THE PAST & PRESENT OF THE FUTURE

ALYSSA A. GOODMAN - HARVARD, SMITHSONIAN & RADCLIFFE - @AAGIE, @PREDICTIONX

PREDICTIONX.ORG

PredictionX: The Past & Present of the Future

Tools

Framework for Predictive Systems edX

Framework for Study Design

Understanding Uncertainty

Timelines

Why predict? ▶

Omens, Oracles & Prophecies

Mesopotamian Haruspicy
Egyptian Priests
Yoruba Ifa
Roman Augury
Tarot
Casting Lots
Chinese Oracle Bones
The Diviner's Guide
Greek Astronomy
Oracle of Delphi
Turkish Tasseography
Astrology
Aztec Rituals
Maya Spacetime
Comets of Doom

edX

cross-cultural conversations

The Rise of Theory

Islamic Science
The Royal Society

The Path to Newton

Indian Mathematics

John Snow & Cholera edX
Cholera Map

Lost without Longitude (Navigation) edX
Tools of the Navigator edX
Help, I'm Lost! edX

Modern Simulation

Health
▶Epidemiology
Personal Genomics

Earth
Earthquakes
Climate Change
▶Tent Tarot edX

Wealth
Personal Finance
World Economy

Space
Futures of our Universe

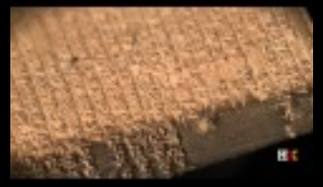
The Future of the Future
▶Artificial Intelligence
Derek's Day

Finished | Coming Soon | Planned | Interactive Resource | ▶ video(s) | edX link to edX (often contains videos + interactives, not marked separately here)

HarvardX · general education · general education · general education · edX predictionx.org

with many thanks to HarvardX course producer Drew Lichtenstein, research assistant Jais Brohinsky + dozens of other experts at Harvard and beyond

income
housing
water

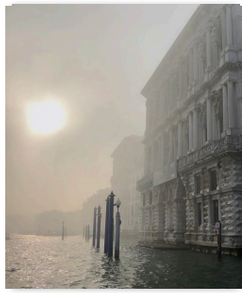


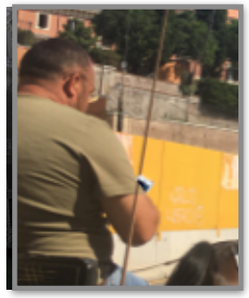
Do we really *want* to know?

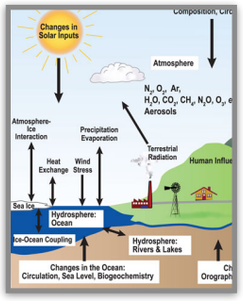
How well *can* we know?

Do we *already* know?

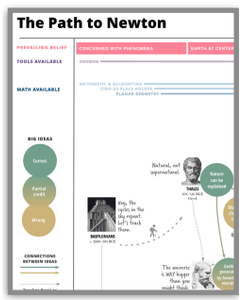
PREDICTION IN. . .

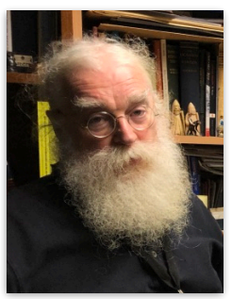


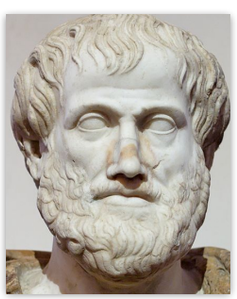


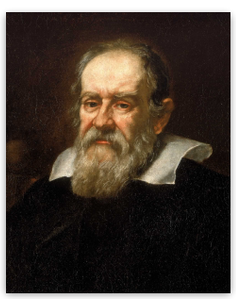


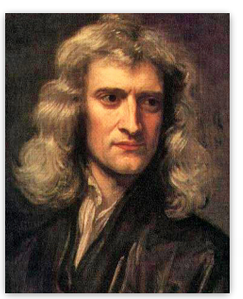
OUR FUTURE











MY WORLD

"YOUR" WORLD

THE WORLD

KARLOS
LIBERO

T-Mobile... 4:16 PM 97%
Via dei Fori Imperiali, 1
Colosseum
4 min
5 min
6 min
Hotel Duca D'Alb
Cavour
Via Giovann
4 min
Basilica di San Pietro in Vincoli
Domus Aurea
Parco Del Colle Oppio
6 min
Arco di Costantino
Ristorante Pizz
4 min (1.1 km)
Fastest route, despite the usual traffic

T-Mobile... 4:16 PM 97%
Via dei Fori Imperiali, 1
Colosseum
4 min
5 min
6 min
Hotel Duca D'Alb
Basilica di San Pietro in Vincoli
Domus Aurea
Parco Del Colle Oppio
Arco di Costantino
4 min (1.1 km)
Fastest route, despite the usual traffic
T-Mobile... 4:18 PM 93%
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New VAMP Feeds
Constellations
Planet Size
Pisces
60:00:00
Look At
Actual
Large
SolarSystem
Imagery
T-Mobile... 4:19 PM 91%
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LOUVRE
PLAN YOUR VISIT
Models of divinatory livers
Models of divinatory livers
© 2007 RMN / Franck Raux
Missions & Organization
Louvre Lens
App St... 4:15 PM 98%
BASIC DIVINATION
THE 5 BASIC POSITIONS
ALAFIA
YES
EJIFE
YES
ETAWA
MAYBE
OKANRAN
NO
OYEKU
NO
No Service 12:33 PM 100%
Boston, MA
30
20
10
0
Today
Wed
Thu
Fri
Sat
Settings
How To
Credits
App St... 7:44 AM 61%
tockaster
Apple Inc. (AAPL)
Analysis
Ratings
News
Info
Historical
Median
Upper
Lower
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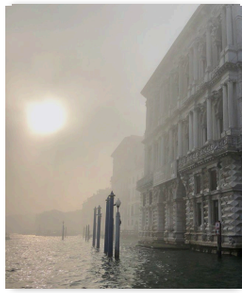
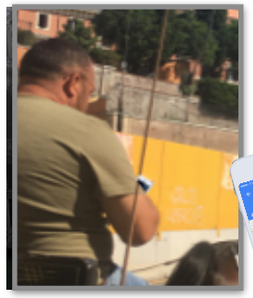
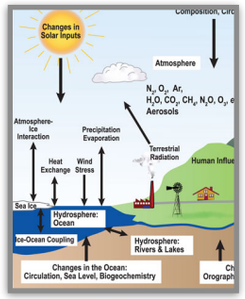
$115.00
$110.00
$105.00
$100.00
$95.00
Aug 1
Sep 1
Oct 1
Nov 1
Dec 1
Quote
Oct 03
@12:00pm
+/-
Volume
29,590,254
29,741,186
+0.51%

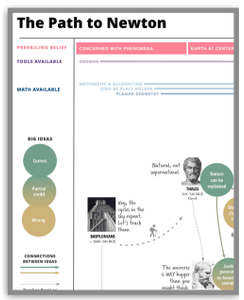
PREDICTION IN . . .

