



# Carl Sagan Essay: "The Pale Blue Dot"

**You are Here**

*"Our posturings, our imagined self-importance, the delusion that we have some privileged position in the universe are challenged by this point of pale light. Our planet is a lonely speck in the great enveloping cosmic dark.*

*In our obscurity, in all this vastness there is NO HINT that help will come from elsewhere to save us from ourselves."*

# The Scientific Revolution

AP European History

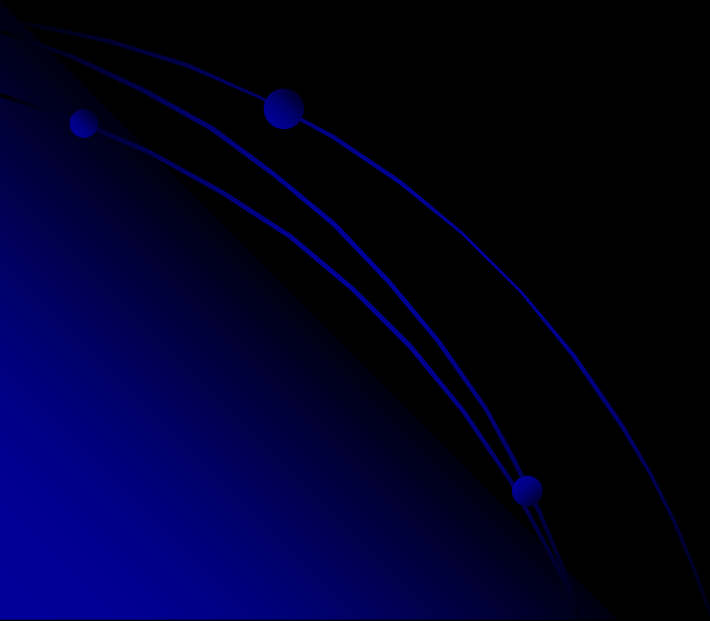


# “Science” of the Middle Ages

- Based on philosophers: Aristotle, Ptolemy, Galen → qualitative (applying reason to determine the nature of objects) – deductive reasoning
- Christianity and Scholasticism (12<sup>th</sup> C.) → accepted general definitions/framework of the church and deduced interpretations from these
- Earth made out of four substances: earth, wind, water, fire
  - Heavens made out of the “quintessence” or fifth substance
- Instead of gravity – it was believed that objects fell toward the Earth to be at one with substance from which they are made
  - Heavy objects were believed to fall faster than light objects
- Church controlled heretical ideas (anti-dissection)

# The Scientific Revolution

Why did it occur when it did?  
(late 16<sup>th</sup> Early 17<sup>th</sup> C.)



# Underlying Forces Breaking the Medieval Worldview



# Was it a revolution?

Yes!



While, not a rapid overthrow of traditional authority, it was a slow dismantling of the irrational religious orthodoxy of medieval Christian Church.

# Changes in Astronomy and Mechanics

- **Big Idea:** *The Scientific Revolution brought about radical changes in the fields of astronomy, mechanics, and medicine.*
- **Bigger Idea:** *Europeans began to see the world as knowable, predictable & knowledge could be obtained from empirical observation.*
- **Key Development:** Geocentric to Heliocentric view of the universe.
  - Built on ideas of Aristotle, Ptolemy, and Christian theology
  - Shift from an Earth Centered to Sun-Centered Cosmos – intellectual and emotional impact



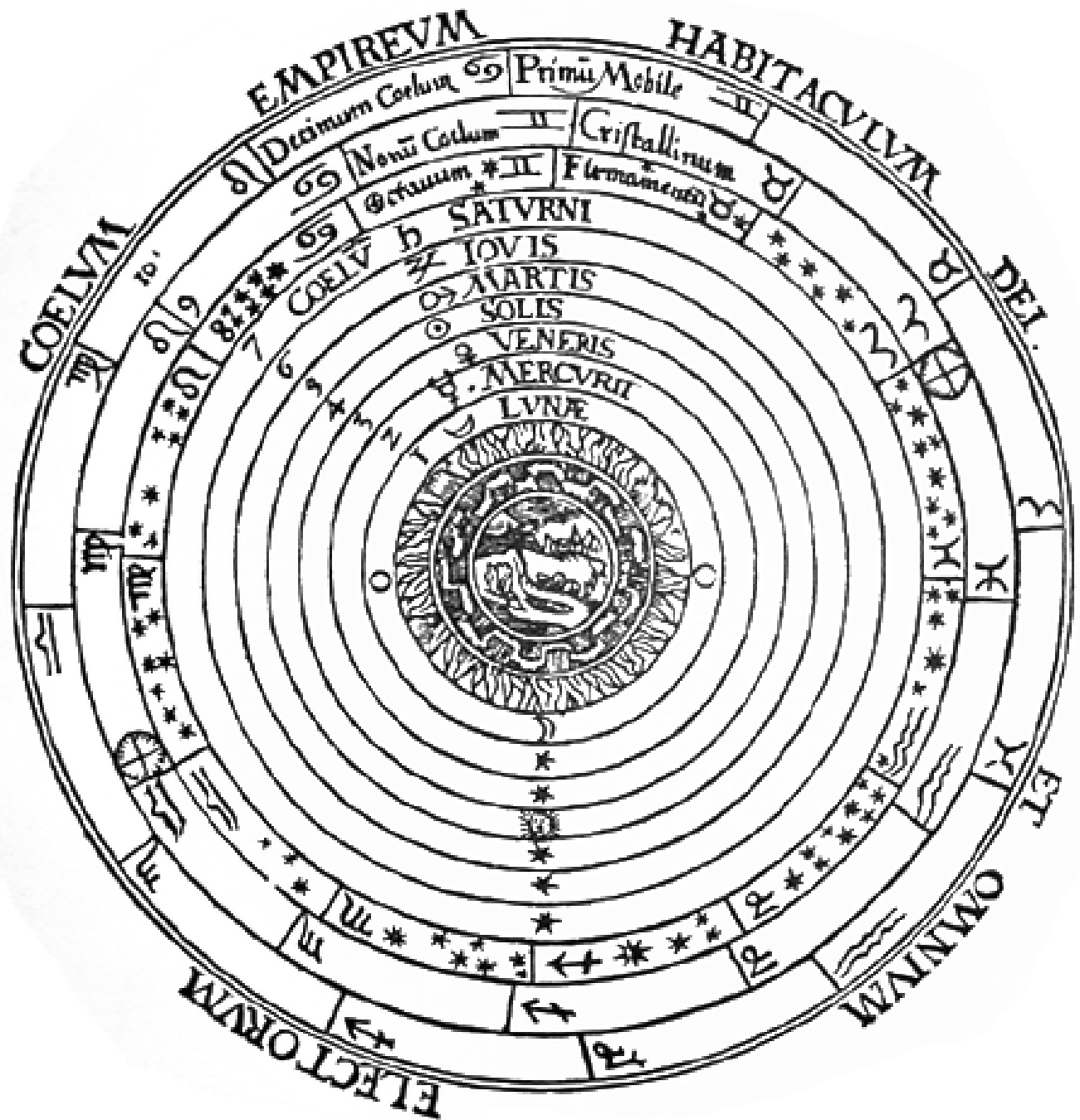
Let's see if the Medieval  
Worldview is still with us....

