



# Astronomy

## *Exploring The Universe*

Summer 2016

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# Flat Earth Society

Hi! I'm a member of the Flat Earth Society.

The Earth is flat, you know that, right?



You don't think so?  
Prove me wrong...

You convinced me...

Ok so you were right... the Earth IS a sphere!!



# Course Goals

Science vs. Pseudo-science

What do we know about the Universe and our place in it?

How can we apply this to our everyday lives?

# This Week's Class

- The Nature of Science
- Motions in the sky (stars, planets, the Moon)
- Seasons
- Astronomical scales

# What is Science?

*Class Answers:*

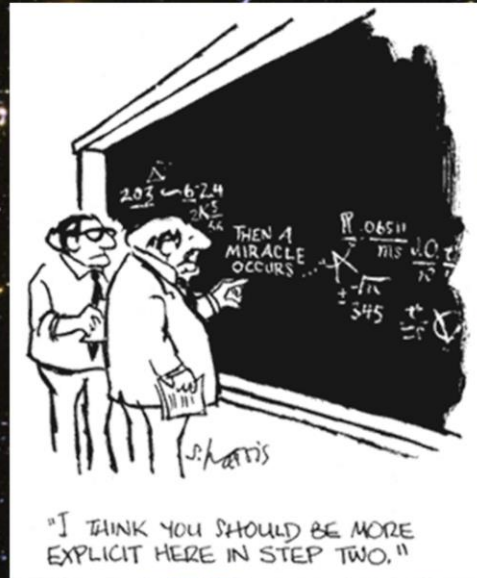
*Scientific method*

- exploring, finding clues*
- prove/disprove current beliefs (hypotheses)*
- conducting experiments*
- discover results*

*Reproducible (process)*

*Study of earth/nature/elements/natural world*

*A HUMAN endeavor*



Here ask students to answer this question in groups – brainstorm. Then put all on board, add to slides later

Observations

Hypothesis

Experiment

Observe again

Test hypothesis

Creativity!!!

**Studying nature**

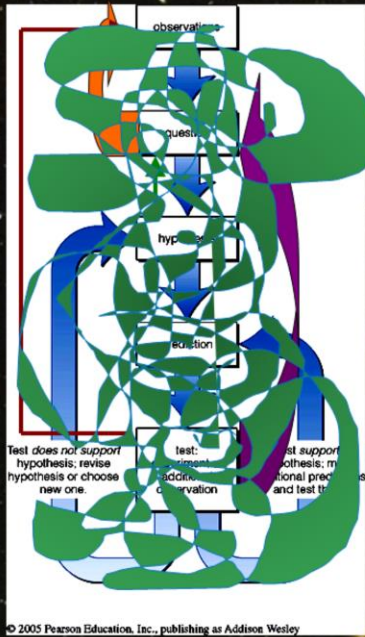
**Using empirical data to understand everything!!!!**

**Empirical = observed, measurable**

**Predictable**

→ **Move to theory (why)**

# The Scientific Method



## Key Features:

- Hypotheses are based on **observations**.
- Hypotheses must be **testable**.
- If the experimental results contradict the hypothesis, the hypothesis must be revised.

It's all much messier than you think....

# Scientific Theory

*It's just a theory.*



## **Theory:**

An explanation of a group of occurrences in nature that has been confirmed by a **substantial** number of experiments and observations.

***Scientific theory is not mere conjecture.***

Emmy Noether

“The most significant creative mathematical genius thus far produced since the higher education of women began” - Einstein



# Scientific Law



Henrietta Swan Leavitt

## Law:

A (mathematical) description of a process in nature, without underlying theoretical explanation.

Simple, **Empirical** description only.

*Can a scientific theory become scientific law?*

Simply stated, while a **law** notes *that* something happens, a **theory** explains *why* and *how* something happens

Henrietta Swan Leavitt's work would be followed by Annie Jump Cannon, who explained the *why* and *how*.

