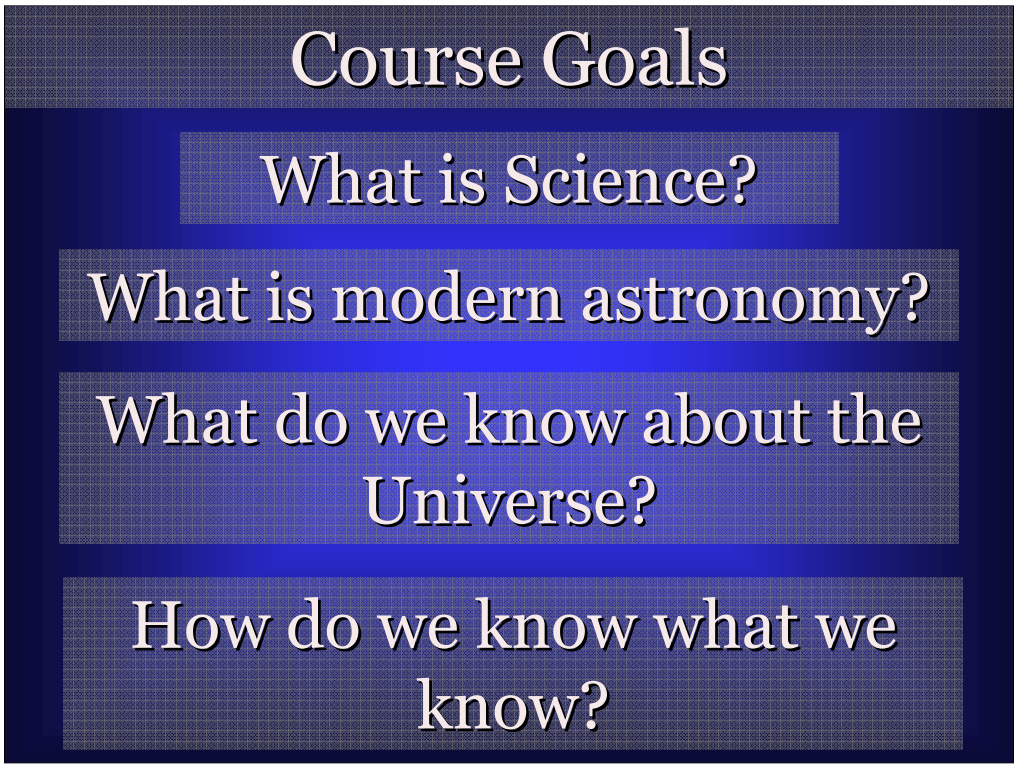


One of the main themes of this course is to answer the question:

What is Science?

At the same time, we want to answer the questions

"What ISN'T Science?"

What is science capable of?

What is it NOT capable of?

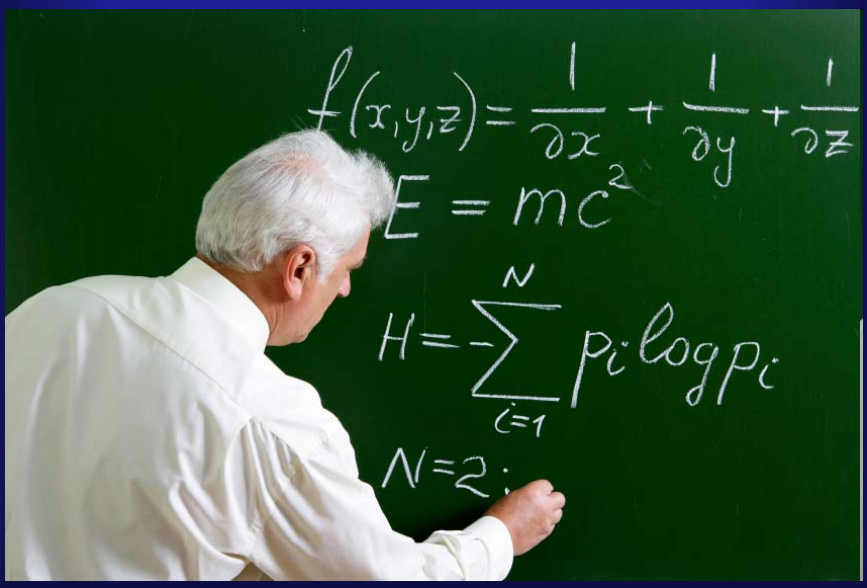
I want to paint a picture of what modern astronomy is.

