How are galaxies important to our existence?

ANSWER:

- ○ Without galaxies, there could not have been a Big Bang.
- ○ Galaxies provide the gravity that prevents us from falling off Earth.
- ○ Without galaxies, the universe could not be expanding.
- ○ Galaxies prevent planets from leaving their orbits around stars; e.g., our galaxy prevents Earth from leaving its orbit of the Sun.
- ◉ Galaxies recycle heavy elements produced in stars into future generations of stars.

Answer Stats:	Students	% Correct	% Unfinished	% Req'd Solution	Wrong/student	Hints/student
Overall	331	95.8%	4.2%	0%	0.6	0
						
SCI199UOFT	44	100%	0%	0%	0.6	0
						

Wrong Answers for SCI199UOFT		
% Wrong	Answer	Response
51.9%	Galaxies prevent planets from leaving their orbits around stars; e.g., our galaxy prevents Earth from leaving its orbit of the Sun.	
25.9%	Without galaxies, the universe could not be expanding.	
11.1%	Without galaxies, there could not have been a Big Bang.	
3.7%	Galaxies provide the gravity that prevents us from falling off Earth.	

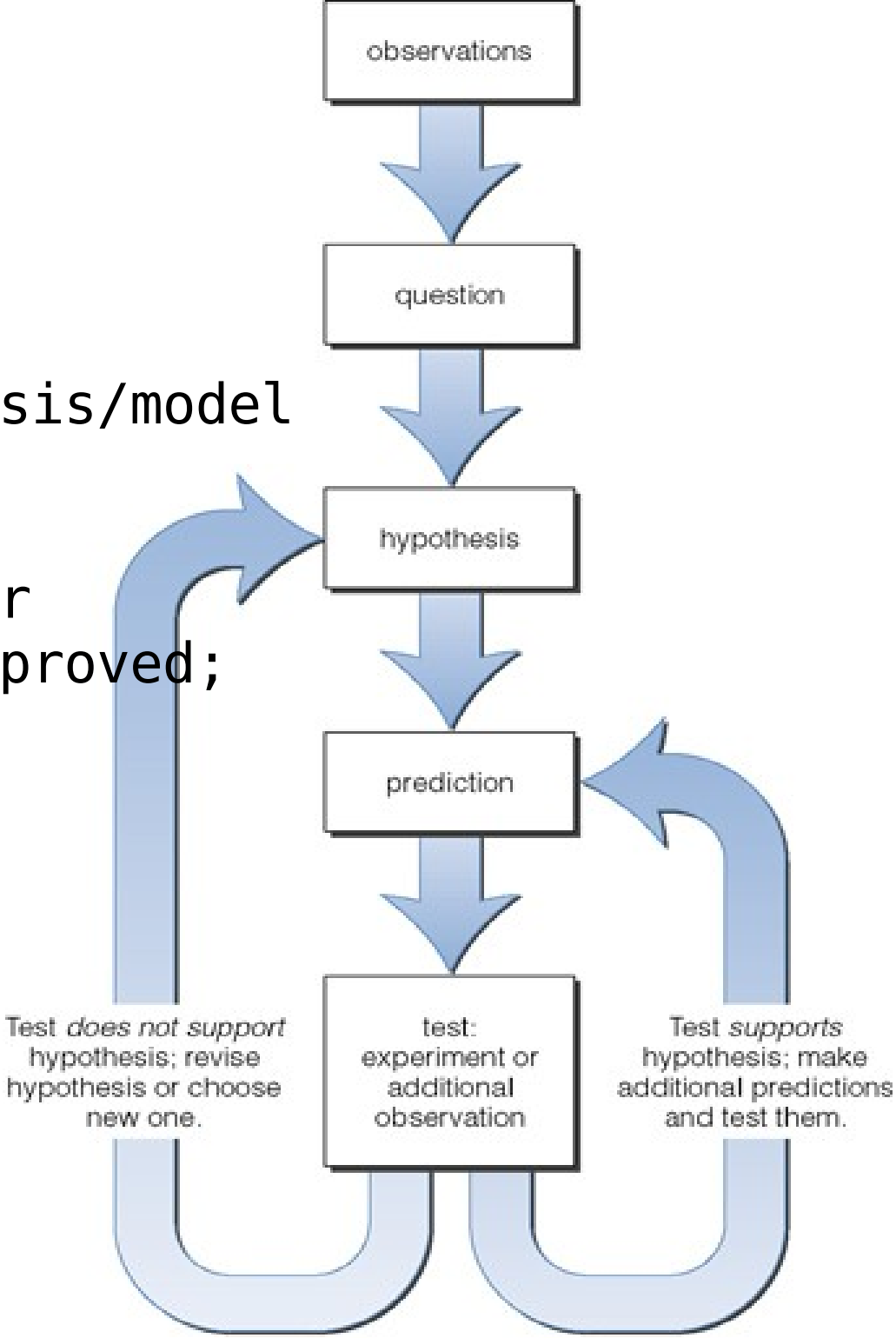
The Scientific Method

The scientific method:

1) propose a hypothesis
(the creative part)

2) use data to test hypothesis/model
(the hard work part)

a hypothesis/model can never
be 'proven', but can be disproved;
it's a never-ending quest



Case study: How the scientific method leads to our current understanding of the solar system

--- the Geocentric model vs. the Heliocentric model

Five important men:

Ptolemy *(Greek, A.D. 100-170)*

Copernicus *(Polish, 1473-1543)*

Tycho Brahe *(Danish, 1546-1601)*

Kepler *(German, 1571-1630)*

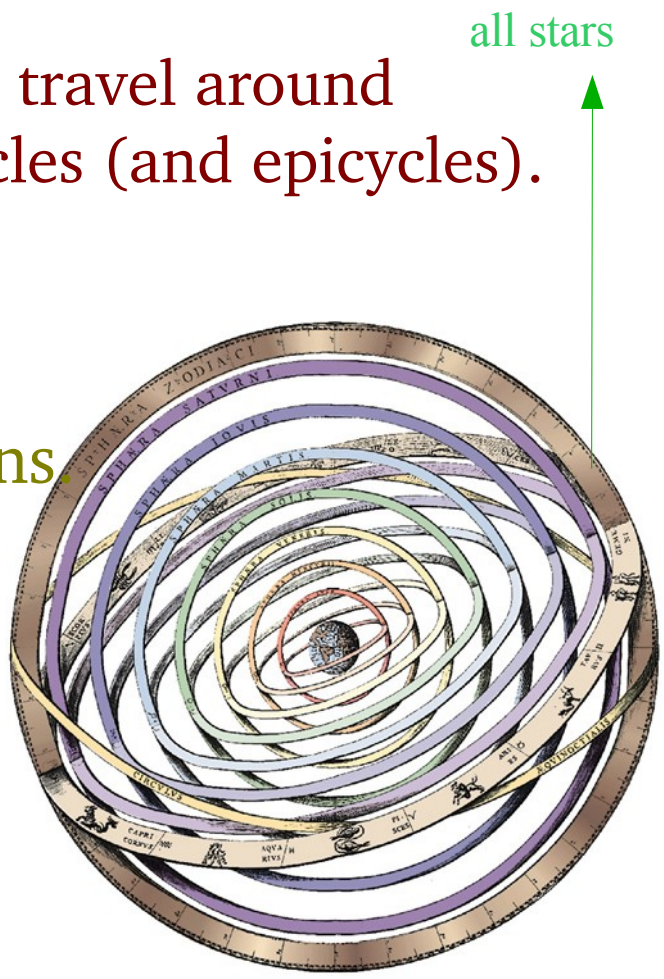
Galileo *(Italian, 1546-1642)*

Ptolemy *(Greek, A.D. 100-170)*

Ptolemy improved on an earlier model
(Earth + a sphere model)
and proposed a 'cosmological model'

Earth is at the centre of the universe.

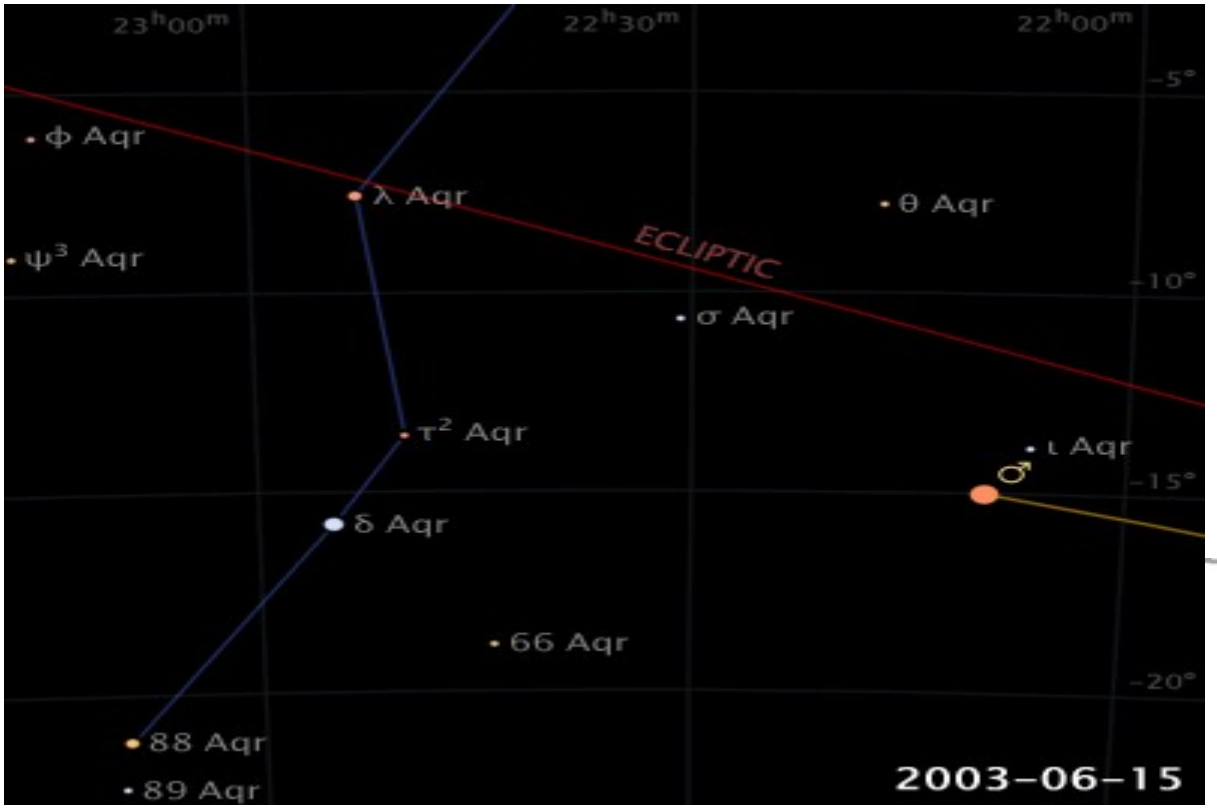
All other celestial objects travel around the Earth in different circles (and epicycles).



Based on aesthetics and naked eye observations.

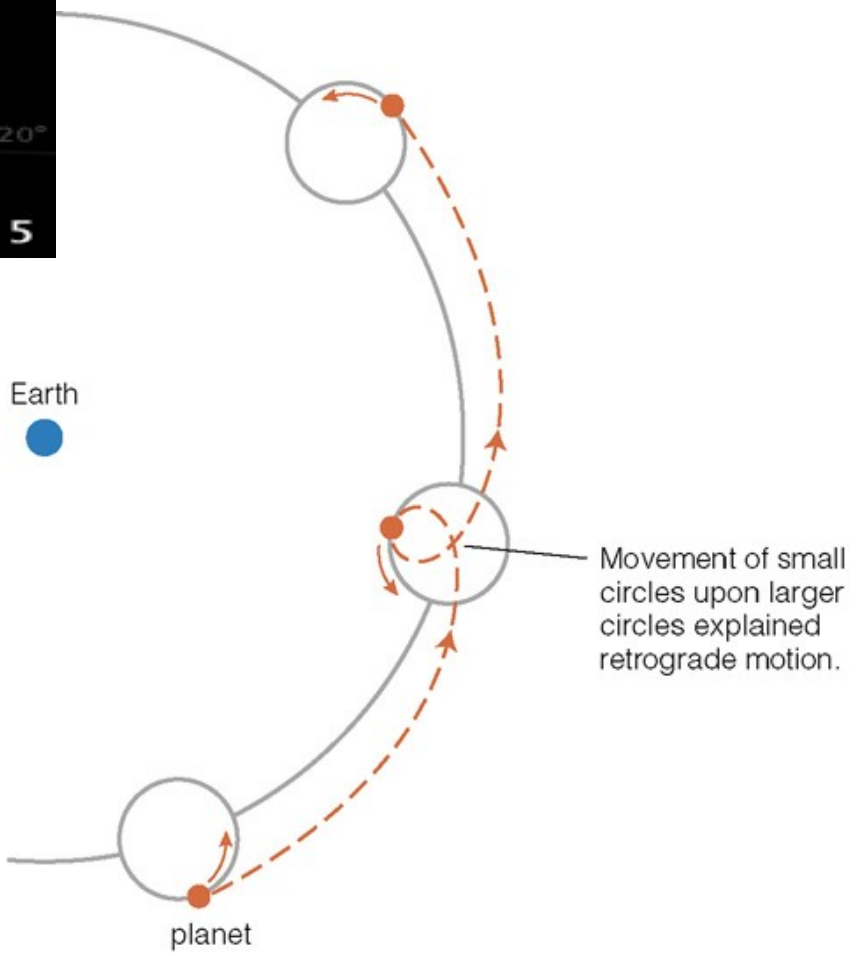
Predictions accurate to within a few degrees and agree with data available at the time.