# Hallmarks of Science:

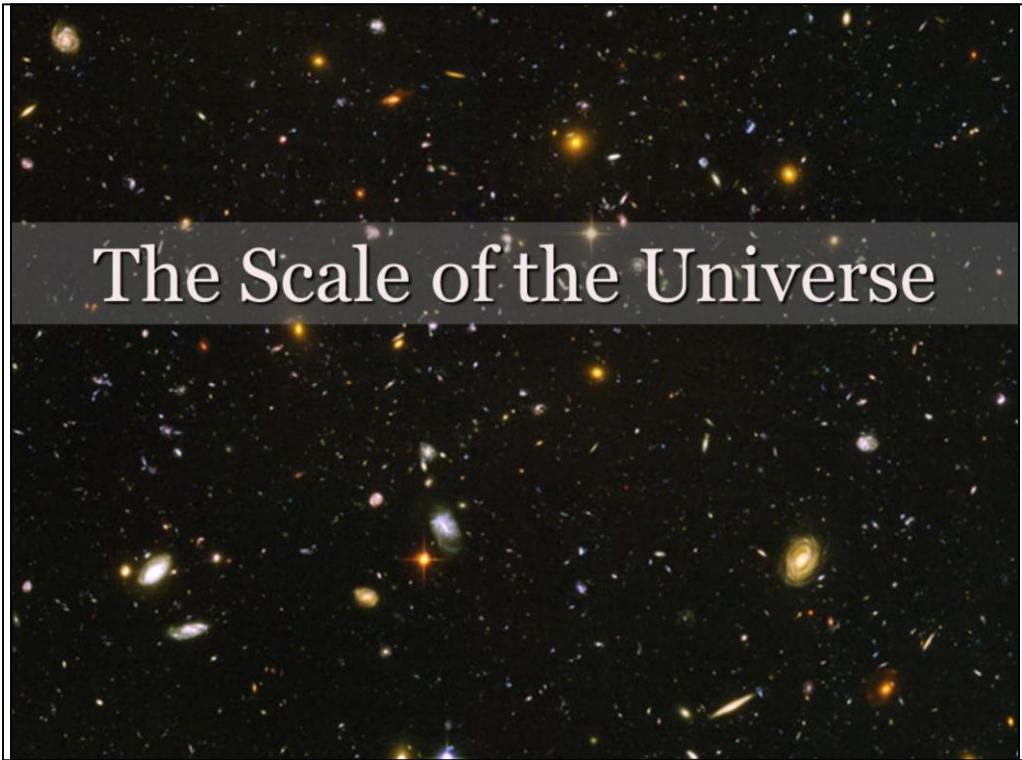
Explanations rely solely on **natural** causes

Create **and test** models (hypotheses)

Models explain nature **as simply as possible**

Must make testable **predictions**

If test fails, **revise or throw it out!**



The Sun is MUCH bigger than the Earth.

It's about 100 Earth diameters across.

The entire Earth/Moon system fits inside the Sun.

# Local Scale

1 mile = 3.3 NC



# Local Scale



North Campus  
0.3 Mile = 1 NC



The United States  
2,600 Miles = 8,600 NC



Earth  
7,926 Miles = 24,320 NC

Units of measure (feet, inches, miles, furlongs, etc.) are defined in a completely arbitrary way. We generally pick a unit that is matched to the thing that we're measuring.

Starting with a view of the North Campus of UST, we'll define a new unit of measure: The North Campus or the NC

One NC = 0.3 miles.

Think about how long it takes you to walk one NC.  
about 4.5 minutes

At 4 mph (13 NCs per hour), it's

The United States is 8,600 NCs across.  
days

At 4 mph, you can walk it in 26

The Earth is 24,320 NCs around.

At 4 mph, you can walk it in 76 days

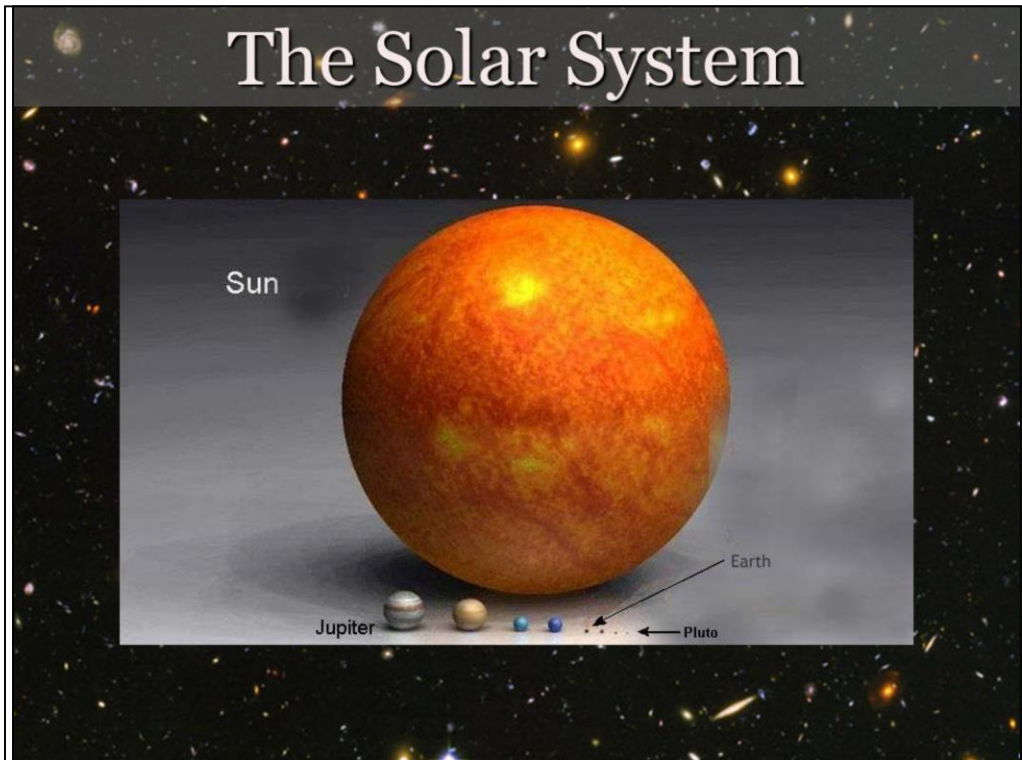
# Sun Earth Comparison



The Sun is MUCH bigger than the Earth.