How exactly do we study astronomy?

I also, of course, want to tell you what we know about the Universe.

But, I also want you to see HOW our modern view of the universe came into being.

Why Study Science?



Science gives us many things.

It improves the length and quality of our life by providing tools and technologies.
It allows us to understand our world, the universe, and our place in each.
It satisfies our innate curiosity and fulfills our spirit of exploration.

Why should we study science?

We need to learn to think rationally. We shouldn't just take what we're told by "authorities" as gospel. We should think critically about what we're told.

To think critically about messages from the scientific community, we must understand something about how the scientific community does business.

We are stewards of this planet and it's critical that we understand the consequences of our actions.

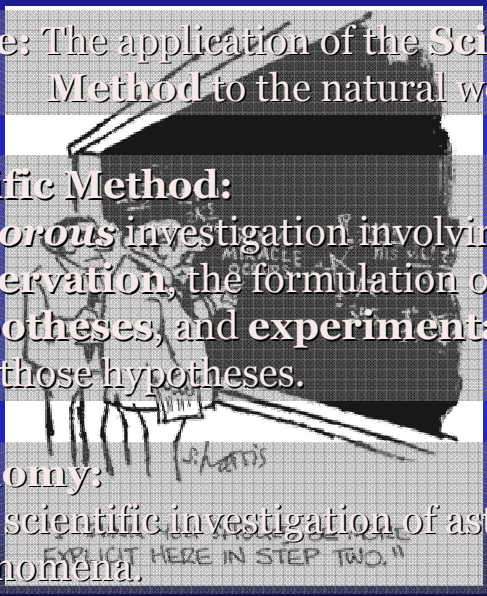
Science cannot progress without the support of an informed public.

Science

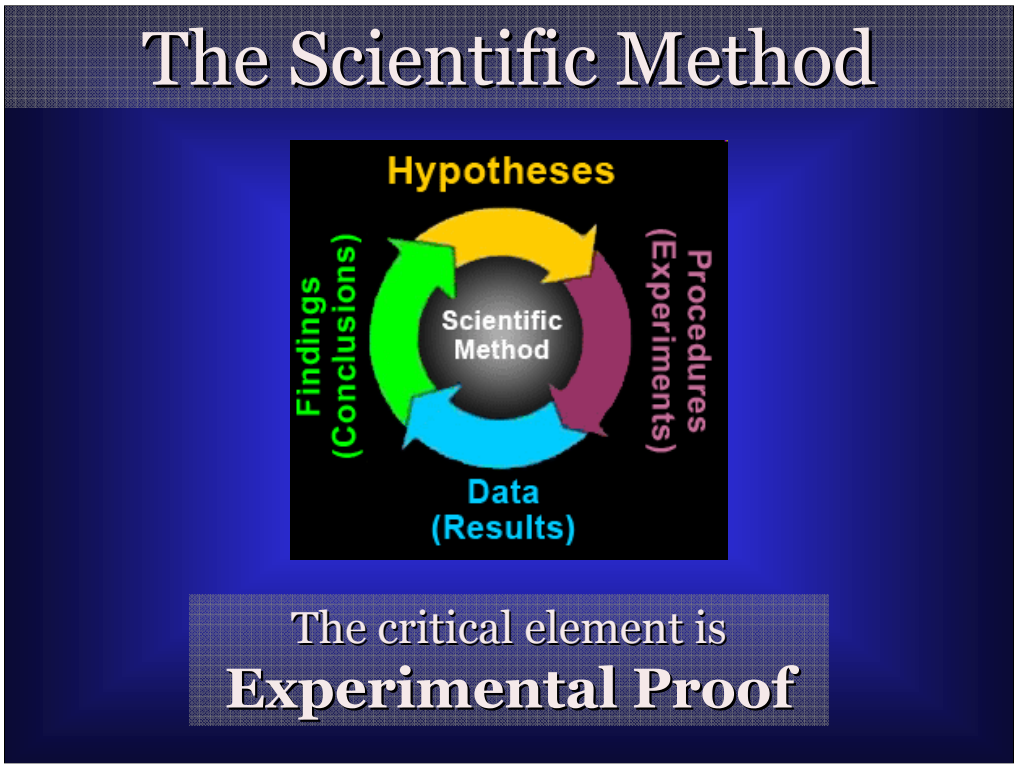
Science: The application of the **Scientific Method** to the natural world.