Used for ~ 1000 years



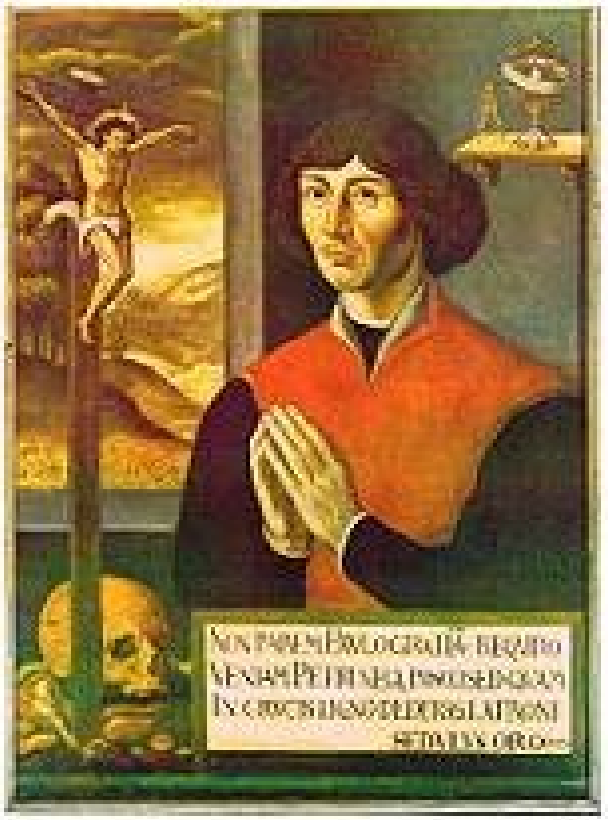
Ptolemy's epicycles: added to 'explain' the sometimes retrograde motion of the planets on the sky

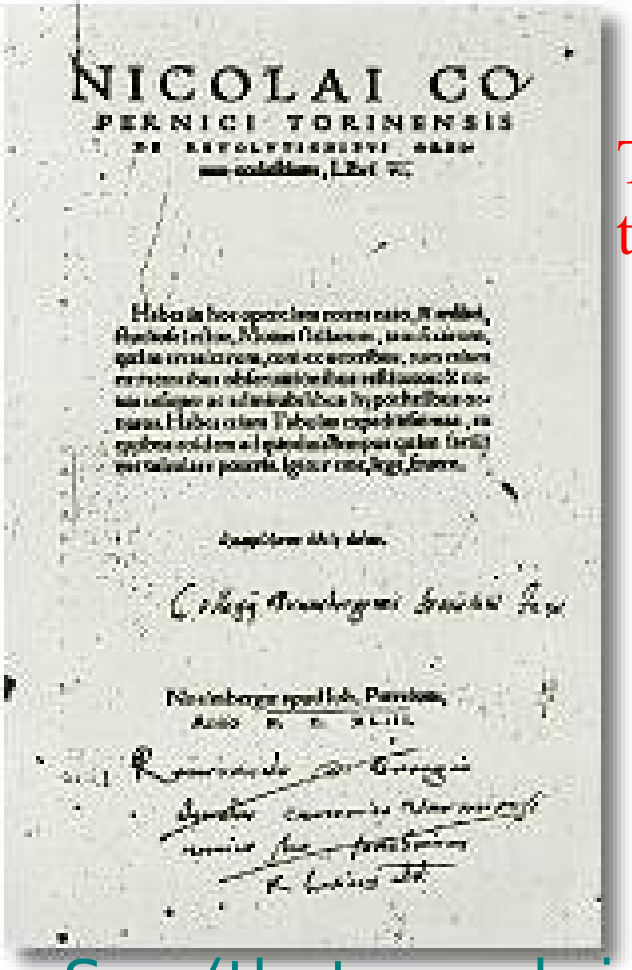
As observations get better, more and more epicylcles have to be added...



Copernicus *(Polish, 1473-1543)*

*mathematician,astronomer, physician,classical scholar, translator,**cleric**,beaurecrat,diplomat,economist...*




NICOLAI CO
PERNICI TORINENSIS

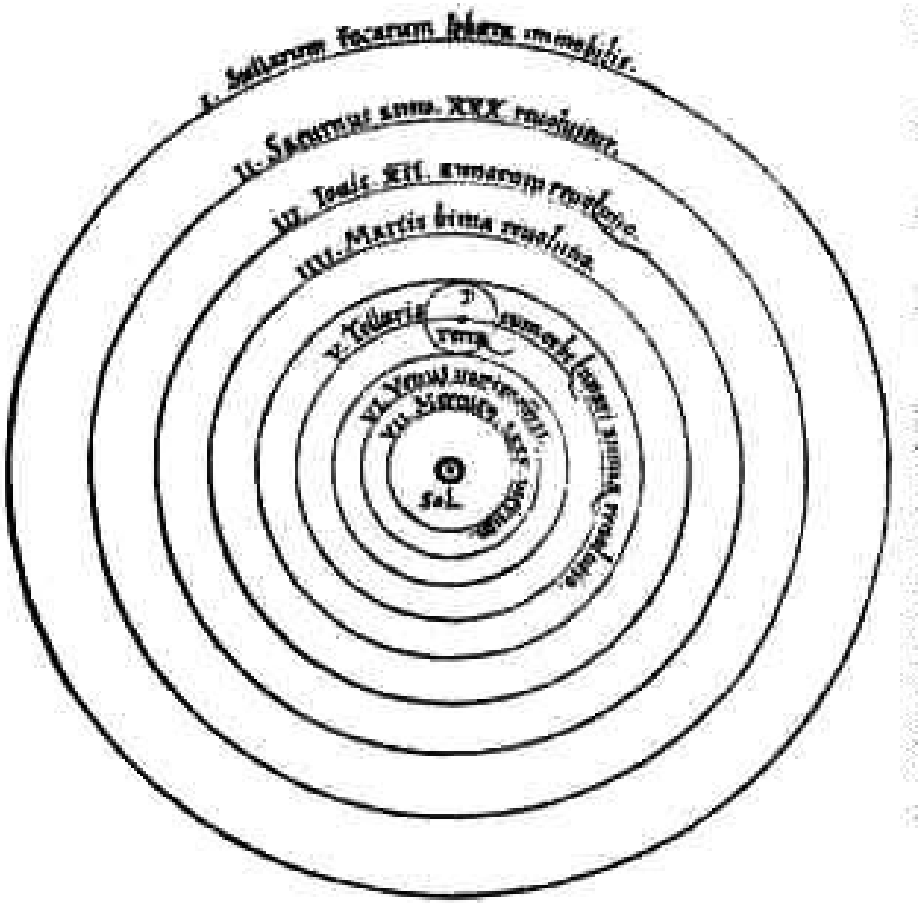
The Revolutions of the Celestial Orbs (1543)