It's about 100 Earth diameters across.

The entire Earth/Moon system fits inside the Sun.

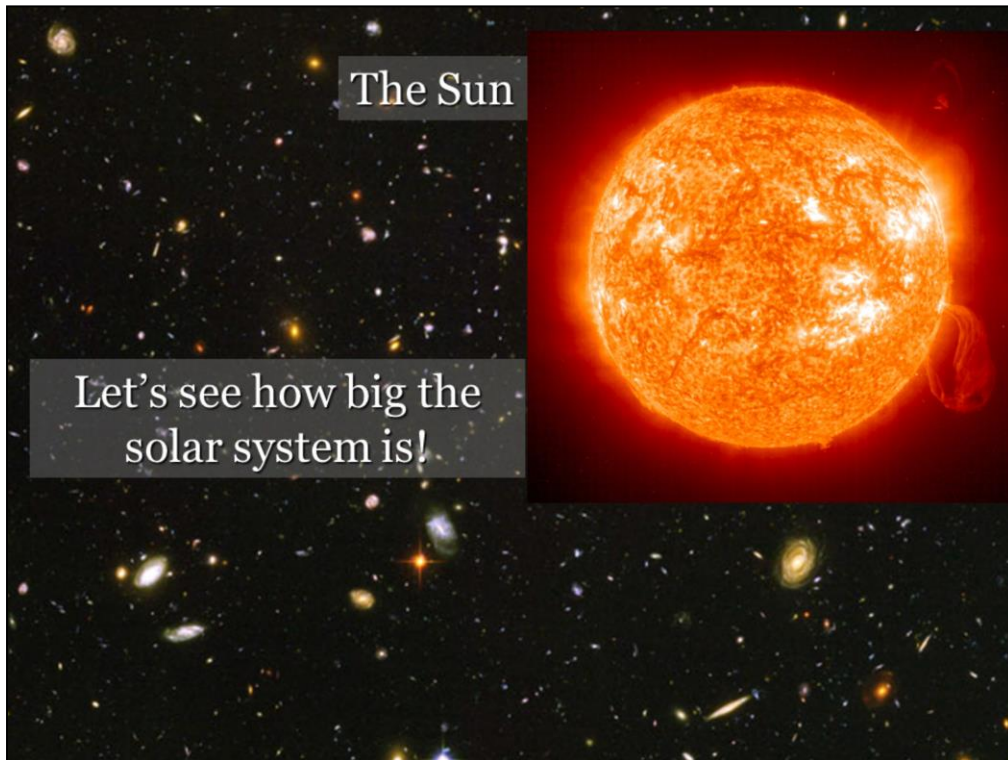


The Sun completely dominates the solar system.

The Earth/Moon system fits easily inside the Sun. Twice  
The arrows represent the entire DIAMETER of the Moon's orbit around the Earth.

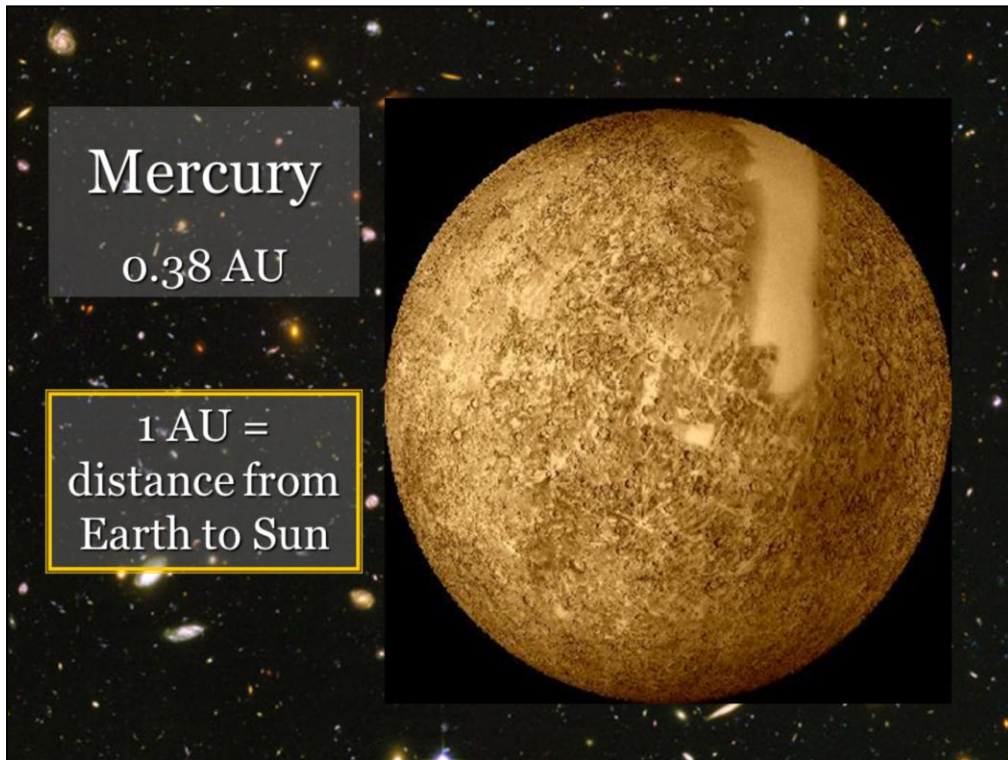
The Sun has 99.87 percent of the mass of the Solar System.

