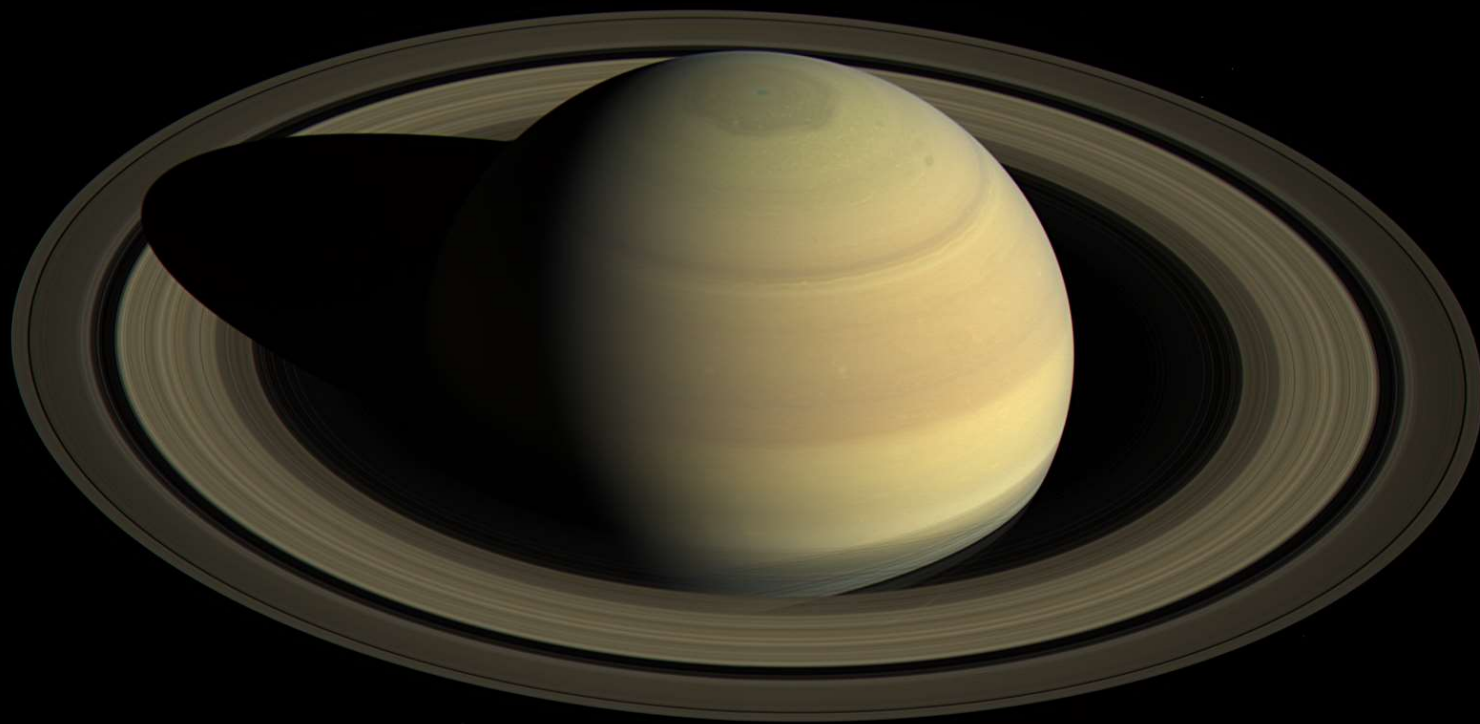


AST 2002

Introduction to Astronomy



A Few Quick Things...

iClickers:

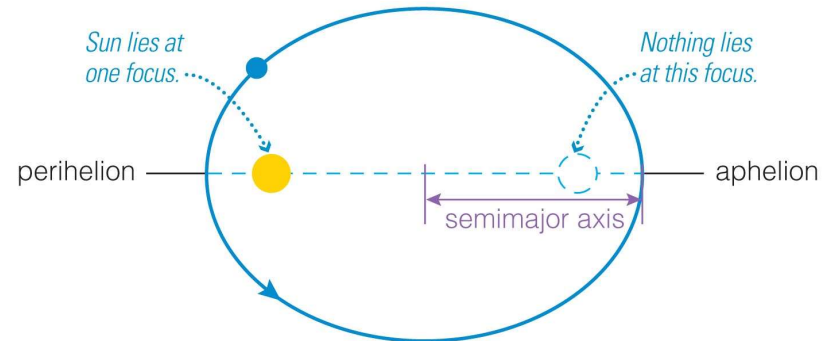
- Reef Mobile Users: There was a duplicate class created which had no polling sessions. This has now been deleted and it should be good. **Needs to be registered in the App with Webcourses, still a few of you using the App, but haven't entered your information...**
- iClicker scores on Webcourses are unlikely to be accurate – Will post accurate updates after each mid-term.
- Had some complaints about starting the iClicker questions being right at the beginning as quite a few people have no option but to get here a few minutes late – will try to bear that in mind.

Help:

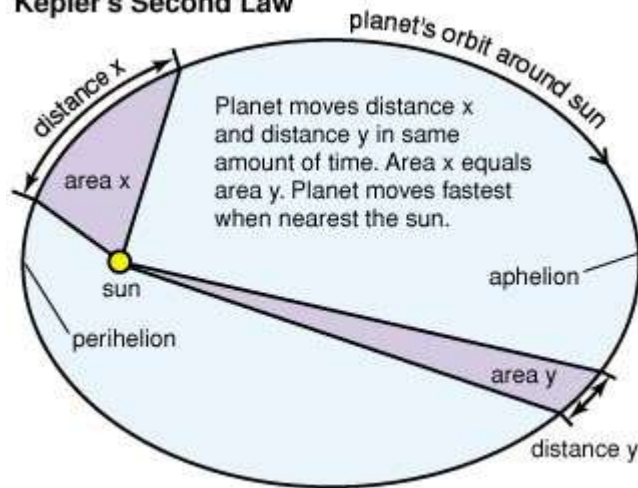
- If you are Struggling with the class, please send me an email, or come and talk to me (at the end of class or during office hours).
- Mary Hinkle, a Graduate Teaching Assistant in Planetary Science has kindly offered to have some office hours each week and before the mid-terms/finals to help out a bit – details coming soon.
- First Knights-under-the-stars event is on Wednesday 31st Jan. (Extra credit)

Summary of Kepler's Laws:

Kepler's 1st Law: Bodies in orbit move in elliptical paths.