Test:

Where is God?



# Ptolemaic/ Geocentric Conception of The Universe



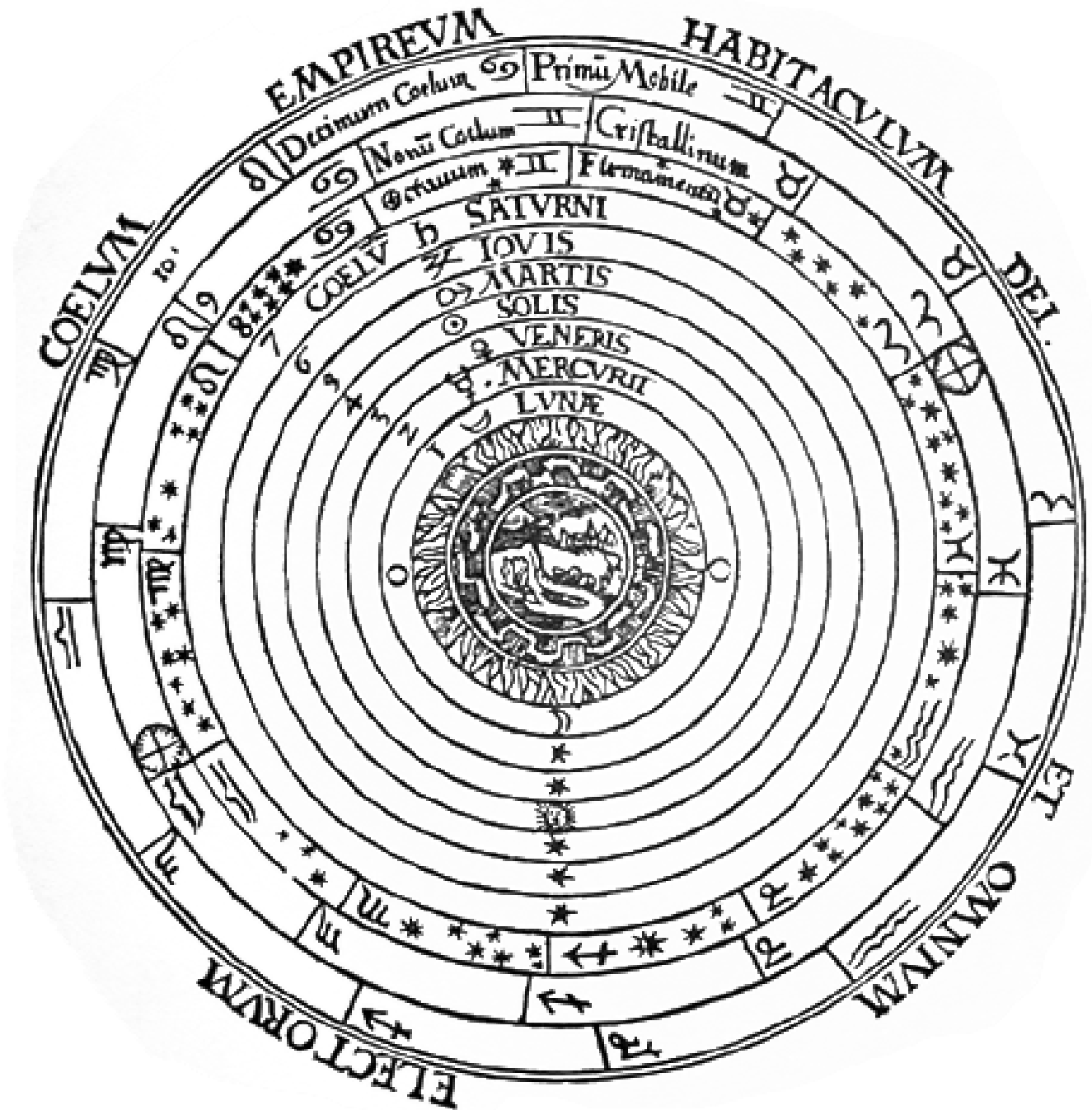
# Ptolemaic/ Geocentric Conception of The Universe



Tim Tebow

...now you know  
what he's pointing  
at and why...

Who knew that the  
same  
God that caused the  
Black Death in the  
14<sup>th</sup> C. would  
have an active  
interest in 21<sup>st</sup> C.  
spectator sports?



