# Planets, Stars, and Galaxies

Astronomy & Science

Presented by Daniel Sega

Based on the slides from Robert Wagner

# What Is Astronomy?

- The study of the universe and everything in it!
  - Planets & Moons
  - Asteroids & Comets
  - Stars
  - Galaxies
  - Nebulae
  - Black Holes
  - And More!

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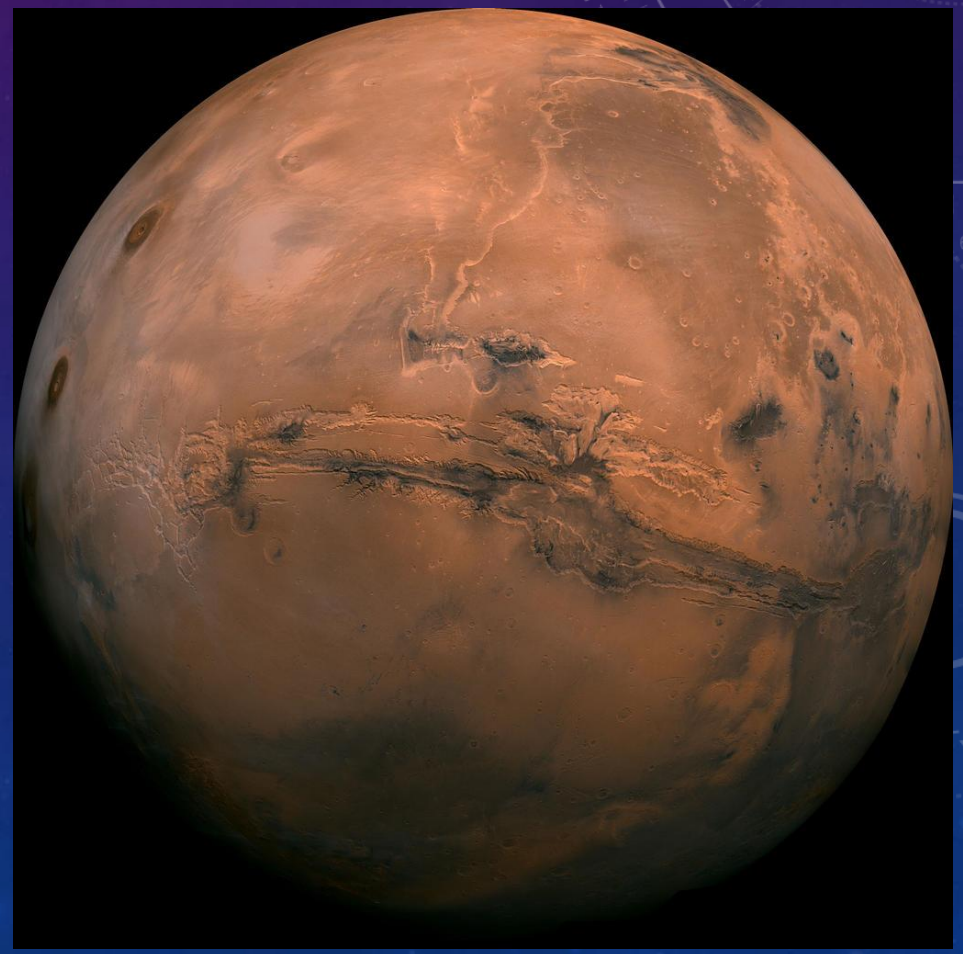

Image Credit: https://mars.nasa.gov/allaboutmars/extreme/

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Image Credit: https://www.nasa.gov/topics/solarsystem/features/watchtheskies/comet-lovejoy-ursa-major.html

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Image Credit: https://www.nasa.gov/mission_pages/hubble/science/ancient-stars.html

