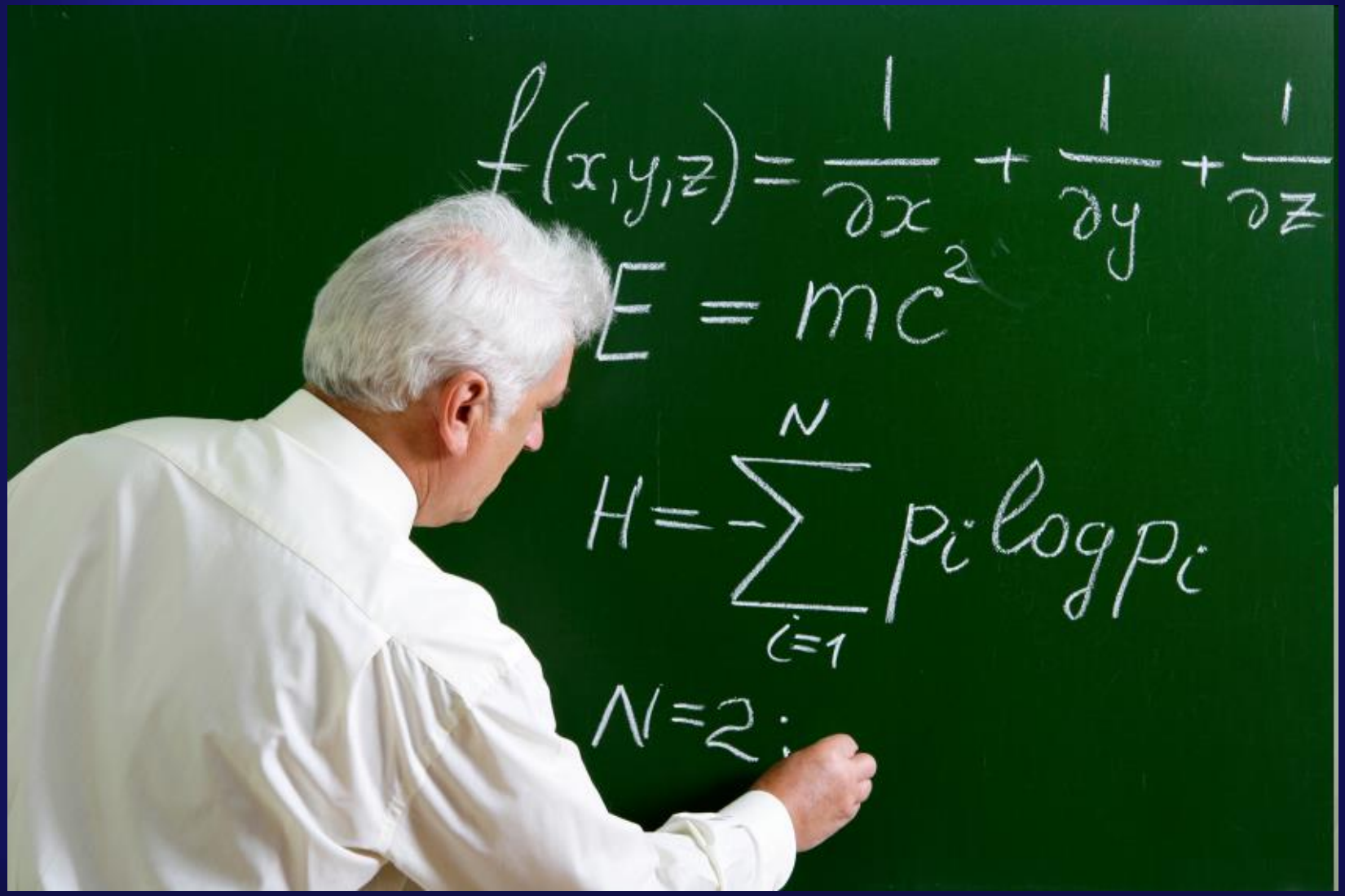
Science!


$f(x,y,z) = \frac{1}{\partial x} + \frac{1}{\partial y} + \frac{1}{\partial z}$
$E = mc^2$
$H = -\sum_{i=1}^{N} p_i \log p_i$
$N = 2$:

Overview

A. Definitions:

1. Scientific Hypothesis
2. Scientific Theory
3. Scientific Model
4. Crystalline Spheres
5. Epicycles
6. Geocentric
7. Heliocentric
8. Ellipse
    1. Focus
    2. Major/Semi-Major axis
    3. Minor/Semi-Minor axis
9. Orbital Period
10. Orbital Velocity

Overview

B. What is Science?
    1. What makes a hypothesis valid?
    2. When does Theory become Fact?
C. Our Model of the Solar System – A history
    1. What are the Models?
    2. What Observation Broke Each Model?
    3. Aristotle – Crystaline Spheres
    4. Ptolemy – Epicycles
    5. Copernicus – Heliocentric Circles
    6. Kepler – Three Laws of orbital motion

