

The background of the image is a deep purple space filled with wispy, ethereal clouds of orange and yellow light, resembling a nebula or the cosmic microwave background. The colors transition from dark purple on the left to a brighter, more intense orange and yellow on the right, creating a sense of depth and movement.

Welcome to the Universe

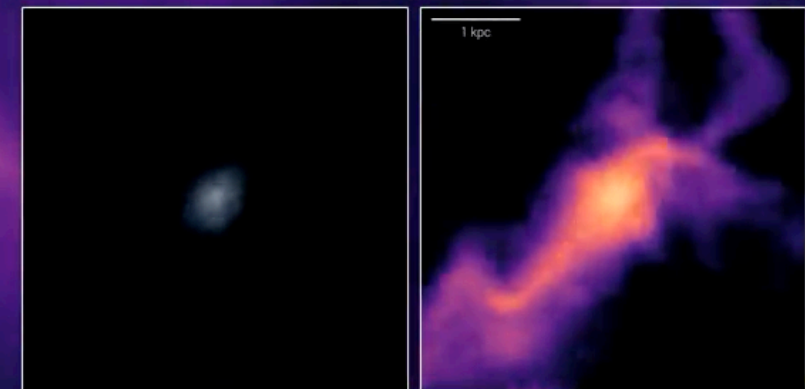
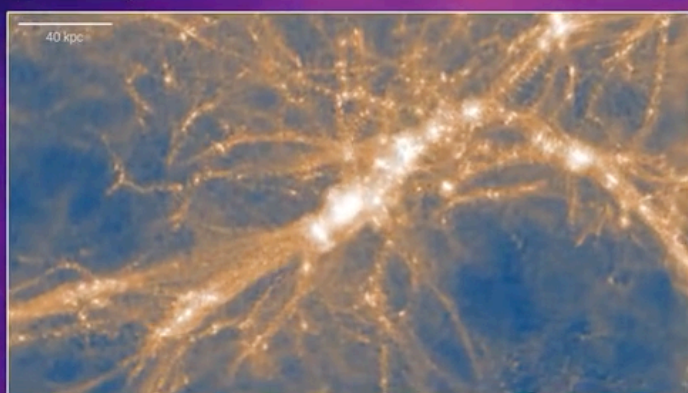
“Newton” Today

100 thousand lightyears

0.78 billion years after the Big Bang

This simulation shows the effects of **gravity***, over time.
Calculations rely on taking tiny steps in time, a key idea from **calculus**.

galaxy stellar mass = 199 million suns



*and several other physical processes, see descriptions of “Illustris TNG” simulations for more

Kepler's planets had *souls*.

Newton saw gravity as the agency of *god*.

Natural
Philosophy
~theoretical

Natural
History
~descriptive

Natural
Science
~empirical

Sneak Preview

Mathematics

Theology

"Science"

Philosophy

Biology

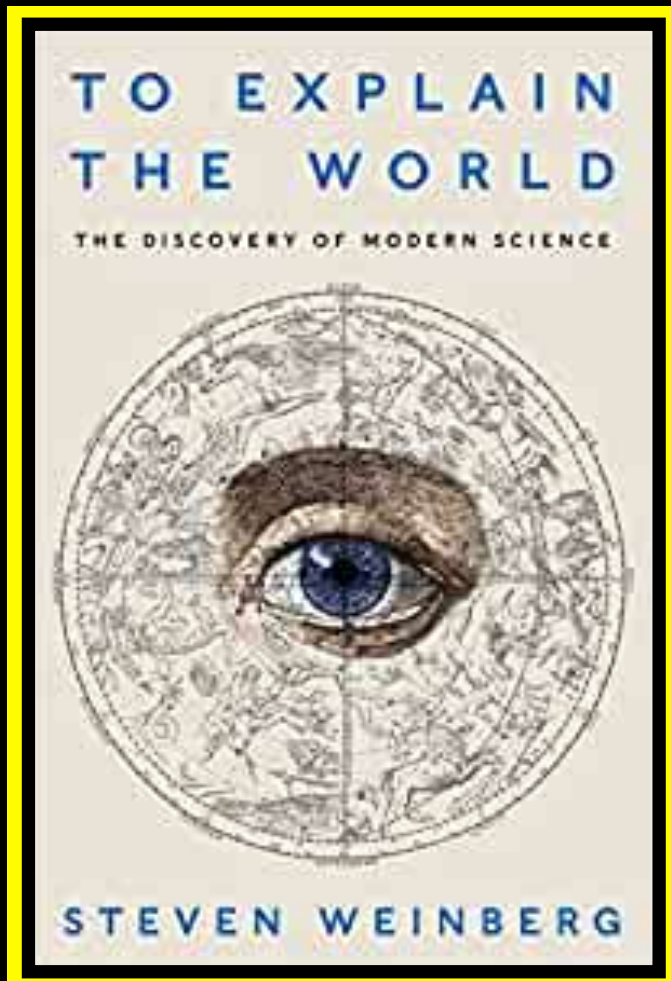
Physics

Chemistry

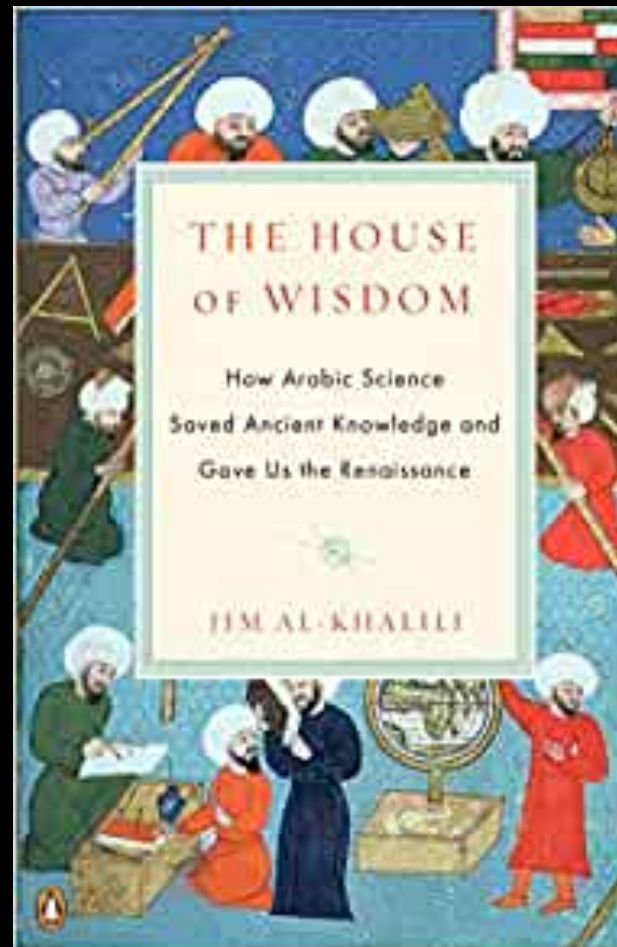
Astronomy

Alchemy

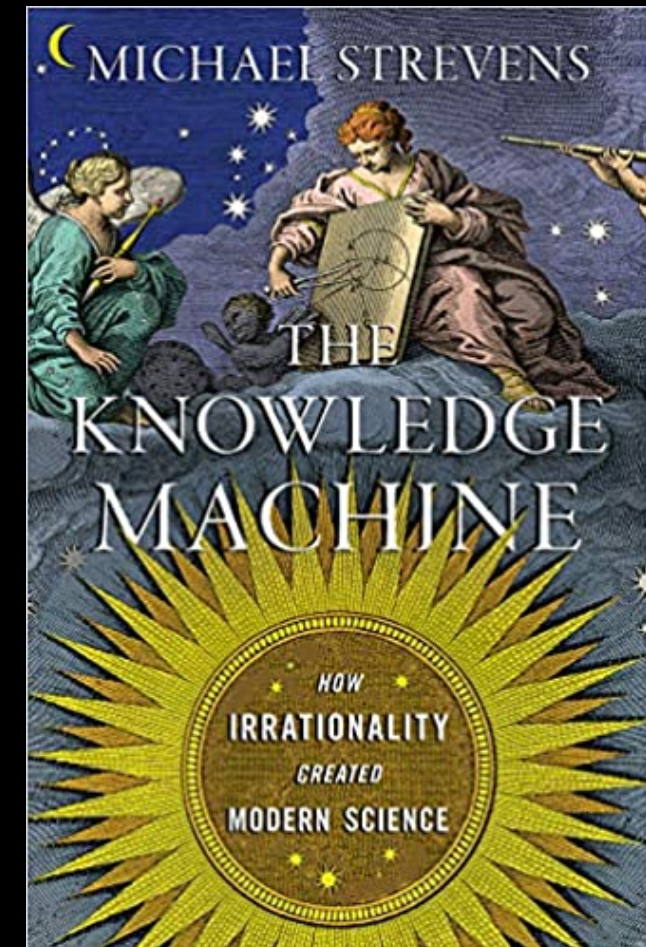
Astrology



**Claims Modern
Science is an Invention**



***shukūk* ('doubts')**



“The Iron Rule”

Demands that all scientific argument be settled by empirical testing alone, and that the results of empirical testing are to be recorded in formal scientific journals for future reference and use.

Prediction: Week 4

Logistics: assignment notifications; section plans; PtN preparations; April fools+ +

“Terrestrial” Motion via Slingshots

Breakout discussions “intuition” (Google Doc)

Terrestrial Motion on the Path to Newton

Celestial Motions on the Path to Newton

Why *would* arrows and stars be related?