Revolution:
1) movement around an axis, rotation
2) complete overthrow of the establishment
--- OED

What about putting the Sun (that very bright fellow) in the middle?

--- the Heliocentric model

1) Sun is centre of the universe
2) Earth, like other planets, rotate around the Sun
3) Earth's rotation gives rise to Sun/star's movement across the sky



Retrograde Motion in the Copernican System

However, insists on perfect circles – so still need epicycles.

No more accurate than the Ptolemaic model.

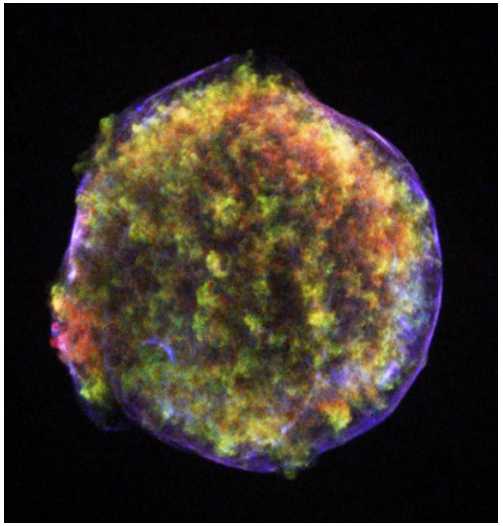
Tycho Brahe *(Danish, 1546-1601)*

the greatest pre-telescope observer

recorded planetary motion
accurate to ~ 1 arcminute
(1/60 of a degree, best humanly possible)

accumulated large data set
but no good model

discovered a *nova*
(Tycho's supernova)

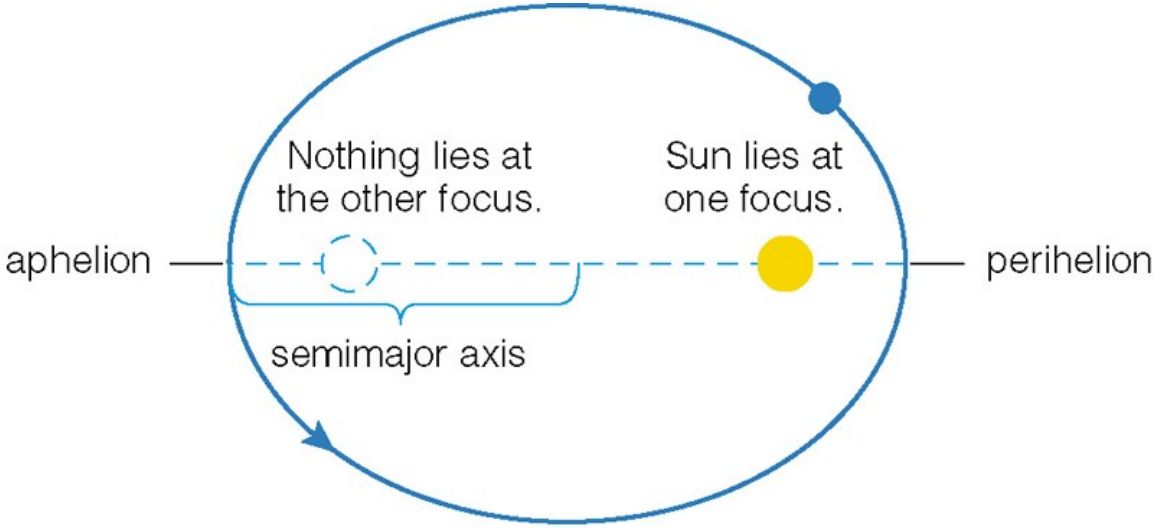


and falsified the notion of
'immutable heaven'

Kepler *(German, 1571-1630)*

Tycho's assistant and protege, *'it may not appear that I (Tycho) have lived in vain'*
motivated by deciphering God's intelligible plans

planets move around the Sun in eccentric orbits



empirical Kepler's laws that govern planetary movements

(even suggested that there is a force from the Sun that result in the motion – Newton's gravity)

explained Tycho's data more accurately and more elegantly than Ptolemy's model can

Galileo *(Italian, 1546-1642)* *physicist, mathematician,astronomer, philosopher, 'father of science'*

First telescopic observation of the heaven
-- privileged view of the cosmos

see sun-spot, lunar craters...
show that the heaven is
neither unchangeable,
nor untarnished

Showed convincingly that Earth was
NOT at the center of the universe (the phase of Venus...)