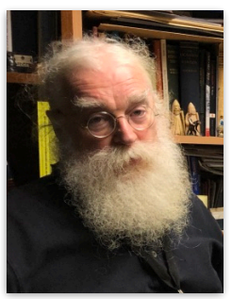


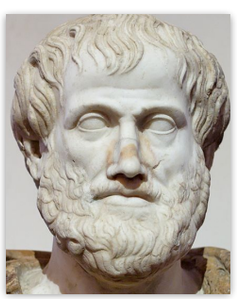


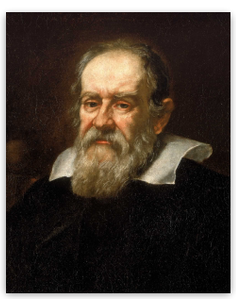


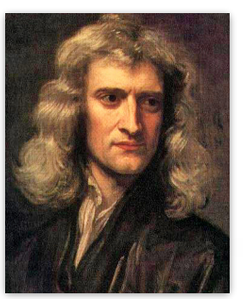
OUR FUTURE









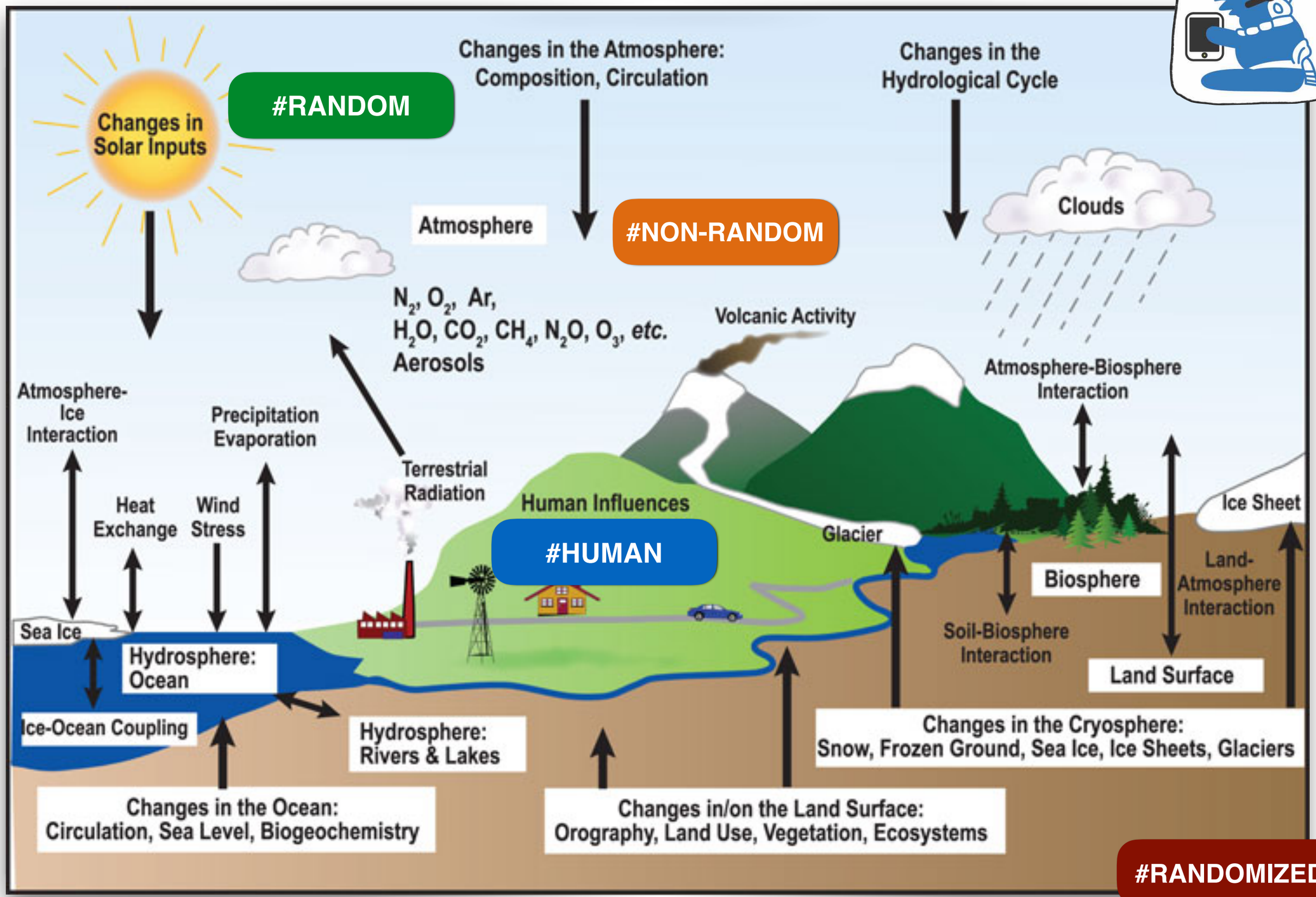


MY WORLD

"YOUR" WORLD

THE WORLD

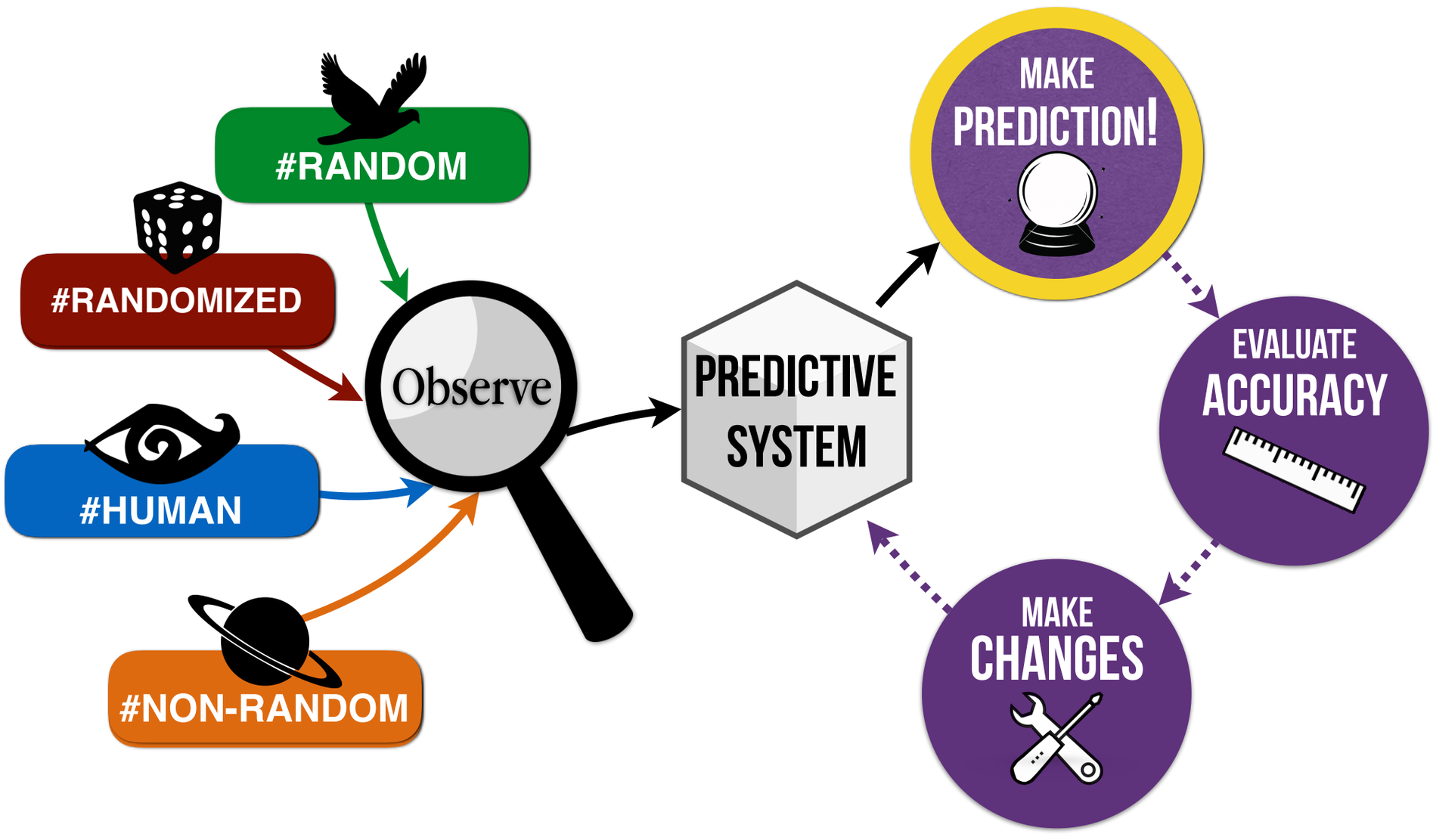
OUR WORLD



blogs.scientificamerican.com/the-curious-wavefunction/are-more-accurate-climate-change-models-worse

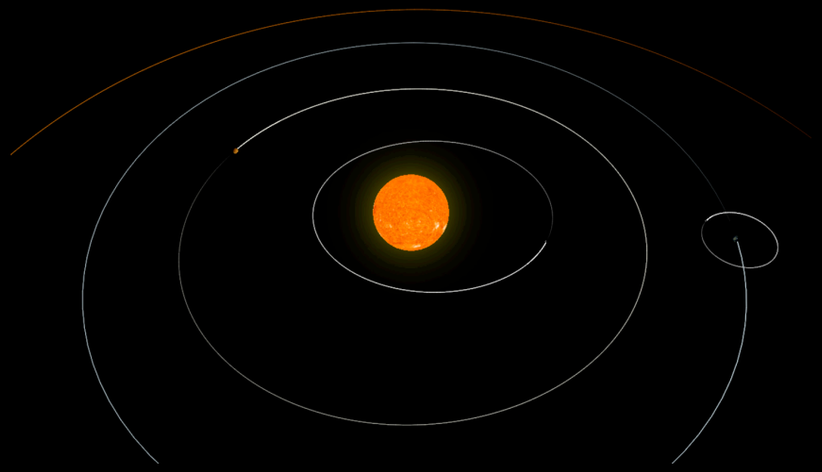
PredictionX

Framework for Predictive Systems



https://openclipart.org/

#NON-RANDOM



Astrology

#RANDOMIZED

Ifa

#HUMAN

Egyptian “Bobble Head”

#RANDOM

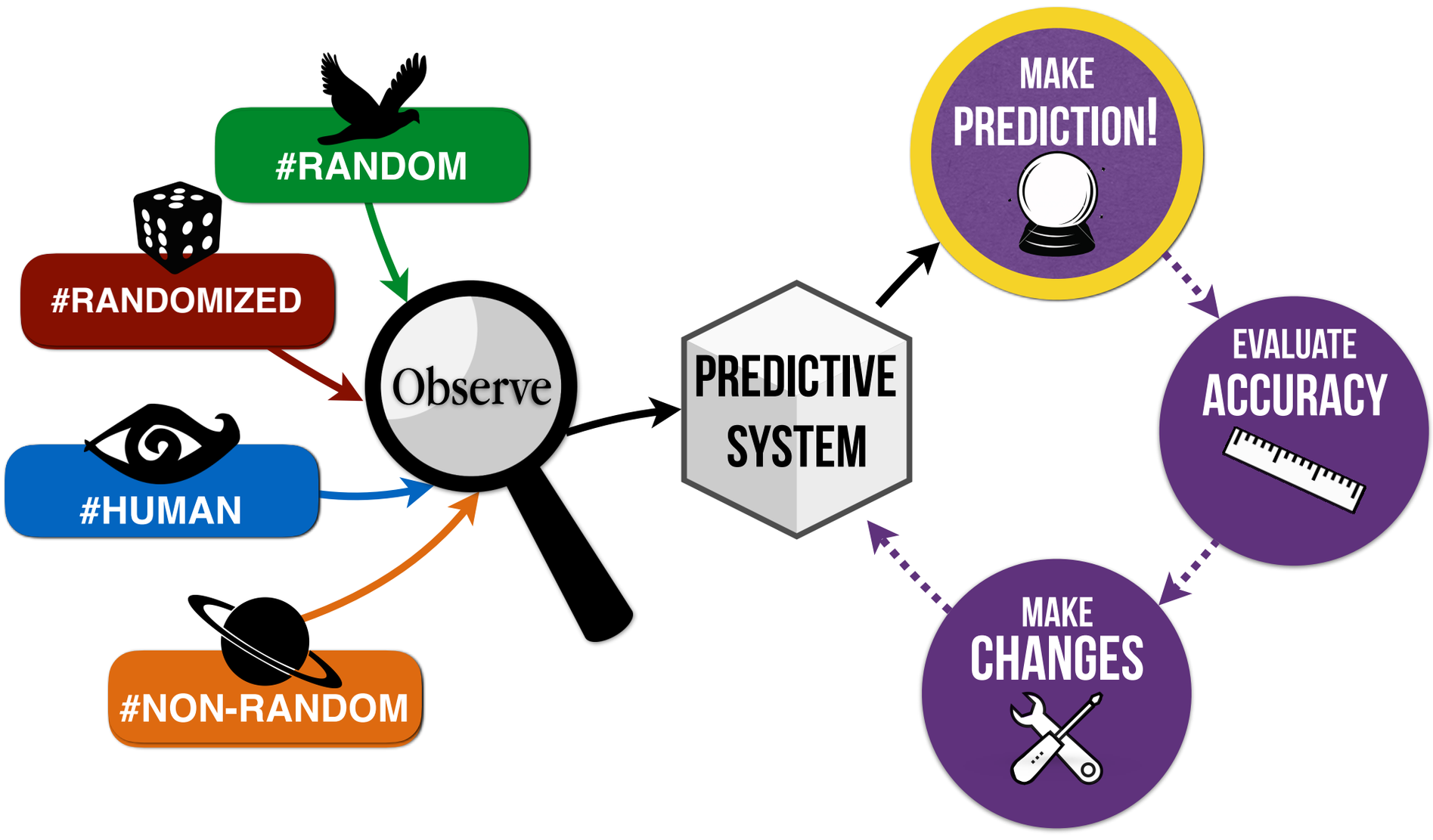
Comets of Doom

#HUMAN

Ancient Egyptian Divination, featuring Prof. Peter der Manuelian (Harvard Semitic Museum)

PredictionX

Framework for Predictive Systems



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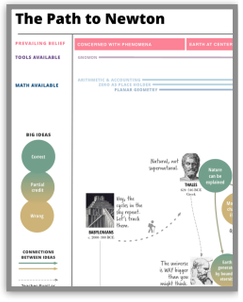
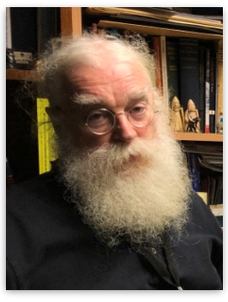
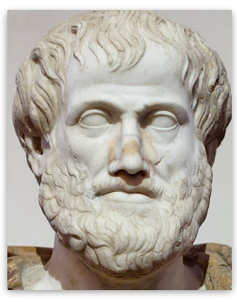
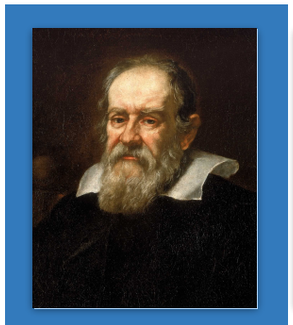
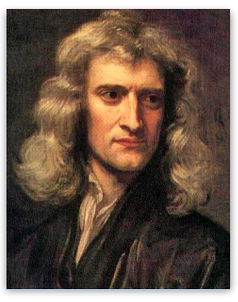