Natural “Philosophy,” “Science,” and “History”: Theory, Empiricism, and Description

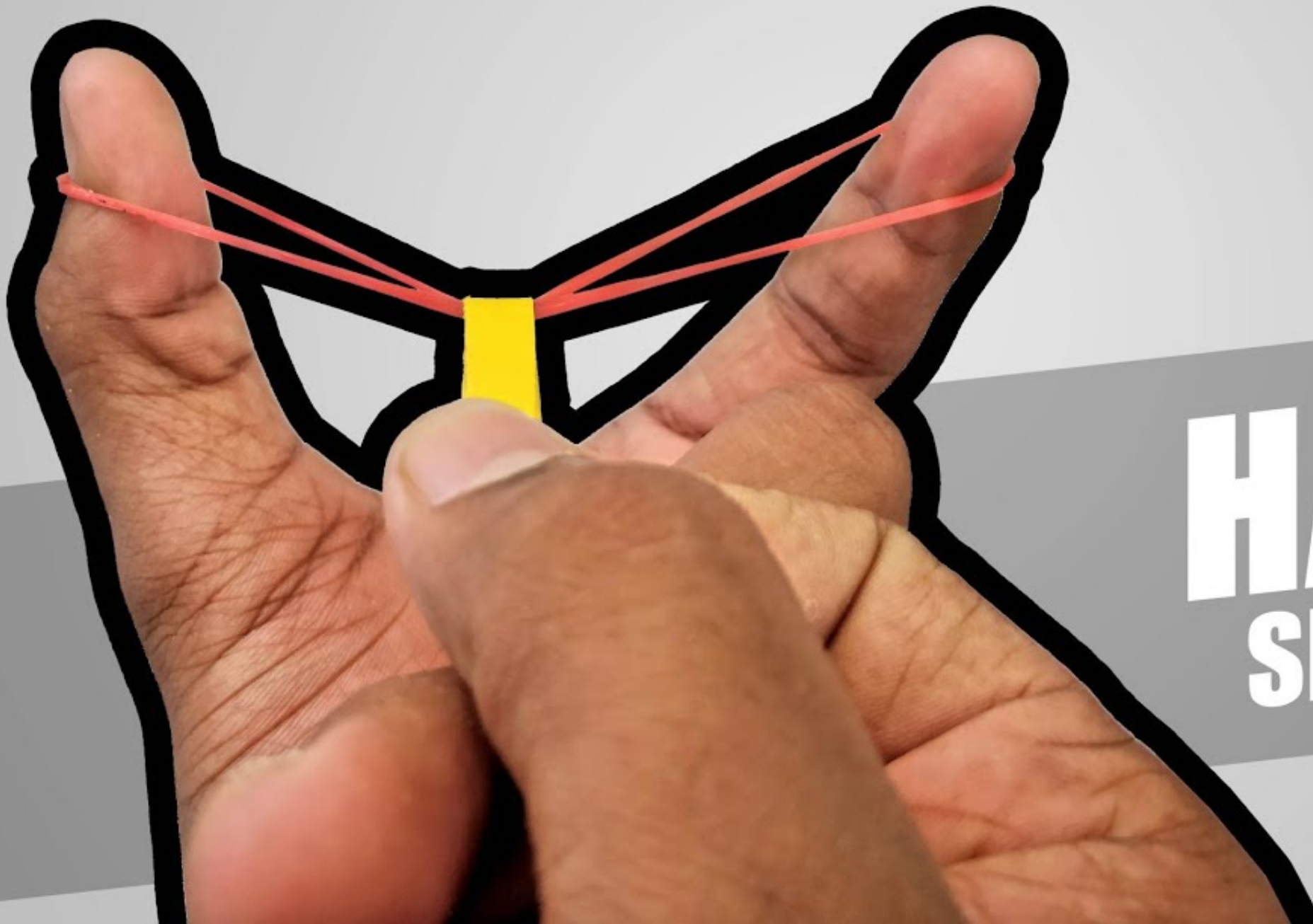
Astronomy 101 “review” to guide you on the Path (WWT)

Notes on PtN Assignment “Parts”

Plans for the PtN “Performance” and Fair

on accuracy & uncertainty (discussion & journal)

“Terrestrial” Motion via Slingshots



**HAND
SLINGSHOT**

“Terrestrial” Motion via Slingshots





Student Ideas on Motion

In-class discussion, GenEd 1112 2/16/21

What is motion? What are we seeing happen? Why does it happen?

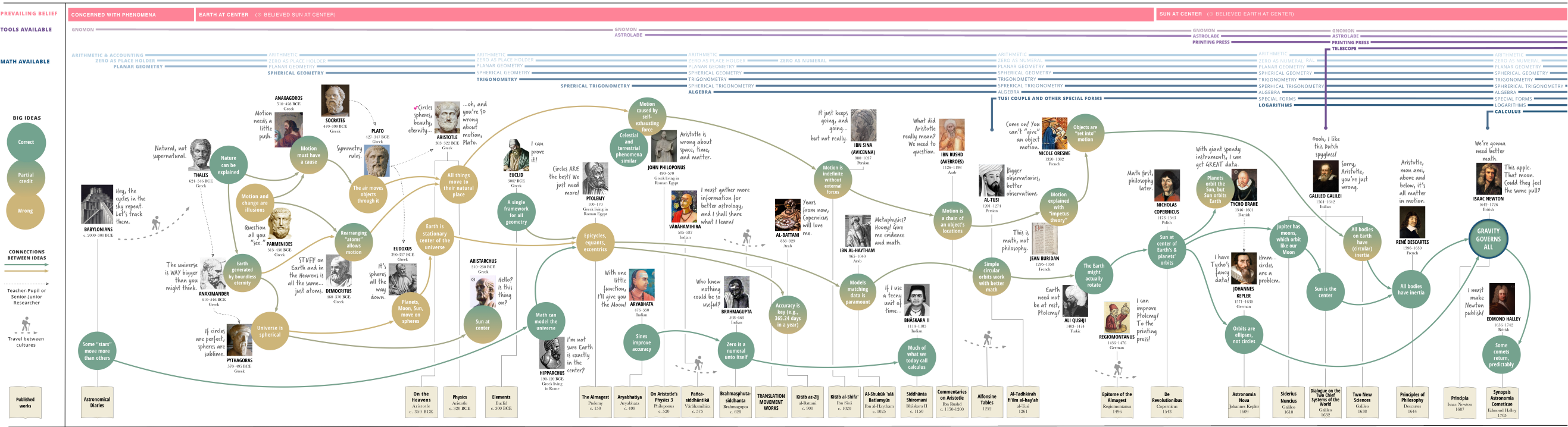
zoom
BREAKOUT ROOMS

Tuesday/Thursday

Predictive Systems, The “Padua Rainbow,” and The Path to Newton



The Path to Newton



or, Experiment

Prediction: Week 4

Logistics: assignment notifications; section plans; PtN preparations; April fools+ +

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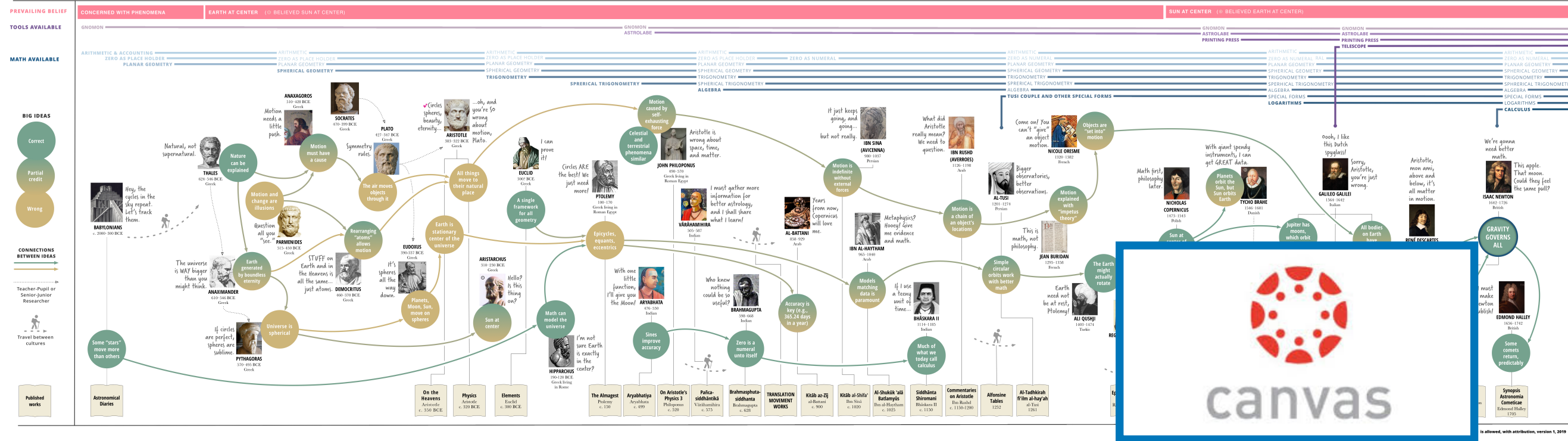
Predictive Systems, The “Padua Rainbow,” and The Path to Newton

State of the signup sheet...



PRESENTING your “character” for the Path to Newton

The Path to Newton



- + Google Slides
- + model of Universe at your person's time
- + AG inserts in slides
- + use tags/symbols from this slide deck, also in Google Slides

Notes on PtN Assignment “Parts”

Plans for the PtN “Performance” and Fair



Resources (including videos) videos for Path to Newton

Sunday, February 16, 2020 11:48 AM

[Interview](#) on **Indian Astronomy & Mathematics** with Caltech's Ashish Mahabal (full video is 46 minutes)



Detailed [discussion of Galileo with Paolo Galluzzi](#), head of the **Galileo Museum** in Florence (full video 28 minutes)



[Link to the Galileo Museum interactive website.](#)

A [video interview](#) where Sara Schechner & Owen Gingerich talk about **comets**, and more (full video 33 min)



A quick interview with Owen Gingerich about **Tycho Brahe's Data**, and it's tremendous significance, including to Kepler (in Owen Gingerich's office).