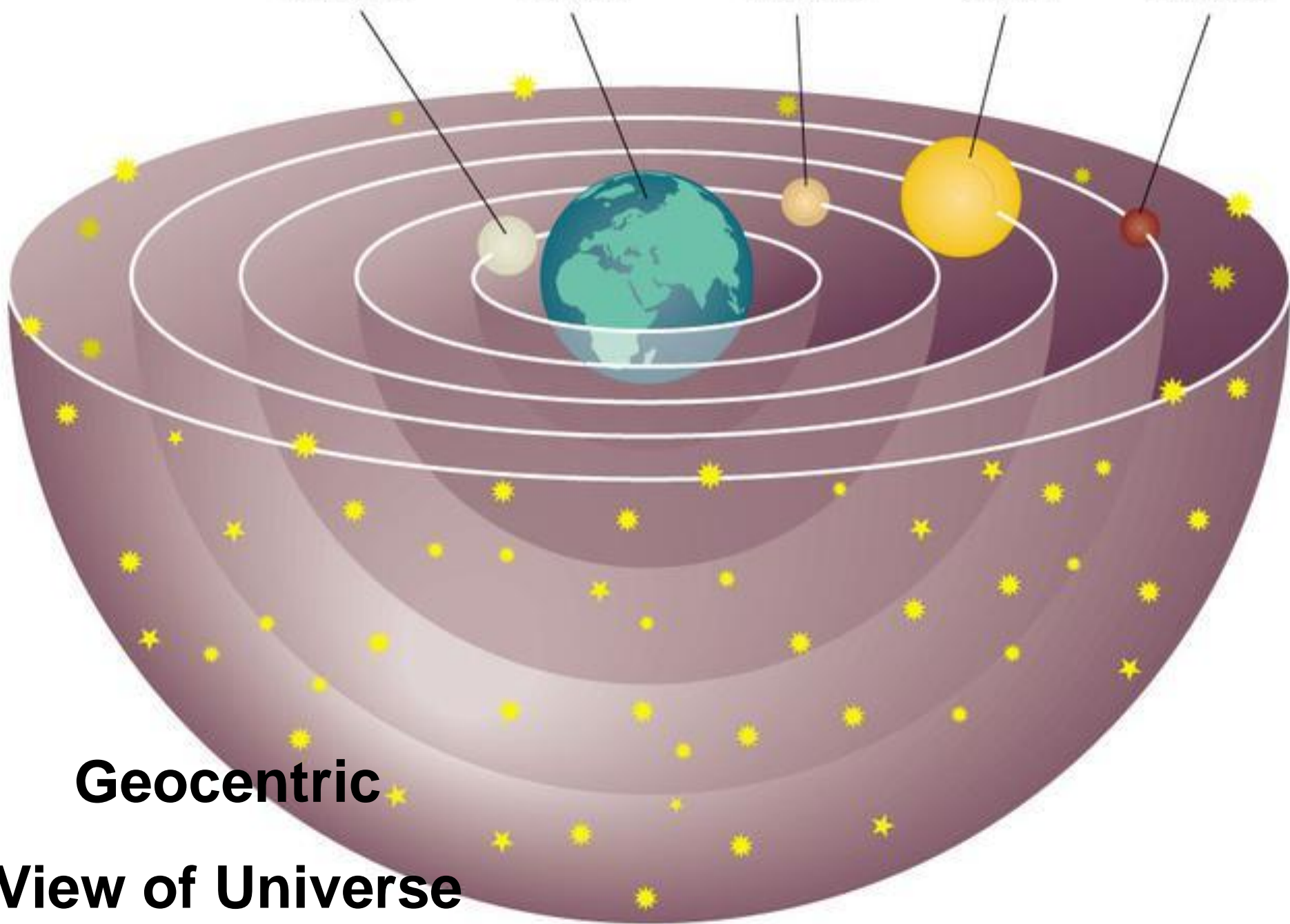
Moon

Earth

Venus

Sun

Mars

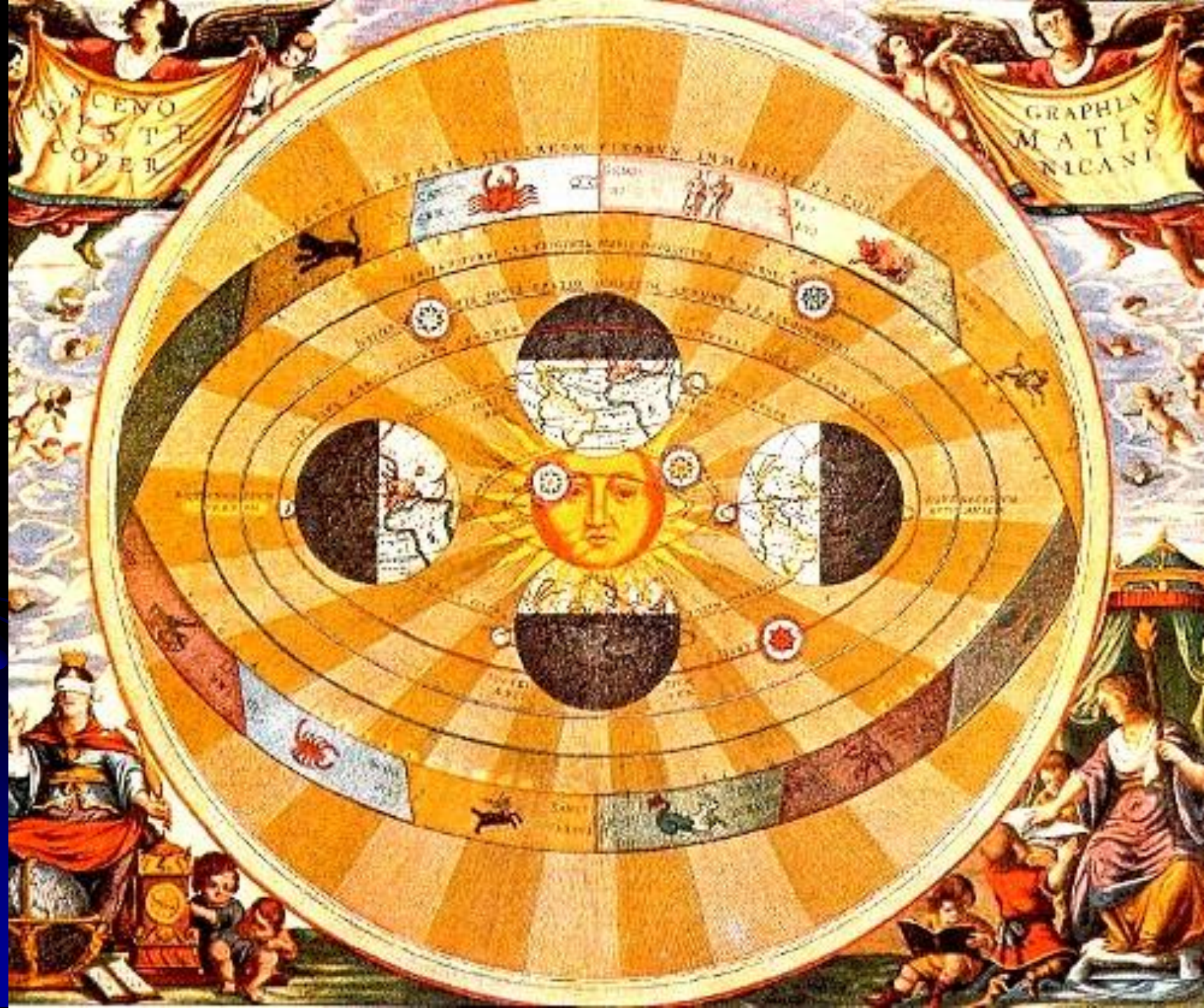


**Geocentric**

**View of Universe**

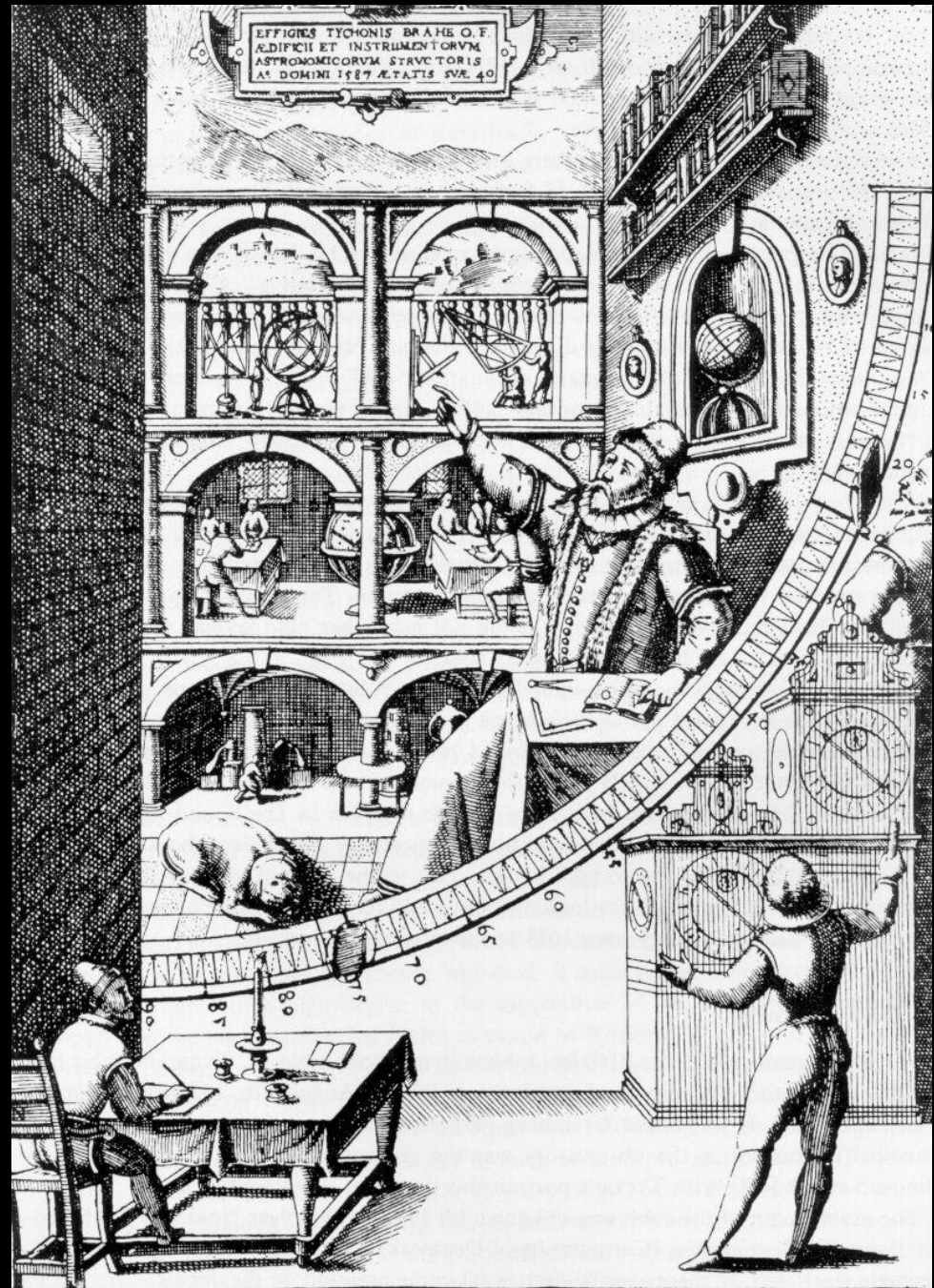
- Nicolaus Copernicus and the heliocentric view of the universe
  - *On the Revolutions of the Heavenly Spheres* (1543)
  - Copernicus' conservatism
  - Attacks by Protestants
    - Luther/followers among the 1<sup>st</sup> religious officials to attack new science
    - P. 486





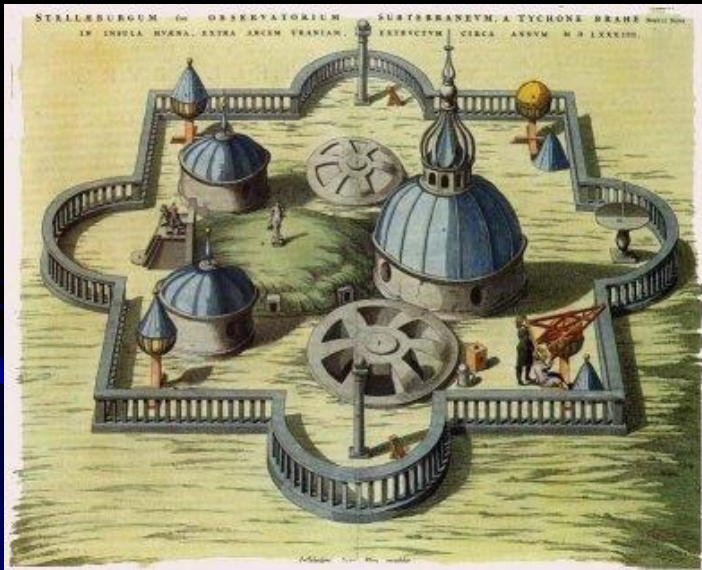
- Tycho Brahe  
Mathematical  
rejection of  
Ptolemaic/geocentric  
theory

Importance of Prague/  
Rudolf II Influence on  
Kepler





Uraniborg main building. Cooper etching from Blee's Atlas Major, 1665.



The observatory was completed in 1584, making it the first astronomical observatory created exclusively for accurately measuring the positions of stars and the orbits of the planets.



- Johannes Kepler (1571-1630)



- Three laws of planetary motion

1. Planets have elliptical orbits (1609)
2. Planets move faster when closer to sun (1619)
3. Planets with larger orbits revolve at a slower average speed (1619)

- Shatters the Ptolemaic crystalline spherical explanation w/ mathematical proof

- Remaining questions

- What are planets made of?
- How do the planets move?