The Sun is a rather small star though...



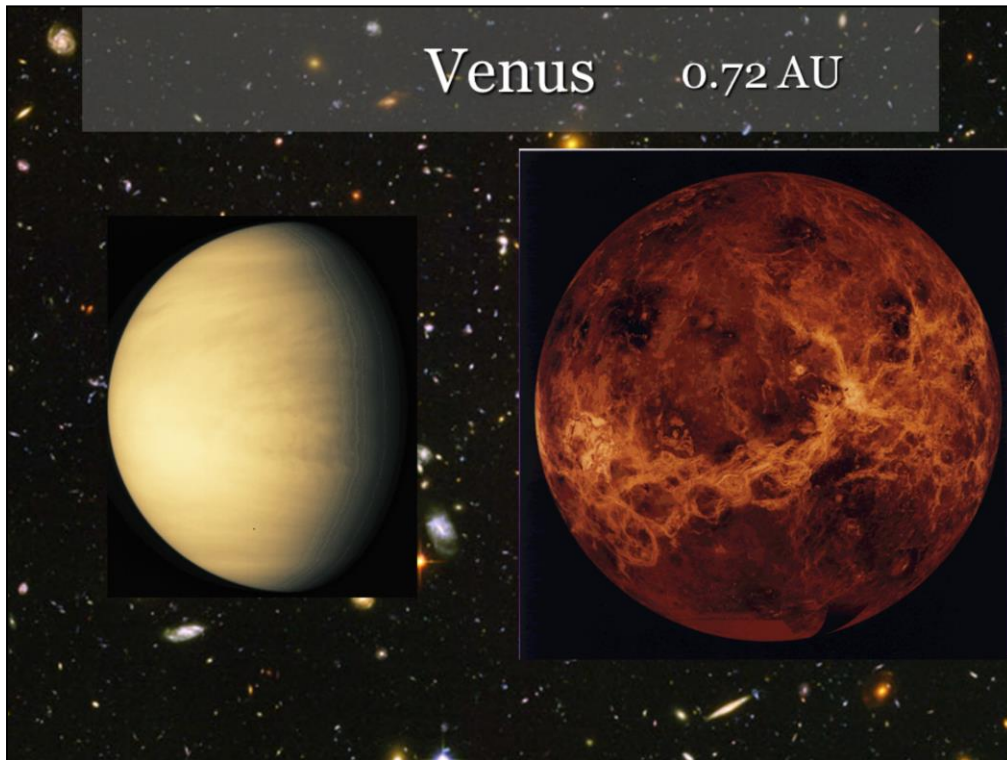
Here ask students to do the exercises with the tapes – break into groups of 4 or 5. Start with them choosing Earth-Sun distance and then guess at the other planets. Then with the other tape go through the next slides with correct distances in AU.





That “bald” spot is where there was no data from Mariner 10 or whatever it was.

Surface gravity – where I have the number in parentheses is how much you would weigh on that planet if you weighed 80 lbs on Earth.



Bottom left – true color

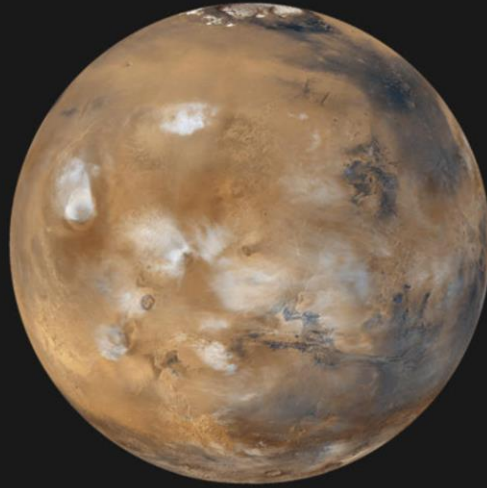
On right – true color of the surface – thru clouds by radar



Have them find (or point out) Minneapolis or Japan or something.