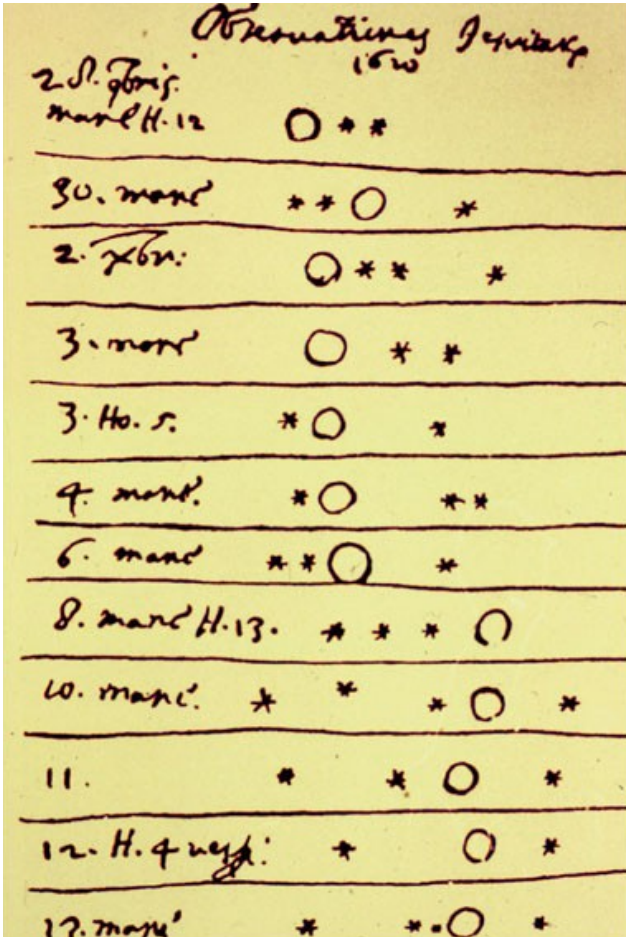
"Dialogue Concerning the two Chief World Systems"
(Simplicius vs. ...)

Tried and convicted of heresy by the inquisition.
Forced to recant his Copernicanism.

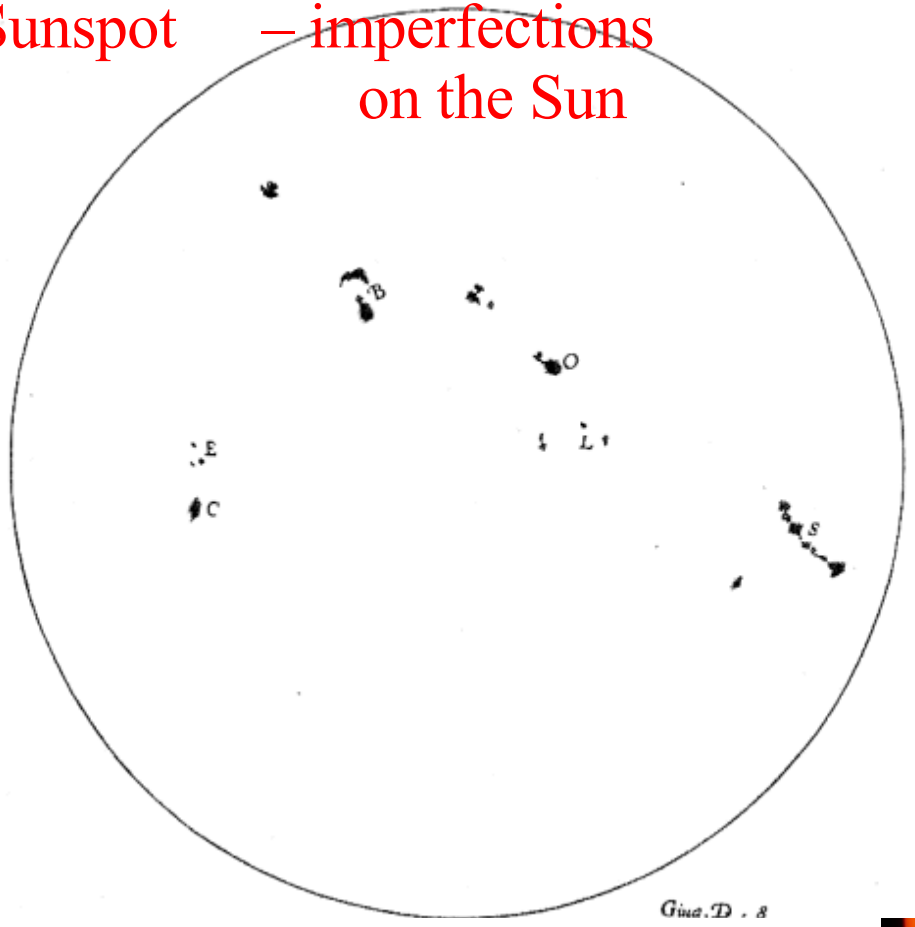
Officially forgiven by the Roman Catholic church in 1981.

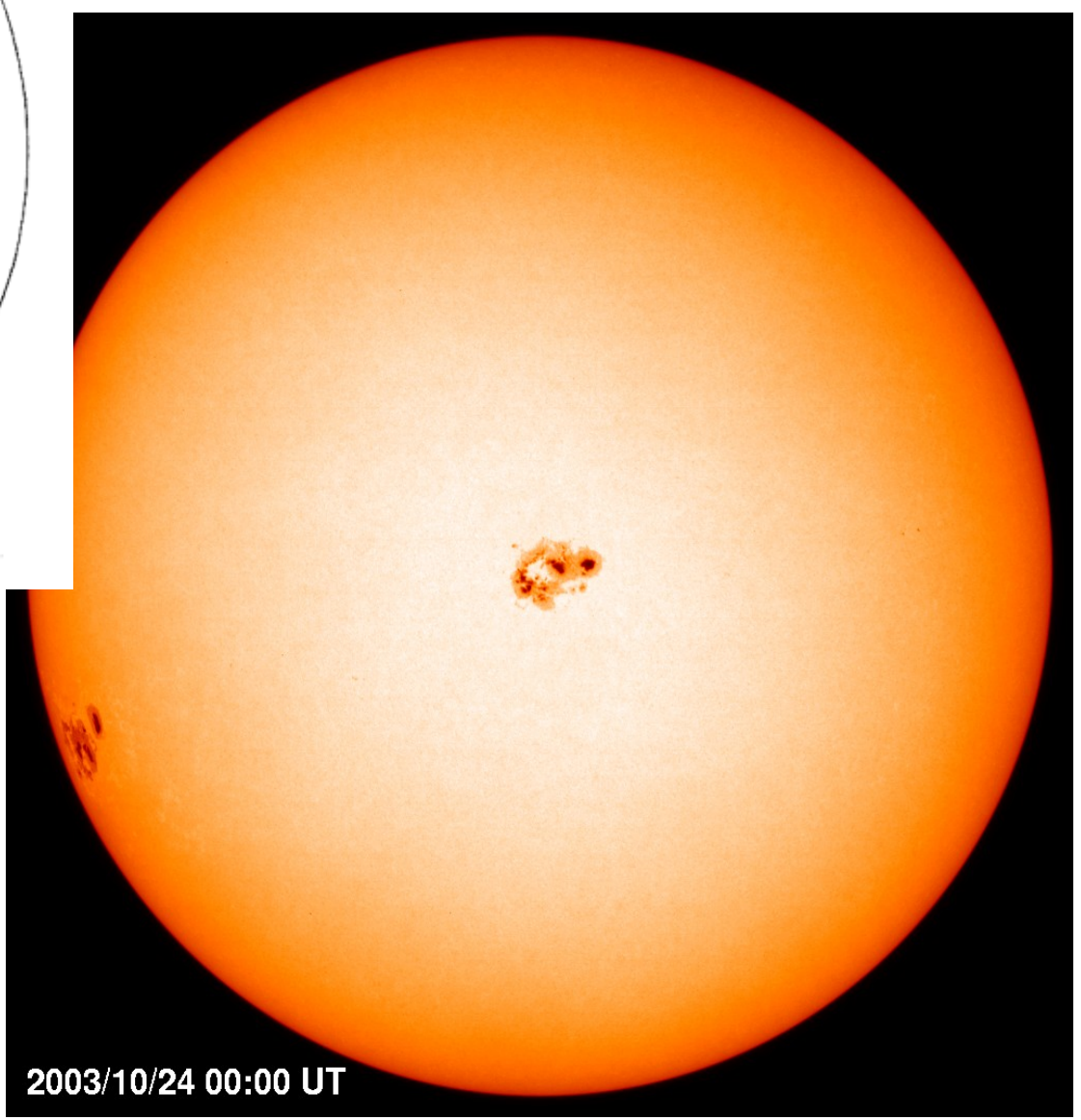
Galileo's great discoveries...