Scientific Method:
Rigorous investigation involving careful **observation**, the formulation of **hypotheses**, and **experimentation** to test those hypotheses.

Astronomy:
The scientific investigation of astronomical phenomena.



What exactly IS science?



We observe a phenomena in nature and develop a hypothesis.

For this hypothesis to be valid, it must be TESTABLE.

Scientific Theory

It's **just** a theory!

Scientific theory is not mere conjecture.

Once a hypothesis has the backing of experimental proof it achieves the status of a Scientific Theory.

If proof comes from several different lines of investigation.

Missing Keys

Absent-Minded Professor Says Cure For Cancer 'Around Here Somewhere'

ENLARGE IMAGE

The cure, involving "smart enzymes" that locate and surround cancerous and anaplastic cells, effectively "suffocating" them, was the result of 28 years of research by the comically forgetful Huggins and his cancer research team at Johns Hopkins.

Sorting through a three-foot-high stack of papers in his living room, Huggins said of the revolutionary cure, "I remember sticking something in here a couple of days ago... I think it might have been the cure."

"Hundreds of thousands of experimental solutions over the last three decades were

Prof. Humbert E. Huggins has lou
over his office, but has not yet b
to find the cure for cancer. He s
the key to eradicating the disea
"in a bag back under my dining roo

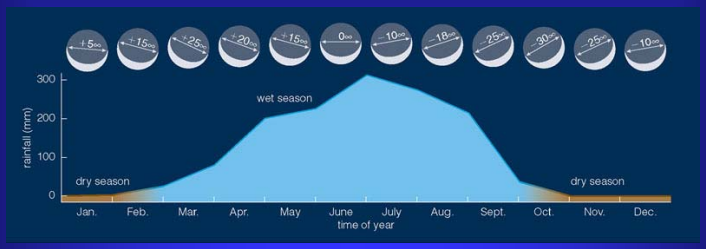
Group Discussion

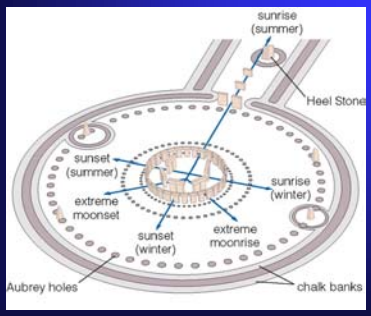
Ancient civilizations used celestial events for several purposes including:

Telling the Time.

Egyptian sundial
Sundial at Knowth, North of Dublin in Ireland
Sundial at the Emperor’s Palace in Beijing