Rough version with an on-screen person-name typo, sorry, is at <https://youtu.be/BWycBGrpBU?t=143>, only watch 1:15-3:35.

Additional Helpful Videos relevant to the Path to Newton, and Lost without Longitude, are on edX, at this [link](#).

Extra content in “Customized PtN Readings (+Videos)” being updated check back Friday...

▼ Week 5++ (Path to Newton)

PtN Character/Idea Presentation (Multi-Part Assignment)

Not available until Feb 18 at 12:00pm | Due Mar 2 at 1:30pm

Customized PtN Readings(+Videos)

Part 1 of Path to Newton Assignment (First Draft, by classtime on February 23)

Due Feb 23 at 1:30pm | 80 pts

Part 2 of PtN assignment: In-class Presentation (due during class on February 23)

Due Feb 23 at 1:30pm | 50 pts

Part 3 of PtN assignment --Final writeup (due March 2)

Due Mar 2 at 1:30pm | 120 pts

(Terrestrial) Motion on the Path to Newton

student ideas from Google Doc

“impetus”

mass

momentum

inertia

velocity, acceleration

Newton's Laws, Calculus

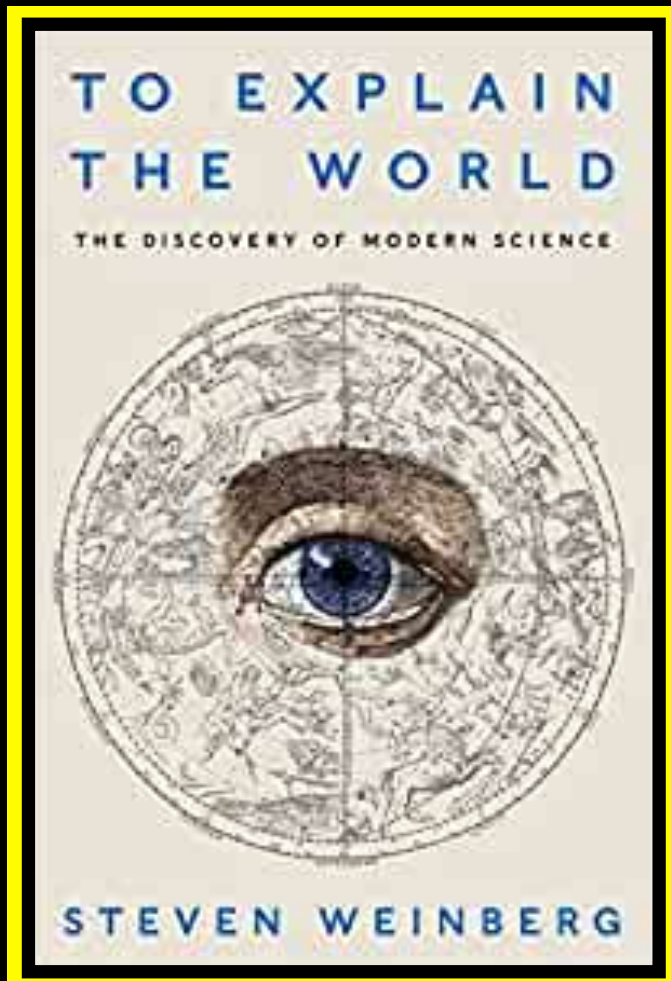
“impetus”

Philoponus vs Aristotle

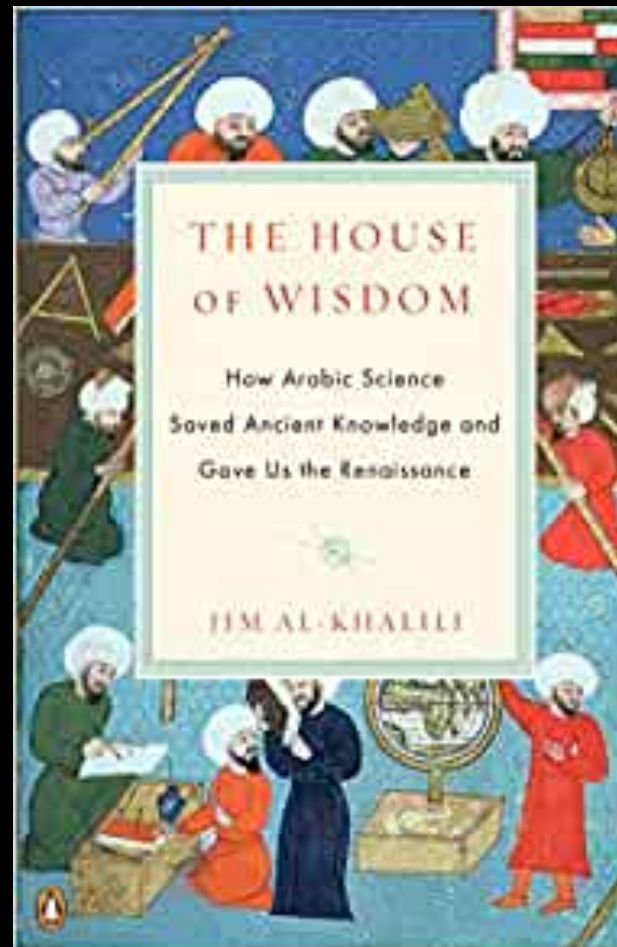
To Aristotle, motion is an effect caused by an external agent – an external force. In Philoponus’ theory, motion is an intrinsic property of the moving object itself. Impetus, the driving agent, is first imparted to an object and set the object in motion and later abides within the moving object on its journey.

This is for the first time in a thousand years when the ideas of Aristotle were seriously and challenged and gain acceptance.

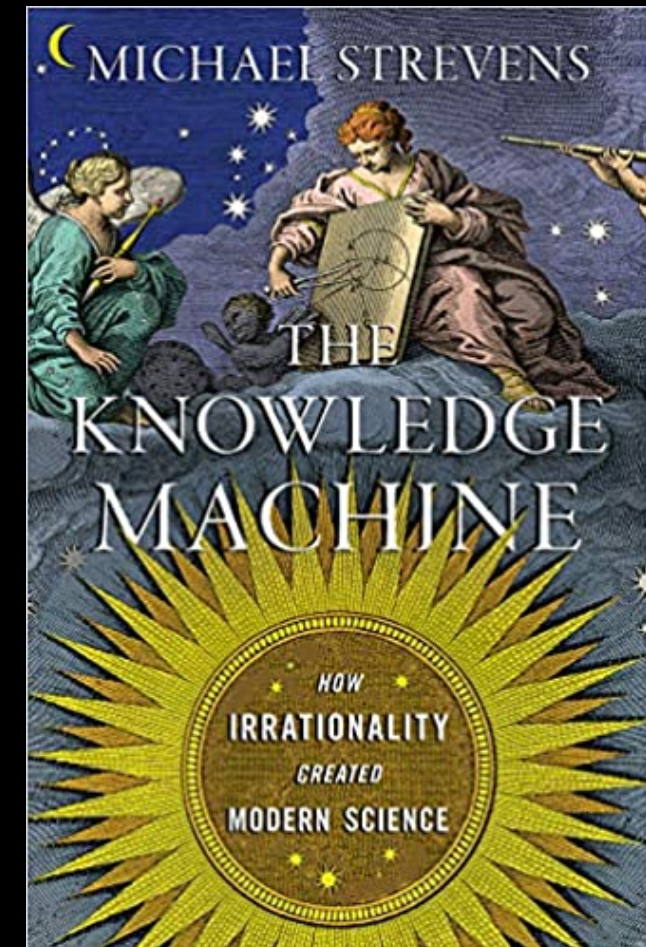




**Claims Modern
Science is an Invention**



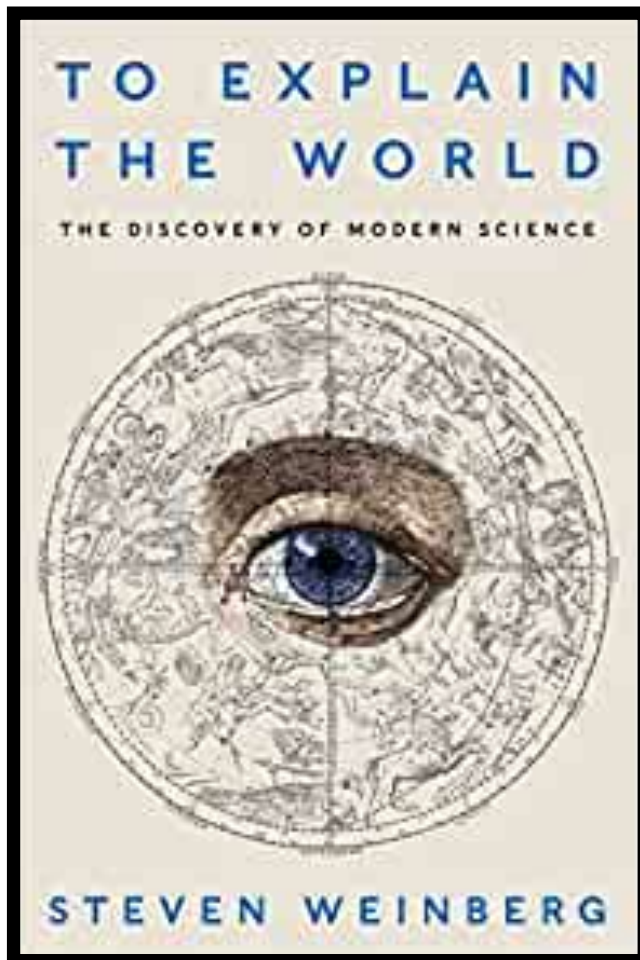
***shukūk* ('doubts')**



“The Iron Rule”

Demands that all scientific argument be settled by empirical testing alone, and that the results of empirical testing are to be recorded in formal scientific journals for future reference and use.