Jupiter has 4 moons
and there is 'weather' on Jupiter



Sunspot – imperfections on the Sun





Even the Church has evolved...

“(The Galileo story) is a lesson to the Church...

Beware of holding steadfastly to a particular interpretation of Scripture and/or a scientific model... for instance, there are various scientific challenges to the Young-Earth Creationist position.

We should hold many ... Biblical interpretations loosely. For we will never have all the right answers this side of heaven.”

--- christiananswers.net

It is rather well tested now that the Sun is
at the center of the solar system.
But converging to such a theory has been
a long journey.

Any other competing theories are weeded out
not because they are aesthetically inferior,
but because they don't agree with observations.

--- the scientific method

Francis Bacon *(English, 1561-1626)*

---- English philosopher

---- “father of modern science”

the “observation & experimentation” theory

-- drawing knowledge from the natural world through observation & experimentation, testing of hypotheses

-- such methods connected with the occult trend of alchemy during his time

-- this 'inductive' methodology has been the backbone of scientific inquiry ever since, and leads to the tremendously successful 'scientific revolution'

“Arguments cannot suffice for the discovery of new work, since the subtlety of Nature is many times greater than the subtlety of argument.” **-- Francis Bacon**

The scientific method:

1) propose a 'scientific' hypothesis/model

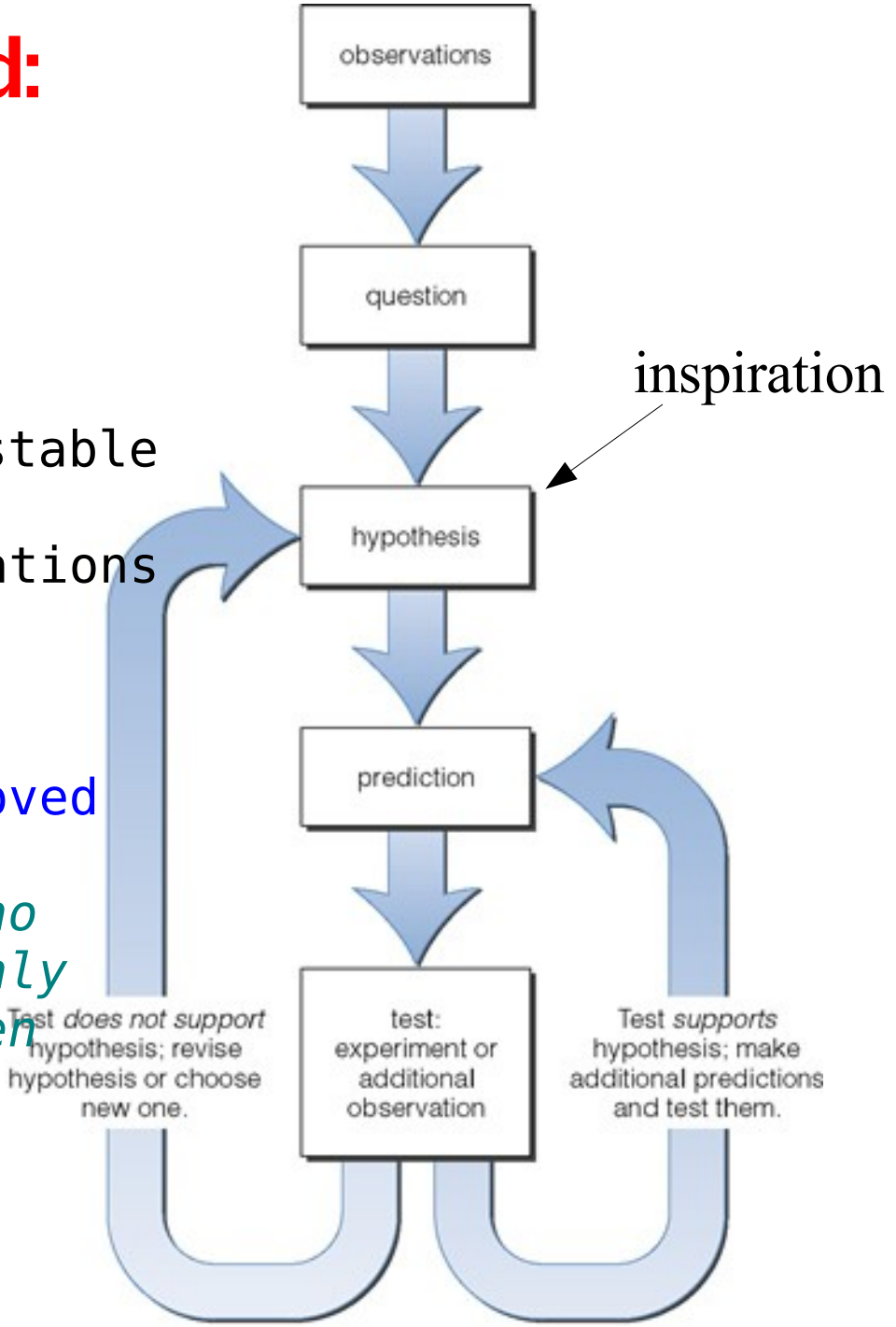
   'scientific' = one that is testable

2) experiments or further observations

   a hypothesis/model can never be 'proved', but can be disproved

   Strictly speaking, there are no 'correct' theory, there are only theories that have not yet been 'disproved' despite numerous experiments/observations

3) it's an unending quest



Is this a scientific statement?