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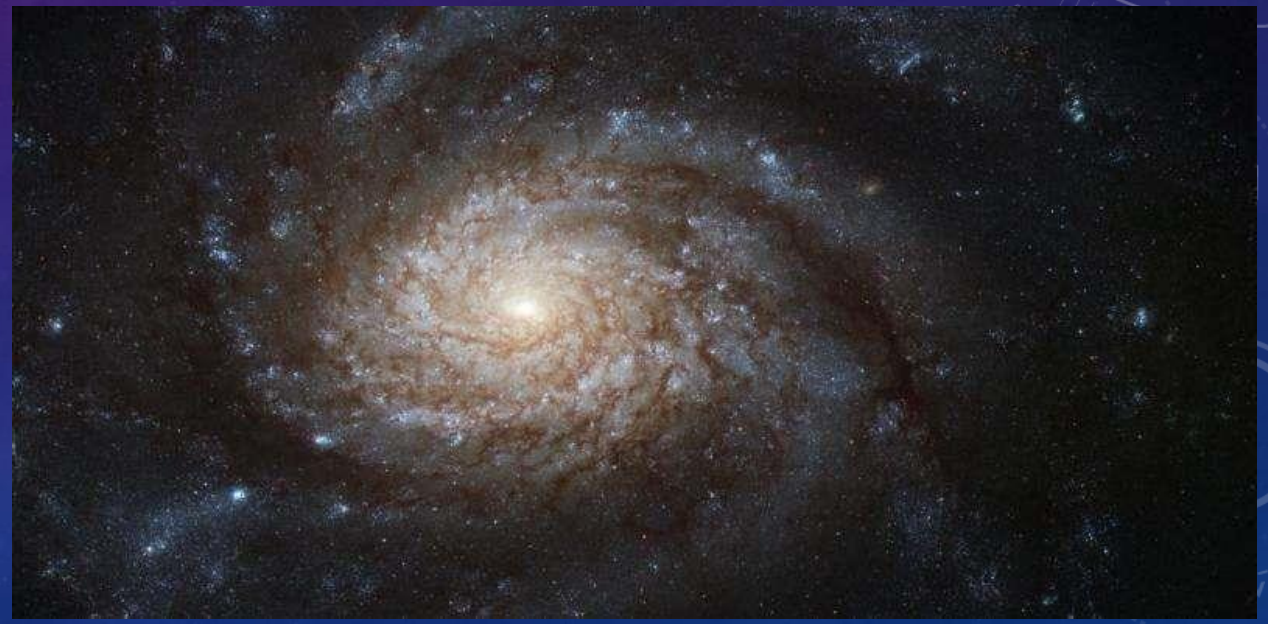

Image Credit: https://phys.org/news/2016-01-milky-galaxy-zombie-dead-dont.html

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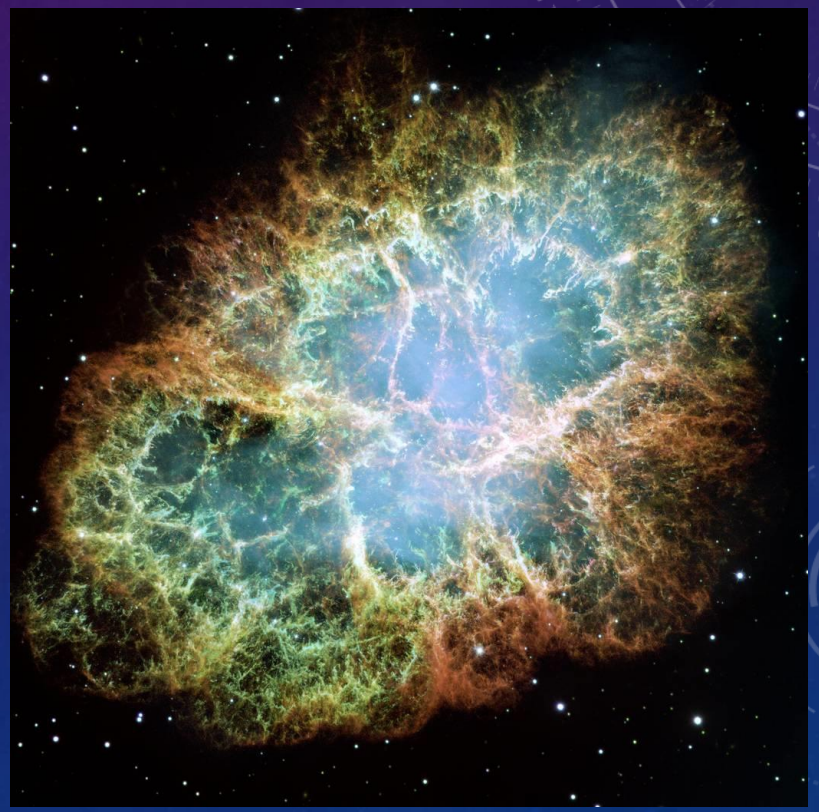