What did Aristotle do to deserve the scorn of modern physicists (and Galileo)?



One of Aristotle's classifications was pervasive in his work, and became an obstacle for the future of science. He insisted on the distinction between the natural and the artificial. He begins Book II of *Physics*⁴ with "Of things that exist, some exist by nature, some from other causes." It was only the natural that was worthy of his attention. Perhaps it was this distinction between the natural and the artificial that kept Aristotle and his followers from being interested in experimentation. What is the good of creating an artificial situation when what are really interesting are natural phenomena?

Aristotle's
Elements & Their
“Natural” Places



Primum Mobile is 'an outer sphere supposed to move around the earth in 24 hours, carrying the inner spheres with it'

Among much else, the “First Day” of [Galileo’s 1638] *Two New Sciences* contains an argument that heavy and light bodies fall at the same rate, contradicting Aristotle’s doctrine that heavy bodies fall faster than light ones. Of course, because of air resistance, light bodies do fall a little more slowly than heavy ones. In dealing with this, Galileo demonstrates his understanding of the need for scientists to live with approximations, running counter to the Greek emphasis on precise statements based on rigorous mathematics.

As Salviati explains to Simplicio: Aristotle says,

“A hundred pound iron ball falling from the height of a hundred braccia hits the ground before one of just one pound has descended a single braccio.”

I say that they arrive at the same time. You find, on making the experiment, that the larger anticipates the smaller by two inches; that is, when the larger one strikes the ground, the other is two inches behind it. And now you want to hide, behind those two inches, the ninety-nine braccia of Aristotle, and speaking only of my tiny error, remain silent about his enormous one.

from: Weinberg, Steven. *To Explain the World: The Discovery of Modern Science* (pp. 190-191). HarperCollins. Kindle Edition.

on accuracy & uncertainty (discussion & journal)