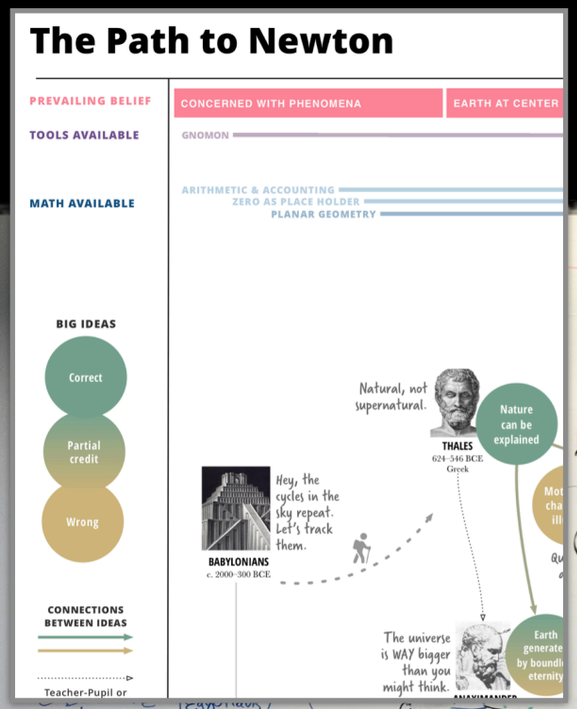


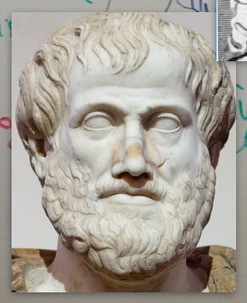
Because we're in Padova & I 💛 Galileo

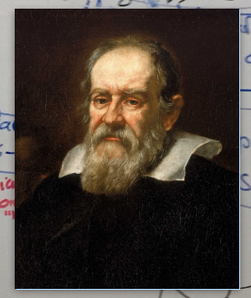


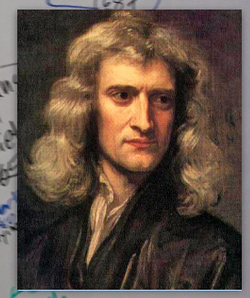
MY WORLD

THE "PATH TO NEWTON" (+ LONGITUDE)

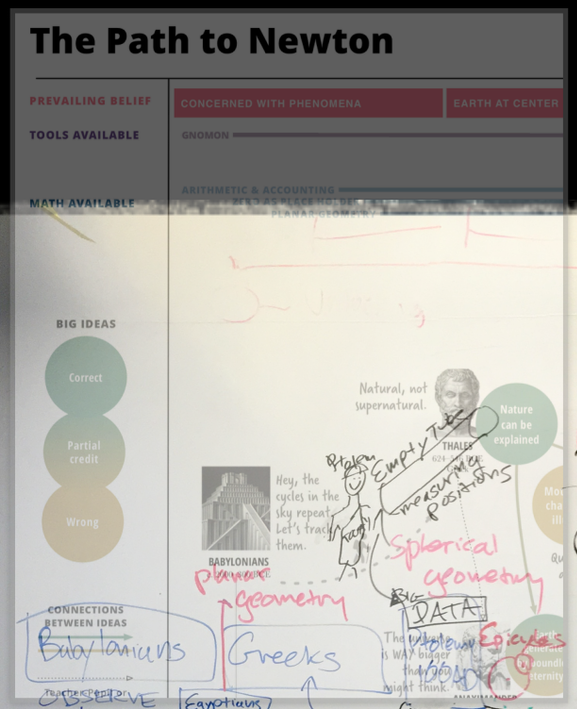








THE "PATH TO NEWTON" (+ LONGITUDE)



2016

The Path to Newton

Alyssa Goodman,
Jais Brohinsky,
Drew Lichtenstein
& Katie Peek

on behalf of Harvard University

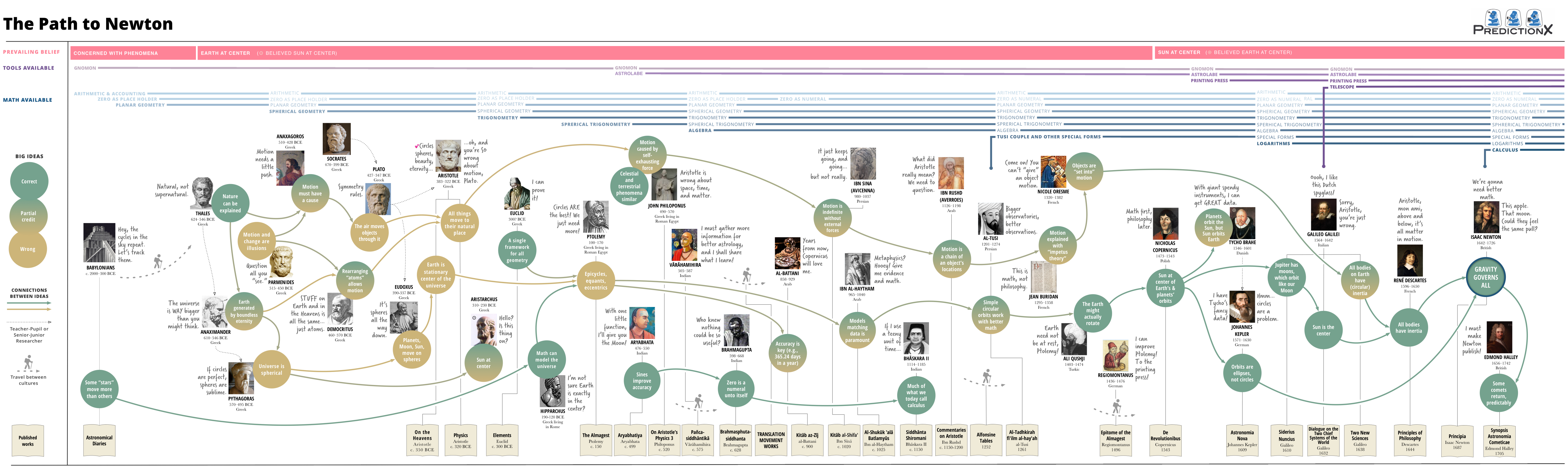
tinyurl.com/aas-path-to-newton

PREDICTIONX

HarvardX

CENTER FOR ASTROPHYSICS | HARVARD & SMITHSONIAN

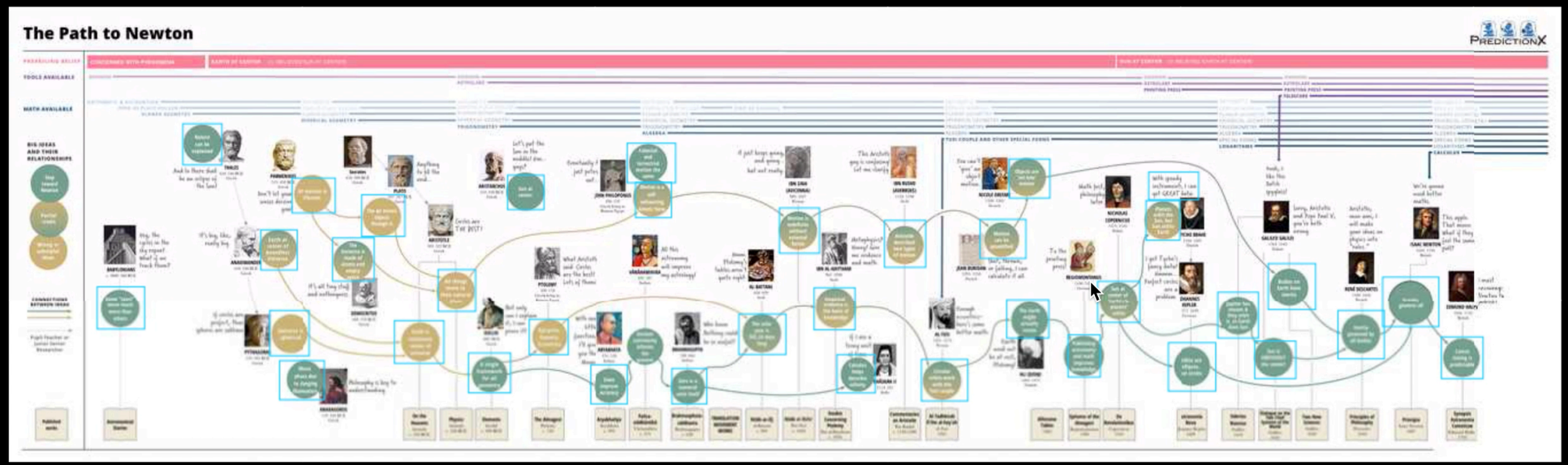
edX



2019

The Path online interacts with a narrative

The Path to Newton



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DrewLich last updated about 14 hours ago

In 1687, Isaac Newton published his *Principia Mathematica* and inaugurated a revolution in physics that would reign supreme until the introduction of Einstein's relativity in the early 20th century. Even though relativity shakes some of the foundations of Newtonian gravity, its modifications are negligible in nearly all Earth-bounded situations. To this day, in classrooms all around the world, Newton's principles and physics continue to be taught and undergird fundamental assumptions about how the universe works.

At the heart of Newton's work was a rigorous definition and mathematical description of *force*. Up until this point, force was theorized qualitatively and used as a noun to describe something being acted upon by something else; however, with Newton, force became an entity unto itself. Since the days of

The Path to Newton

PREVAILING BELIEF

CONCERNED WITH PHENOMENA

EARTH AT CENTER (⊙ BELIEVED SUN AT CENTER)

TOOLS AVAILABLE

GNOMON

GNOMON
ASTRO

MATH AVAILABLE

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

BIG IDEAS

Correct

Partial credit

Wrong

CONNECTIONS BETWEEN IDEAS

Teacher-Pupil or Senior-Junior Researcher

Travel between cultures

Published works

Hey, the cycles in the sky repeat. Let's track them.

BABYLONIANS
c. 2000–300 BCE

Some "stars" move more than others

Astronomical Diaries

Natural, not supernatural.

THALES
624–546 BCE
Greek

Nature can be explained

Motion and change are illusions

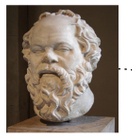
Question all you "see."

PARMENIDES
515–450 BCE
Greek

Motion needs a little push.

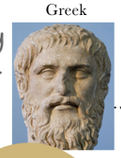
ANAXAGOROS
510–428 BCE
Greek

Motion must have a cause



SOCRATES
470–399 BCE
Greek

PLATO
427–347 BCE
Greek



Symmetry rules.

The air moves objects through it

Rearranging "atoms" allows motion

The universe is WAY bigger than you might think.

ANAXIMANDER
610–546 BCE
Greek

Earth generated by boundless eternity

If circles are perfect, spheres are sublime.

PYTHAGORAS
570–495 BCE
Greek

Universe is spherical

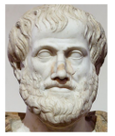
STUFF on Earth and in the Heavens is all the same... just atoms.

DEMOCRITUS
460–370 BCE
Greek

It's spheres all the way down.

EUDOXUS
390-337 BCE
Greek

Planets, Moon, Sun, move on spheres



Circles, spheres, beauty, eternity...

ARISTOTLE
383–322 BCE
Greek

...oh, and you're so wrong about motion, Plato.

All things move to their natural place

Earth is stationary center of the universe

On the Heavens
Aristotle
c. 350 BCE

Physics
Aristotle
c. 320 BCE

I can prove it!