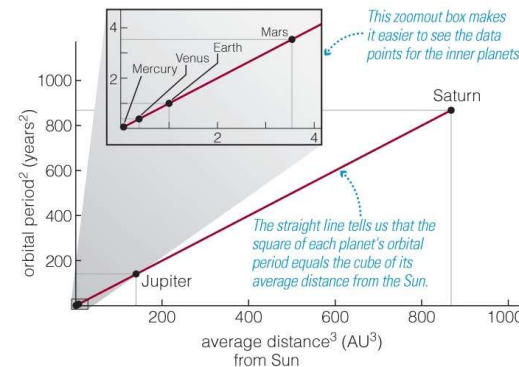
Kepler's Second Law



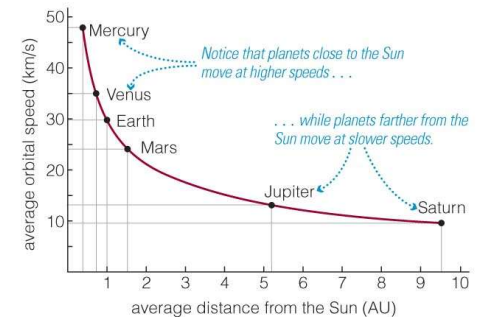
© 2006 Encyclopædia Britannica, Inc.

Kepler's 2nd Law: As a planet moves around its orbit, it sweeps out equal areas in equal times

Kepler's 3rd Law: More distant planets orbit the Sun at slower average speeds, according to $p^2 = a^3$



a This graph shows that Kepler's third law ($p^2 = a^3$) holds true; the graph shows only the planets known in Kepler's time.



b This graph, based on Kepler's third law and modern values of planetary distances, shows that more distant planets orbit the Sun more slowly.

Code = BC

iClicker Question #1

Does Kepler's 1st law allow for a circular orbit?

A. Yes.

B. No.

iClicker Question #1

Does Kepler's 1st law allow for a circular orbit?

A. Yes.

B. No.

iClicker Question #2

Does Kepler's 2nd law state or imply that while traveling in their orbits, the planets...

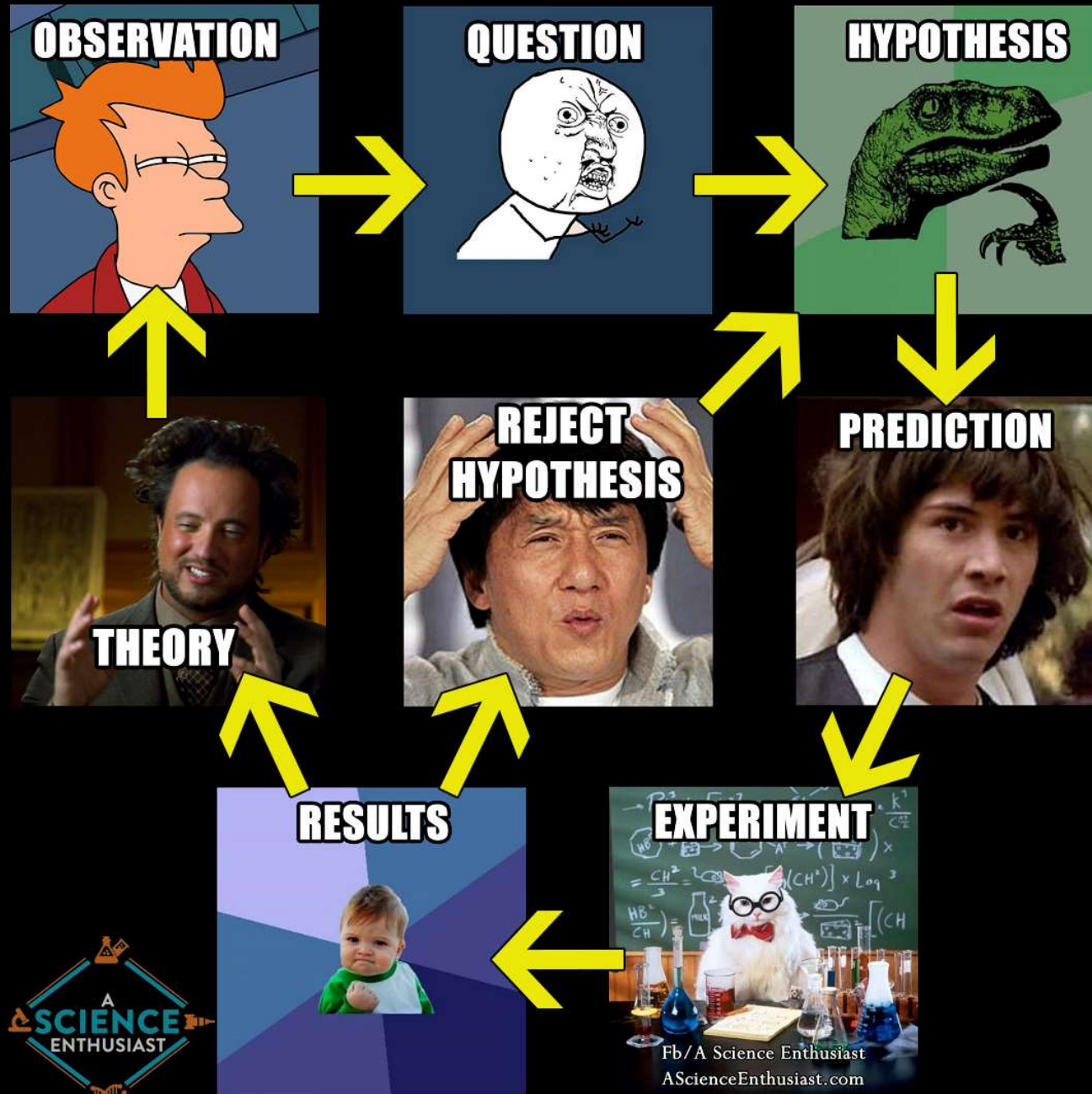
- A. Sweep out equal areas in equal times
- B. Move fastest when they are closest to the Sun
- C. Move slowest when they are farthest from the Sun
- D. All of the above are correct

iClicker Question #2

Does Kepler's 2nd law state or imply that while traveling in their orbits, the planets...

- A. Sweep out equal areas in equal times
- B. Move fastest when they are closest to the Sun
- C. Move slowest when they are farthest from the Sun
- D. All of the above are correct**

The Scientific Method



Theories are kind of a big deal in Science

What is a Theory:

The word theory has a different meaning in science than in everyday life. In science, a theory is NOT the same as a hypothesis.

A scientific theory must:

- Explain a wide variety of observations with a few simple principles
- Be supported by a large, compelling body of evidence
- NOT have failed any crucial test of its validity

However,

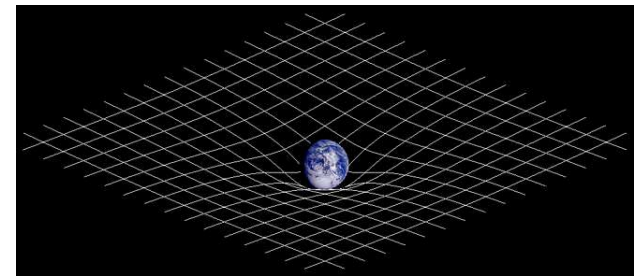
- **Scientists do not BELIEVE in theories.....**
- **Scientific theories are always tentative and subject to corrections or inclusion in a yet wider theory**

A few Examples of Scientific Theories:

- Germ Theory
- Theory of Evolution
- Gravitational Theory (actually several different versions)

What is a Scientific Law?