Course Goals

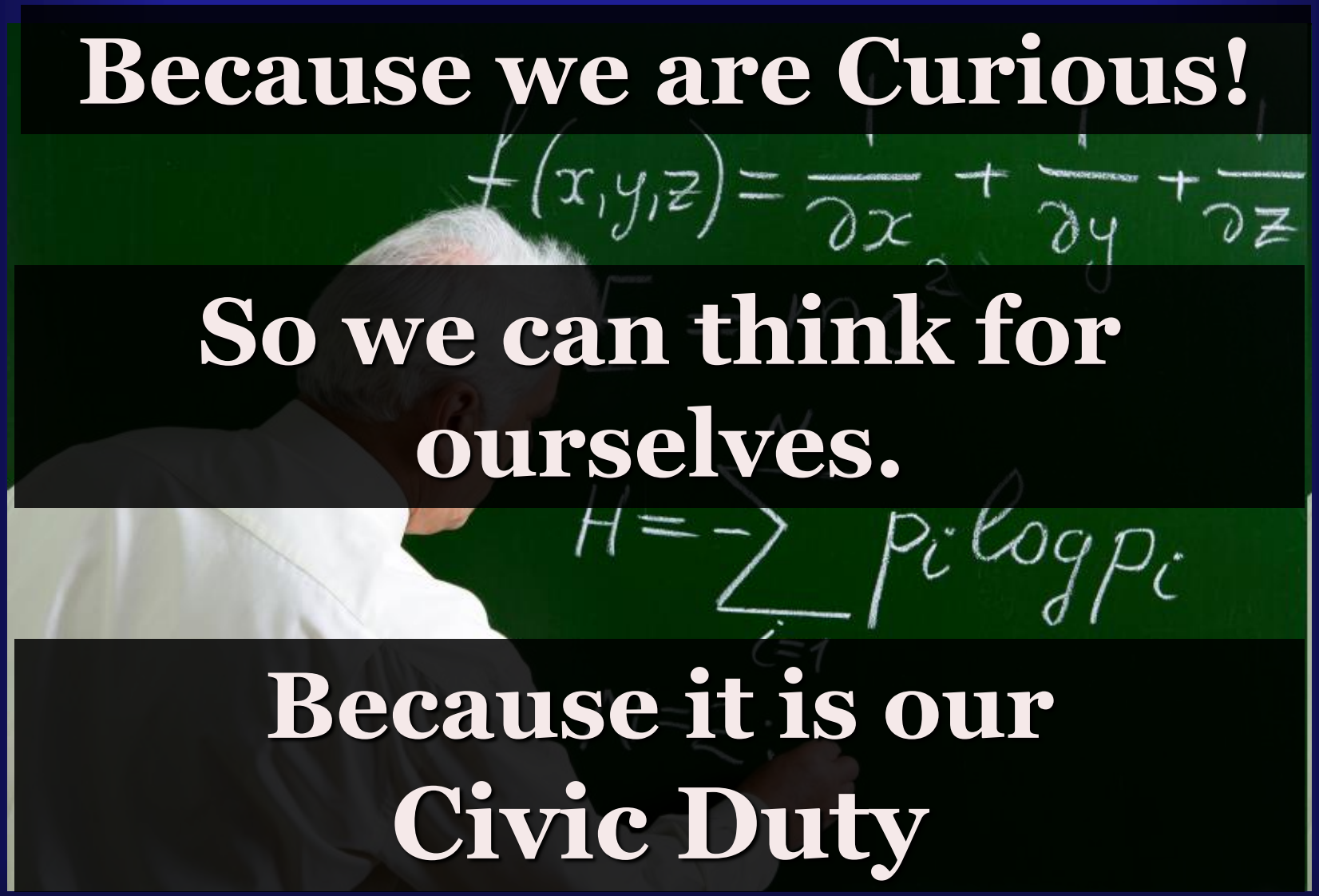
What is Science?

What is modern astronomy?

What do we know about the Universe?

How do we know what we know?

Why Study Science?



ABCD

A Scientific Theory is:

A. An explanation for natural phenomena for which little or no evidence yet exists.

B. An explanation for natural phenomena that has been irrefutably proven.

C. An explanation for natural phenomena for which there is a substantial body of experimental evidence.

ABCD

A Scientific Hypothesis is:

A. An explanation for natural phenomena for which little or no evidence yet exists.

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ABCD

A Scientific Idea becomes irrefutably "True" when:

A. The central committee for scientific ideas declares its truth.

B. The majority of scientists agree that it is true.

C. A successful experiment reveals that the idea is true.

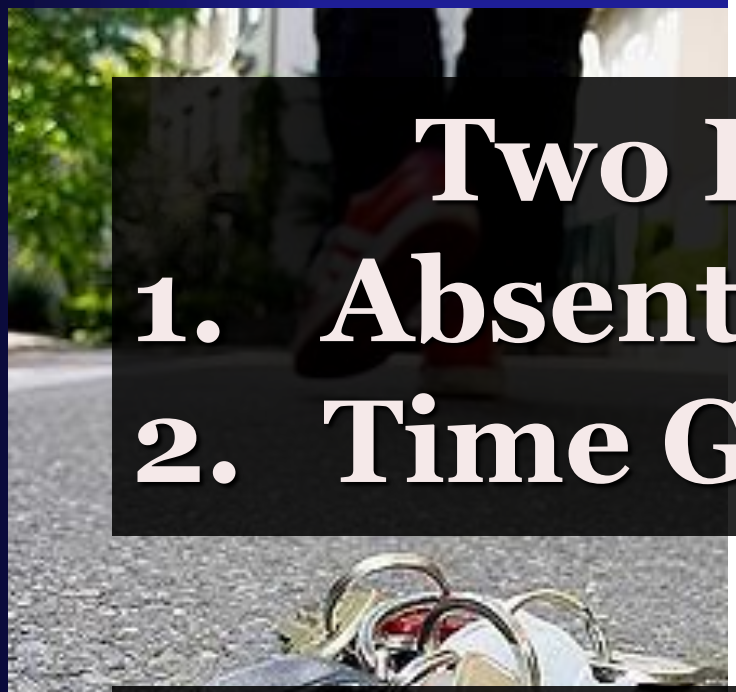
D. Never.

Scientific Hypothesis

I have a **Hypothesis!**

It's valid because it's **Falsifiable!**

Missing Keys



Two Hypothesis:

1. **Absent Minded**
2. **Time Gnomes**

Which is valid?
What is the Test?

Scientific Theory

It's **just** a theory!