People born between April 21 and May 21 are more persistent and determined than people born at other times of the year.

Yes	1 hand up
No	2 hands up

A scientific statement is one that is falsifiable by observations or experiments.

Is this a scientific statement?

There are multiple universes that we can not observe or infer existence of in any way.

Yes	1 hand up
No	2 hands up

A scientific statement is one that is falsifiable by observations or experiments.

Is this a scientific statement?

God causes leafs to change color in the Fall.

Yes	1 hand up
No	2 hands up

A scientific statement is one that is
falsifiable by observations or experiments.

Is this a scientific statement?

God does not cause leafs to change color in the Fall.

Yes — 1 hand up

No — 2 hands up

A scientific statement is one that is falsifiable by observations or experiments.

"A scientific statement can be falsified by experiments or observations. "

Even if you don't know the answer, knowing that a statement is 'scientific' and falsifiable is important:

1) it's impossible to know all facts, but knowing whether a statement is scientific (falsifiable) is easy.

2) You can then take the attitude of either agreeing with the statement or disagreeing with it, pending on the outcome of relevant experimentation/observation.

3) You don't waste time toying with non-scientific arguments.

1) Astrology: every scientific (falsifiable) statements made has been falsified by detailed studies.

2) More dangerous are statements that are non-falsifiable.

Evolution: *University of Michigan survey (2005)*

80% Europeans and 78% of Japanese believe that humans evolved from other species. But in the U.S. only 40% of adults believe whole-heartedly in evolution, while 39% called it "absolutely false".

1) Evolution is in-consistent with Bible.

scientific statement?

2) Human and monkey are so different in looks we could not possibly evolve from them.

scientific statement?

3) Animals don't have intelligence.

scientific statement?

“Scientific Literary”

You are being trained to become voters and citizens,
and to become intelligent decision makers.

You need to think scientifically in your daily life.

Should we build “expensive” solar power stations/wind-farms or
“cheaper” nuclear stations?
Is global warming a real threat for Canada? .
or should we focus first on air quality?
Should I buy genetically-modified food?
Should I be more worried about a car accident or a flight disaster?
Is universal health insurance damaging the nation's economy?
Should we fluorinate our water?
Should we allow stem-cell research?
Should we be against globalization?
Should we continue to build the International Space Station?.....

Is this a scientific statement?

Steven Harper is a worse prime minister than Stephane Dion.

Yes	1 hand up
No	2 hands up

Example Short Presentations

1) Concepts: Kepler's Laws for Planetary Movements

Using Tycho's massive data, Kepler suggested 3 simple rules that govern how planets move around the Sun (1605)

1. Planet orbits in an ellipse w/ Sun at a focus

2. Planet moves faster closer to Sun, and slower further away

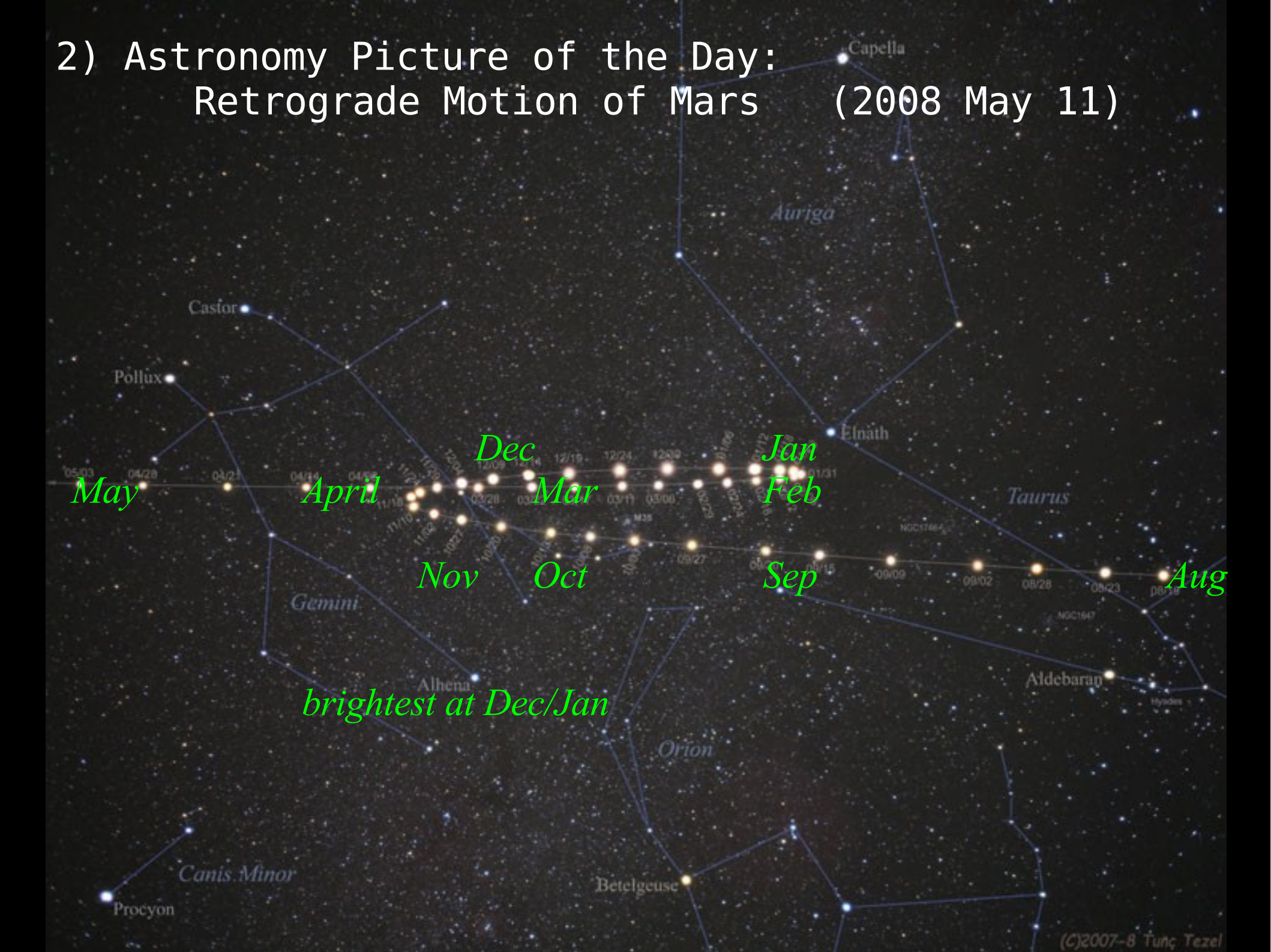
3. $P^2 = a^3$

This explains ...