- A concise verbal or mathematical statement of a relation that expresses a fundamental principle of science
 - BUT: Laws DO NOT suggest a mechanism or explanation of phenomena.
 - In this way laws are WEAKER statements than theories.
 - Laws are a distillation of the results of observation
- A law is limited to circumstances resembling those already observed, and is often found to be false when extrapolated.
 - Newton's law of universal gravitation only applies in weak gravitational fields.
 - Newton's Laws of Motion fail when you approach the speeds of light (approximation to the theory of relativity).
 - The early laws of aerodynamics such as Bernoulli's principle do not apply in case of compressible flow (e.g., supersonic flight).
 - Ohm's law only applies to constant currents.
- Many Laws have been disproven over time.



Science and Pseudoscience

- **Science:**

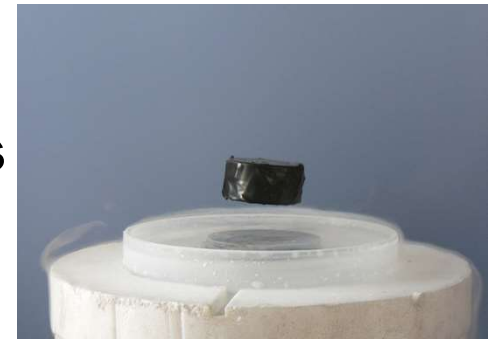
- Science seeks explanations of observations that rely solely on natural causes.
- A scientific theory must make testable predictions.
 - Tests that fail force us to revise or abandon the model.
- Science is not perfect, not always right, but most successful discipline at predicting the way nature works.

- **Pseudoscience:**

- Not properly sourced - “Some researchers say.....”
- “Cherry-picks” evidence available (some medical studies)
- Tends to play on emotions and fears instead of logic
- Just because something is “unexplained” doesn’t mean it is unexplainable..... (e.g., creationism)
- Homeopathic Remedies....
- Vaccines cause autism....
- Vitamin C helps cure colds... (Linus Pauling)
- 97% global warming scientists...

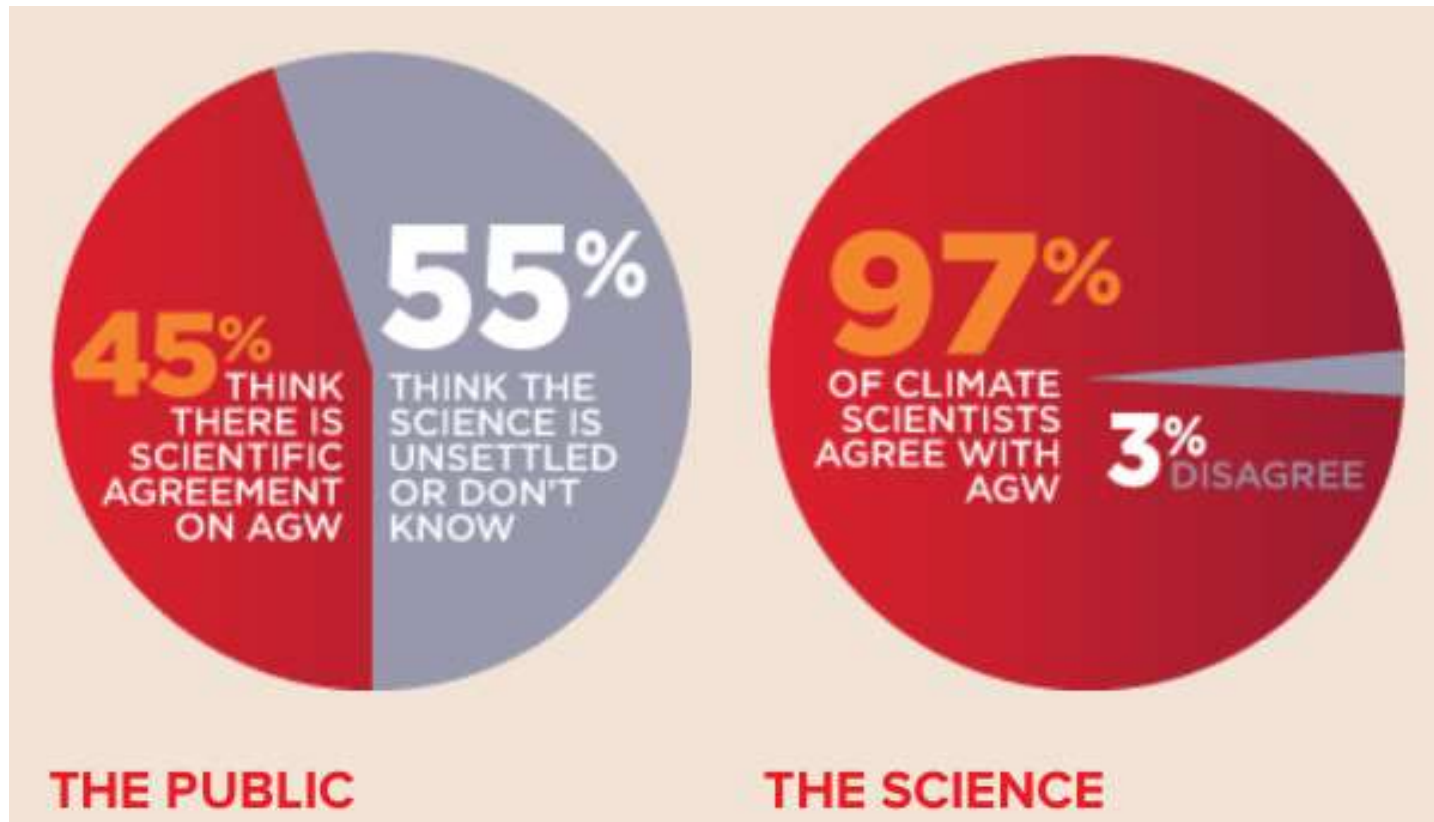
Scientific Controversy

- Many issues that are presented as scientific controversies are actually *political controversies*.
 - Human Caused Global Warming
 - Evolution by Natural Selection
 - Smoking-Related Cancer
- In each case the vast majority of scientists in these fields strongly support these theories.
- Examples of real scientific controversies
 - The origin of Saturn's rings
 - The nature of dark matter and energy
 - High temperature superconductivity
 - The formation of chondrules in meteorites



The Result of Politicizing Scientific Topics

Has eroded the trust the public has in Science



In fact: The 3% of articles that disagree were generally found to be flawed...
<https://qz.com/1069298/the-3-of-scientific-papers-that-deny-climate-change-are-all-flawed/>