Scientific theory is not mere conjecture.

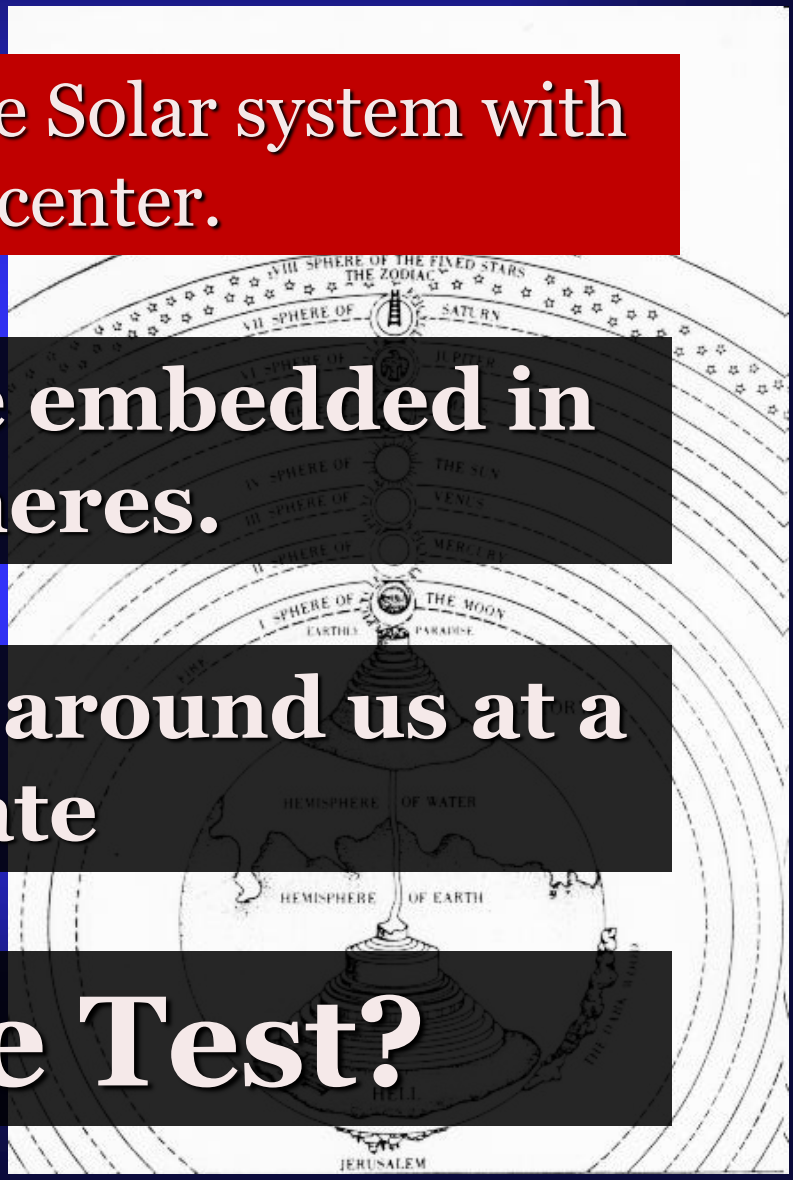
Theory: A **valid** hypothesis backed by experimental **evidence**.

A Hypothesis

Th
ar
~Aristotle

Geocentric: A model of the Solar system with the **Earth** in the center.

Celestial objects are embedded in Crystal Spheres.



Each Sphere rotates around us at a Fixed Rate

What is the Test?