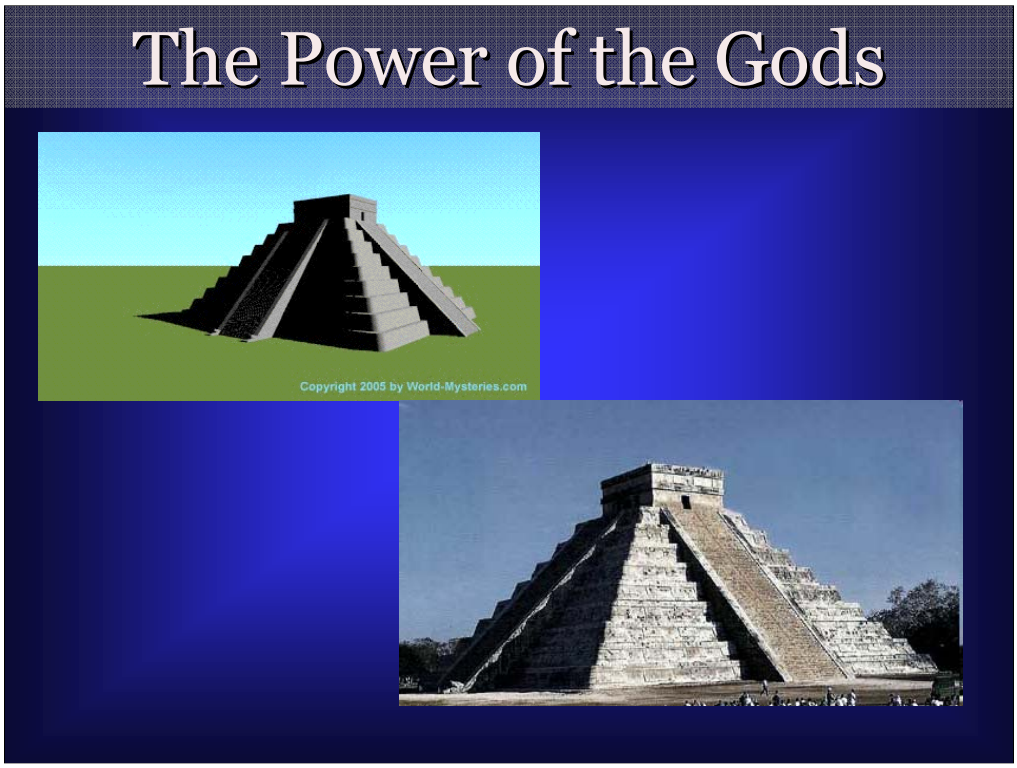
Predicting the Seasons





Predicting the seasons for agricultural use.

Moon crescents used in central Africa around 6500bc to predict the weather.



In their religious practice.

The Greeks created theoretical models to explain natural phenomena.

As far as we know, they were the first to do this.

(at least the Western world calls Greece the birthplace of modern science)

They were adept mathematicians, engineers, and philosophers

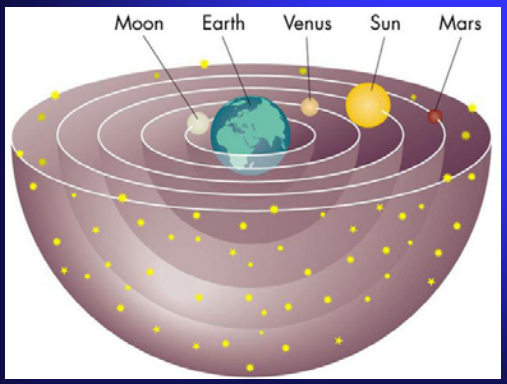
They brought us the idea of the University.

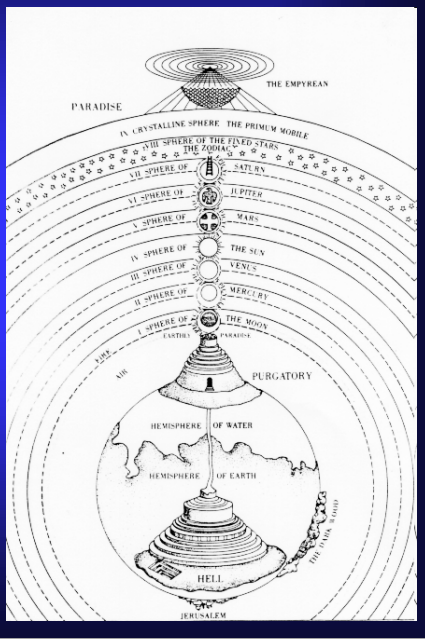
The image on the right is the Antikythera device, a Greek astronomical computer.

This isn't what I mean by "model"

A Hypothesis

The heavens are perfect and unchanging.
~Aristotle





Aristotle believe that one could sit around and simply THINK about nature and understand it.

Aristotle really believed that the heavens consisted of crystalline spheres.

Everything was “perfect” things moved in perfect circles.

The Earth was the realm of the imperfect and impermanent.

Aristotle’s spheres could not explain retrograde motion the apparent “backwards” motion of a planet against the background stars.