The Theory of Evolution & Natural Selection

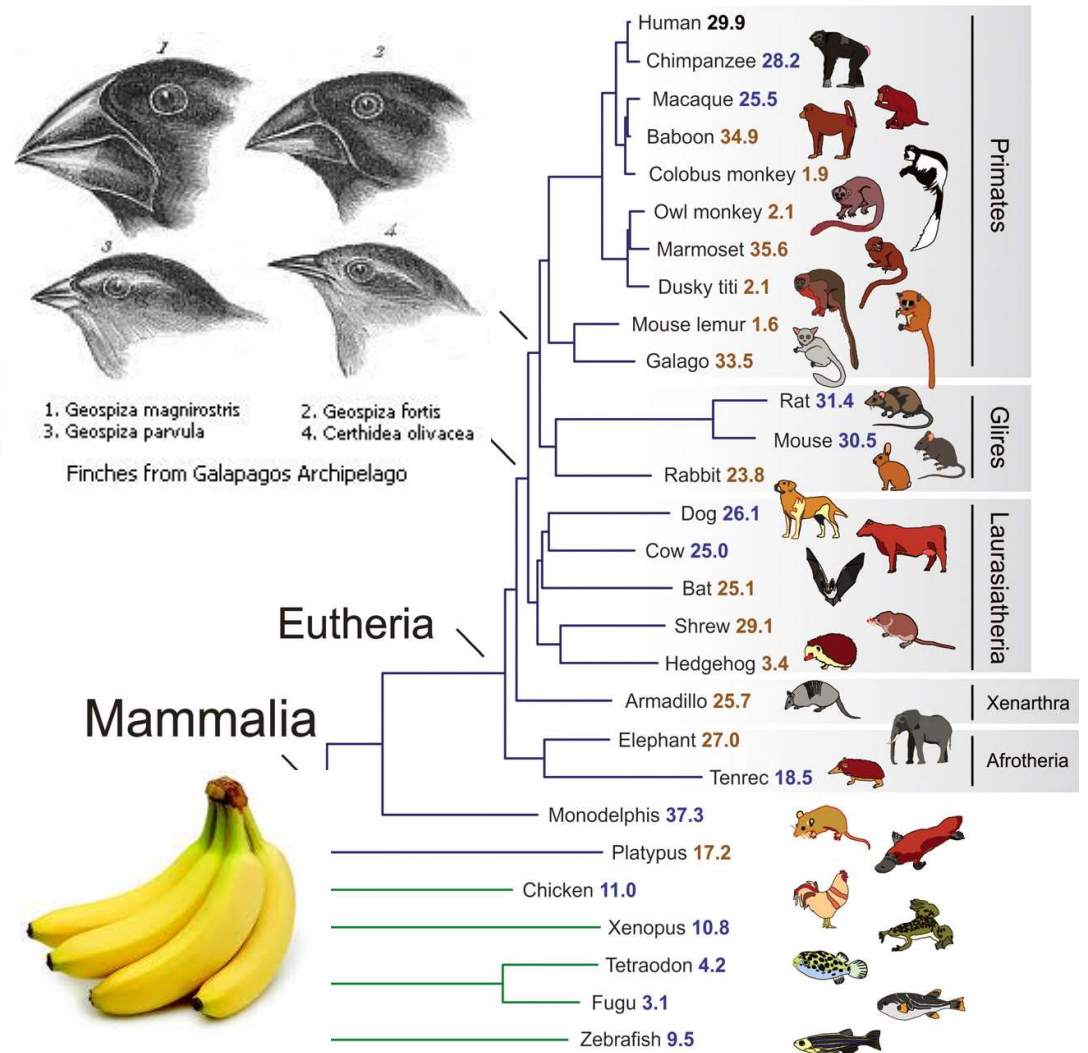
Charles Darwin – The origin of Species.

Apes and Humans have a common ancestor

Evolutionary Trees typically based on:

- i) DNA similarity
- ii) Similarity of conserved genes

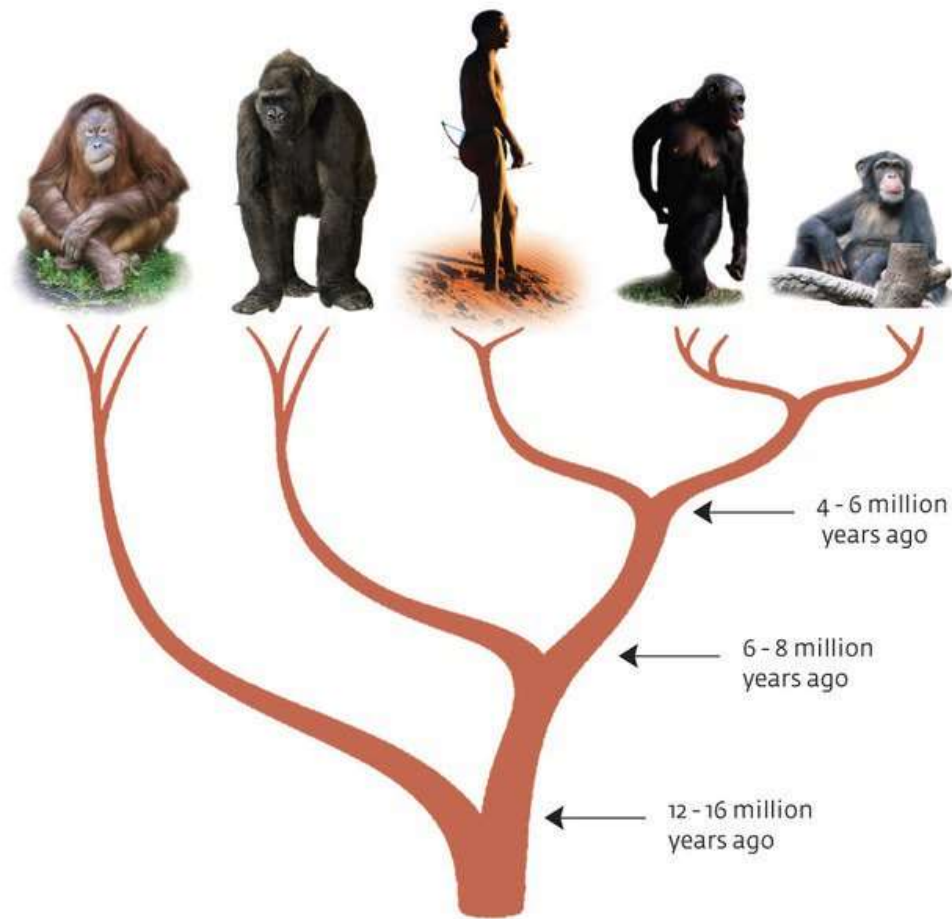
- Every species is fertile enough that if all offspring survived to reproduce, the population would grow (fact).
- Despite periodic fluctuations, populations remain roughly the same size (fact).
- Resources such as food are limited and are relatively stable over time (fact).
- A struggle for survival ensues (inference).
- Individuals in a population vary significantly from one another (fact).
- Much of this variation is heritable (fact).
- Individuals less suited to the environment are less likely to survive and less likely to reproduce; individuals more suited to the environment are more likely to survive and more likely to reproduce and leave their heritable traits to future generations, which produces the process of natural selection (fact).
- This slowly effected process results in populations changing to adapt to their environments, and ultimately, these variations accumulate over time to form new species (inference).