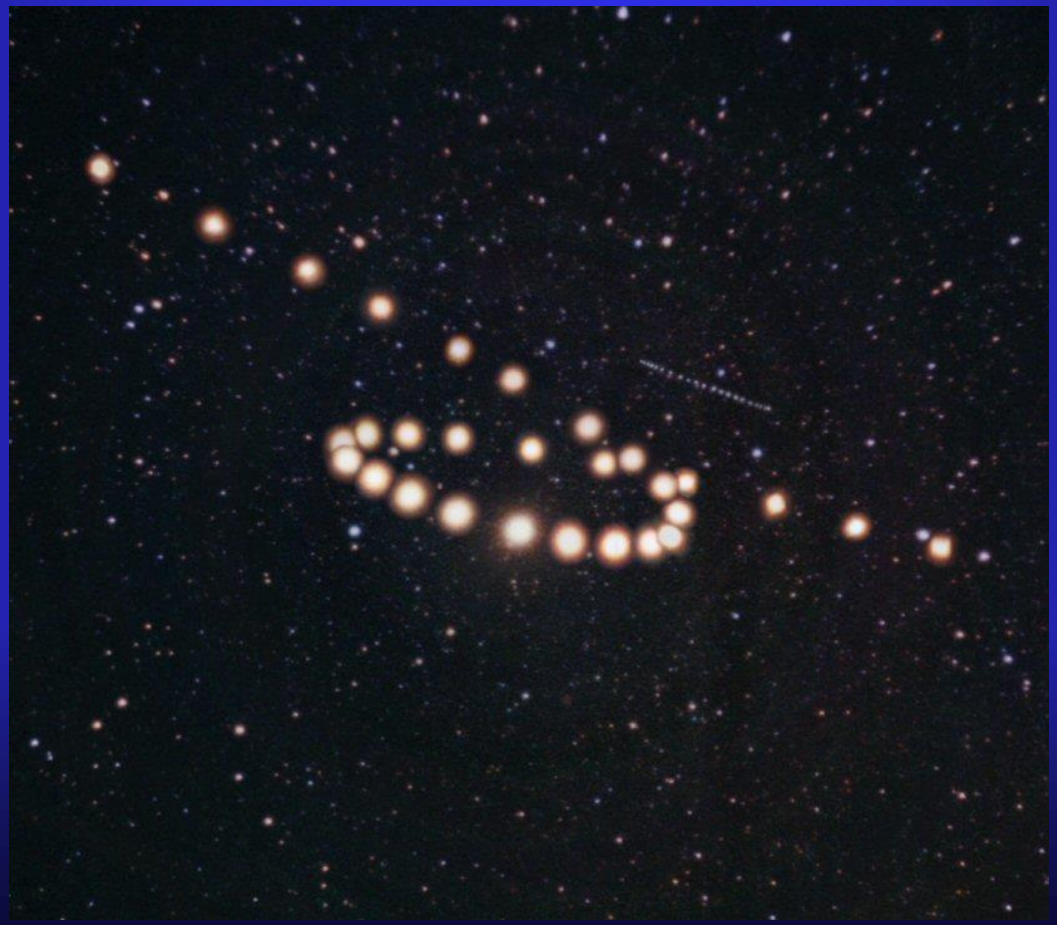
Scientific Models

The power of a model…

Is in it's ability to **Predict!**

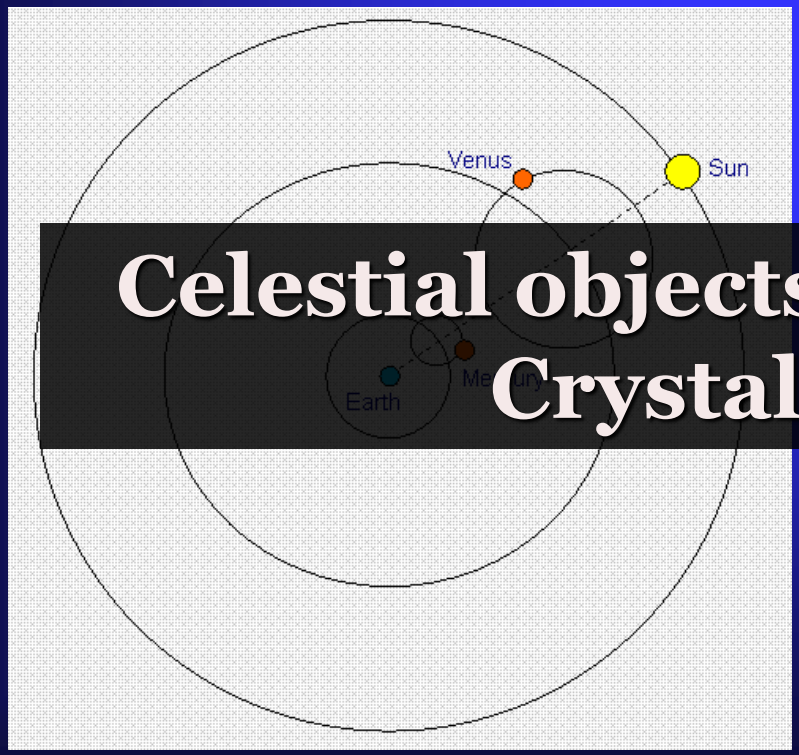
Except…

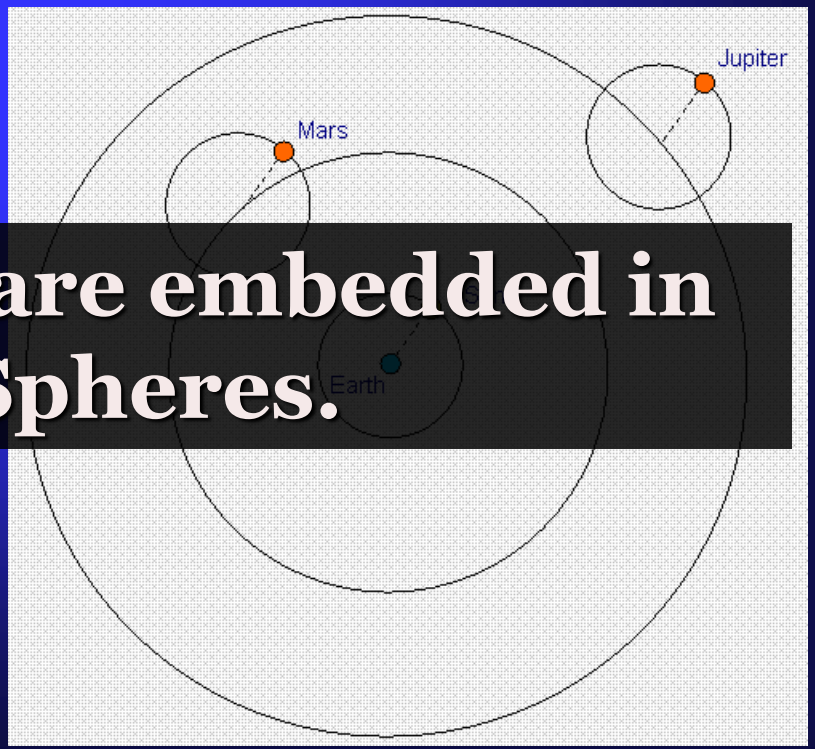
The crystal spheres can't explain *Retrograde Motion*



The Ptolemaic Model

Epicycle: A small circle, the center of which moves on the circumference of a larger circle at whose center is the earth





Celestial objects are embedded in Crystal Spheres.

An Alternative Model

Heliocentric: A model of the Solar system with the **Sun** in the center.

Nicholas Copernicus

Sun centered model, 1543

- Simple retrograde solution
- Simple orbital period calculation
- Position predictions ***still*** inaccurate.

Scientific Models

Two Models

With equal predictive power…

Which one is **True?**

ABCD

How can we absolutely choose between competing theories that make equally accurate predictions?