Terrestrial Motion on the Path to Newton

TOOLS AVAILABLE

MATH AVAILABLE

BIG IDEAS

Correct

Partial credit

Wrong

CONNECTIONS BETWEEN IDEAS

Teacher-Pupil or Senior-Junior Researcher

Travel between cultures

Published works

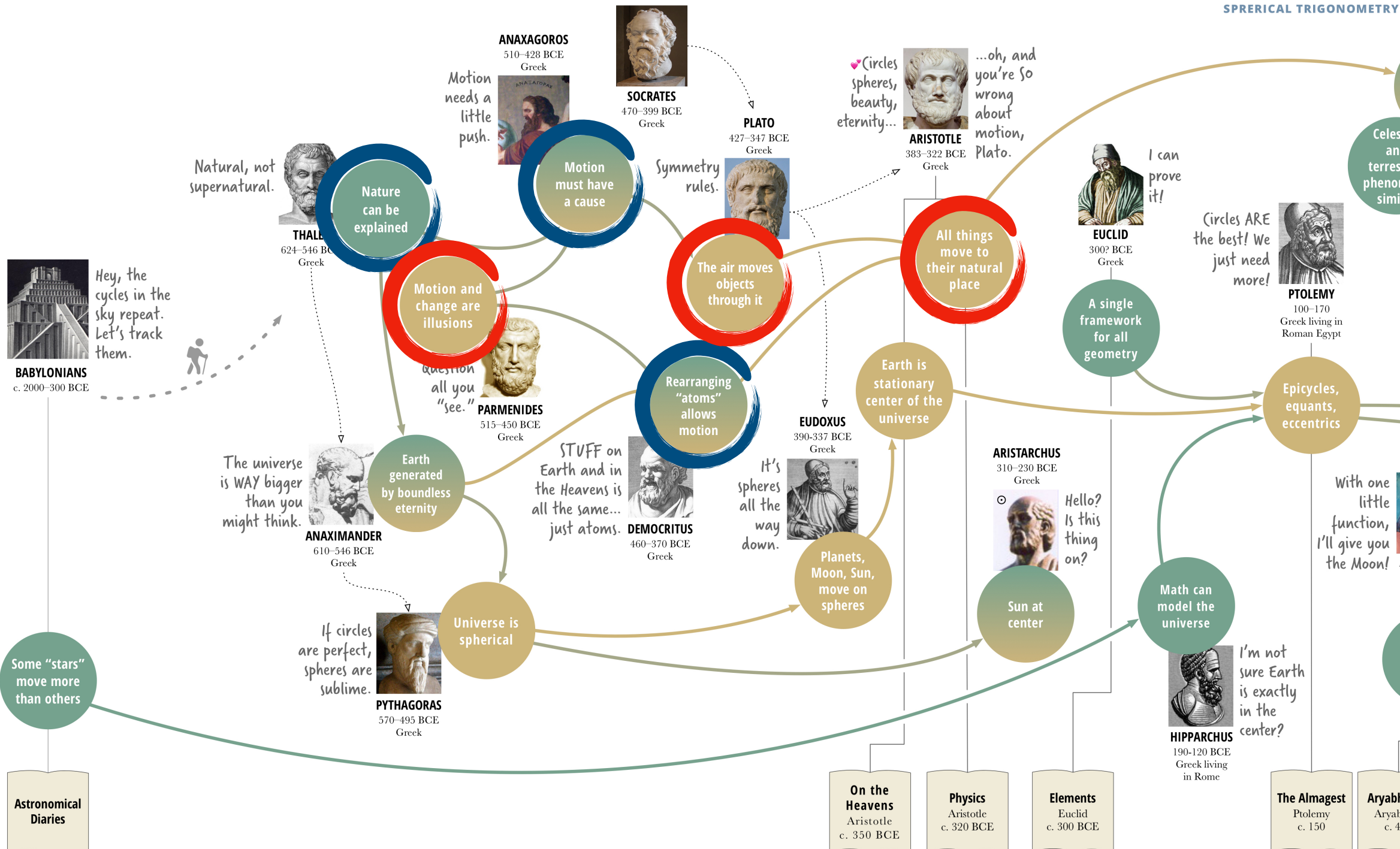
GNOMON

ARITHMETIC & ACCOUNTING
ZERO AS PLACE HOLDER
PLANAR GEOMETRY

ARITHMETIC
ZERO AS PLACE HOLDER
PLANAR GEOMETRY
SPHERICAL GEOMETRY

ARITHMETIC
ZERO AS PLACE HOLDER
PLANAR GEOMETRY
SPHERICAL GEOMETRY
TRIGONOMETRY

SPRERICAL TRIGONOMETRY

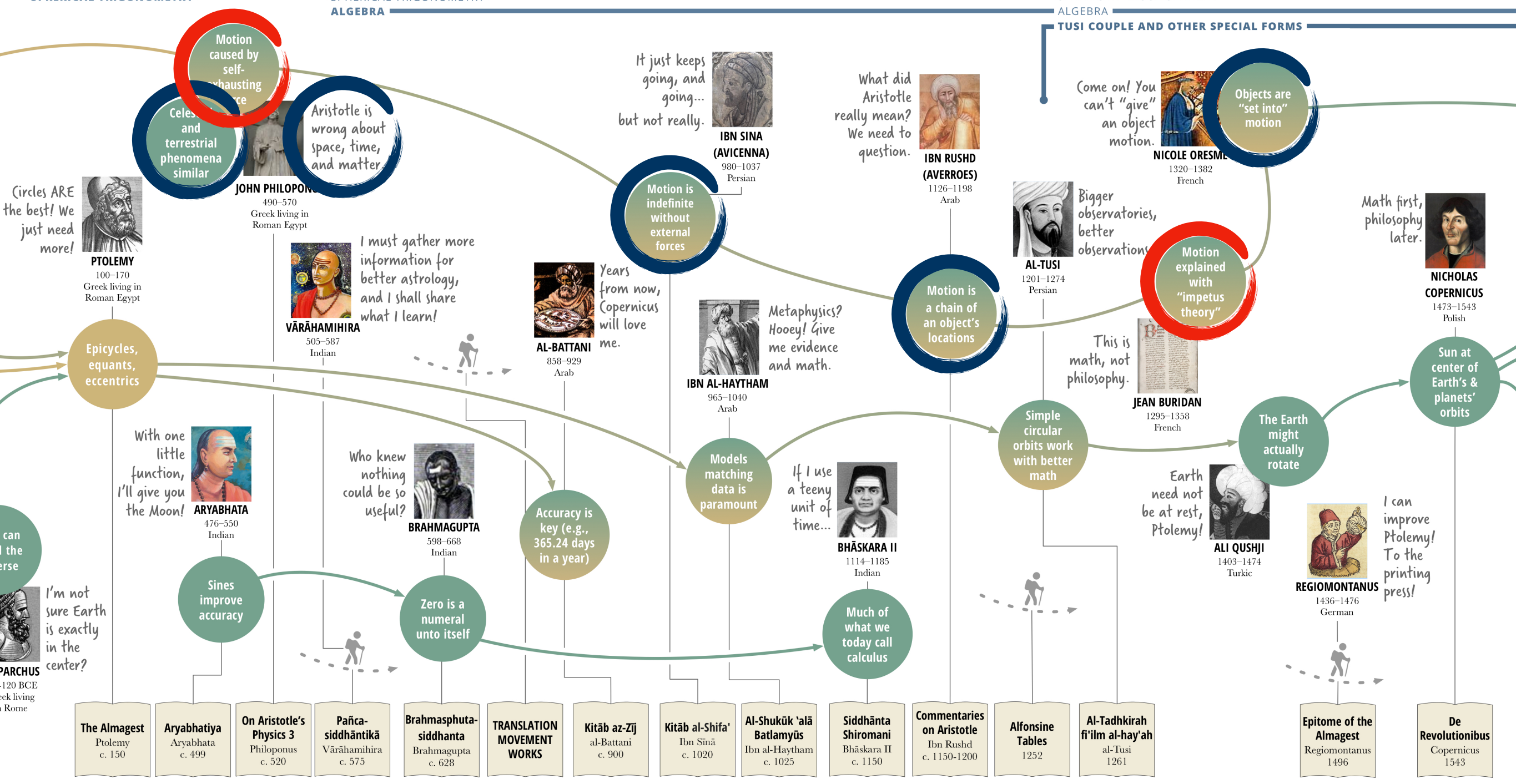


GNOMON
ASTROLABE

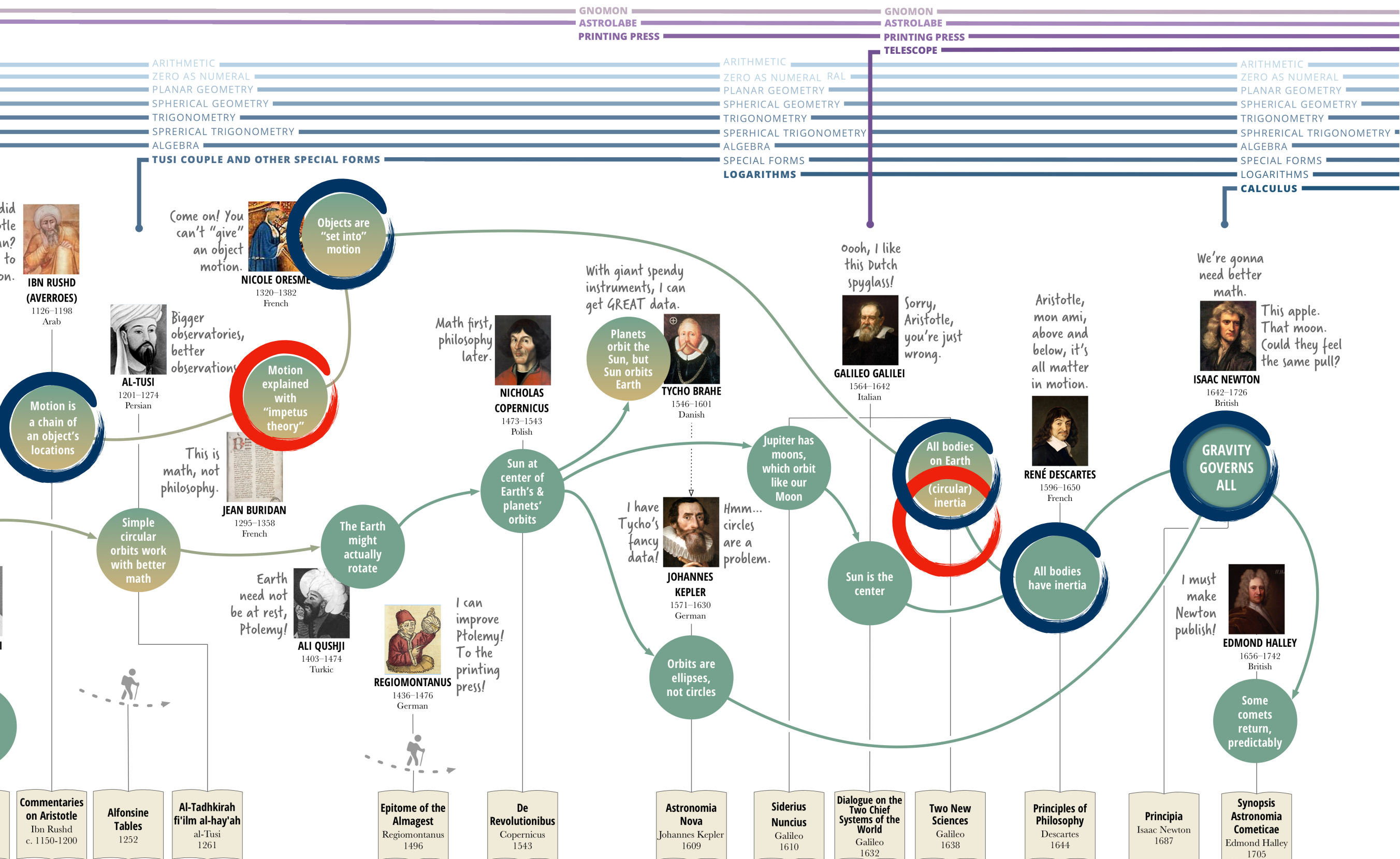
ARITHMETIC
ZERO AS PLACE HOLDER
PLANAR GEOMETRY
SPHERICAL GEOMETRY
TRIGONOMETRY
SPHERICAL TRIGONOMETRY
ALGEBRA

ARITHMETIC
ZERO AS NUMERAL
PLANAR GEOMETRY
SPHERICAL GEOMETRY
TRIGONOMETRY
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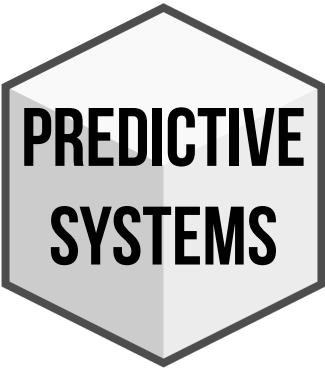
TUSI COUPLE AND OTHER SPECIAL FORMS



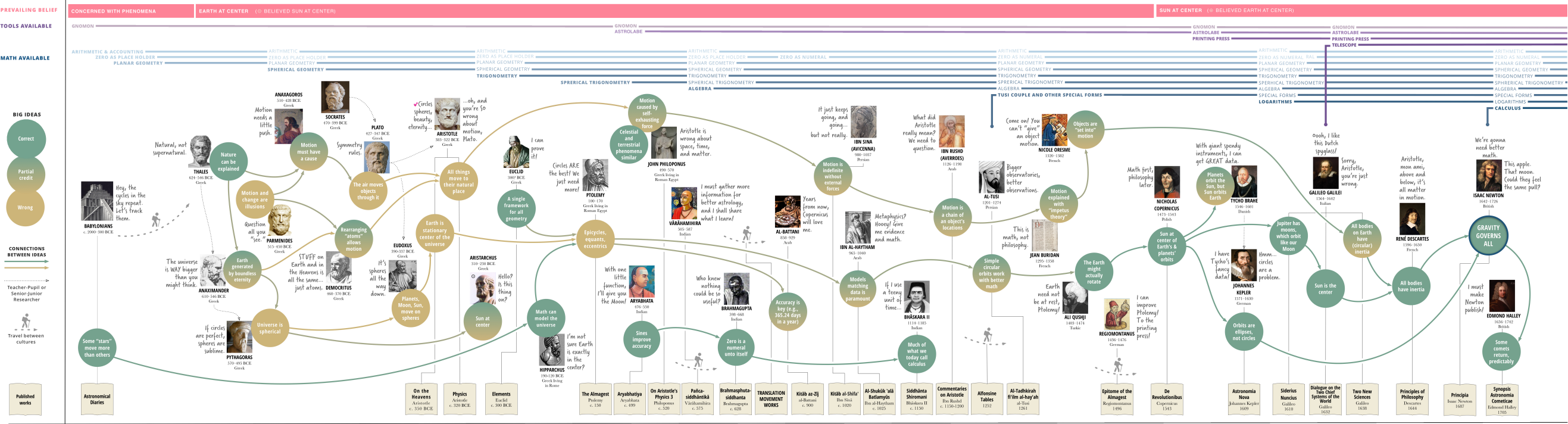
SUN AT CENTER (⊕ BELIEVED EARTH AT CENTER)



Predictive Systems, The “Padua Rainbow,” and The Path to Newton



The Path to Newton



or, Experiment

Newton's 3 Laws



Alyssa Goodman holds the (REAL) Principia, at the Royal Society, London, 2015

Newton's 3 Laws

Newton's laws of motion in physics

LAW #1

A body at rest will remain at rest, and a body in motion will remain in motion unless it is acted upon by an external force.

LAW #2

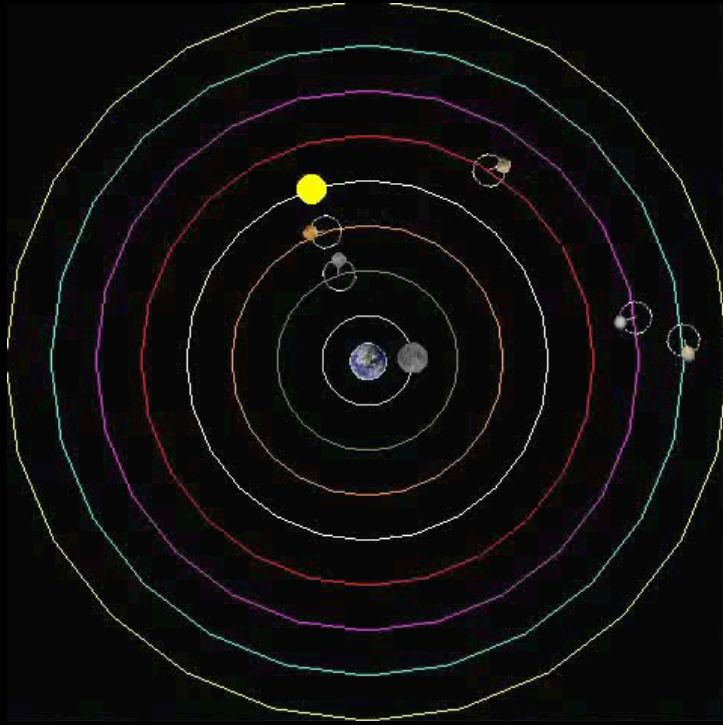
The force acting on an object is equal to the mass of that object times its acceleration, $F = ma$.