<https://www.wired.com/2009/11/speciation-in-action/> observation of new species.

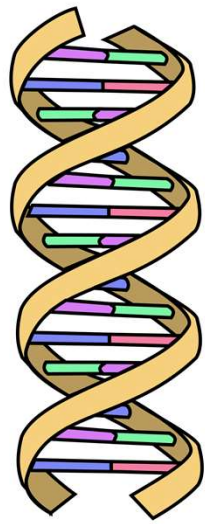
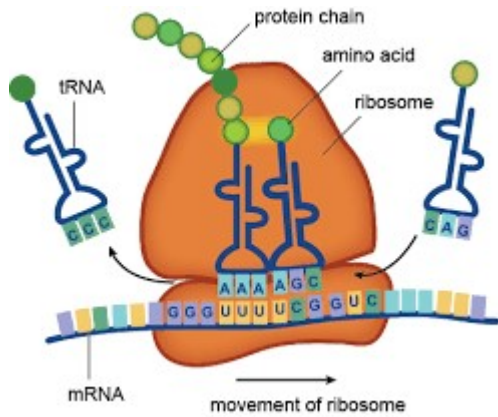
Humans and Chimpanzees share a common ancestor.

We did not evolve *from* apes...



Phylogenetic Tree of Life Based on PCR of 16S Ribosomal RNA Subunit

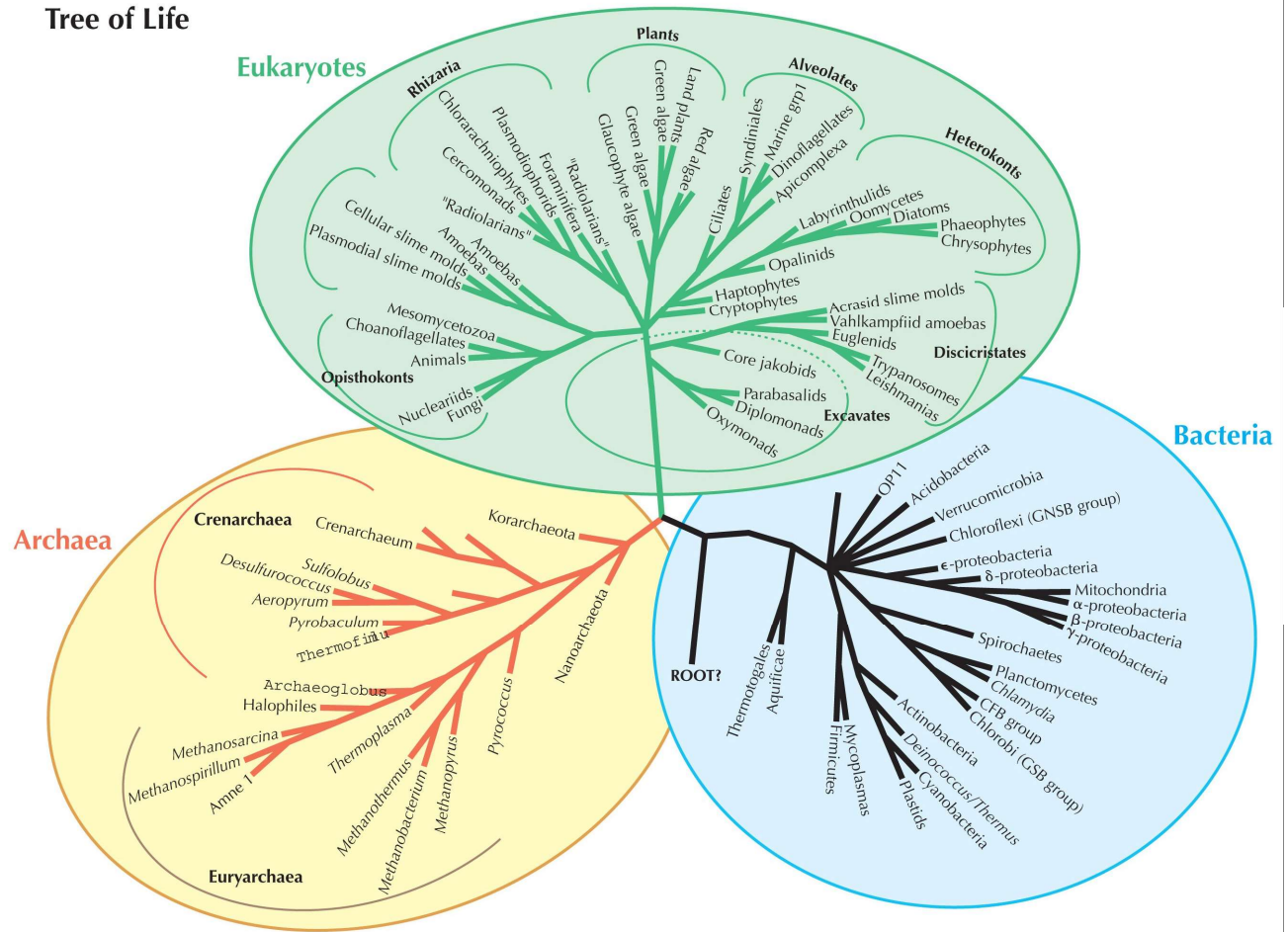
- A highly conserved and ancient gene responsible for reading and decoding your DNA!



- = Adenine
- = Thymine
- = Cytosine
- = Guanine
- = Phosphate backbone

DNA

Tree of Life



The Missing Link

<https://futurism.com/there-is-no-missing-link-in-evolution/>

True: We do not currently have a fossil record of every single living species that lived

- Turns out very specific conditions are required for fossils to be left behind...

True: There are still some issues being worked out (why are there no baby dinosaurs?)

False: That we don't have enough information to solve the puzzle proving evolutionary theory to be true...

Creationist Wheel of Fortune: Where every spin lands on *Bankrupt!*

EVOL T ON

That can't possibly be *evolution!* There are too many gaps!