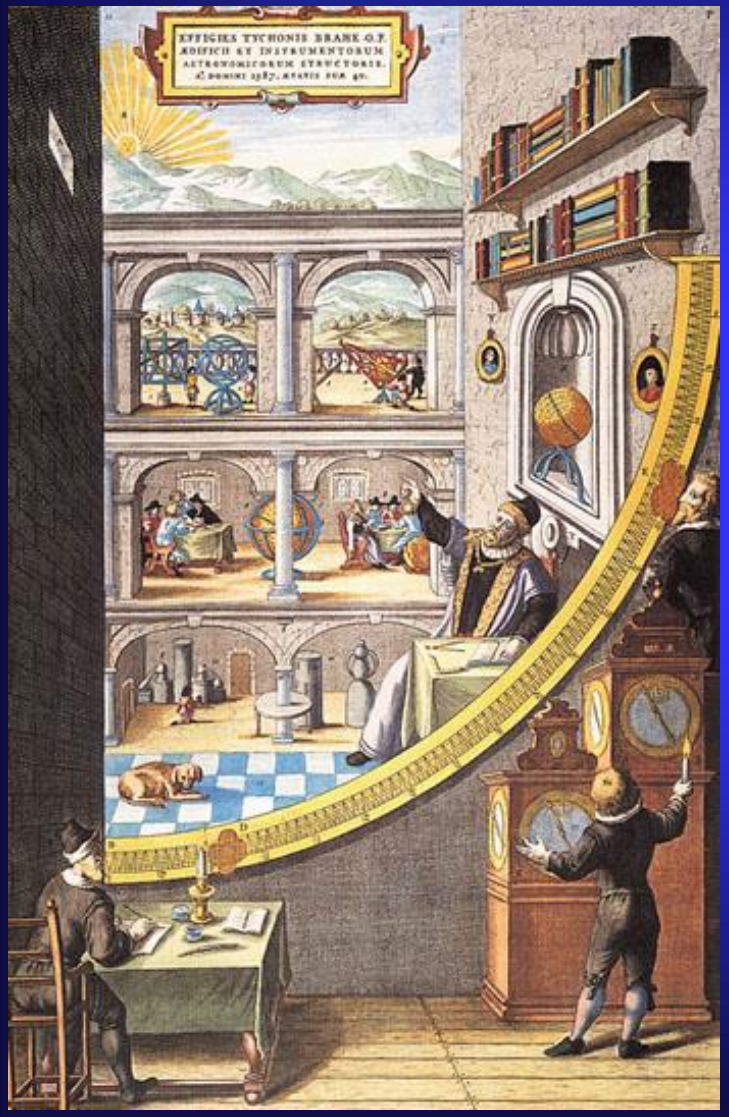
A. The least complex is correct.