EUCLID
300? BCE
Greek

A single framework for all geometry

Elements
Euclid
c. 300 BCE

Circles ARE the best! We just need more!

PTOLEMY
100–170
Greek living in Roman Egypt

Epicycles, equants, eccentrics

The Almagest
Ptolemy
c. 150

With one little function, I'll give you the Moon!

ARISTARCHUS
310–230 BCE
Greek

Hello? Is this thing on?

Sun at center

Math can model the universe

I'm not sure Earth is exactly in the center?

HIPPARCHUS
190-120 BCE
Greek living in Rome

SUN AT CENT

GNOMON
ASTROLABE

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

ZERO AS NUMERAL

SPRERICAL TRIGONOMETRY

ARITHMETIC
ZERO AS NUMERAL
PLANAR GEOMETRY
SPHERICAL GEOMETRY
TRIGONOMETRY
SPRERICAL TRIGONOMETRY
ALGEBRA

TUSI COUPLE AND OTHER SPECIAL FORMS

Motion caused by self-exhausting force

Celestial and terrestrial phenomena similar

Aristotle is wrong about space, time, and matter.

JOHN PHILOPONUS
490–570
Greek living in Roman Egypt

Circles ARE the best! We just need more!

PTOLEMY
100–170
Greek living in Roman Egypt

I must gather more information for better astrology, and I shall share what I learn!

VĀRĀHAMIHIRA
505–587
Indian

Epicycles, equants, eccentrics

With one little function, I'll give you the Moon!

ARYABHATA
476–550
Indian

Sines improve accuracy

I'm not sure Earth is exactly in the center?

PARCHUS
-120 BCE
ek living
Rome

Who knew nothing could be so useful?

BRAHMAGUPTA
598–668
Indian

Zero is a numeral unto itself

Accuracy is key (e.g., 365.24 days in a year)

Years from now, Copernicus will love me.

AL-BATTANI
858–929
Arab

It just keeps going, and going... but not really.

IBN SINA (AVICENNA)
980–1037
Persian

Motion is indefinite without external forces

Metaphysics? Hooey! Give me evidence and math.

IBN AL-HAYTHAM
965–1040
Arab

Models matching data is paramount

If I use a teeny unit of time...

BHĀSKARA II
1114–1185
Indian

Much of what we today call calculus

What did Aristotle really mean? We need to question.

IBN RUSHD (AVERROES)
1126–1198
Arab

Motion is a chain of an object's locations

Bigger observatories, better observations.

AL-TUSI
1201–1274
Persian

Motion explained with "impetus theory"

Simple circular orbits work with better math

This is math, not philosophy.

JEAN BURIDAN
1295–1358
French

Come on! You can't "give" an object motion.

NICOLE ORESME
1320–1382
French

Objects are "set into" motion

The Earth might actually rotate

Earth need not be at rest, Ptolemy!

ALI QUSHJI
1403–1474
Turkic

Math first, philosophy later.

NICHOLAS COPERNICUS
1473–1543
Polish

Sun at center of Earth's & planets' orbits

I can improve Ptolemy! To the printing press!

REGIOMONTANUS
1436–1476
German

The Almagest
Ptolemy
c. 150

Aryabhatiya
Aryabhata
c. 499

On Aristotle's Physics 3
Philoponus
c. 520

Pañca-siddhāntikā
Vārāhamihira
c. 575

Brahmasphuta-siddhanta
Brahmagupta
c. 628

TRANSLATION MOVEMENT WORKS

Kitāb az-Zīj
al-Battani
c. 900

Kitāb al-Shifa'
Ibn Sīnā
c. 1020

Al-Shukūk 'alā Batlamyūs
Ibn al-Haytham
c. 1025

Siddhānta Shiromani
Bhāskara II
c. 1150

Commentaries on Aristotle
Ibn Rushd
c. 1150-1200

Alfonsine Tables
1252

Al-Tadhkirah fi'ilm al-hay'ah
al-Tusi
1261

Epitome of the Almagest
Regiomontanus
1496

De Revolutionibus
Copernicus
1543

PREDICTIONX

SUN AT CENTER (⊕ BELIEVED EARTH AT CENTER)

GNOMON
ASTROLABE
PRINTING PRESS

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

IBN RUSHD (AVERROES)
1126–1198
Arab

AL-TUSI
1201–1274
Persian

Bigger observatories, better observations.

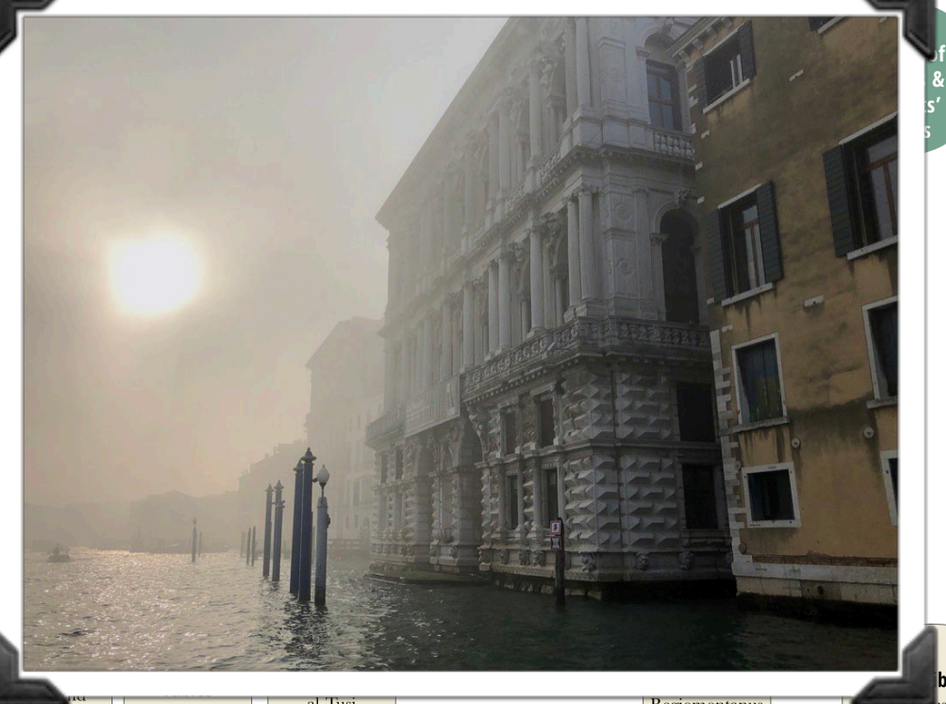
Motion is a chain of

Motion explained with "impetus theory"

Come on! You can't "give" an object motion.

NICOLE ORESME
1320–1382
French

Objects are "set into" motion



Math first, philosophy later.

NICHOLAS COPERNICUS
1473–1543
Polish

With giant spendy instruments, I can get GREAT data.

Planets orbit the Sun, but Sun orbits Earth

TYCHO BRAHE
1546–1601
Danish

I have Tycho's fancy data!

Hmm... circles are a problem.

JOHANNES KEPLER
1571–1630
German

Orbits are ellipses, not circles

Jupiter has moons, which orbit like our Moon

Sun is the center

All bodies on Earth have (circular) inertia

All bodies have inertia

GNOMON
ASTROLABE
PRINTING PRESS
TELESCOPE

ARITHMETIC
ZERO AS NUMERAL RAL
PLANAR GEOMETRY
SPHERICAL GEOMETRY
TRIGONOMETRY
SPERHICAL TRIGONOMETRY
ALGEBRA
SPECIAL FORMS
LOGARITHMS

Oooh, I like this Dutch spyglass!

Sorry, Aristotle, you're just wrong.

GALILEO GALILEI
1564–1642
Italian

Aristotle, mon ami, above and below, it's all matter in motion.

RENÉ DESCARTES
1596–1650
French

ARITHMETIC
ZERO AS NUMERAL
PLANAR GEOMETRY
SPHERICAL GEOMETRY
TRIGONOMETRY
SPHRERICAL TRIGONOMETRY
ALGEBRA
SPECIAL FORMS
LOGARITHMS
CALCULUS

We're gonna need better math.

This apple. That moon. Could they feel the same pull?

ISAAC NEWTON
1642–1726
British

GRAVITY GOVERNS ALL

I must make Newton publish!

EDMOND HALLEY
1656–1742
British

Some comets return, predictably

Astronomia Nova
Johannes Kepler
1609

Siderius Nuncius
Galileo
1610

Dialogue on the Two Chief Systems of the World
Galileo
1632

Two New Sciences
Galileo
1638

Principles of Philosophy
Descartes
1644

Principia
Isaac Newton
1687

Synopsis Astronomia Cometicae
Edmond Halley
1705

c. 1150-1200

1252

al-Tusi
1261

Regiomontanus
1496

1543

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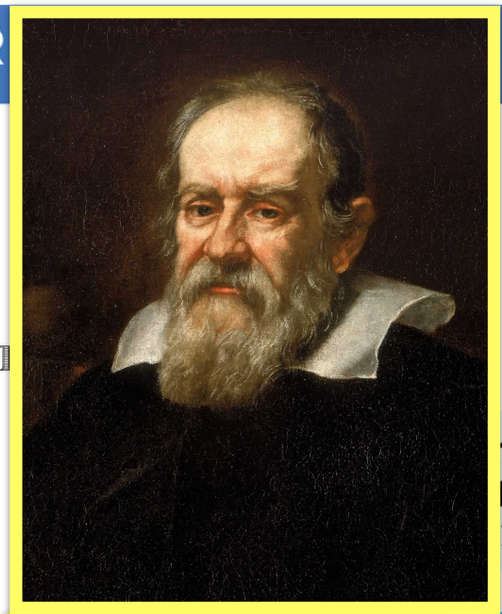
PredictionX

PredictionX: the past & pr… e future



Tools

- Framework for Predictive Systems (edX)
- Framework for Study Design
- Understanding Uncertainty
- Timelines
- Why predict?