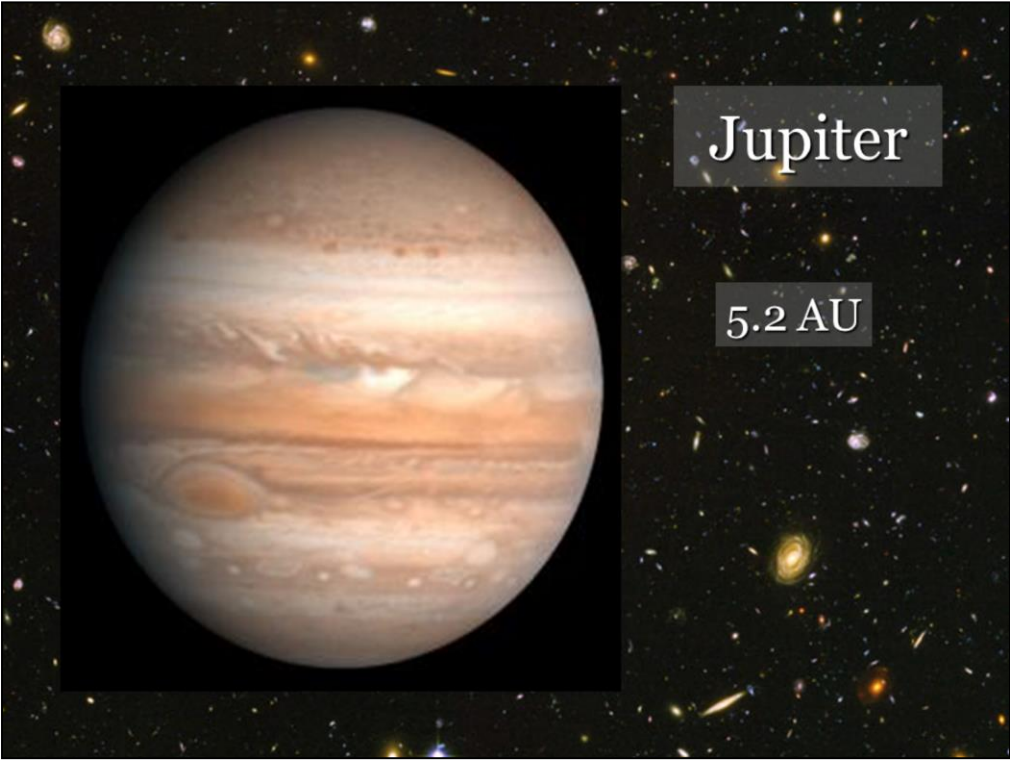
Mars

1.52 AU





\*Ceres is a dwarf planet



Jupiter

5.2 AU

Saturn

9.5 AU



Uranus

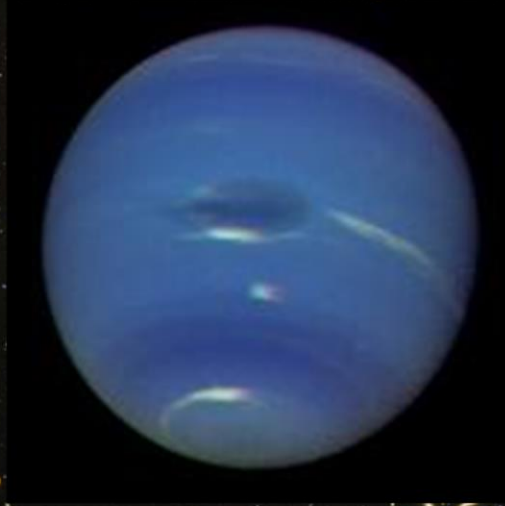
19 AU

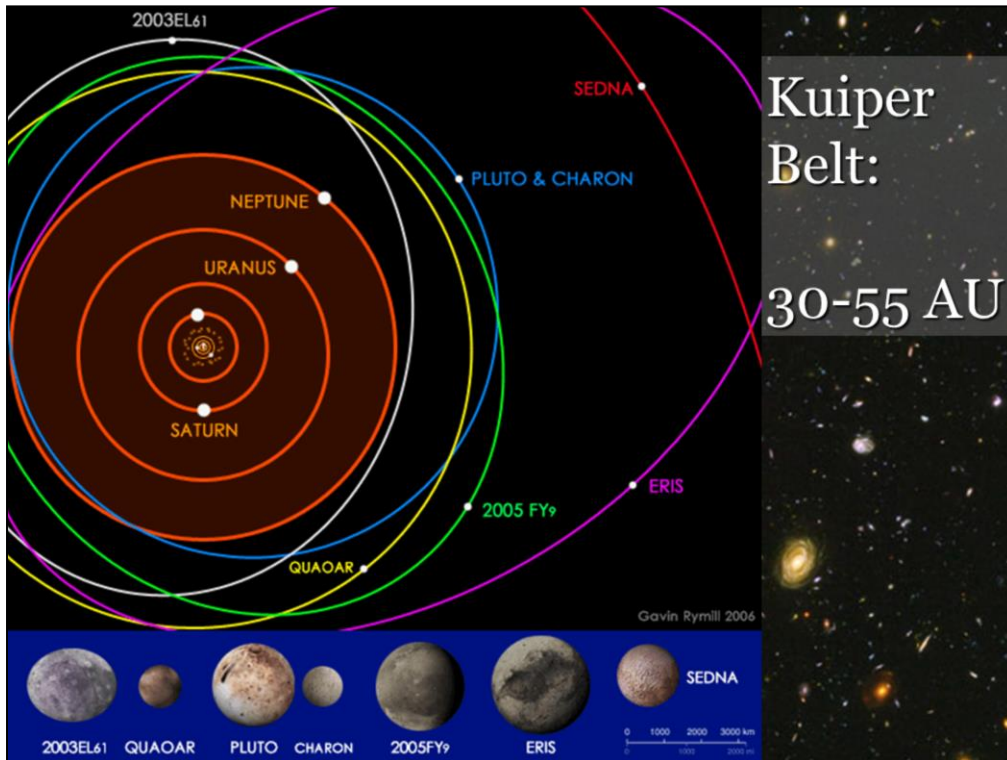




# Neptune

30 AU

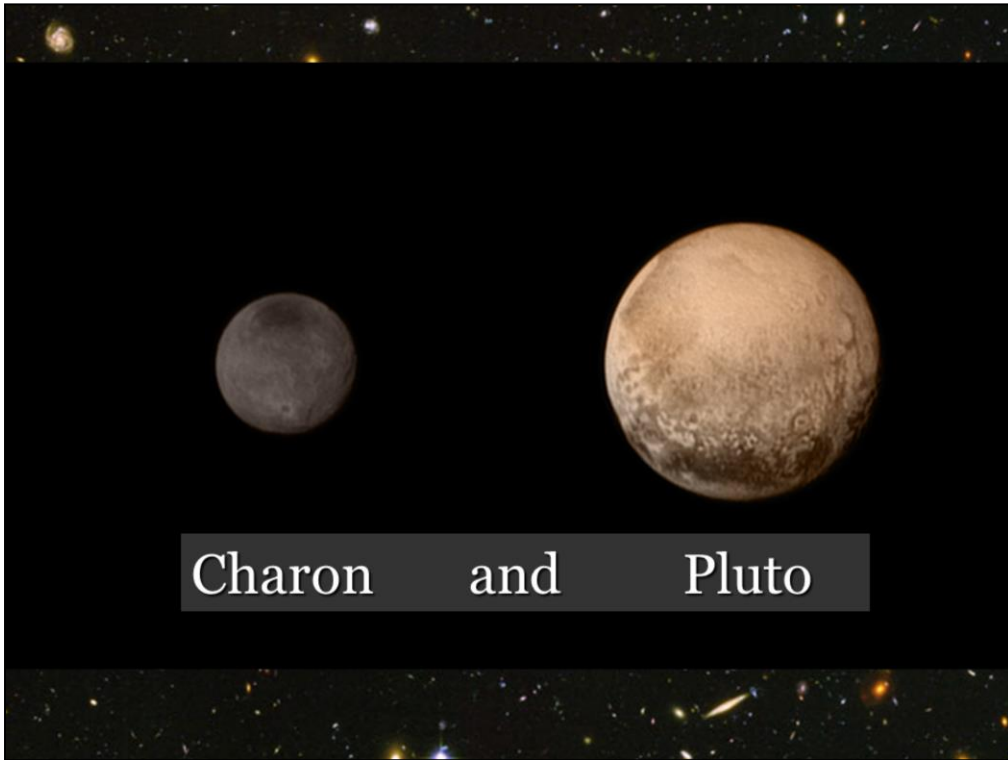




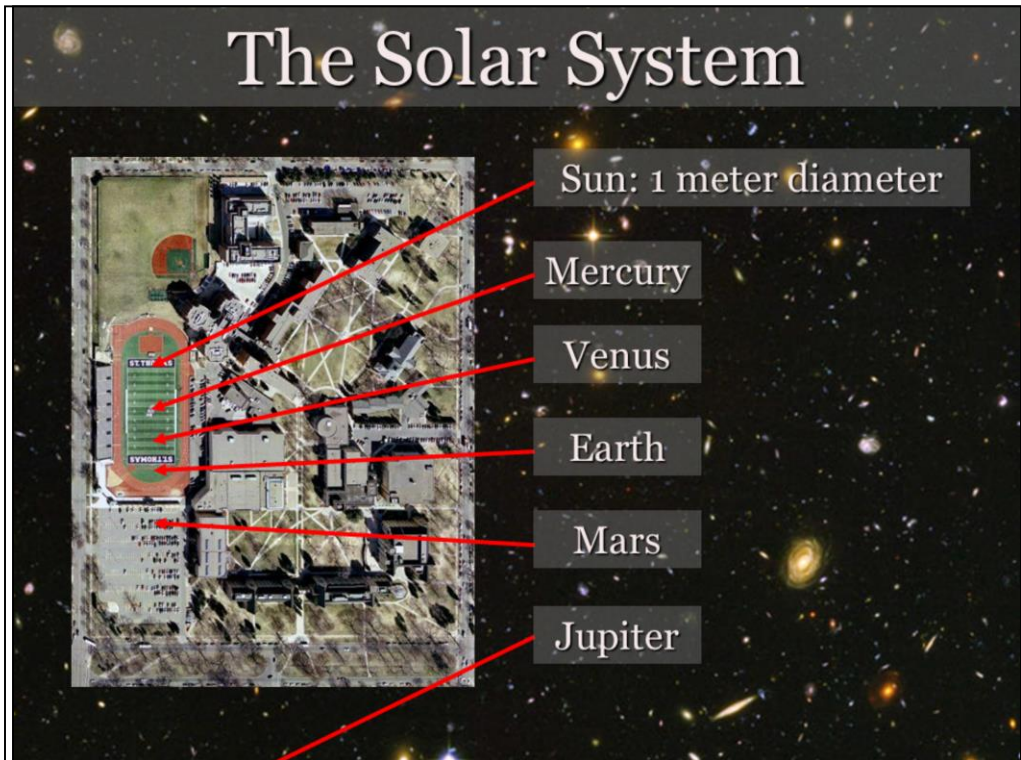
Discuss with students their comparisons between their guesses and the real answers