B. The scientist with the most prestige wins.

C. A vote is held by the Central Science Committee.

D. There is no way to choose.

New Observations



Tycho Brahe

Took 2 decades worth of naked eye planet observations

Accuracy to within 1 minute of arc

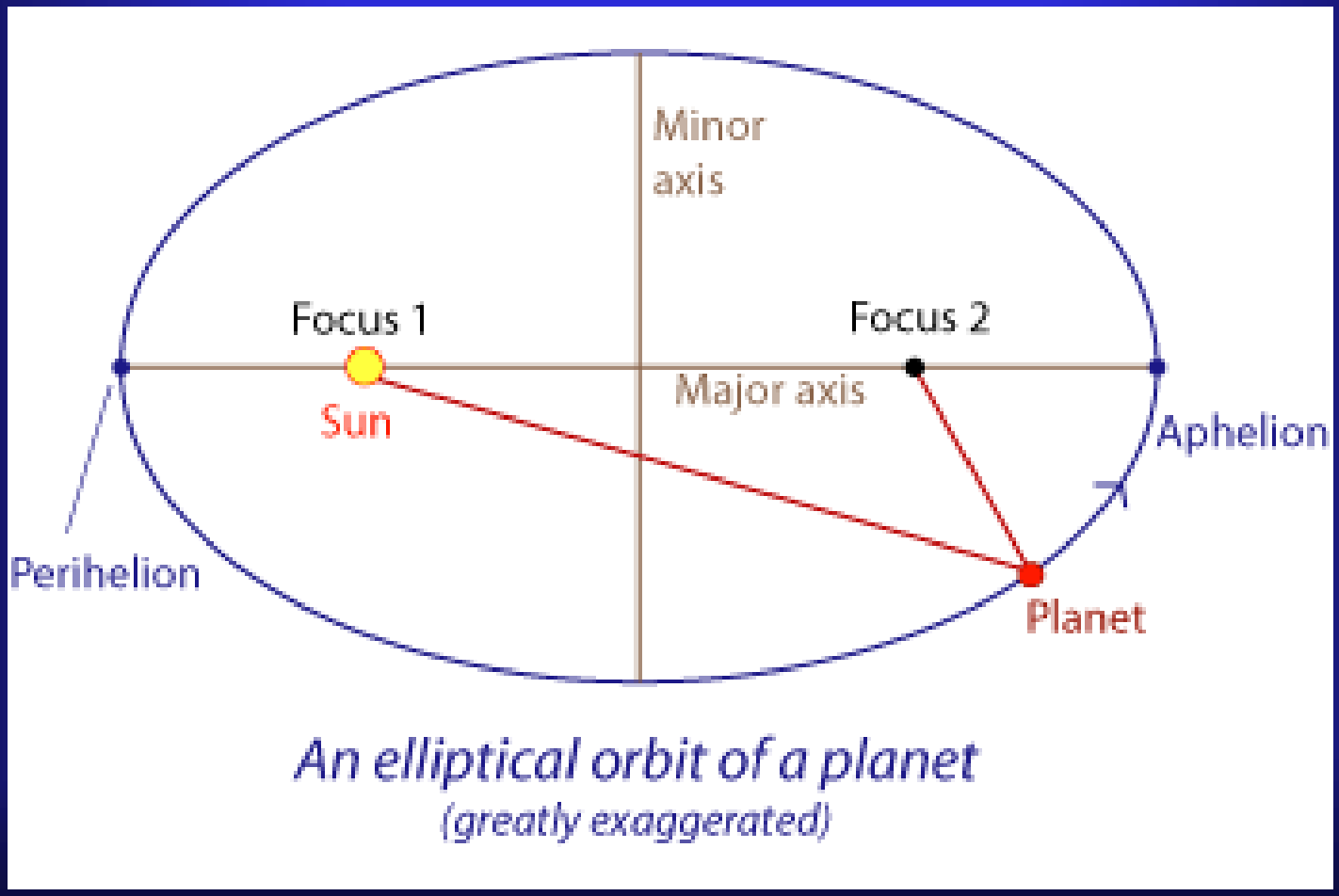
Theory

Johannes Kepler

- A student of Tycho
- Studied Tycho's data
- Discovered three **empirical** relationships
- Believed Copernicus
- Suggested that the Sun exerts a force on the planets.

Kepler's 1st Law

Orbits are ellipses



An elliptical orbit of a planet
(greatly exaggerated)

Definitions

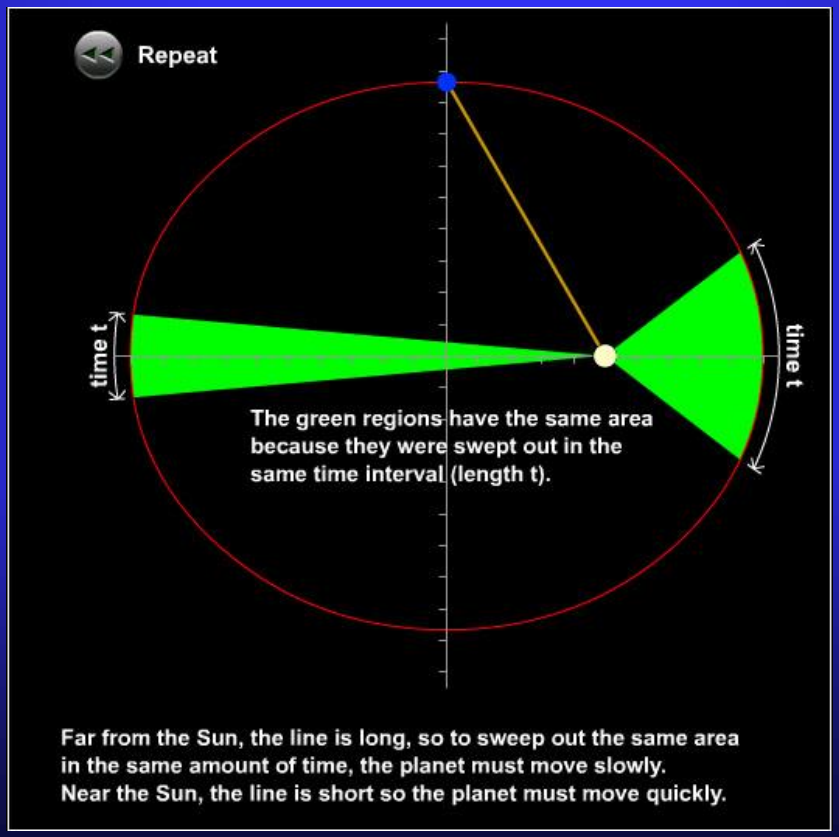
Orbital Period:
The **time** required to complete one **orbit**.

Orbital Velocity:
The **speed** of a planet in its orbit.

Kepler's Second Law

Kepler's 2nd Law:

A line joining a planet and the Sun sweeps out equal areas during equal intervals of time.



What?

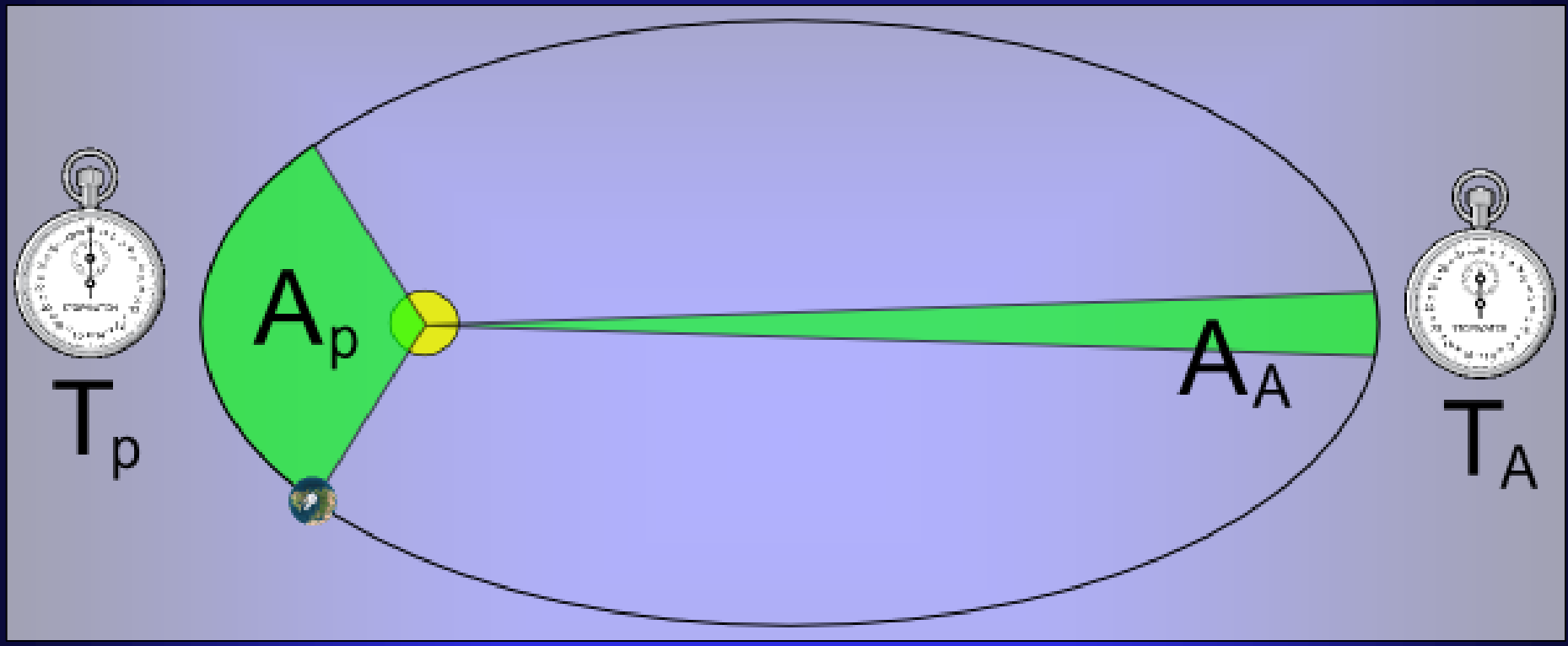
Kepler's 2nd Law:
A line joining a planet and the Sun sweeps out equal areas during equal intervals of time.