LAW #3

For every action, there is an equal and opposite reaction.

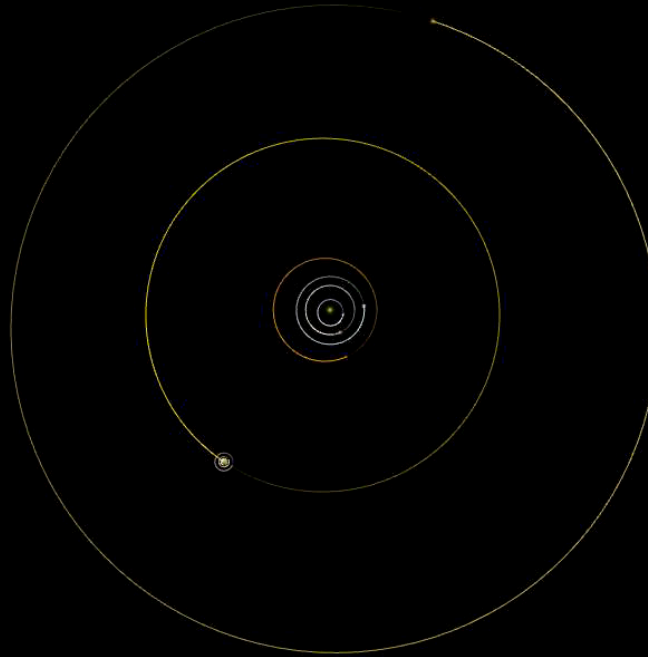
Ptolemaic

*Geocentric,
with Epicycles*



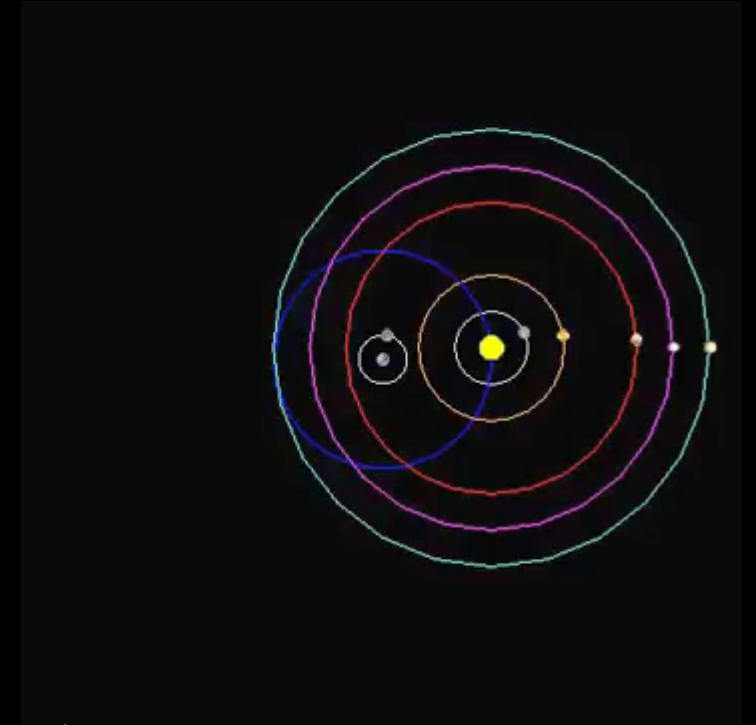
Copernican

*Heliocentric
(correct)*



Tychonic

*Geoheliocentric
hybrid*



Astronomy 101 “review” to guide you on the Path (WWT+)



150 A.D.



1543



1587

Astronomy 101 “review” to guide you on the Path (WWT+)

+ **stars** are **VERY far away**, but Universe is **finite** (in space & time)

+ stars apparent motion on the Sky is **due almost entirely to Earth's Rotation** on its axis

+ **planets** of OUR Solar system are **SUPER close** compared to stars

For example, the Sun is 93 million miles from Earth, and the next nearest star is 25 trillion miles, about 300,000 times, farther away.

+ **Earth DOES move** (both in its orbit + spins on its axis)

+ the **force of gravity** is proportional to the “inverse square” of the distance between any two objects (=“Newton's Law of Universal Gravitation”)

> which means that “orbits” are ellipses

+ if one object has MUCH more mass than the other, it's at a focus of an elliptical orbit

So, for example, the Sun is at the focus of Earth's (or Mars, or Pluto's) elliptical orbit (=“Kepler's First Law”)

WorldWideTelescope.org

AAS WorldWide Telescope

Explore

Guided Tours

Search

Communities

View

Settings

Sign Out

Use Layer Manager to Control User Settings

Name My Location

Lat 47:43:01

Alt 100.0m

Lng -122:05:09

☐ View From This Location

Setup

2092/08/31 07:50:26

X 1000000 : Paused

Now

☐ Galactic Plane Mode

View in ESASky

Layers

☒ Sun

☒ Mercury

☒ Venus

☒ Earth

☒ Mars

☒ Jupiter

☒ Saturn

☒ Uranus

☒ Neptune

☒ Pluto

☒ Sky

☐ Overlays

☐ Constellations

☐ Constellation Pictures

☒ Constellation Figures

☒ Constellation Boundaries

☐ Constellation Names

☒ Grids

☐ Equatorial Grid

☐ Galactic Grid

Time Scrubber

Look At

SolarSystem

Imagery

3D Solar System View

Tracking Earth

1 of 2

Planet Size

Actual

Large

Pisces

00:52:08

Sun

Mercury

Venus

Earth

Mars

Jupiter

Saturn

Uranus

Neptune

Pluto

Lat: 22:18:06

Lng: 177:04:35

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The Path to Newton

PREVAILING BELIEF

TOOLS AVAILABLE

MATH AVAILABLE

CONCERNED WITH PHENOMENA

EARTH AT CENTER (☉ BELIEVED SUN AT CENTER)