Omens, Oracles & Prophecies

- Mesopotamian Haruspicy
- Egyptian Priests
- Yoruba Ifa
- Roman Augury
- Tarot
- Casting Lots
- Chinese Oracle Bones
- **The Diviner's Guide**
- *Greek Astronomy*
- Oracle of Delphi
- Turkish Tasseography
- Astrology
- Aztec Rituals
- Maya Spacetime
- Comets of Doom
- cross-cultural conversations

T…

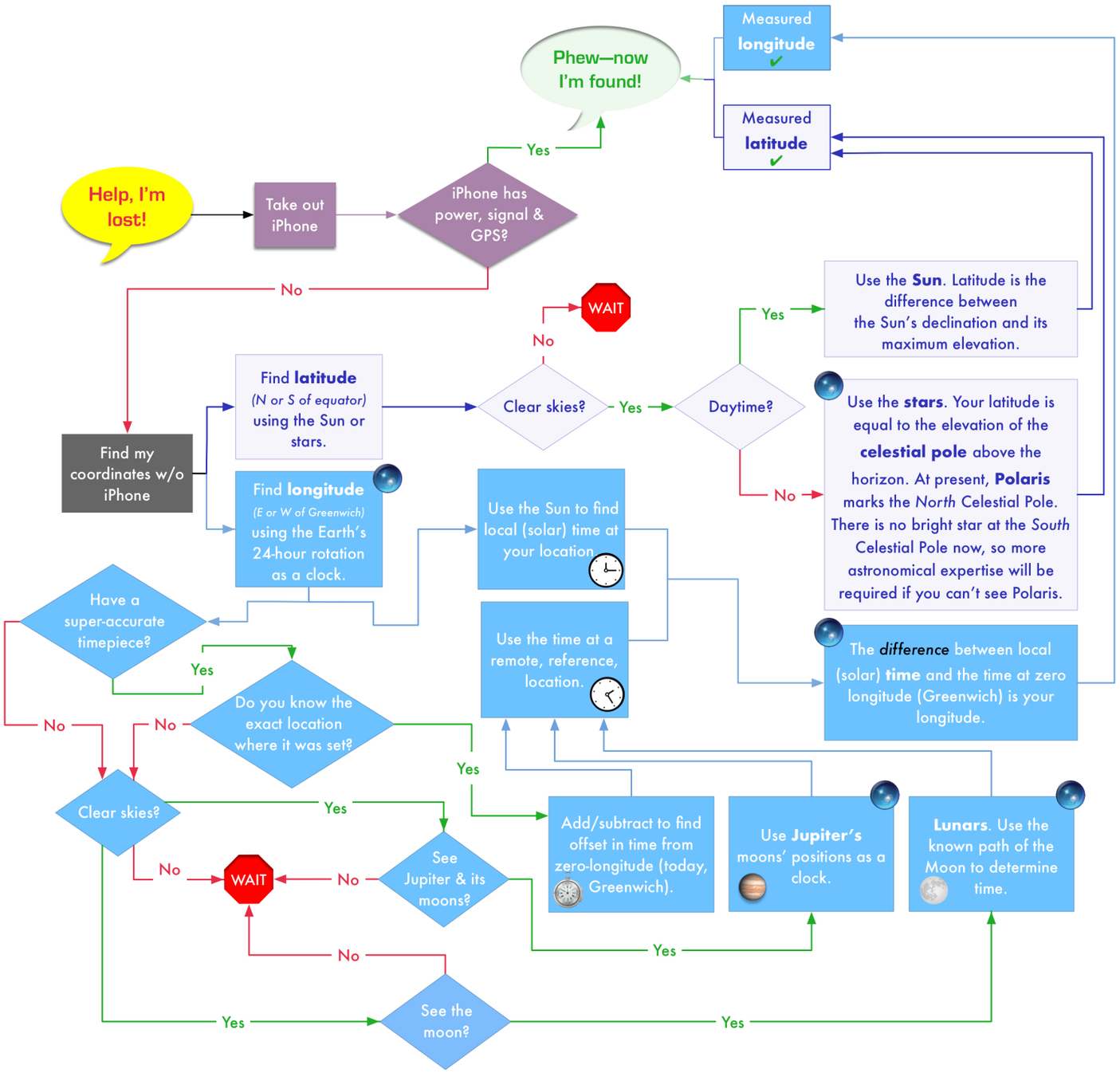
- The Path to Newton
- Lost without Longitude (Navigation)
- …n Snow …holera …lera Map
- …Indian Mathematics
- Tools of the Navigator (edX)
- Help, I'm Lost! (edX)

Modern Simulation

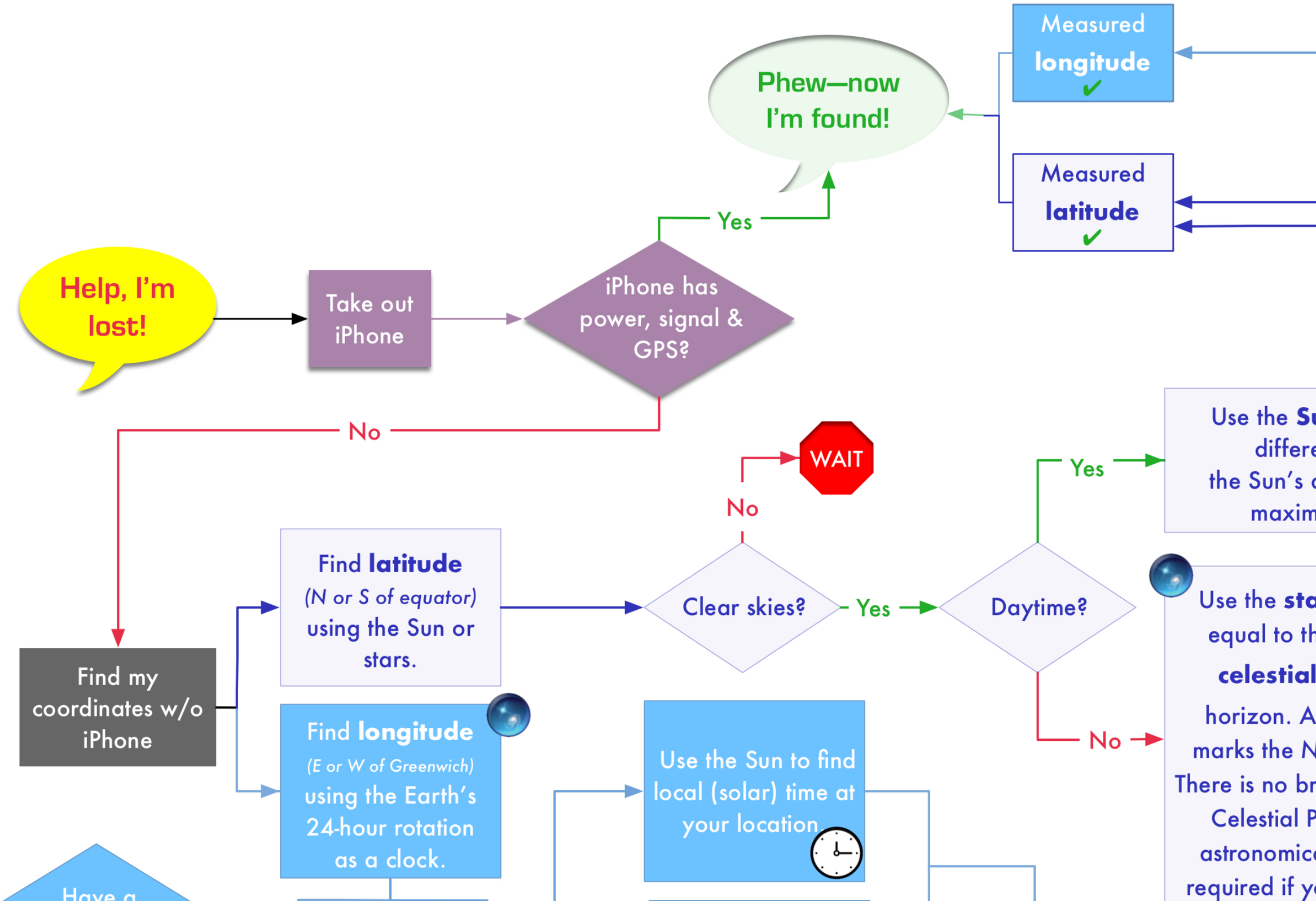
- **Health**
  - Epidemiology
  - Personal Genomics
- **Earth**
  - Earthquakes
  - Climate Change
  - Tent Tarot (edX)
- **Wealth**
  - Personal Finance
  - World Economy
- **Space**
  - Futures of our Universe
- **The Future of the Future**
  - Artificial Intelligence
  - Derek's Day

Finished | Coming Soon | Planned | Interactive Resource | video(s) | edX link to edX (often contains videos + interactives, not marked separately here)

“Lost without Longitude”



“Lost without Longitude”



No

marks the *North* Celestial Pole. There is no bright star at the *South* Celestial Pole now, so more astronomical expertise will be required if you can't see Polaris.

Use the Sun to find local (solar) time at your location.

Use the time at a remote, reference, location.

The ***difference*** between local (solar) **time** and the time at zero longitude (Greenwich) is your longitude.

Yes

Add/subtract to find offset in time from zero-longitude (today, Greenwich).

Use **Jupiter's** moons' positions as a clock.

Lunars. Use the known path of the Moon to determine time.

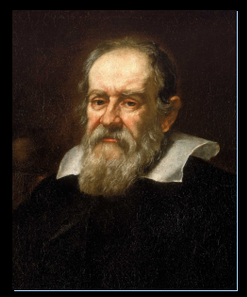
See Jupiter & its moons?

Yes

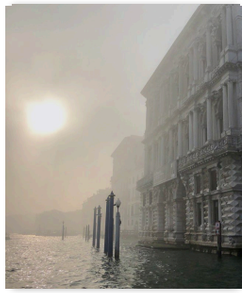
See the moon?

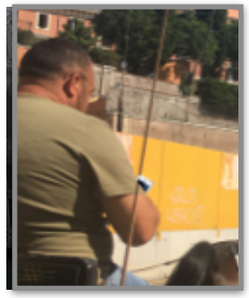
Yes

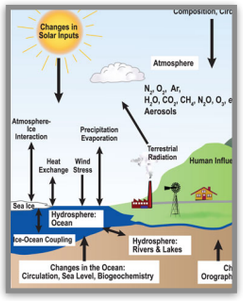
Galileo Observations of Jupiter's Moons, from Padova



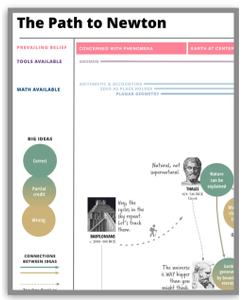
PREDICTION IN. . .