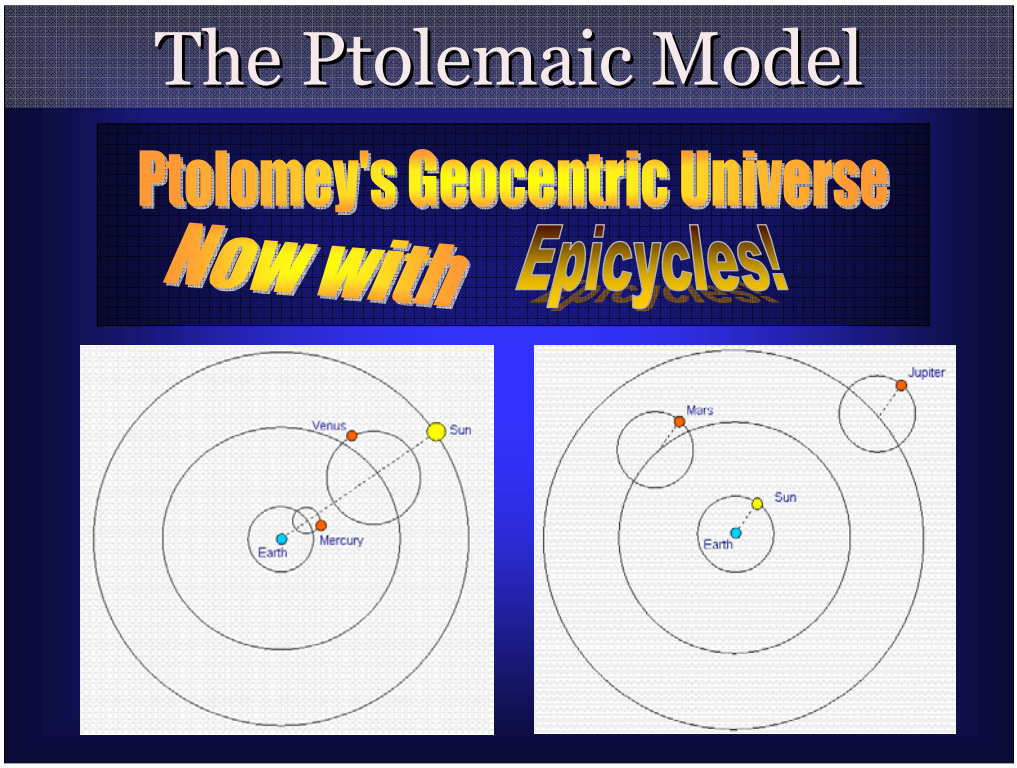
It was pretty lousy at making accurate predictions.

Except…

The crystal spheres can't explain *Retrograde Motion*

Aristotle's spheres could not explain retrograde motion
the apparent "backwards" motion of a planet against the background stars.

And, it was pretty lousy at making accurate predictions.



The Ptolemaic model is the first solar system model to attempts to accurately predict planetary positions.

By adjusting the rates of each main orbit (deferent) and

each epicycle, the model could be tuned to fit observations

Ptolemy is REDICULOUSLY complex.

It took a team of mathematicians many years to complete a table of predictions using this framework.

An Alternative Model

Ptolemy is now noticeably inaccurate

Nicholas Copernicus

Sun centered model, 1543

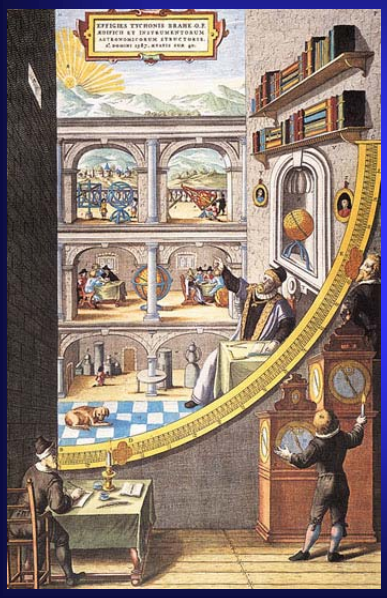
- Simple retrograde solution
- Simple orbital period calculation
- Position predictions ***still*** inaccurate.

Scientists were faced with recalculating Ptolemy's tables or trying something new.

Still used circular orbits but put the Sun at the center.

Copernicus's system was as inaccurate as Ptolemy's but MUCH simpler to calculate

New Observations



Tycho Brahe

Took 2 decades worth of naked eye planet observations

Accuracy to within 1 minute of arc

ABCD

What was different about Ptolemy's model versus Aristotle's?

A. The spheres were glass, not crystal

B. The Sun is at the center, not the Earth.

C. He included EPICYCLES

D. Some of the crystal spheres went backwards.

Why wasn't Copericus's model immediately accepted as truth?