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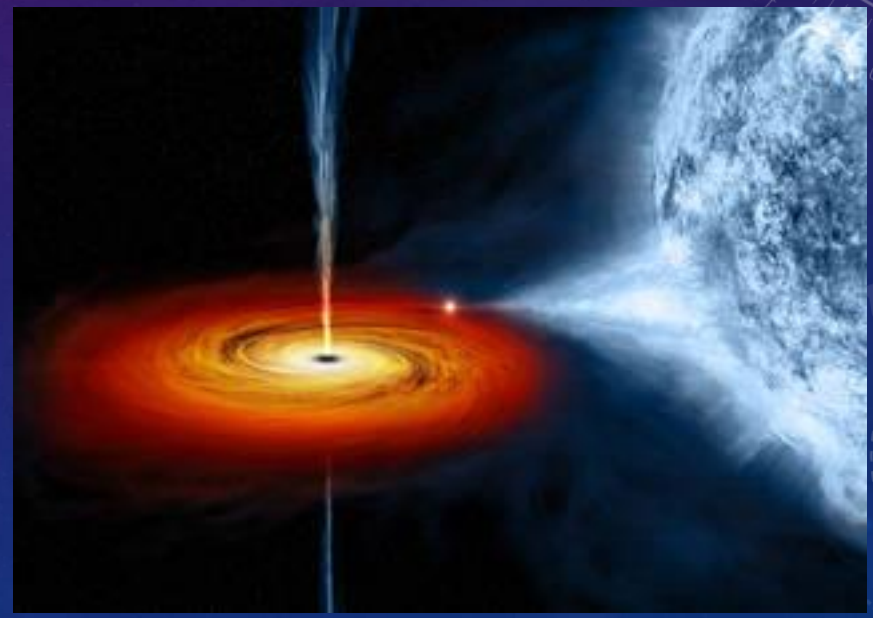


Image Credit: https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-a-black-hole-58.html

# Why Study Astronomy?

- Studying astronomy (and other sciences) teaches a way of thinking
  - Critically analyze information
  - Apply to everyday situations
  - Broader understanding of the universe and our place in it

# Scientific Thinking - Definition

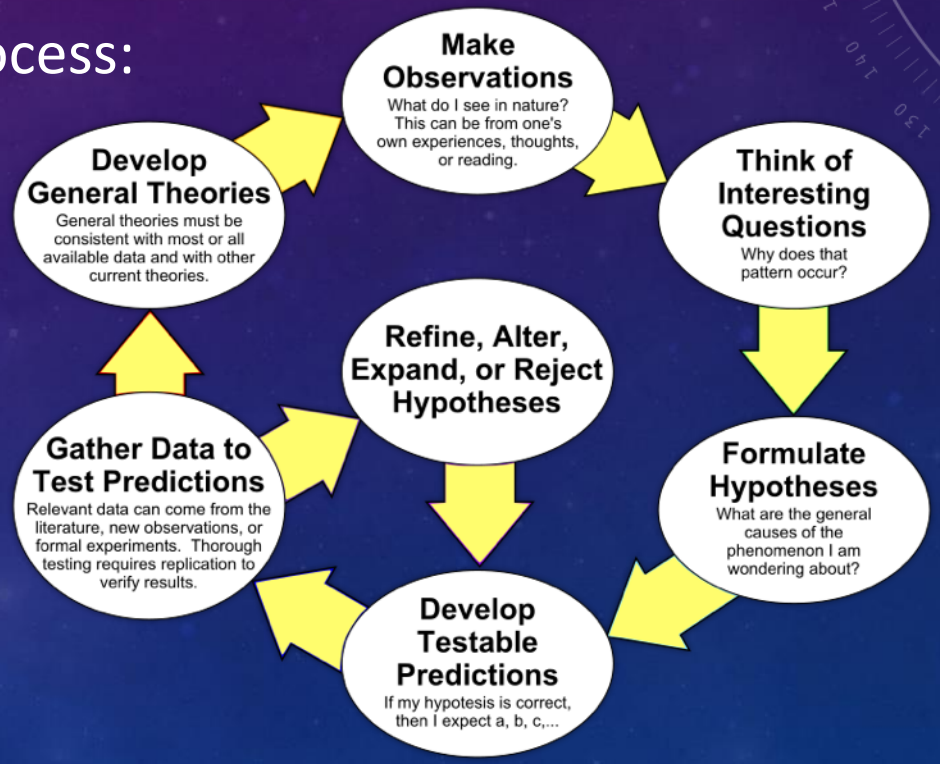
- Theory
  - Must be testable – “The Moon is made of Green Cheese!”
  - Based on observations and study
- Model
  - Simplified representation of how things work
- Hypothesis
  - Proposal to explain some observation
    - “We see the Sun rise in the East every day, therefore the Sun must orbit the Earth”