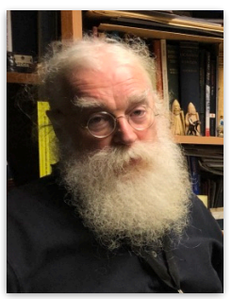


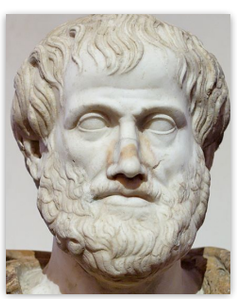


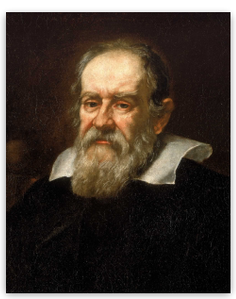


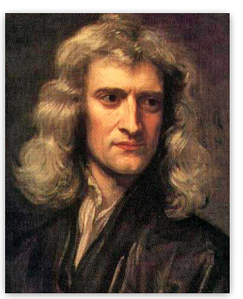
OUR FUTURE











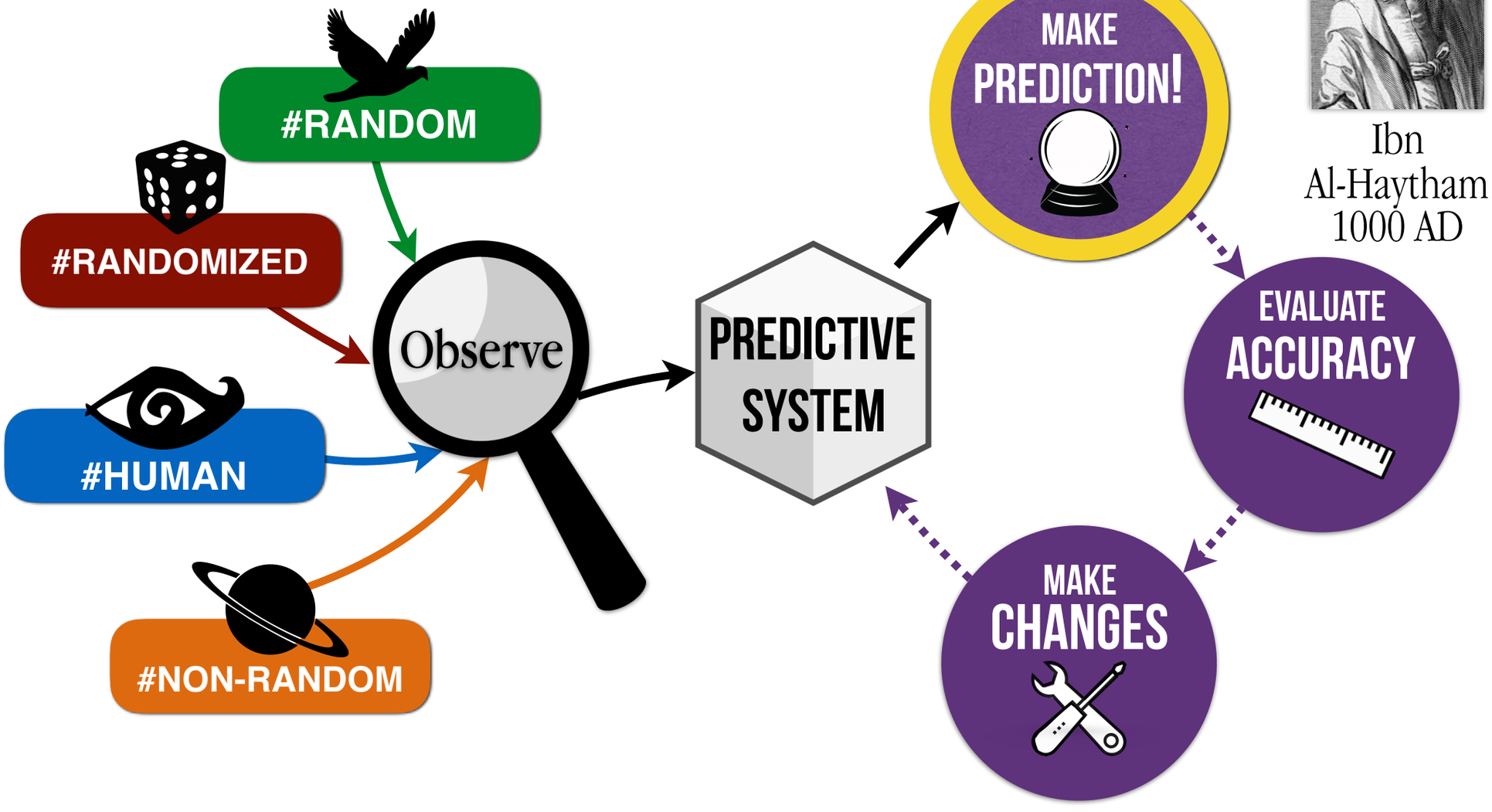
MY WORLD

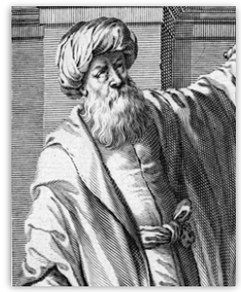
"YOUR" WORLD

THE WORLD

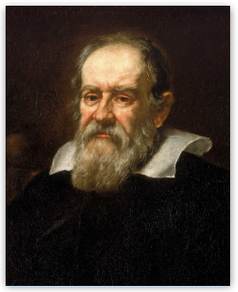
PredictionX

Framework for Predictive Systems





Ibn Al-Haytham 1000 AD



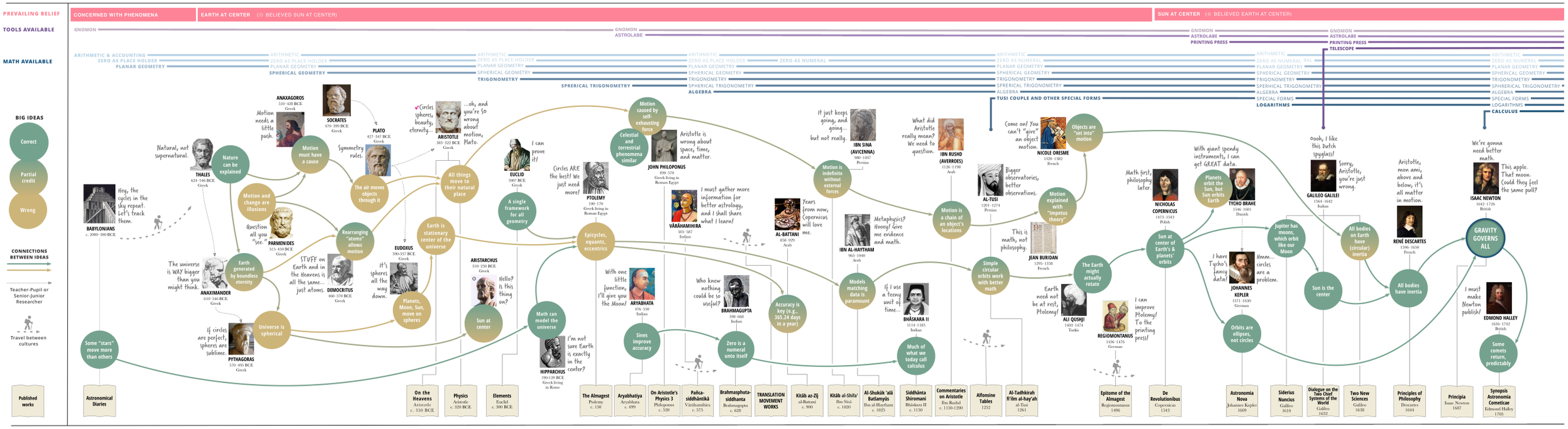
Galileo 1600 AD

https://openclipart.org/

Phenomenon | Observation* | Data | Rule | Theory | Explanation | Prediction

The Path to Newton

PredictionX



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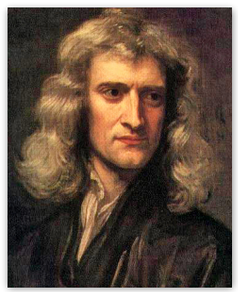
or, Experiment

Phenomenon | Observation | Data | Rule | Theory | Explanation | Prediction

Correct

EMPIRICAL ANALYTICAL

Kepler's Laws of Planetary Motion

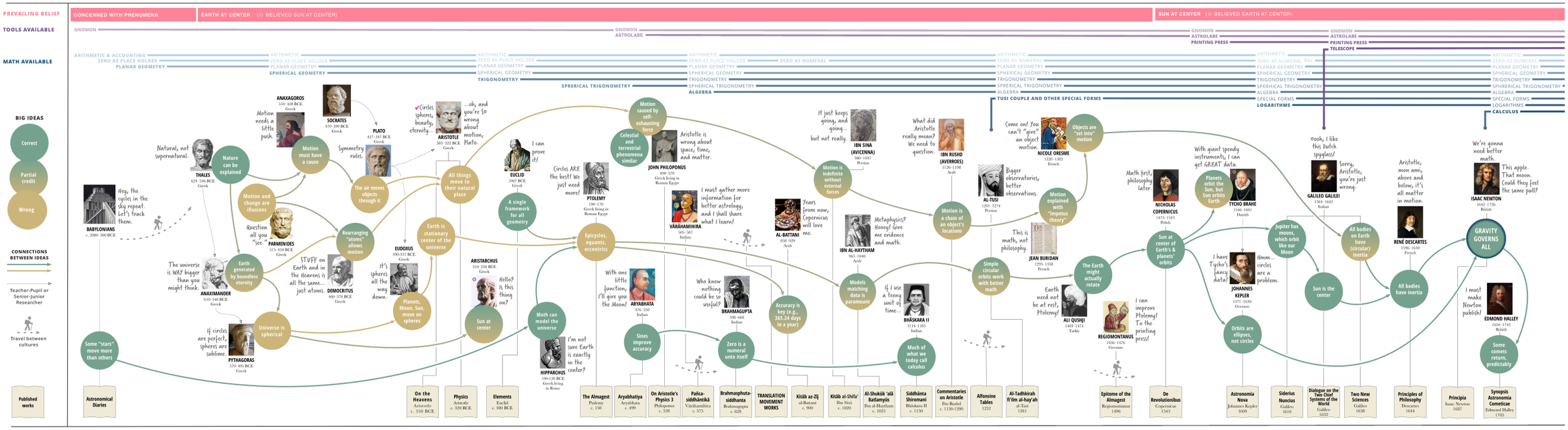


Newton's Theory of Gravity

Phenomenon | Observation | Data | Rule | Theory | Explanation | Prediction

The Path to Newton

PREDICTIONX



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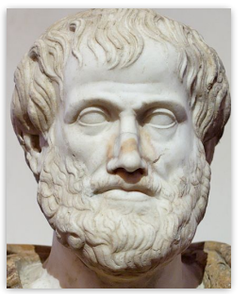
Wrong

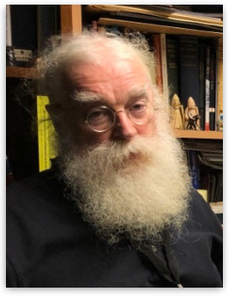
EMPIRICAL ANALYTICAL

Phenomenon | Observation | Data | Rule | Theory | Explanation | Prediction

Ptolemy's Epicycles

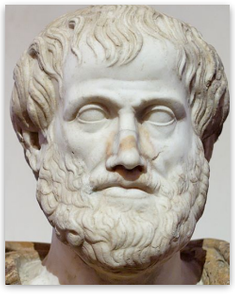


Aristotle's Natural Philosophy



Babylonians

Phenomenon | Observation | Data | Rule



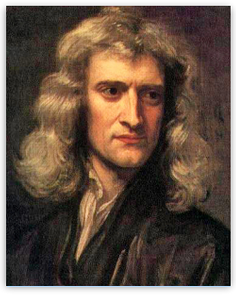
Aristotle

Phenomenon | Observation

Theory | Explanation | Prediction

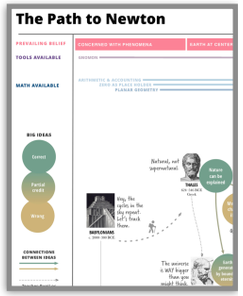
Kepler

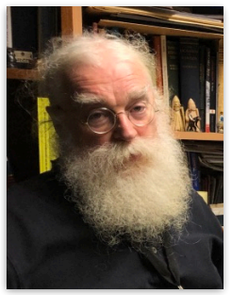
Phenomenon | Observation | Data | Rule | Prediction

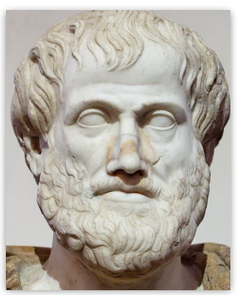


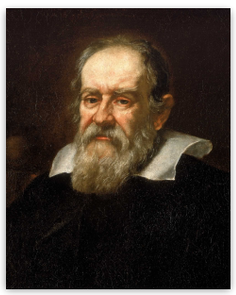
Newton

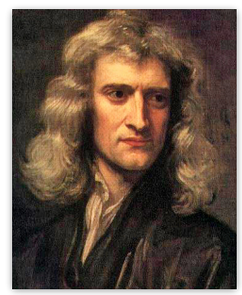
Phenomenon | Observation | Data | Rule | Theory | Explanation | Prediction