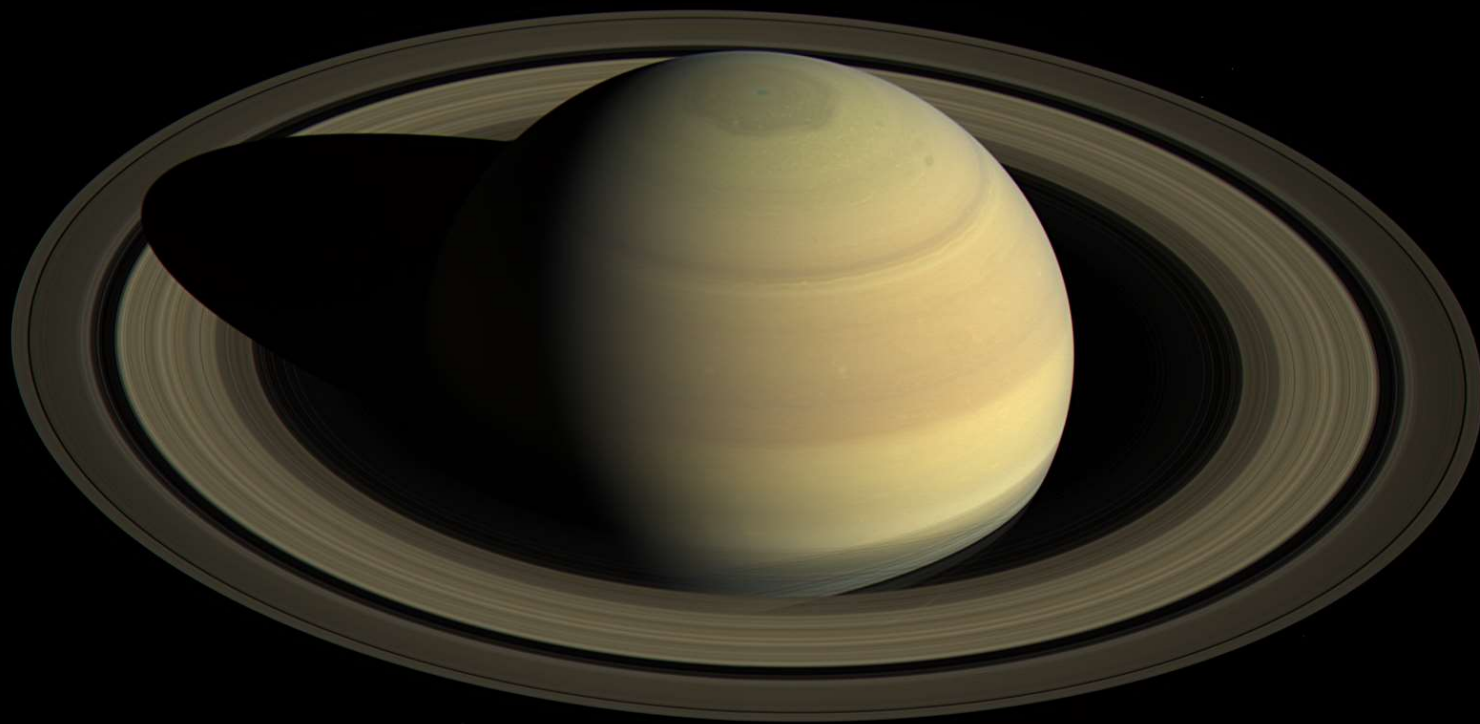
That must mean the answer to the puzzle is *Creation!*



SaintGasoline.com

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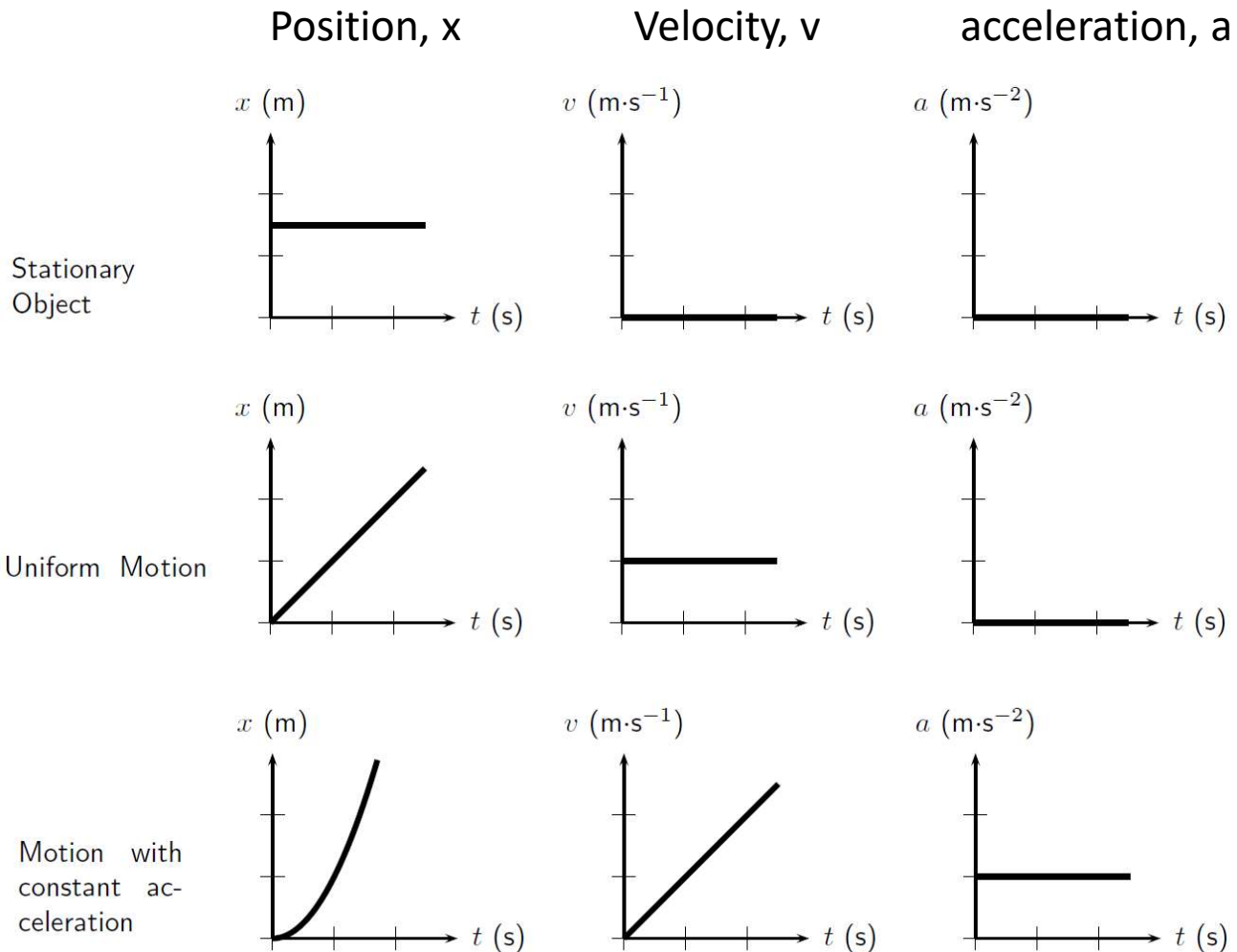
Introduction to Astronomy