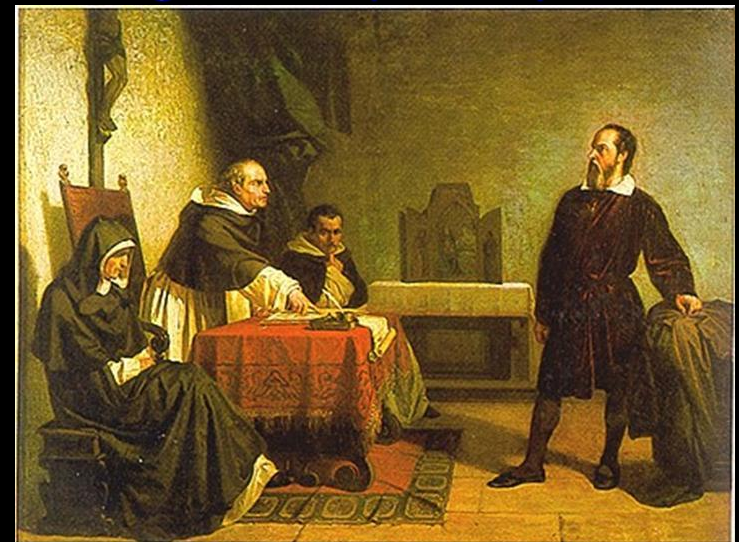
- Galileo Galilei (1564-1642)
  - Observations with telescope
  - **Earthshaking discovery** – universe made of matter like earth (not perfect/unchanging)
    - 1610: *The Starry Messenger*
    - Reaction - - p. 489
    - Inquisition – fact vs. mathematical supposition

### Condemned by the Catholic Church

- Heavens no longer a spiritual world!
- Humans no longer at the center!
- God no longer in a specific place!



Cardinal: “The intention of the Holy Spirit is to teach us not how the heavens go, but how to go to heaven.”

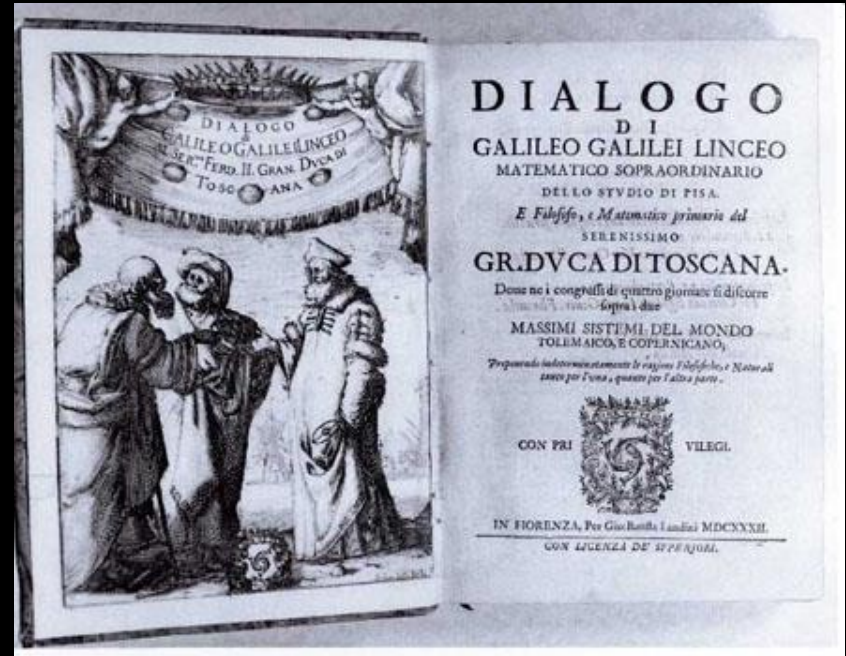


## 1632: *Dialogue on the Two Chief World Systems*

- Written in Italian
- Dialogue between Simplicio (Aristotle and Ptolemy) and Salviati (Copernicus)

### The Church's perspective? (read 492-493)

- Condemns Galileo
- 1633 – Inquisition threats of torture
- Galileo forced to recant
- House arrest in Florence where he focuses on mechanics



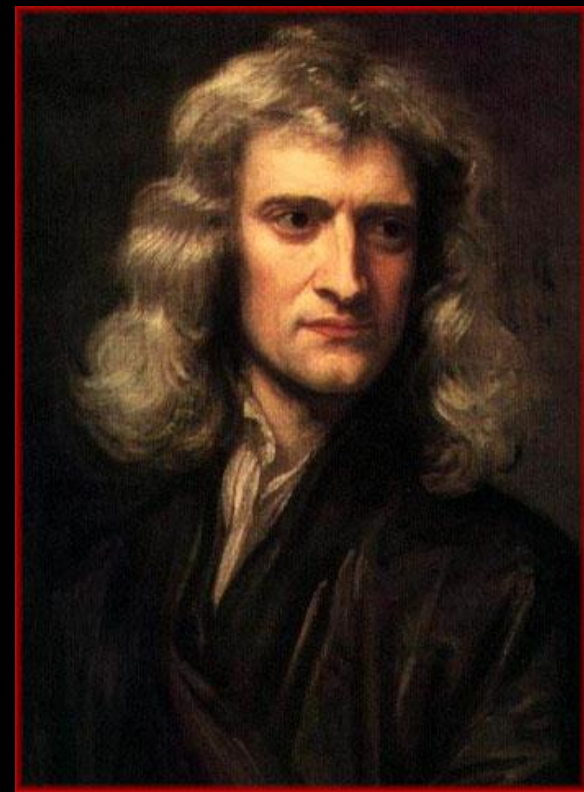
- Aristotelian conception of motion
  - Object remains at rest unless external force acts upon it
  - If force is constantly exerted, object moves at constant rate; force is removed, object stops
  - Didn't fit with Copernican system
- Galileo's 2 contributions to study of motion
  - 1 - Uniform force applied to an object causes accelerated speed, not constant speed
  - 2 - Principle of inertia: body in motion continues in uniform motion forever unless deflected by external force
  - Still didn't fit with Copernican system