A. Don't be silly, it was a SMASH hit!

B. It's ***predictions*** were only as accurate as Ptolemy's but no better.

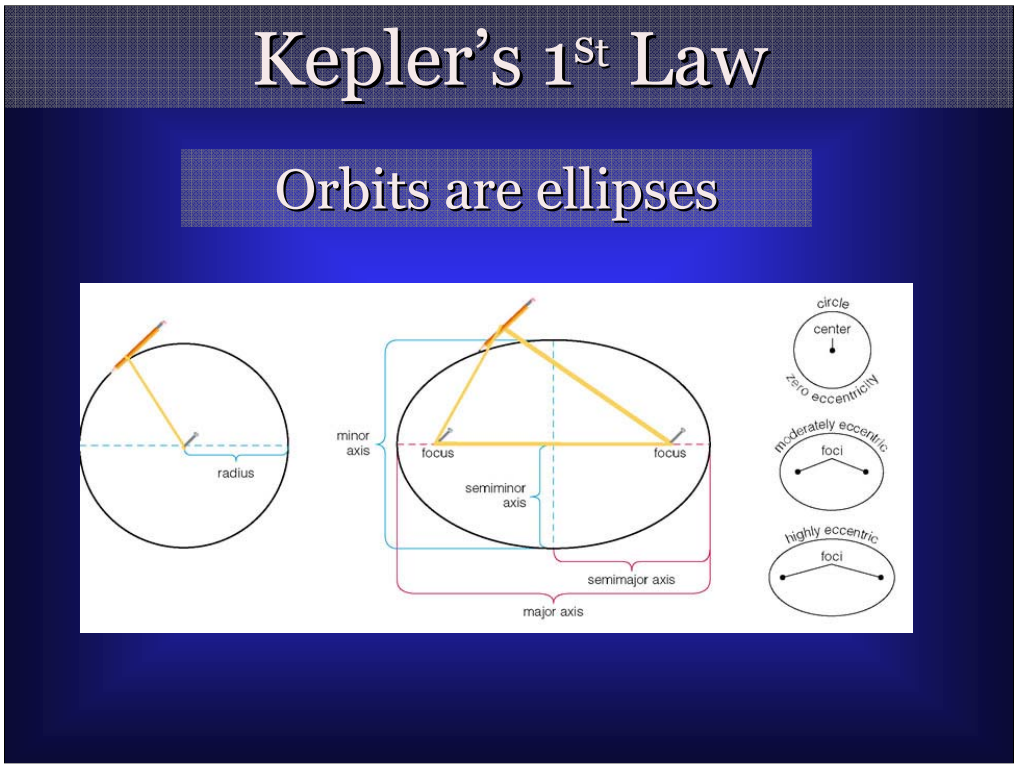
C. Copernicus was just not well liked.

