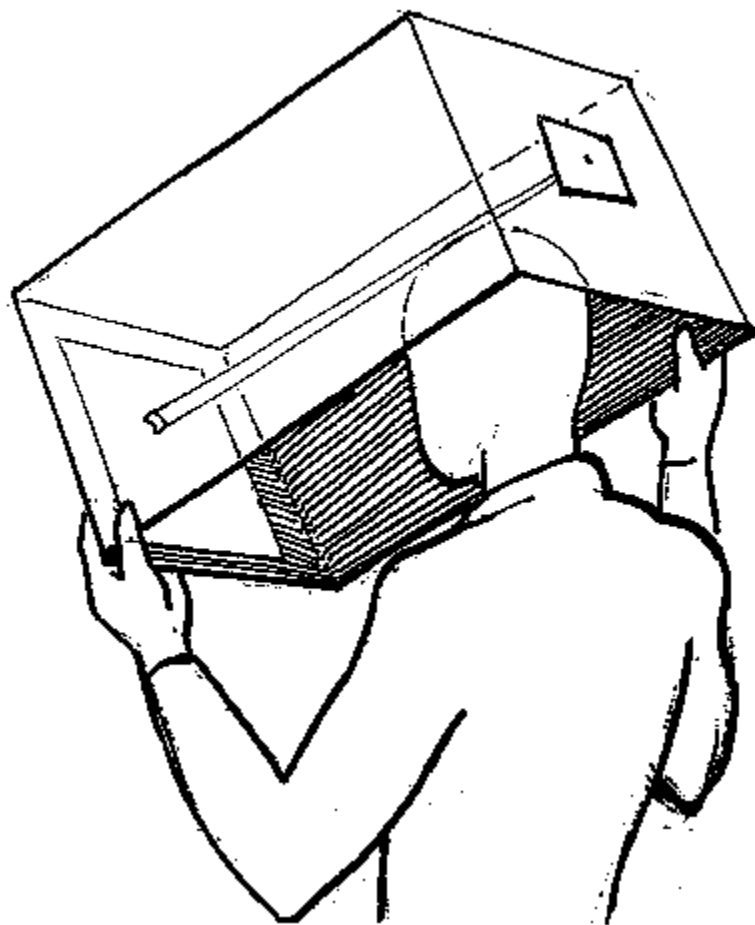


- The Moon does not completely disappear because of the refraction of sunlight by the Earth's atmosphere
- If the Earth had no atmosphere, the Moon would be completely dark during an eclipse.
- The red color arises because sunlight reaching the Moon must pass through the Earth's atmosphere, where it is scattered.
- Shorter wavelengths are more likely to be scattered by the small particles. By the time the light has passed through the atmosphere, the longer wavelengths dominate. This resulting light reflected from the Moon we perceive as red.

Solar eclipse



SAFE WAY TO VIEW ECLIPSE





- Solar eclipses occur approximately every 18 months
- However, they recur (on average) at any given place only once every 370 years
- Moon's umbra moves eastward at over 1,700 km/hr
- Every year, there are at least two lunar eclipses.
- Can be viewed anywhere on the night side of the Earth



Solar eclipse of July 22, 2009

- Lasted a maximum of 6 minutes and 39 seconds off the coast of Southeast Asia

http://upload.wikimedia.org/wikipedia/commons/f/f2/Solar_eclipse_animate_%282009-Jul-22%29.gif



http://en.wikipedia.org/wiki/File:Solar_eclipse_22_July_2009_taken_by_Lutfar_Rahman_Nirjhar_from_Bangladesh.jpg

Any Questions?