Next - Newton's Laws of Motion

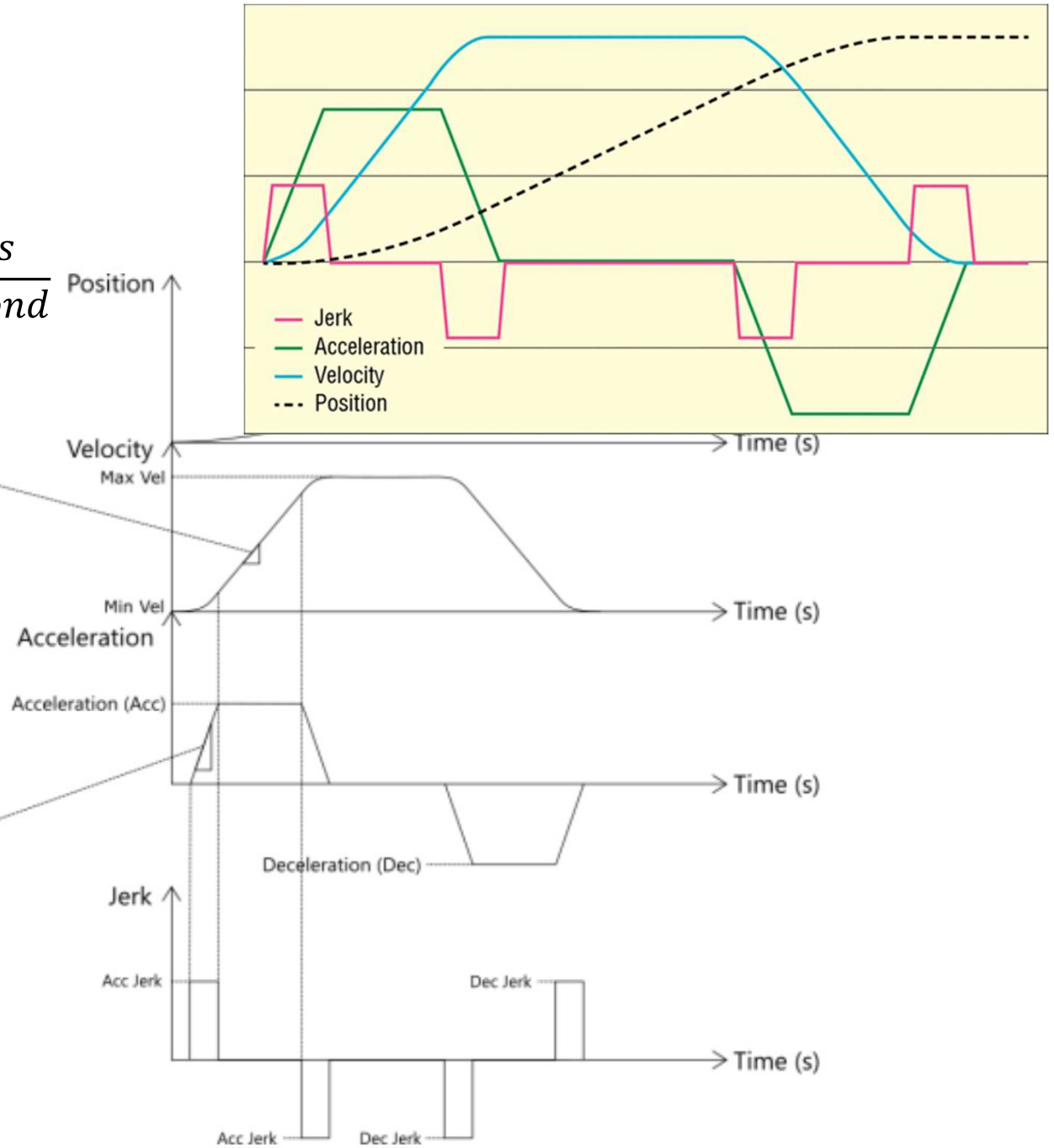
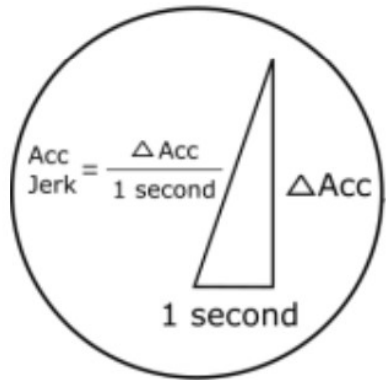
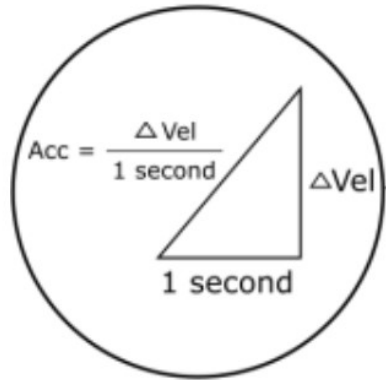
- **1st Law:** An object in motion will not alter its course unless another force acts upon on (inertia)
- **2nd Law:** Net forces cause a change in the motion of an object (acceleration, $F=ma$)
- **3rd Law:** Forces are paired and are equal in strength but act in the opposite direction (action-reaction pairs)

Position, Speed vs. Velocity, Acceleration (and Jerk)

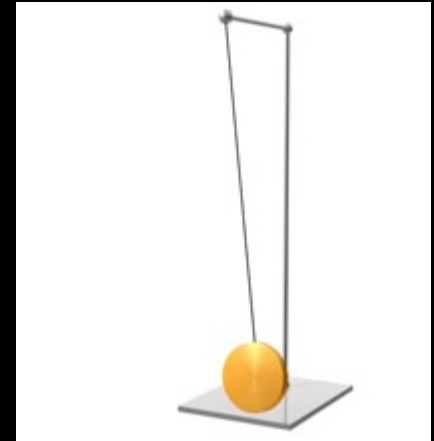




$$vel = \frac{\Delta pos}{1 \text{ second}}$$



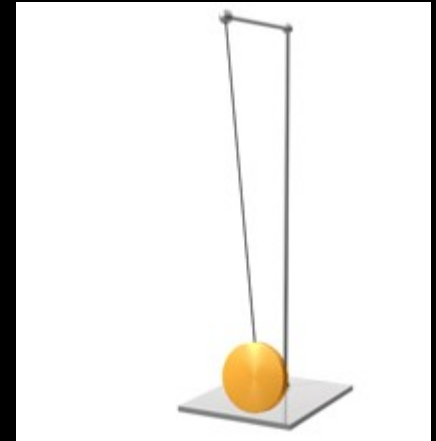
iClicker Question



When a Pendulum Swings..., when it is in the center (pendulum is vertical, position, $x=0$)