**P. 492 – FAITH VS. REASON**

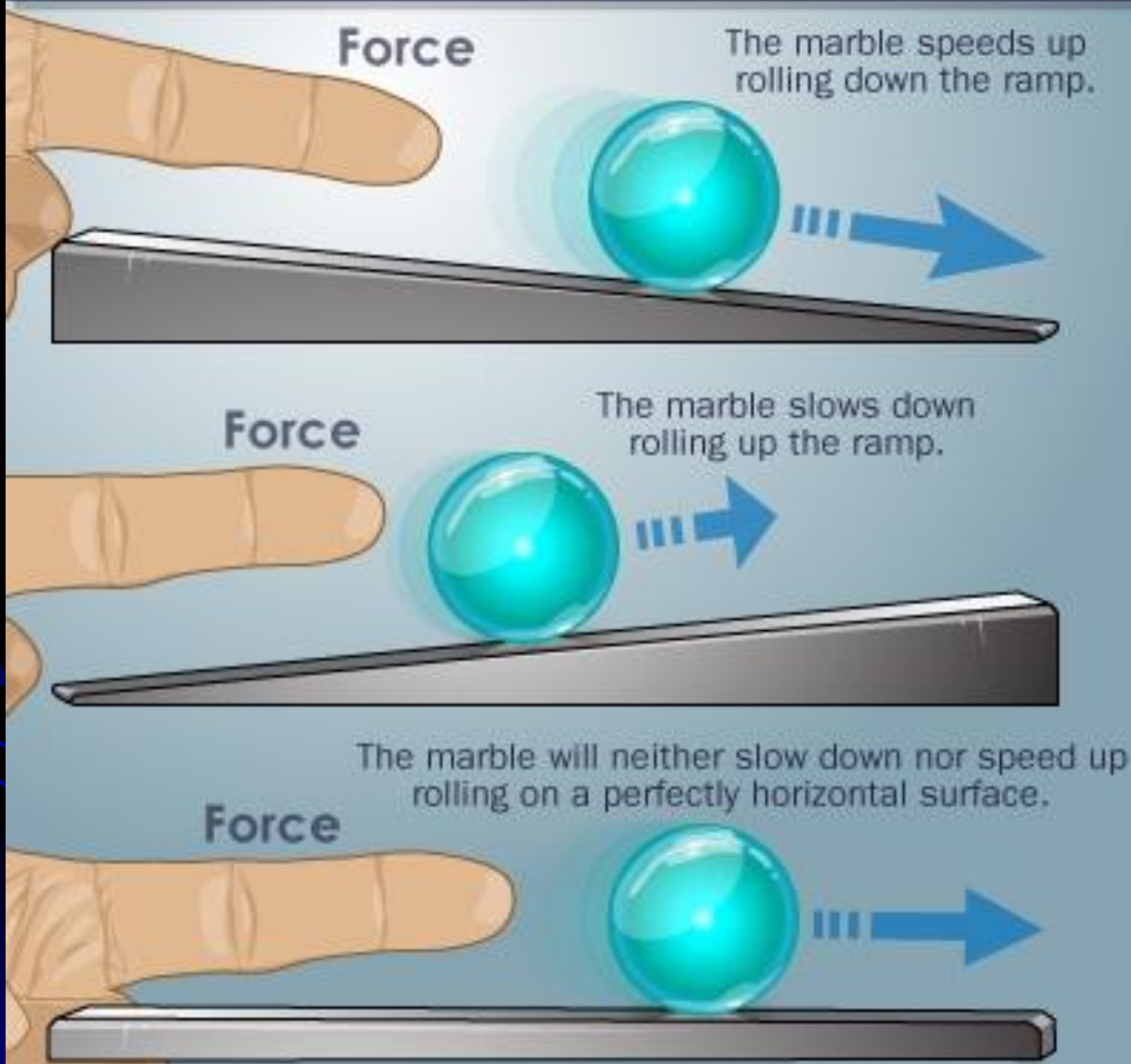
- Isaac Newton (1643-1727)

(Cambridge University)

- Calculus – calculating rates of change
- *Principia (Mathematical Principles of Natural Philosophy)*
  - Three laws of motion
  - Universal law of gravitation
    - Every object in universe is attracted to every other object by a force (gravity)
      - The heavier the mass of objects, greater the force
      - The greater the distance between objects, lighter the force



- Newton: culmination of the work of Copernicus, Kepler and Galileo
  - Elaboration and mathematical proofs of natural laws of motion
- Three Laws of Motion
  1. Every object continues in a state of rest or uniform motion in a straight line unless deflected by a force.
  2. The change in motion proportional to the force acting upon it.
  3. To every action, there is an equal and opposite reaction.



- Significance of Newton's discoveries
  - One law to explain all! (Gravity works the same here as anywhere else...)
  - Newtonian world-machine! (Mechanical Clock Metaphor)
  - Secrets of the world could be known by humans! (Knowable, predictable universe)
  - Problems could be solved by humans (disease, famine, natural forces, human nature)
  - Less in the thrall of God – self reliant



Ideas would later be modified / replaced by Einstein



# The Beginnings of a New Way of Thinking

<u>Before the Scientific Revolution</u>	<u>After the Scientific Revolution</u>
Acceptance of certain 'authorities'	Questioning of all previous authorities
Natural laws beyond human understanding – God's domain	Humans could comprehend natural laws
Religious/Superstitious	Secular/Rational
Deductive Reasoning	Inductive/Emperical Reasoning – Scientific Method
Source of Truth: Looking backward to established "truths"	Source of Truth: Looking forward- human rationality applied to systematic empirical observation

# René Descartes (1596-1650) and Rationalism

- Famous work: *Discourse on Method* (1637)
  - Starting point: doubt everything
  - He would accept only those things his *reason* said were true
  - Only one fact beyond doubt: his own existence
    - “I think, therefore I am” (*cogito, ergo sum*)

# 30-Second Pause

- What did Descartes mean when he said, “I think, therefore I am”?