Which is true?

A. Fast a Perihelion, Slow at Aphelion
B. Slow at Perihelion, Fast at Aphelion
C. Same speed

Why? Make an argument.

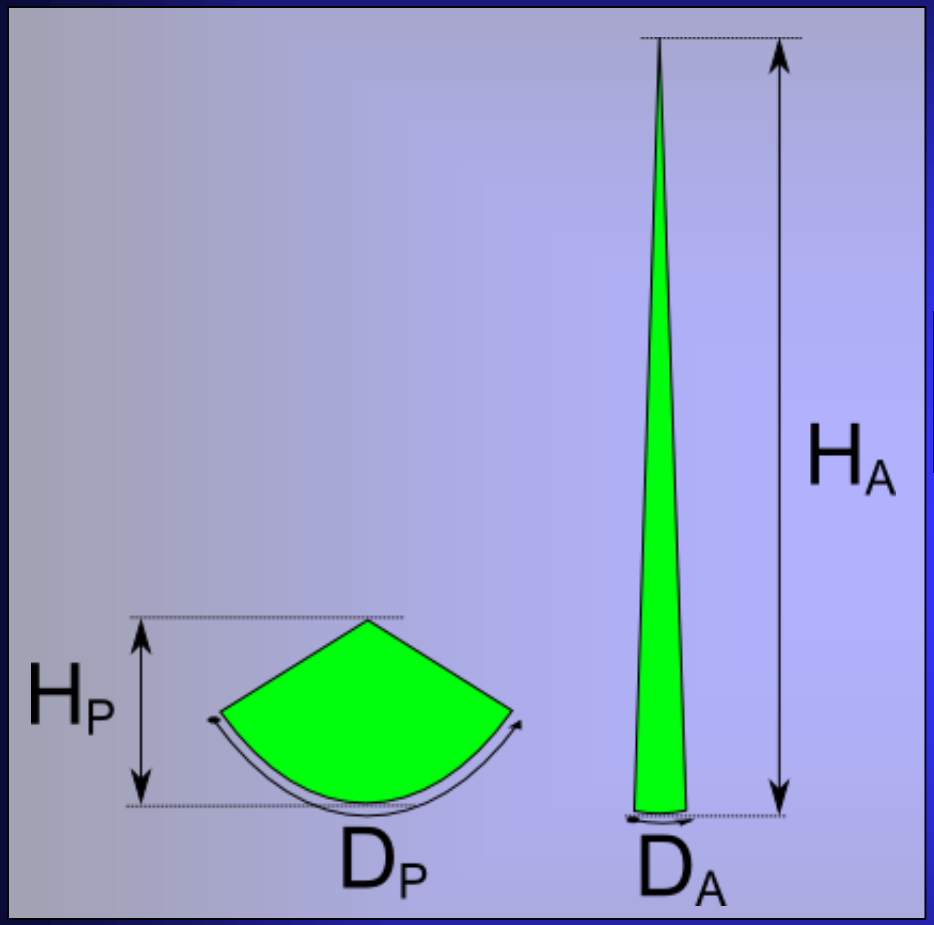
Kepler's 2nd Law



If: $T_P = T_A$

Then: $A_P = A_A$

Kepler's 2nd Law: What?

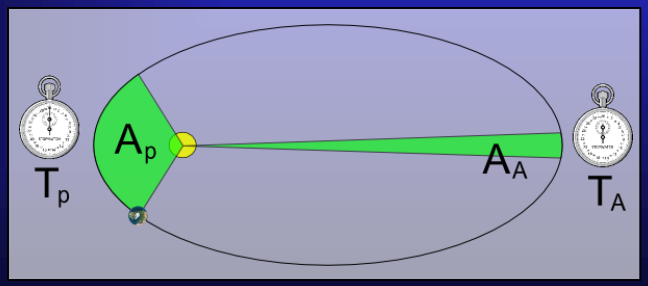


If: $A_P = A_A$

And: $H_p < H_A$

Then: $D_p > D_A$

And: $V_p > V_A$



ABCD

If all planets had the same orbital velocity, which would have the longest year?

A. Earth

B. Mars

C. Pluto

D. Their years would be the same length

ABCD

If all planets had the same period, which would have the longest year?