D. It's ***predictions*** were MUCH worse than Ptolemy's.

Theory

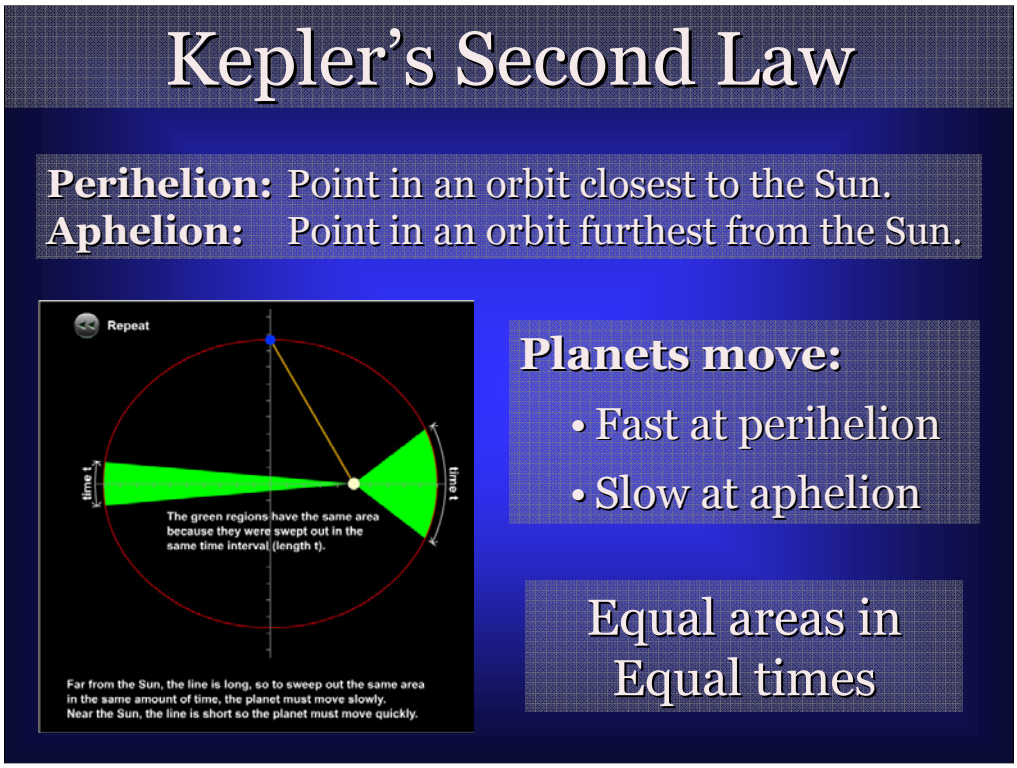
Johannes Kepler

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



A CIRCLE is a special kind of ellipse whose MAJOR and MINOR axis are equal.

The ECCENTRICITY of an ellipse



Kepler's Second Law says:

A planet in its orbit moves FAST at perihelion
and SLOW at aphelion.

Kepler's Third Law

$$P^2 = a^3$$

The harmonic law:
A precise mathematical relationship between the **orbital period** and the semi major axis.

Orbital Period:
The time required to complete one orbit

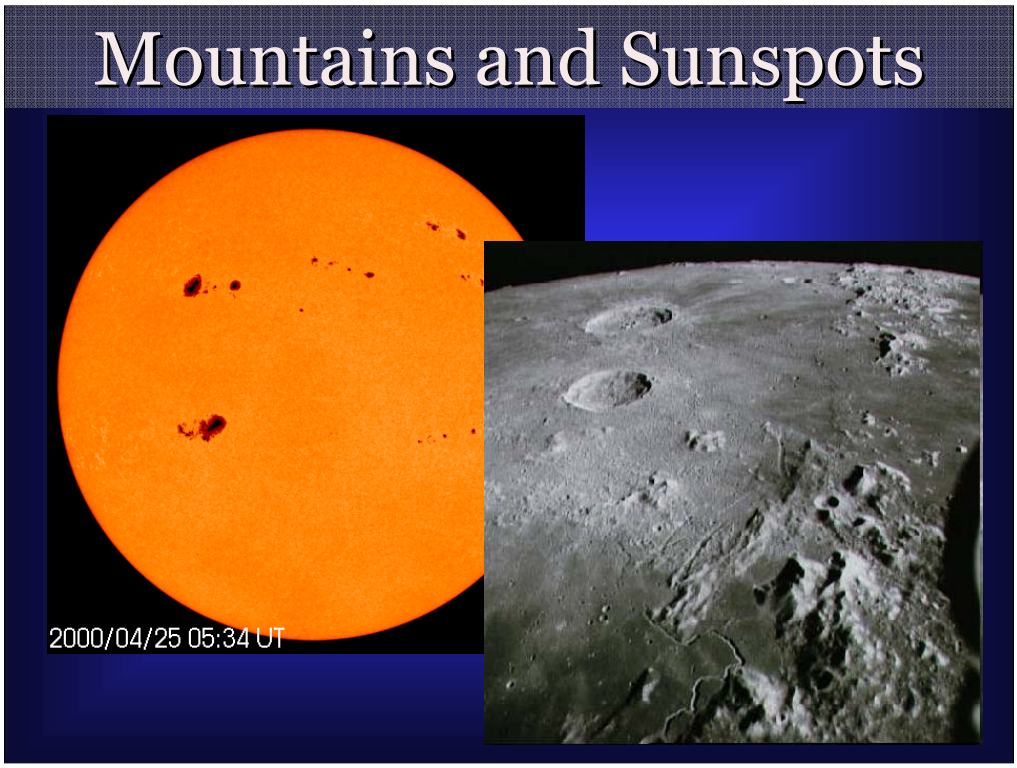
Kepler's Third Law says:

Planets far from the Sun have longer orbital periods than planets close to the Sun.