# The Scientific Method

- Starts with an observation – but never ends!
- Come up with an hypothesis to explain the observation
  - Must make a testable prediction
- Test the predictions made – make more observations
- Predictions found to be correct
  - Great! Make more predictions and continue testing
- Predictions found to be incorrect
  - Oops! Modify or reject your hypothesis

# The Scientific Method

- The scientific method as an ongoing process:



# Summary

- Astronomy is the study of the universe and everything in it
- We study astronomy to learn the scientific way of thinking
- The scientific method is a never ending process that allows scientists to continually modify, refine and improve their theories and models

# Introduction to Astronomy

Numbers and Light Travel Time

Presented by Daniel Sega

# Numbers in Astronomy

- Astronomy studies both the very large and very small
  - Numbers need to be expressed in scientific notation
    - Example – The distance from the Earth to the Sun can be written as:
      - 150,000,000 km or $1.5 \times 10^8$ km. The latter is more convenient for the vastly larger distances we will deal with!
- Scientific Notation
  - To convert a number to scientific notation, move the decimal point until there is only 1 number to the left – Count the number of places moved
    - Move the decimal point to the left – positive exponent ; to the right – negative exponent

# Scientific Notation - Examples

- Example 1:
  - 314,000,000
    - We move the decimal point to the left 8 places
    - The number becomes $3.14 \times 10^{8}$
- Example 2:
  - 0.00004563
    - We move the decimal point to the right 5 places
    - The number becomes $4.563 \times 10^{-5}$

# SI or Metric Units

- All scientific measurements are made in metric units
  - Meter for length
  - Second for time
  - Kilogram for mass

- Other units can be derived from these
  - Velocity, Density, etc.

# Distances in Astronomy

- The nearest star is 40,000,000,000,000 km from the Earth (40 trillion km!)
  - We can write this in scientific notation as $4.0 \times 10^{13}$ but it is still a number beyond our comprehension
- Astronomers use the light-year for measuring large distances
  - The speed of light in a vacuum is a constant: 300,000 km/sec
  - The light-year is the distance light travels in one year (about 10 trillion km!)
  - In light-years, the nearest star is a little over 4 light years away
    - We may not be able to comprehend the distance, but the number is now more manageable

# Distances in Astronomy - 2

- The light-year is too large to be used in the solar system
  - We use the astronomical unit (AU) to measure distances in the solar system

- The AU is defined to be the average distance between the Earth and the Sun
  - 1 AU = 150,000,000km
  - At this scale: Mars would be 1.5AU from the Sun and Neptune would be about 30AU from the Sun
- It is much easier to comprehend 1 mile than 5280 feet or 63,360 inches
- These definitions make the numbers more manageable

# Light Travel Time

- Because light does not travel infinitely fast, it takes a certain amount of time to get to us
  - The light from the Sun takes about 8.5 minutes to get to Earth
  - The light from Alpha Centauri takes about 4.3 years to get to us
  - The light from the Andromeda Galaxy to us takes about 2.5 million years to get to us
- This means that:
  - We see the Sun as it was 8.5 minutes ago
  - We Alpha Centauri as it was 4.3 years ago
  - We see the Andromeda Galaxy as it was 2.5 million years ago!

# Light Travel Time - 2

- This means we can never see any object as it is right now
- When we look out into space, we are also looking back into time
- This means we can see what objects looked like long ago

# Summary

- Scientific notation is used in astronomy to express both the very large and very small numbers that we work with
- Scientific measurements are made using SI (metric) units
- Distances in astronomy are so large that astronomers use the Astronomical Unit (AU) and light year to measure the vast distances

# Summary

- Because light does not travel infinitely fast, we never see any object as it is at this instant in time

# Introduction to Astronomy

A Tour of the Universe

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# A Trip Through the Universe!

- Let’s take a trip where we can travel as fast as we wish and are not bothered by limitations like the speed of light
- We will start with our Earth and zoom outward to the edge of the universe
- We will then zoom back in and look at the universe of the very small objects

# The Scale of the Universe

- We will use a website created by Cary and Michael Huang that allows us to scroll through both the largest and smallest scales of the universe - http://htwins.net/scale2/

- The Scale of the Universe

# The Universe is Empty!

- If the Sun were the size of a basketball, the Earth would be a pea about a hundred feet away!
- The nearest star would be a few thousand kilometers away
  - There is nothing in between except those few peas and specks of dust in the solar system!
- Our solar neighborhood would be a dozen or so basketballs each a few thousand kilometers from each other
  - Space is very empty!

# Summary

- We have seen the range of the universe, from the very large to the very small
- We have seen that the solar system and the universe are both essentially empty