GNOMON

ARITHMETIC & ACCOUNTING —
ZERO AS PLACE HOLDER
PLANAR GEOMET

■ ARITHMETIC

ZERO AS PLACE HOLDER

- ARITHMETIC
- ZERO AS PLACE HOLDER
- PLANAR GEOMETRY

GENOMICS
ASTRO

Celestial Motions on the Path to Newton

BIG IDEAS

Correct

Partial credit

Wrong

CONNECTIONS BETWEEN IDEAS

Teacher-Pupil or
Senior-Junior
Researcher

Travel between cultures

Published works

Astronomical Diaries

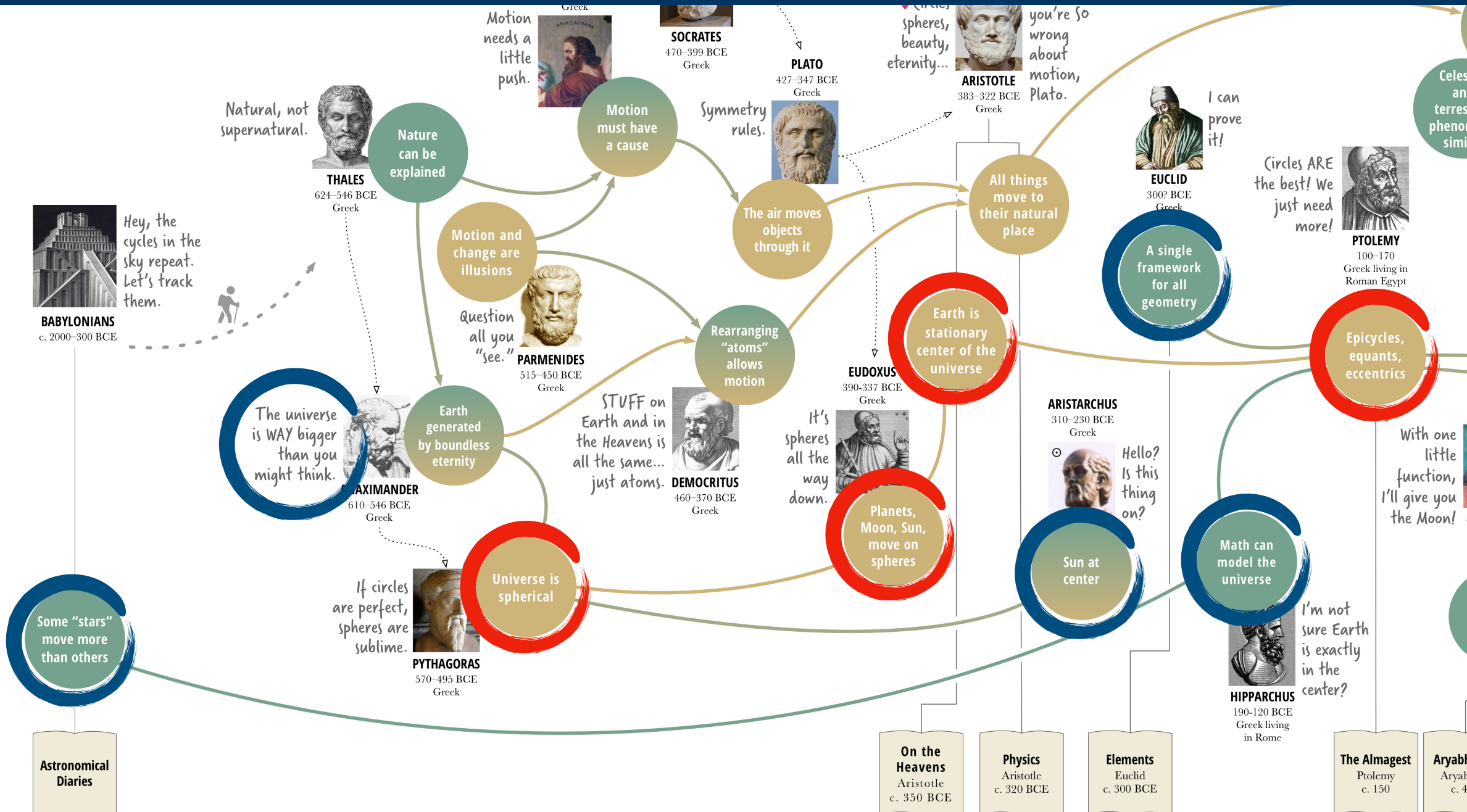
**On the
Heavens**
Aristotle
c. 350 BCE

Physics
Aristotle
c. 320 BCE

Elements
Euclid
c. 300 BCE

The Almagest Ptolemy c. 150	De Revolutionibus Copernicus 1543
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Aryab
c. 4

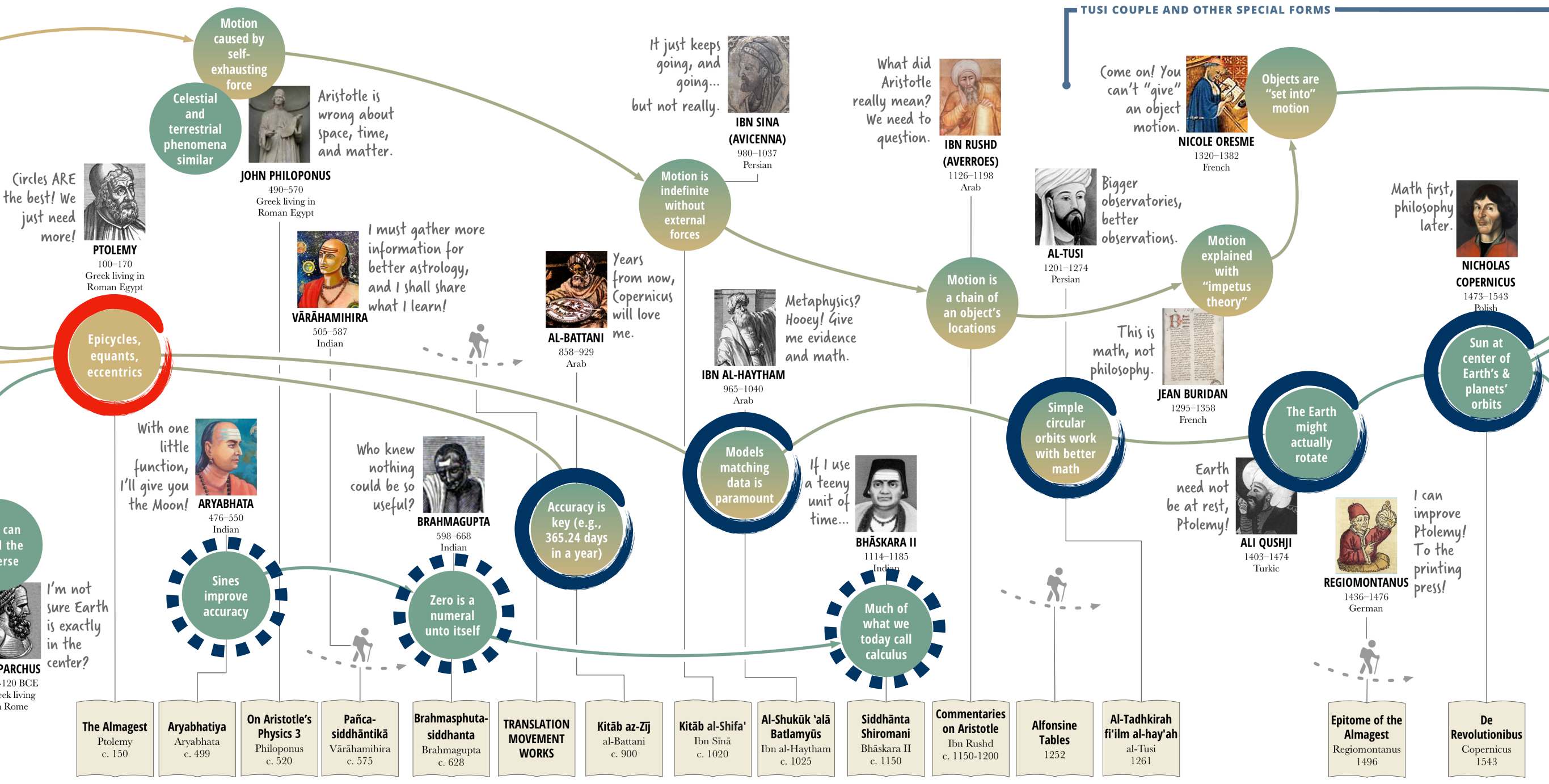


GNOMON
ASTROLABE

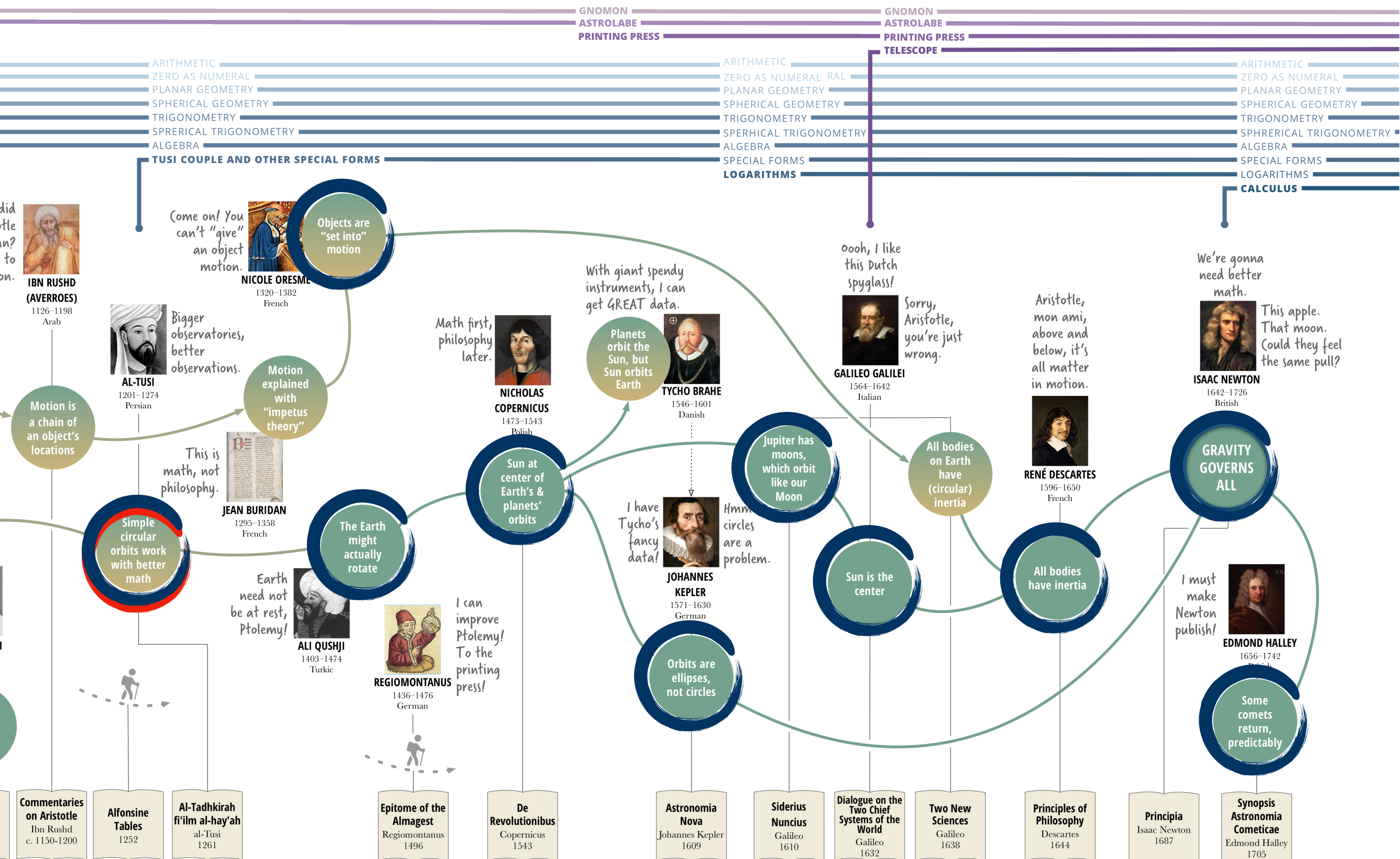
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TUSI COUPLE AND OTHER SPECIAL FORMS