Pluto takes MUCH longer to go around the Sun than the Earth

The End of Geocentrism … ?

Galileo in trouble.



Aristotle says:

The heavens are perfect and unchanging.

The Sun, the Moon, the planets, and the stars are perfect spheres.

The Earth is the realm of the imperfect

Galileo observes:

The moon's surface is much like the Earth's with mountains, canyons and Craters.

The Sun has sunspots that come and go

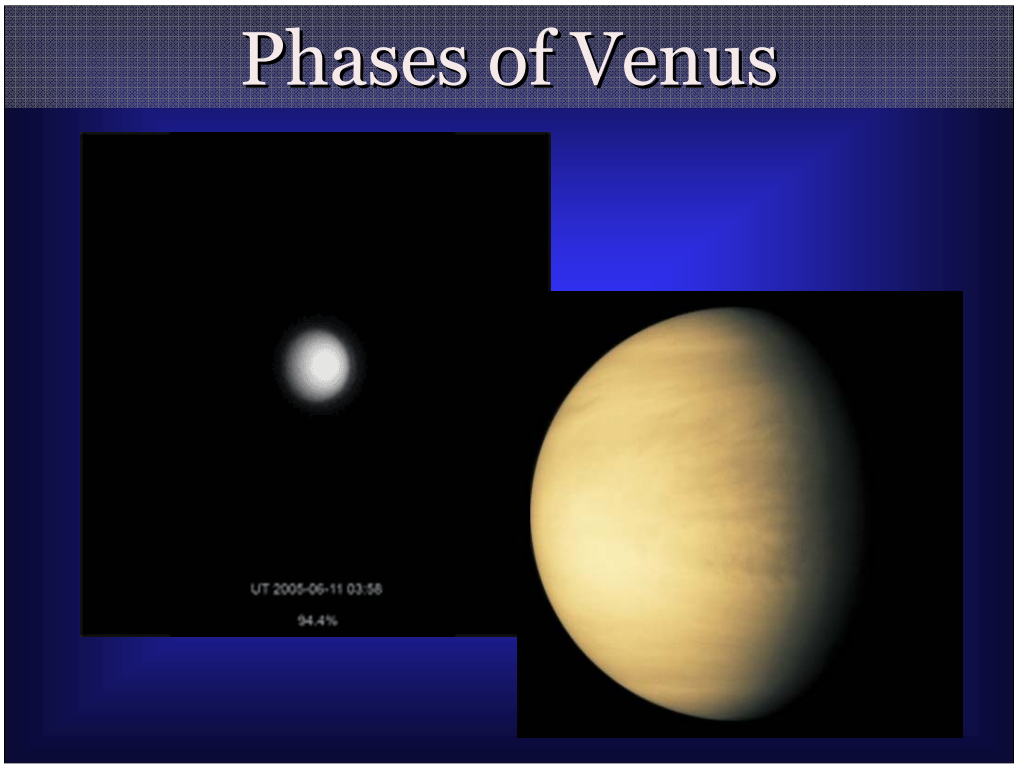
Aristotle says:

The Earth is at the center and EVERYTHING goes around it.

Galileo observes:

Jupiter has satellites of its own.

These “moons” are NOT going around the Earth



This is the KILLER observation.

Aristotle says:

The Earth is at the center and EVERYTHING goes around it.

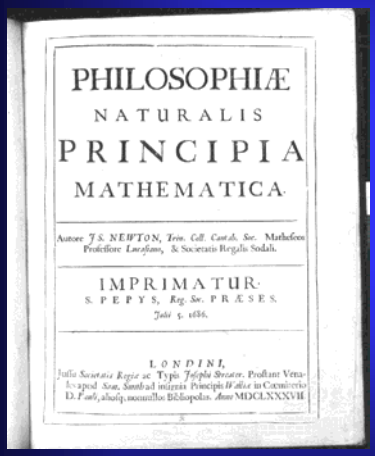
Galileo observes:

Venus and the Earth's Moon have phases.

The only plausible explanation is that Venus and the Earth orbiting the Sun

AND the orbit of Venus is interior to the orbit of Earth.

The Rise of Modern Physics



PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA

Autore Is. 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 Cœmeterio D. Pauli, aliasq; 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.