Discuss with students their comparisons between their guesses and the real answers



Don't forget Nix, Hydra, Styx and Kerberos



Let the Sun have a diameter of 1 meter and place in the end zone of the UST football field.

Mercury ends up on the 45 yard line.

Venus is about 75 yards away

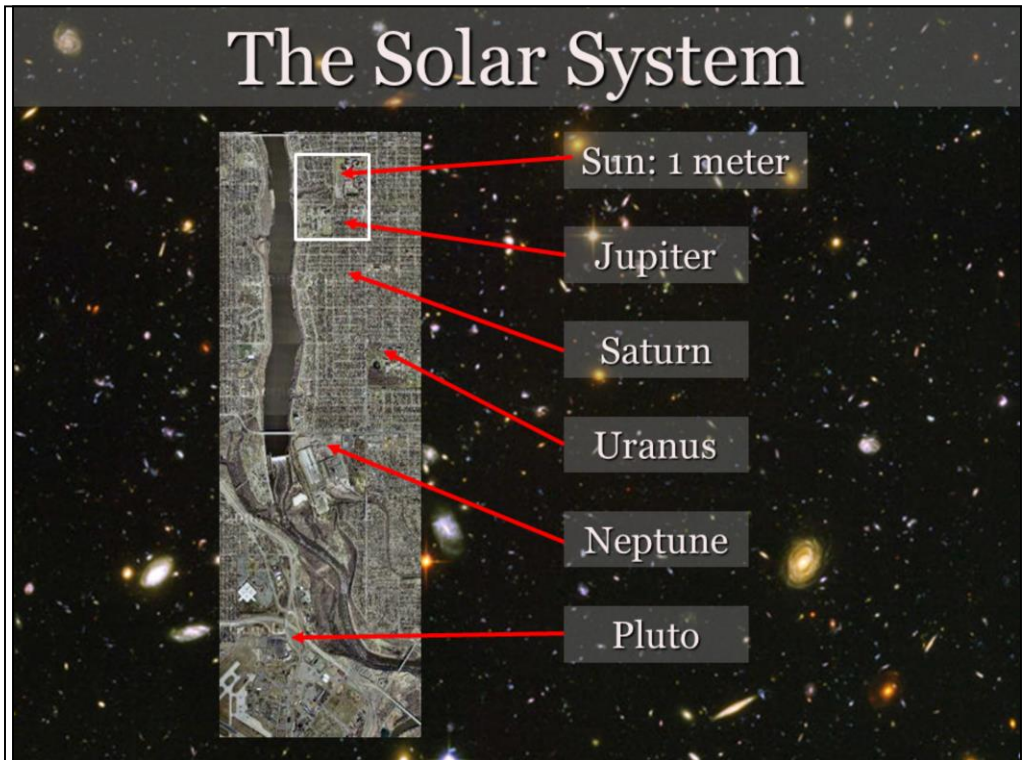
Earth is just beyond the opposing end zone.

Mars is in the Parking lot

Jupiter is... off the map

In the solar system, we use a unit of distance called an Astronomical Unit (AU).

It is the average distance between the Earth and the Sun (about 93 million miles)



The gassy planets are much further away from the Sun than the Earth is.  
Jupiter is around South Campus.

5 times further away than the Earth is from the Sun.

We say it's 5 AU away.

1 AU = the average Earth Sun distance.

And they're made of gas (mostly). VERY different than the terrestrial planets.