*“How do you know that this whole thing isn’t just a dream?”*

*Premise 1: I know I’m thinking about it.*

*Premise 2: What thinks must exist. THEREFORE*

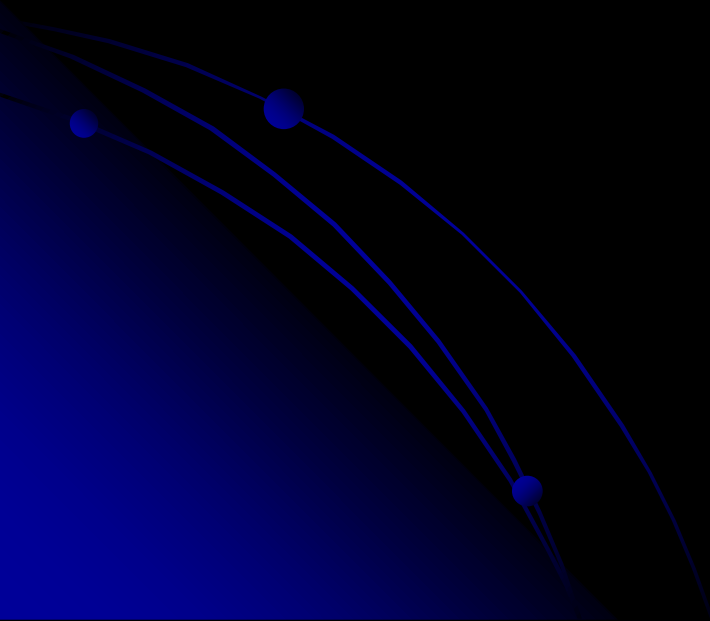
*(Conclusion): I exist.*

● *Thinking is proof of his being... STARTING POINT*

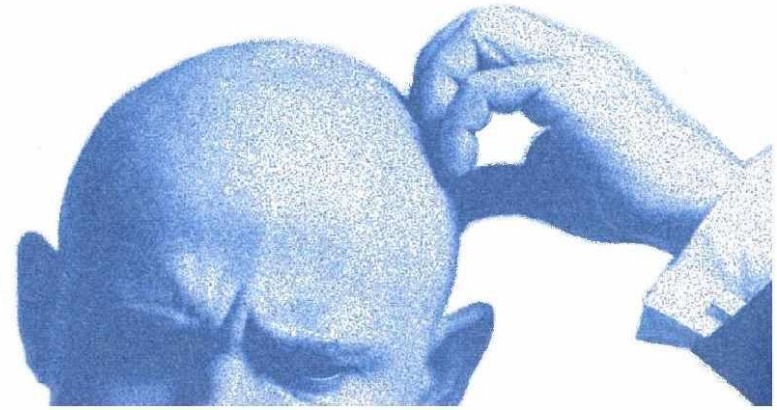
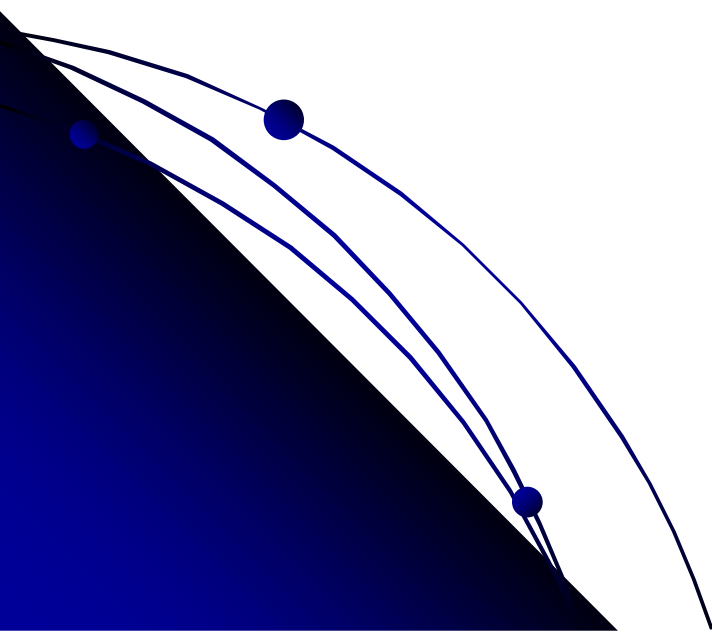


# The Scientific Method

- Descartes' method
  - Believed in deductive reasoning to acquire knowledge
    - Preceding from self-evident, accepted truths (axioms) to a more complex conclusion



- Founder of modern *rationalism*
  - Complex problems to be broken down into small understandable parts
  - System of thought based on belief that all knowledge comes from human *experience* and *reason* (*vs. authority/tradition*)



- From this, deduced two additional beliefs
  - Existence of God
  - Cartesian dualism
    - Separation of mind and matter
      - *thinking* substance and *extended* substance
    - We can use our *minds* to understand *matter*
    - Matter now viewed as dead and inert, could be studied *objectively* and *rationally*



# 30-Second Pause

- What impact did Cartesian dualism have on the way people thought about the universe?



# Descartes Quotes:

- *“nothing is true which I did not evidently know to be such...”*
- *“avoid precipitance and prejudice”*
- *“divide each of the difficulties I examined into as many parts as may be required for its adequate solution...[and] arrange my thoughts in order, beginning with things the simplest and easiest to know...”*
- *“...all the things we human beings are competent to know are interconnected in the same manner, and that none are so remote as to be beyond our reach or so hidden that we cannot discover them – that is, provided we abstain from accepting as true what is not thus related.”*



# 30-Second Pause

- How are each of the below examples of irrational thought?
  - Religious/Superstitious beliefs...
  - Belief that the Cubs will one day win the World Series

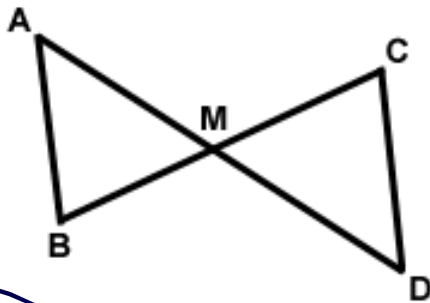


**Statements**

1. Segment AD bisects segment BC.
2. Segments AM and MD are congruent.
3. Segment BC bisects segment AD.
4. Segments BM and CM are congruent.
5. Angles AMB and DMC are congruent.
6. Triangles ABM and DCM are congruent.

**Reasons**

1. Given.
2. When a segment is bisected, the two resulting segments are congruent.
3. Given.
4. When a segment is bisected, the two resulting segments are congruent.
5. Vertical angles are congruent.
6. SAS postulate (2, 4, 5).