- A. velocity = 0, acceleration = 0
- B. velocity = max, acceleration = max
- C. velocity = max, acceleration = 0
- D. velocity = 0, acceleration = max

iClicker Question

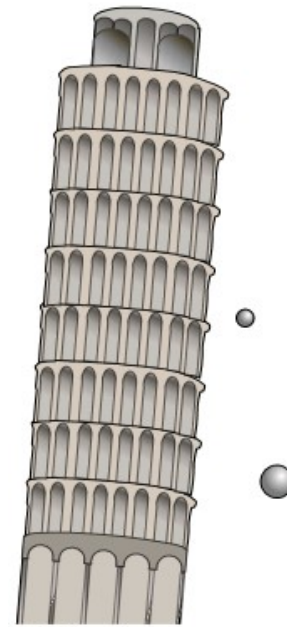


When a Pendulum Swings..., when it is in the center (pendulum is vertical, position, $x=0$)

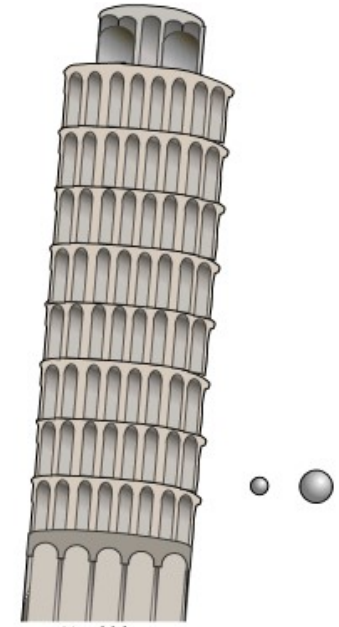
- A. velocity = 0, acceleration = 0
- B. velocity = max, acceleration = max
- C. velocity = max, acceleration = 0**
- D. velocity = 0, acceleration = max

Galileo and Tower of Pisa

- Experiments with falling objects and created models of motion.
- An object in motion will continue moving in a straight path with constant speed until another force acts upon it.
- Galileo showed that g is the *same* for all falling objects, regardless of their mass.

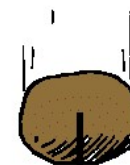


Old idea



Galileo

$$m = 10 \text{ kg}$$



$$F_{\text{grav}} = 100 \text{ N}$$

$$a = \frac{F}{m}$$

$$a = \frac{100 \text{ N}}{10 \text{ kg}}$$

$$a = 10 \text{ m/s}^2$$

$$m = 1 \text{ kg}$$



$$F_{\text{grav}} = 10 \text{ N}$$

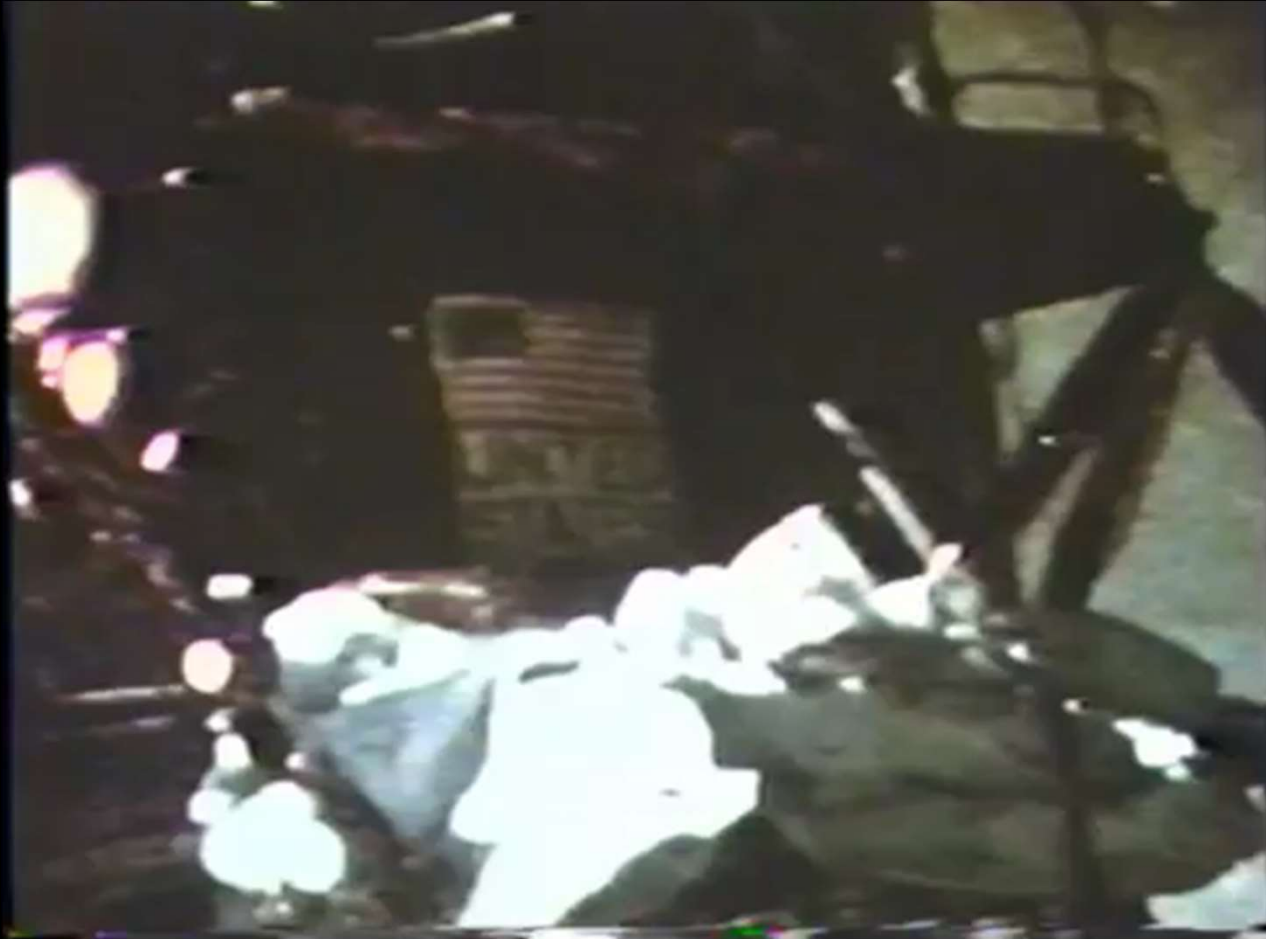
$$a = \frac{F}{m}$$

$$a = \frac{10 \text{ N}}{1 \text{ kg}}$$

$$a = 10 \text{ m/s}^2$$

Lets try this on the Moon

<https://www.youtube.com/watch?v=E43-CfukEgs> – to see Dr. Brian Cox performing the same experiment in a vacuum chamber



End of Today's Lecture