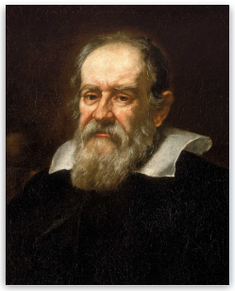


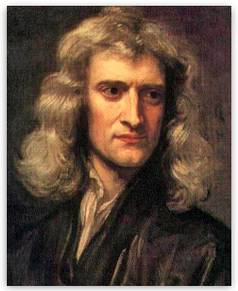
MY WORLD

"YOUR" WORLD

THE WORLD

1687



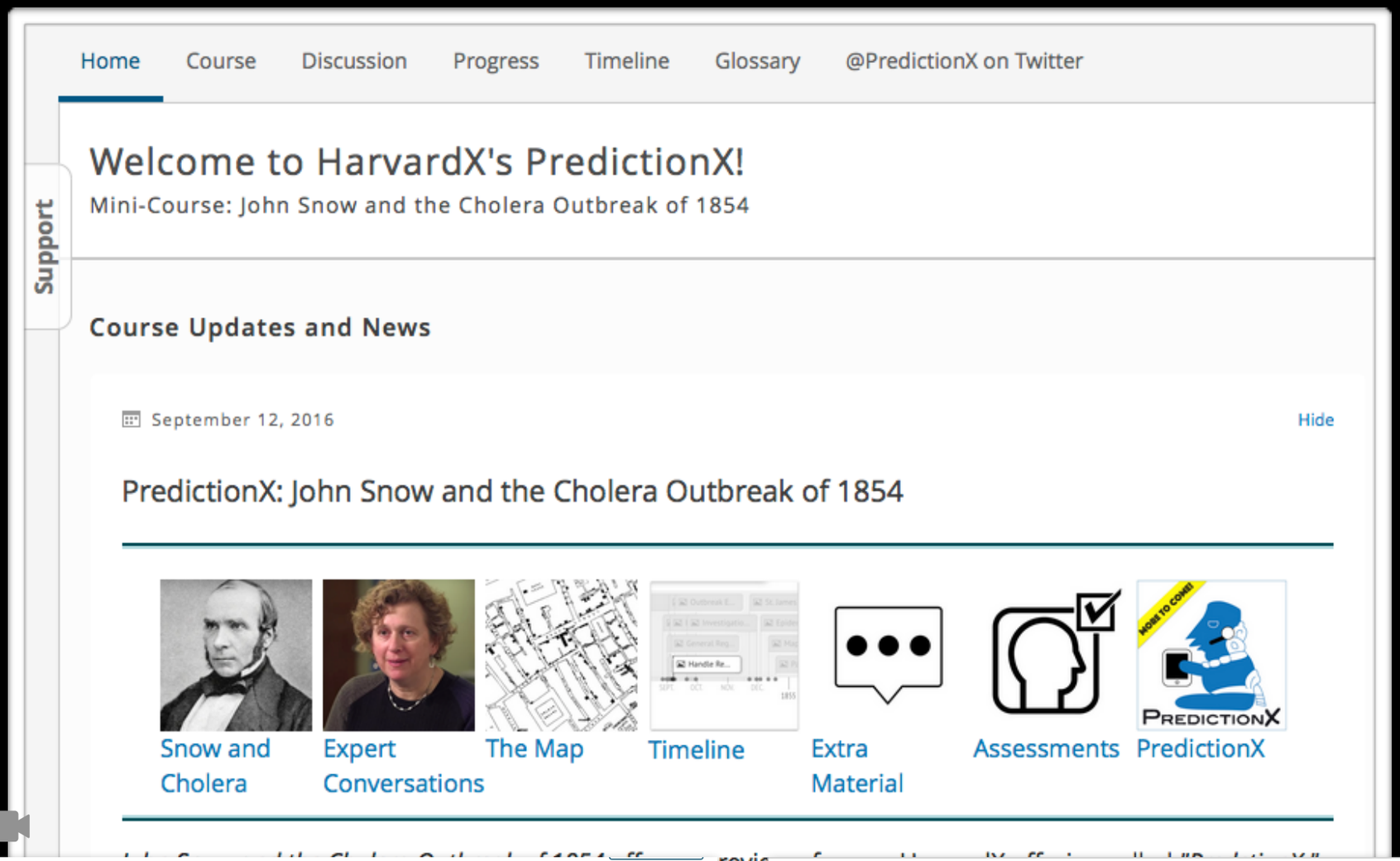


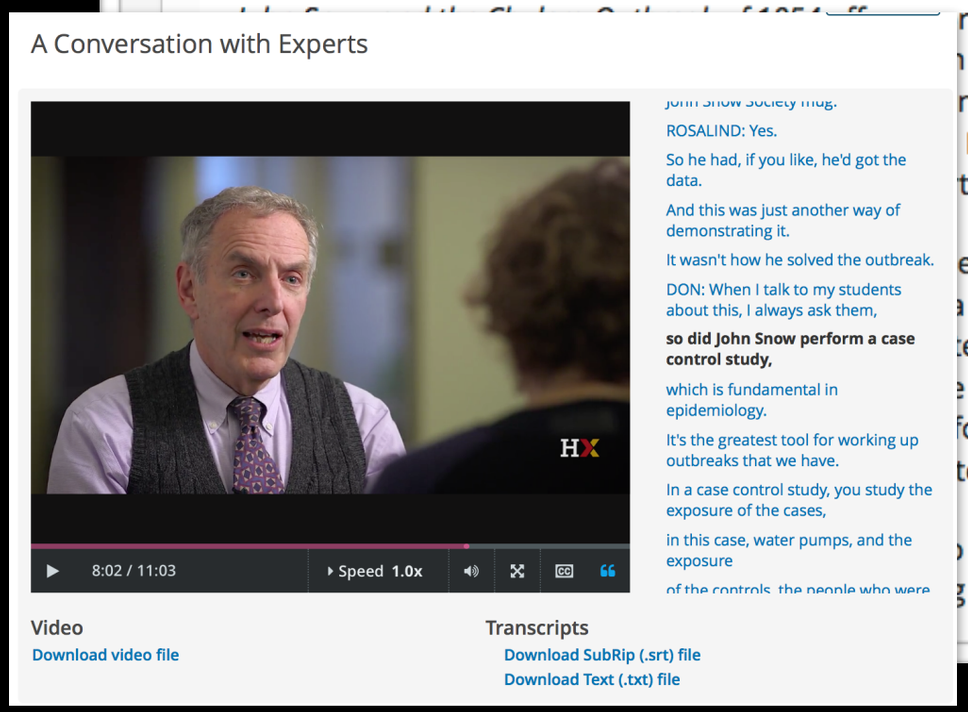
MY WORLD

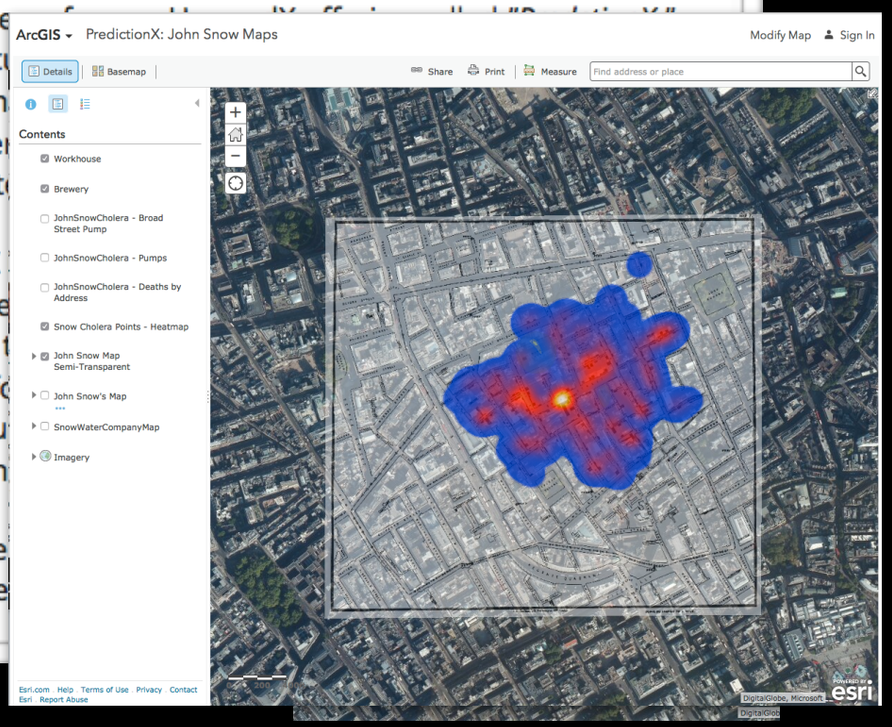
"YOUR" WORLD

1854

JOHN SNOW & CHOLERA







featuring Don Goldmann, AG & Rosalind Stanwell-Smith

EMPIRICAL STATISTICAL

Phenomenon	Observation*	Data	Rule	Theory	Explanation	Prediction

Mendel's Rules

Darwin's Theory of Evolution

or, Experiment

PREDICTIVE SYSTEMS

Mendel

Phenomenon | Observation | Data | Rule | Prediction

Darwin

Phenomenon | Observation | Data | Theory | Explanation | Prediction

Mendel

Phenomenon | Observation | Data | Rule | Prediction

Darwin

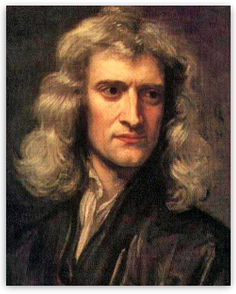
Phenomenon | Observation | Data | Theory | Explanation | Prediction

"YOUR" WORLD (BIOLOGY)

MY WORLD (PHYSICS)

Kepler

Phenomenon | Observation | Data | Rule | Prediction



Newton

Phenomenon | Observation | Data | Rule | Theory | Explanation | Prediction

Mendel

Phenomenon | Observation | Data | Rule | Prediction

Darwin

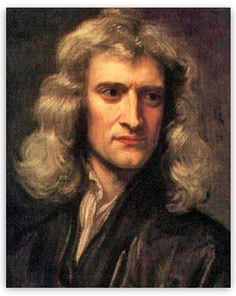
Phenomenon | Observation | Data | Theory | Explanation | Prediction

NO FULLY PREDICTIVE GENERAL THEORY

FULLY PREDICTIVE GENERAL THOERY

Kepler

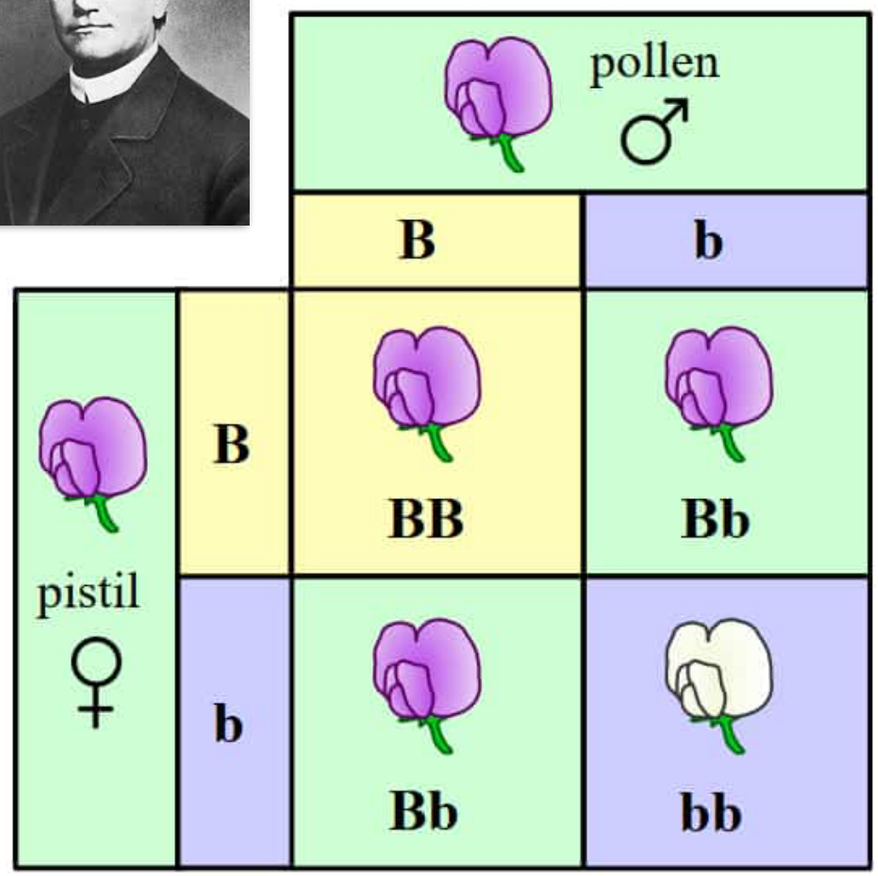
Phenomenon | Observation | Data | Rule | Prediction