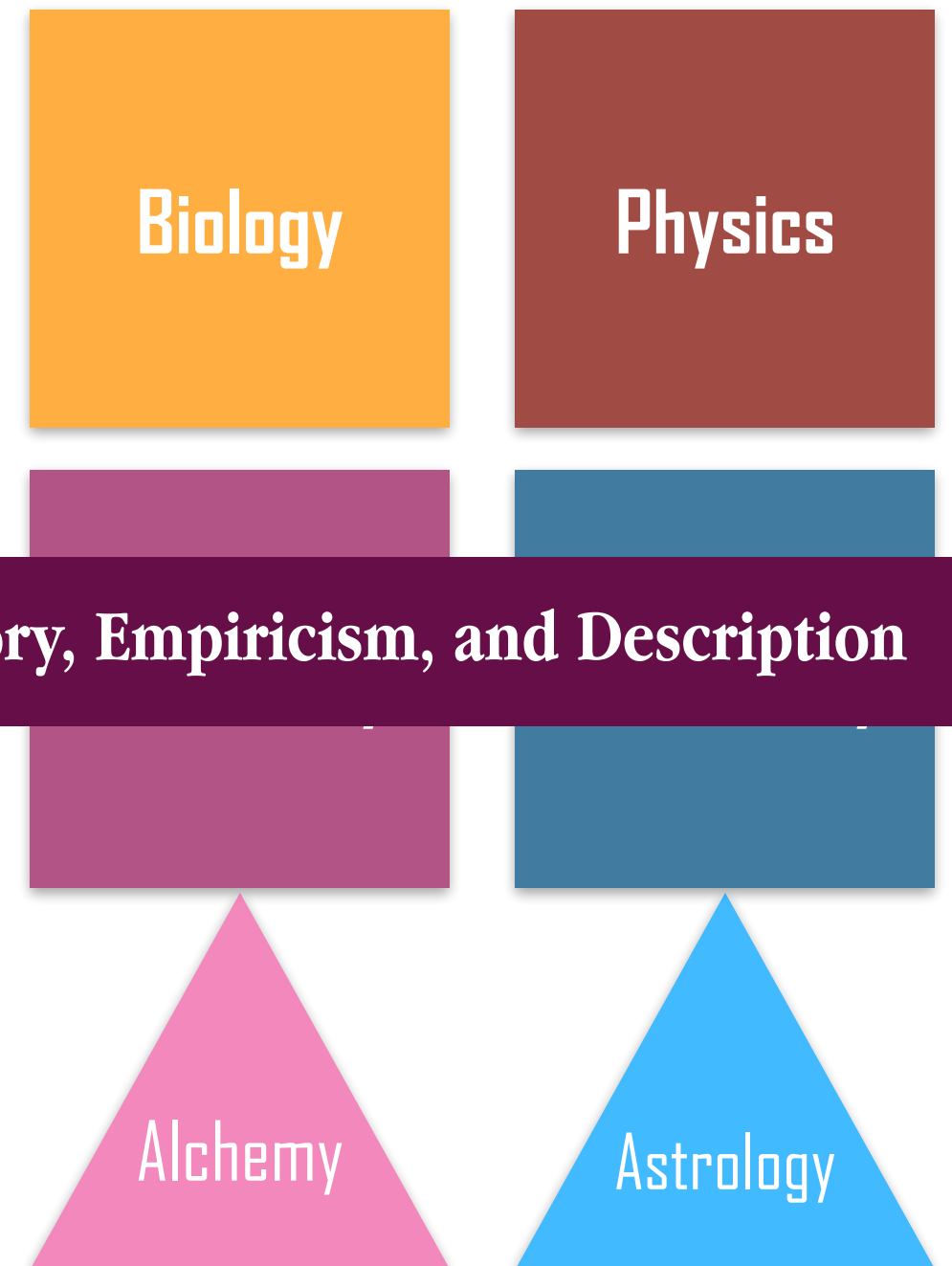
SUN AT CENTER (⊕ BELIEVED EARTH AT CENTER)



Why *would* slingshots and stars be related? (or not)



Bonus: *Why is Astronomy so important to (the history of) Prediction?*



Natural “Philosophy,” “Science,” and “History”: Theory, Empiricism, and Description

"Science"

Theology

Natural
Science
~empirical

Natural
Philosophy
~theoretical

Natural
History
~descriptive

Astronomy

Physics

Biology

Mathematics

Philosophy

Think about all of these
relationships in your
research.
(You should use these
markers in your slides.)

Chemistry

Astrology

Alchemy

Phenomenon

Observation

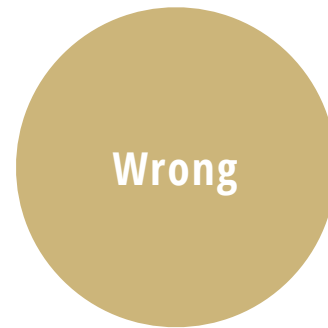
Data

Rule

Theory

Explanation

Prediction



Wrong

EMPIRICAL

ANALYTICAL

Phenomenon

Observation

Data

Rule

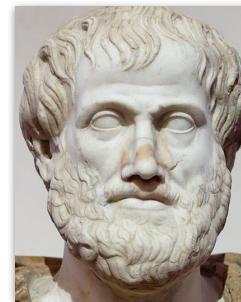
Theory

Explanation

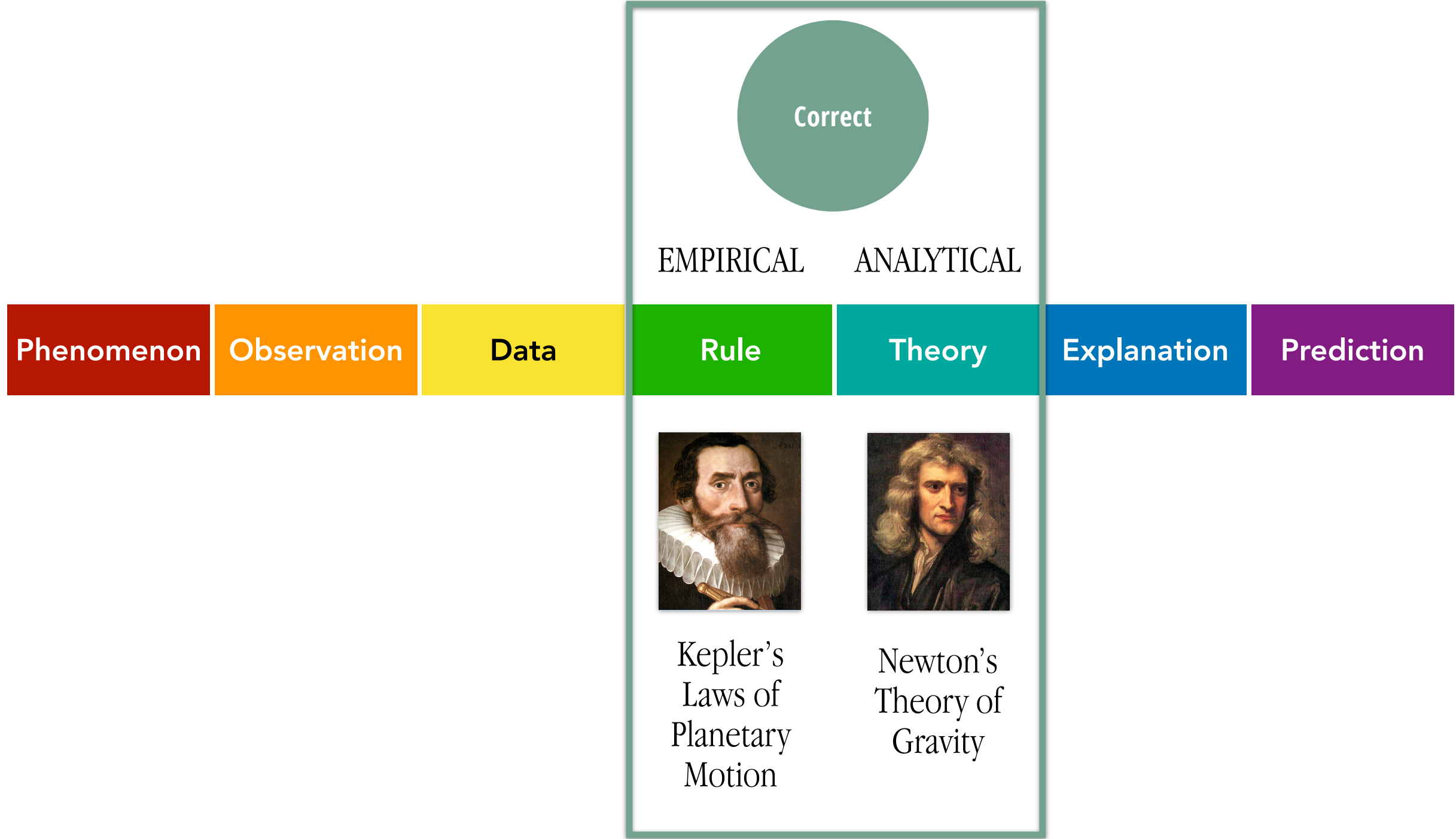
Prediction



Ptolemy's
Epicycles



Aristotle's
Natural
Philosophy





Kepler

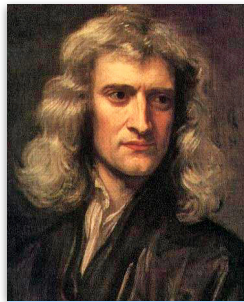
Phenomenon

Observation

Data

Rule

Prediction



Newton

Phenomenon

Observation

Data

Rule

Theory

Explanation

Prediction

Kepler's planets had souls.

Newton saw gravity as the agency of god.