**Given:**

*Segment AD bisects segment BC.*

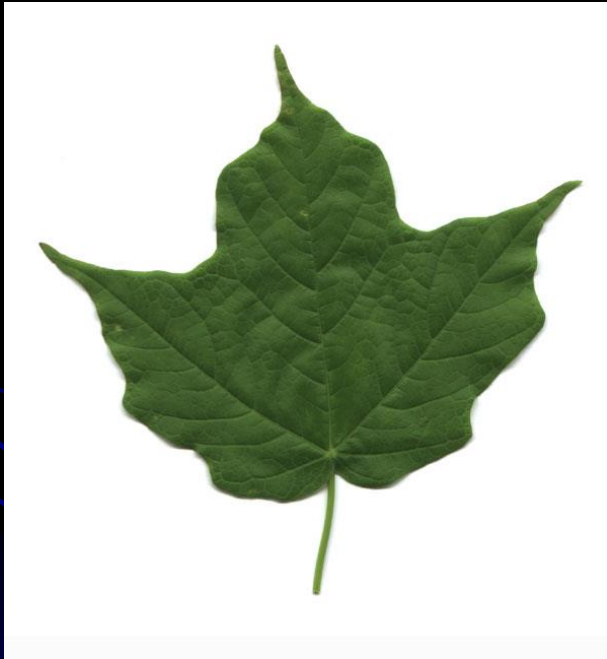
*Segment BC bisects segment AD.*

**Prove:**

*Triangles ABM and DCM are congruent.*

- Kind of like a geometric proof

- Example: leaves



- Francis Bacon's method

- Famous work: *The Grand Instauration*

- Believed in inductive reasoning to acquire knowledge

- Preceding from systematic observations of world to general principles

- *Empiricism*: practice of relying on observation and experiment

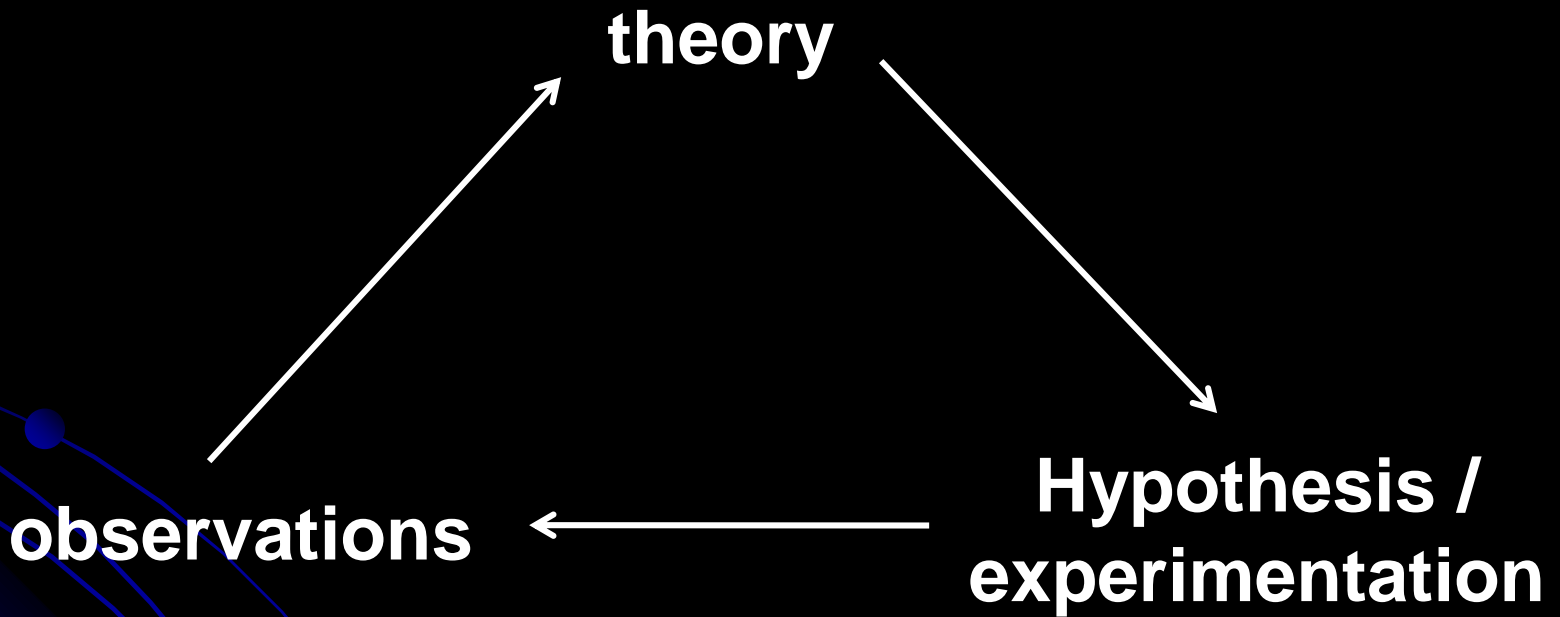
Consequences? “to conquer nature in action”

Challenge long-held authorities (Aristotle)

- **Example: leaves**



- Newton's method



# 30-Second Pause

- Discuss the difference between *deductive* reasoning and *inductive* reasoning.

Goal of deductive reasoning: certainty

Goal of inductive reasoning: probability



# Science and Religion

- Galileo's trial
  - Established a competition between science and religion







- Some tried to reconcile science and religion
  - Benedict de Spinoza (Dutch, 1632-1677)
    - Believed in Descartes' rationalism, but not his dualism

- Born “Baruch,” a Jew (Amsterdam) – family from Spain
- Later rejects traditional Judaism and external view of God
- *The Ethics*
- Quasi-Scientific approach - against the idea of an external interventionary “Superbowl” God
- Rejects prayer, miracles, divine punishment/reward, bible is not divinely inspired, God is an imagination
- NOT AN ATHEIST – Monism – God IS the Universe
- Human beings should try to UNDERSTAND the way nature/the universe works and in doing so one gets to know God
  - Humans themselves, their desires & emotions, are part of the natural order, and can therefore be studied rationally
  - Nature does not exist strictly for humans’ use; humans are a part of nature

*“The wise man the person who understand how and why things are possesses eternally true complacency of spirit.*

- Freedom from the guilt, sorrow, pity, shame of traditional religion
- Excommunicated from Jewish Quarter in Amsterdam



- **Blaise Pascal (French)**
  - Scientific mind/poor health – hunchback, mother died when he was 3
  - Famous work:  
*Pensées* (The Thoughts)

- Blaise Pascal (French, 1623-1662)

- Pessimistic

- Recognizes the misery of human condition (sin/suffering)
- Humans hate being on their own to think/explore our own mortal condition *“all of man’s unhappiness comes from his inability to stay peacefully alone in his room.”* // *“The eternal silence of those infinite spaces strikes me with terror.”*
- People will do anything to avoid considering their reality *“What is man? Nothing compared to the infinite.”*  
Happiness = illusion, misery is the norm, humans are prone to overestimating his own importance
- Christianity and reason are compatible
- Christianity is a good choice for skeptics, a safe bet (*Pascal’s Wager*)
- Reason can only take us so far to discover truth; faith must take us the rest of the way



*Experiment with an Air Pump* – Joseph Wright (1768)