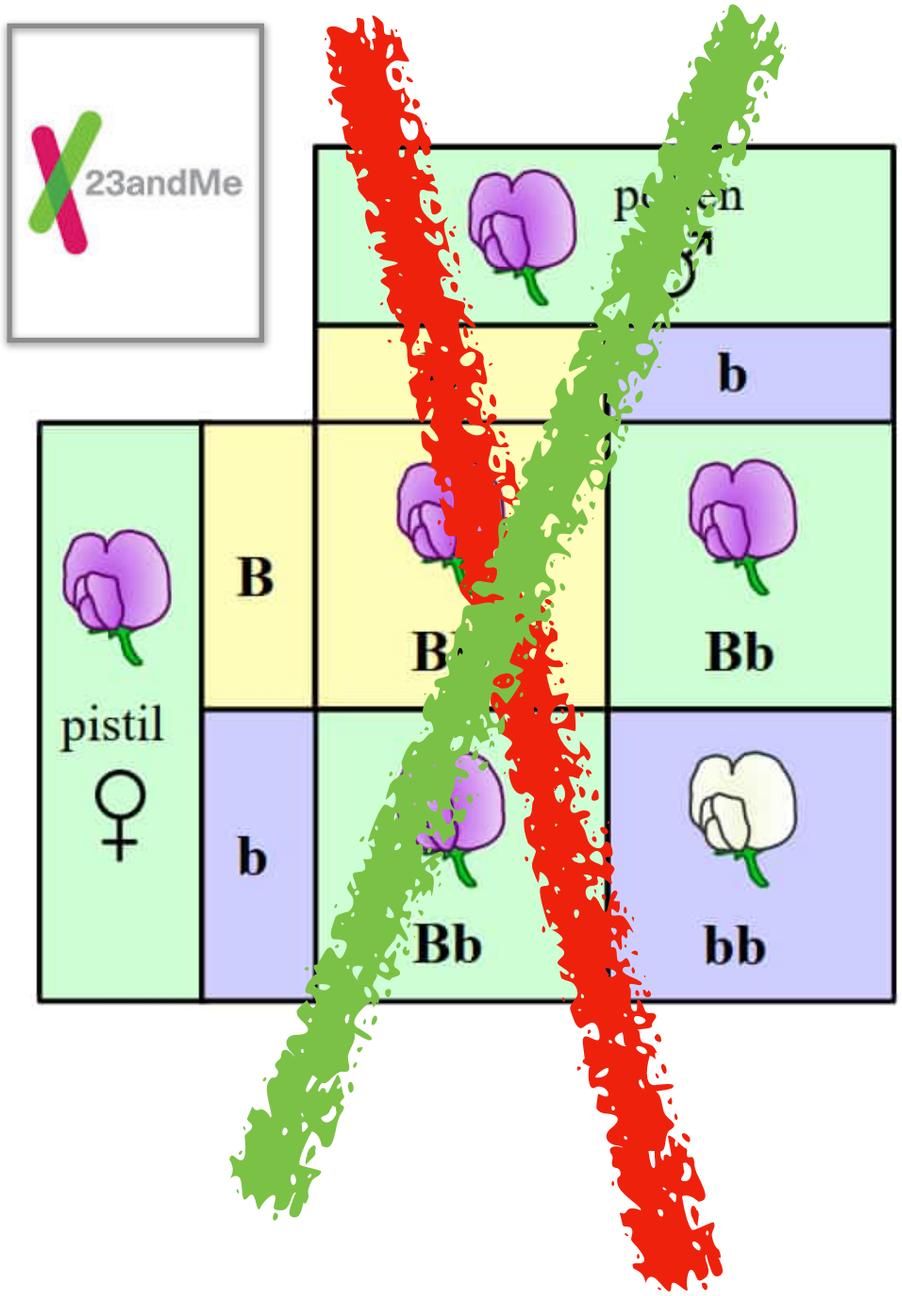


Newton

Phenomenon | Observation | Data | Rule | Theory | Explanation | Prediction

NO FULLY PREDICTIVE GENERAL THEORY



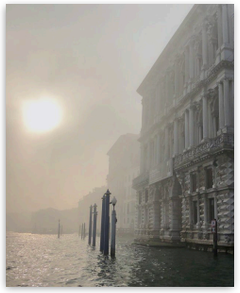


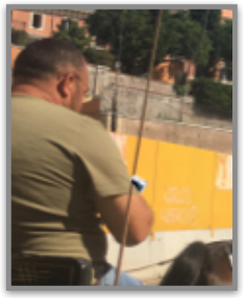
THE FUTURE OF THE FUTURE

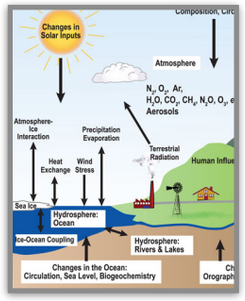
20th century

21st century?

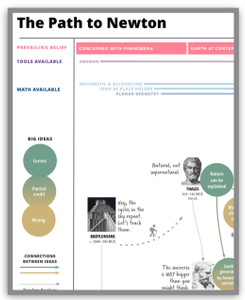
PREDICTION IN. . .

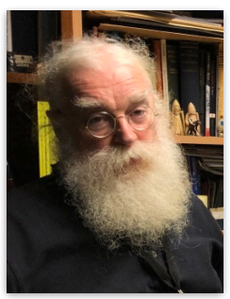


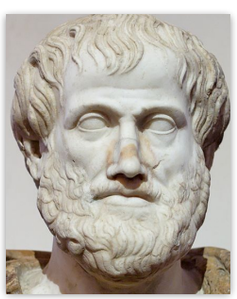


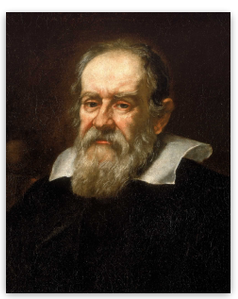


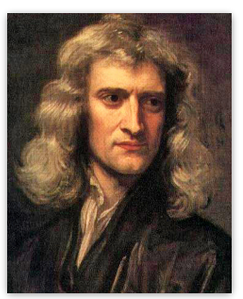
OUR FUTURE











MY WORLD

"YOUR" WORLD

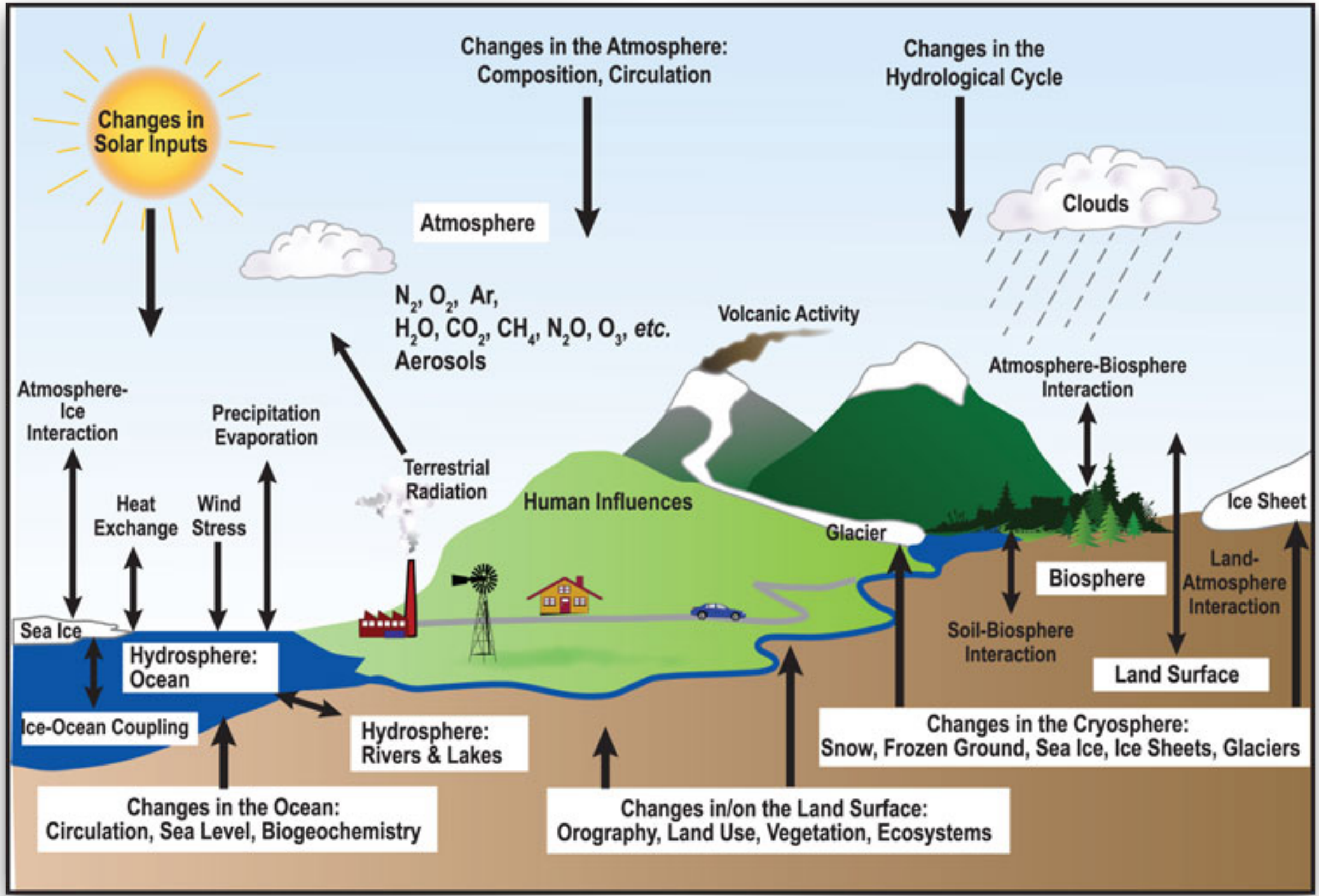
THE WORLD

The SHEEP of DESTINY

He SMILES because he sees your future.

And Oh, how HAPPY shall that future be!

EDWARD MONKTON © Portobello Rights Ltd.



blogs.scientificamerican.com/the-curious-wavefunction/are-more-accurate-climate-change-models-worse