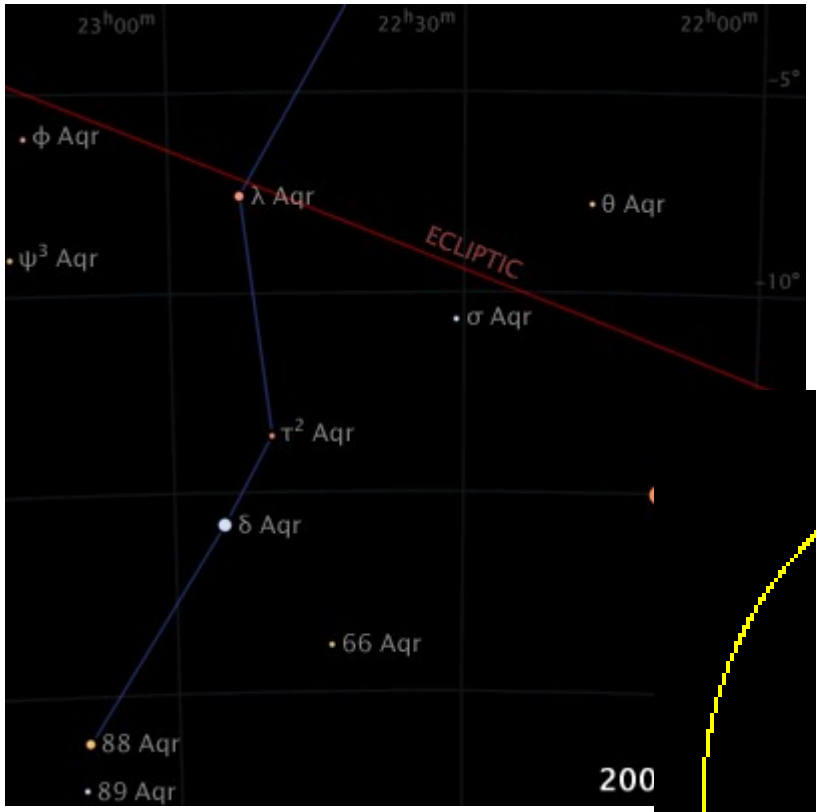
This is significant ...

--- Kepler laid the foundation for our understanding of gravity (Newton 1687)

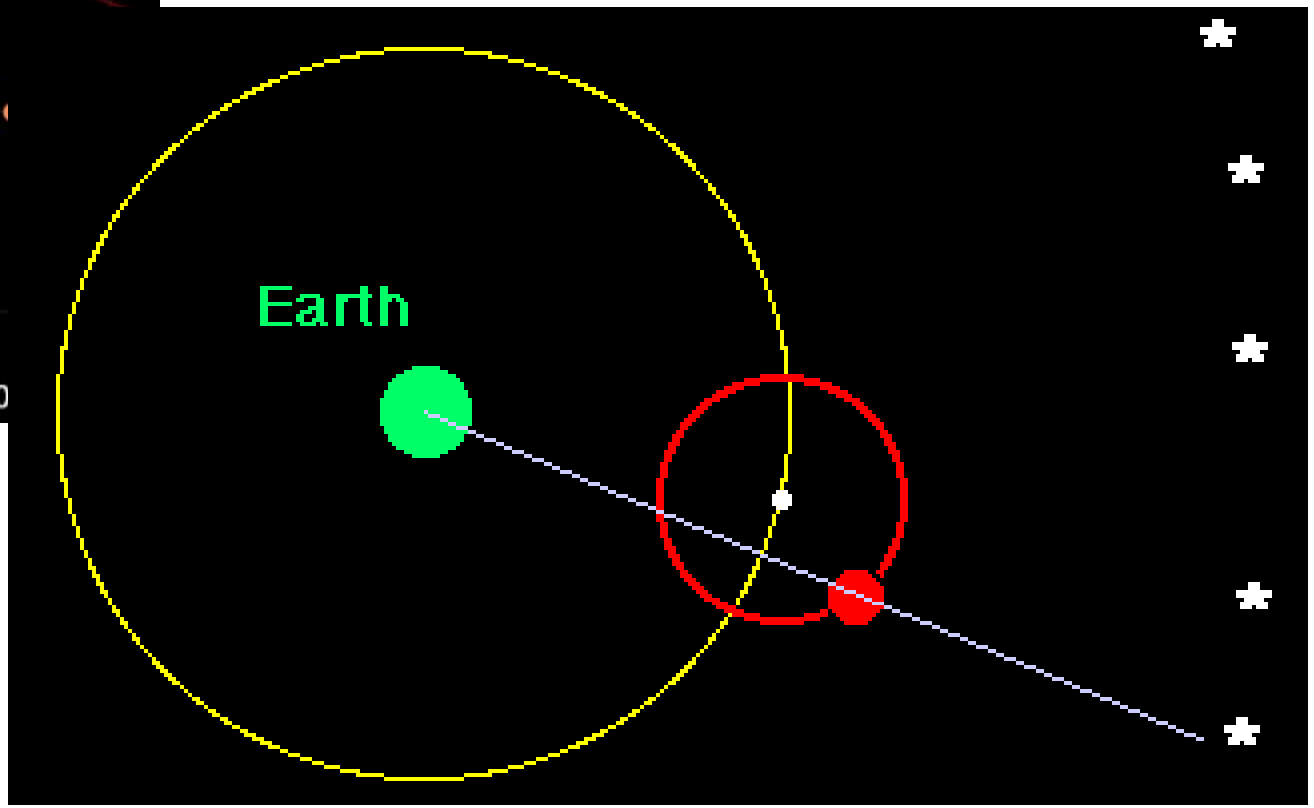
2) Astronomy Picture of the Day: Retrograde Motion of Mars (2008 May 11)



In the geocentric view (Ptolemy ~ 200AD), celestial bodies go around us



. Mars moves on a circle
. Mars moves along an epicycle on circle
. ... more epicycles



“Heaven must be wrong if it disagrees with Ptolemy's theory”

In the heliocentric view (Copernicus ~1500AD), we all go around the Sun

inner planets move faster relative to outer ones
simplest explanation for complicated planetary movements
continuously being confirmed by observations