A. Earth

B. Mars

C. Pluto

D. Their years would be the same length

ABCD

If all planets had the same period, which would have the highest orbital velocity?

A. Earth

B. Mars

C. Pluto

D. Their years would be the same length

Kepler's 3rd Law

$$P^2 = a^3$$

a = Semi-major axis

P = Orbital Period

ABCD

When must a Scientific Theory die?

A. When the people who believe it die.

B. When enough scientists think that it should die.

C. Popular Vote.

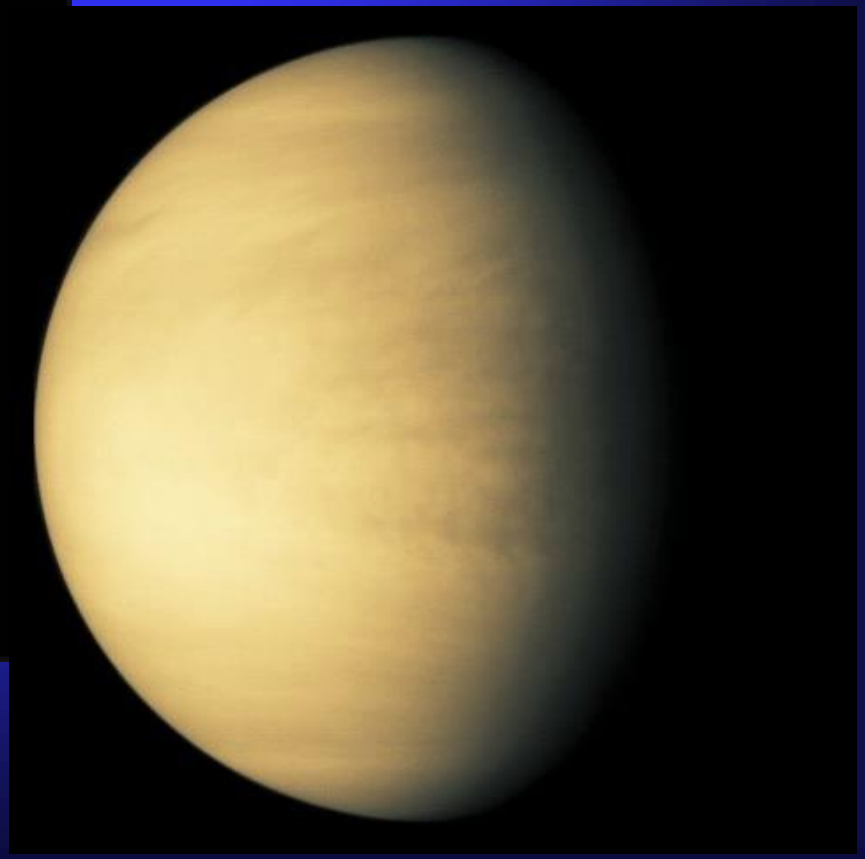
D. When it makes predictions that don't agree with nature.

The End of Geocentrism … ?

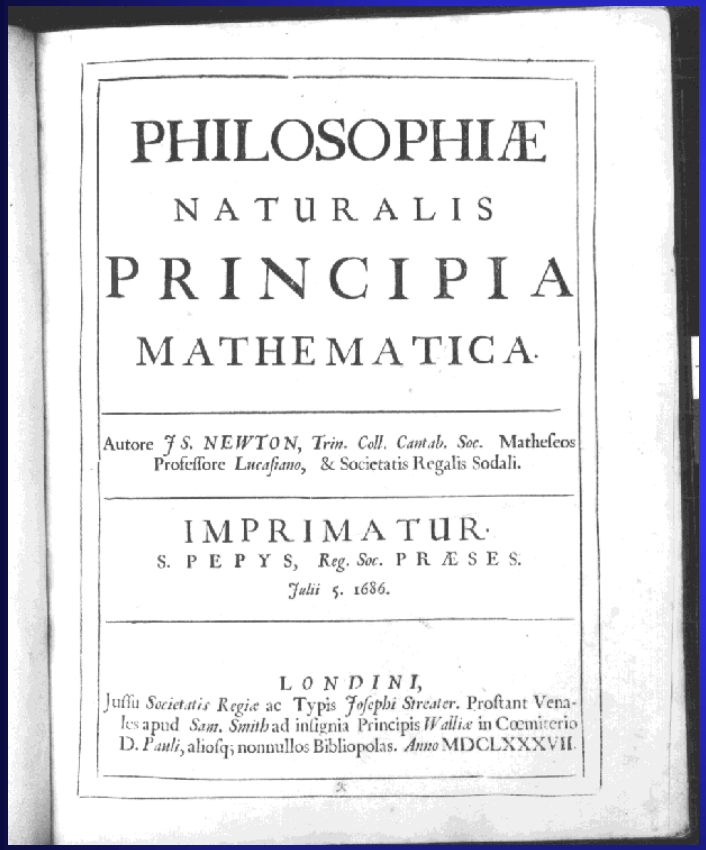
Mountains and Sunspots

Moons of Jupiter

Phases of Venus



The Rise of Modern Physics



PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore *J. S. NEWTON, Trin. Coll. Cantab. Soc.* Matheseos Professore *Lucasiano*, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, *Reg. Soc.* PRÆSES.
Julii 5. 1686.

LONDINI,
Jussu *Societatis Regiæ* ac Typis *Josephi Streater*. Prostant Venales apud *Sam. Smith* ad insignia Principis *Walliæ* in Coemiterio D. *Pauli*, aliosq; nonnullos Bibliopolas. *Anno* MDCLXXXVII.

Isaac Newton

- Three laws of motion
- Universal Gravitation
- The Calculus

Simple central principals from which all motion, either on Earth or in the heavens, can be derived.