# The Solar Neighborhood

**Light Year:** The distance light travels in 1 year.

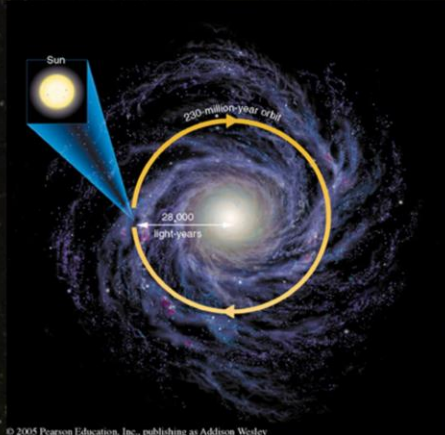
1 yr = 63,240 AU =  $5.9 \times 10^{12}$  miles =  $2.0 \times 10^{13}$  NC



Our Nearest Star:  
Alpha Centauri  
4.4 ly

# The Milky Way: Our Galaxy

**Galaxy:** A huge assembly of stars, gas, and dust held together by gravity

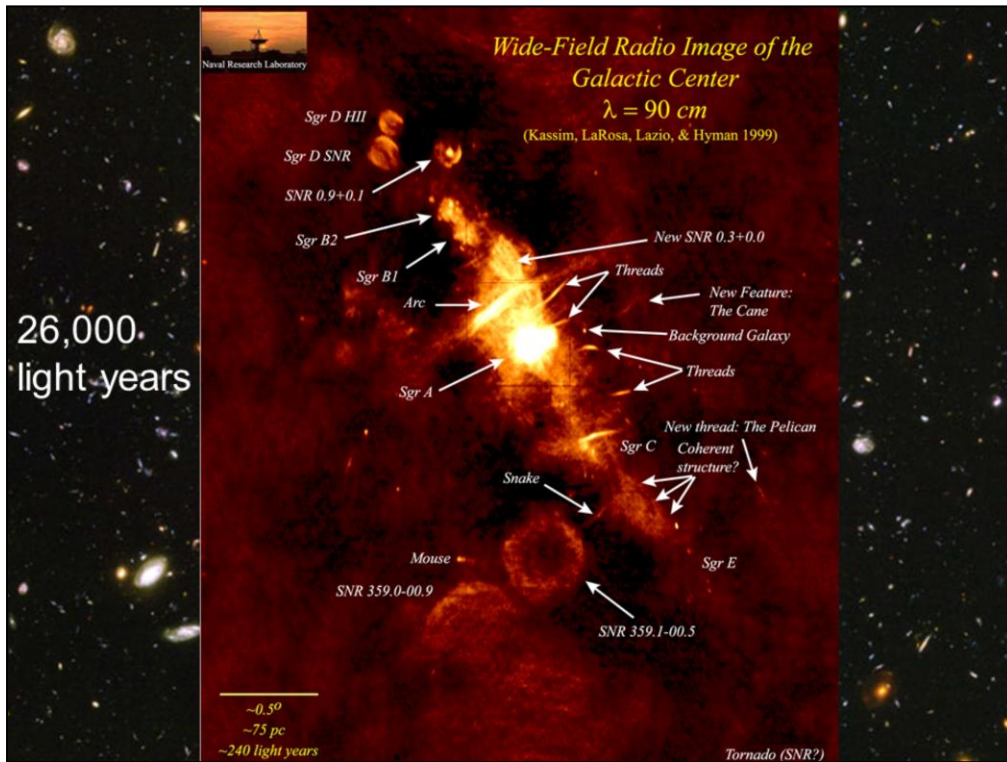


More than 100 billion  
**stellar systems**

100,000 lyr diameter

If  $R_{\text{sun}} = 1$  meter  
 $R_{\text{galaxy}} = 4.5$  AU



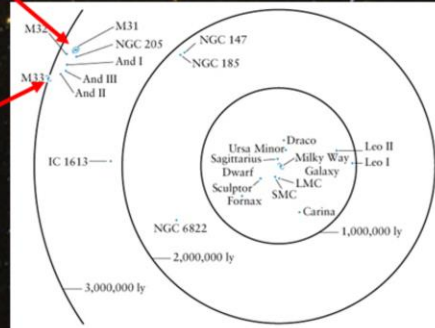


# The Galactic Neighborhood



**Andromeda:** 2.5 million lyr  
25 Milky Way diameters

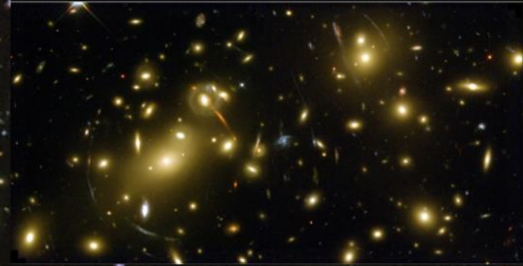
**M33:** 3 million lyr  
30 Milky Way diameters



# The Universe

**The Universe:** The collection of EVERYTHING

**The Observable Universe:**  
The collection of everything that we can SEE



The edge of the *observable universe* is approximately 14 billion light years away.

Hubble Deep Field HST WFFC2



The Universe is Really Big!!