UNV Week 1: What is life? Where do we come from? Our planet and the solar system

This Week's Learning Objectives:

By the end of this week, you should be able to:

Recognize Earth as a biosphere, and describe its position and motion in a larger structure such as the Solar system, an environment that hosts a habitable planet

1. Distinguish **"living"** from "non-living" by evaluating their essential characteristics
2. Identify and differentiate the constituents of our **solar system**, and describe our position (uniqueness) in the universe
3. Explain the difference between **vector** and **scalar** quantities by giving examples
4. Analyze a simple motion of an object by correctly calculating the **position**, **velocity** and **acceleration** values/functions at given instances, given any one of the functions
5. Given the **graph** of any one of position, velocity or acceleration as a function of time, sketch the graph of other parameters as a function of time

Virtual Lecture

1. Introduction to Universe Module


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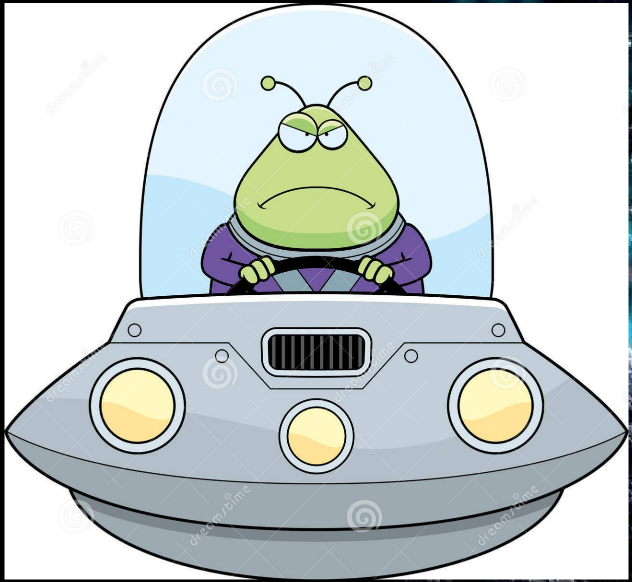


http://time.com/3747812/life-in-space-alone/

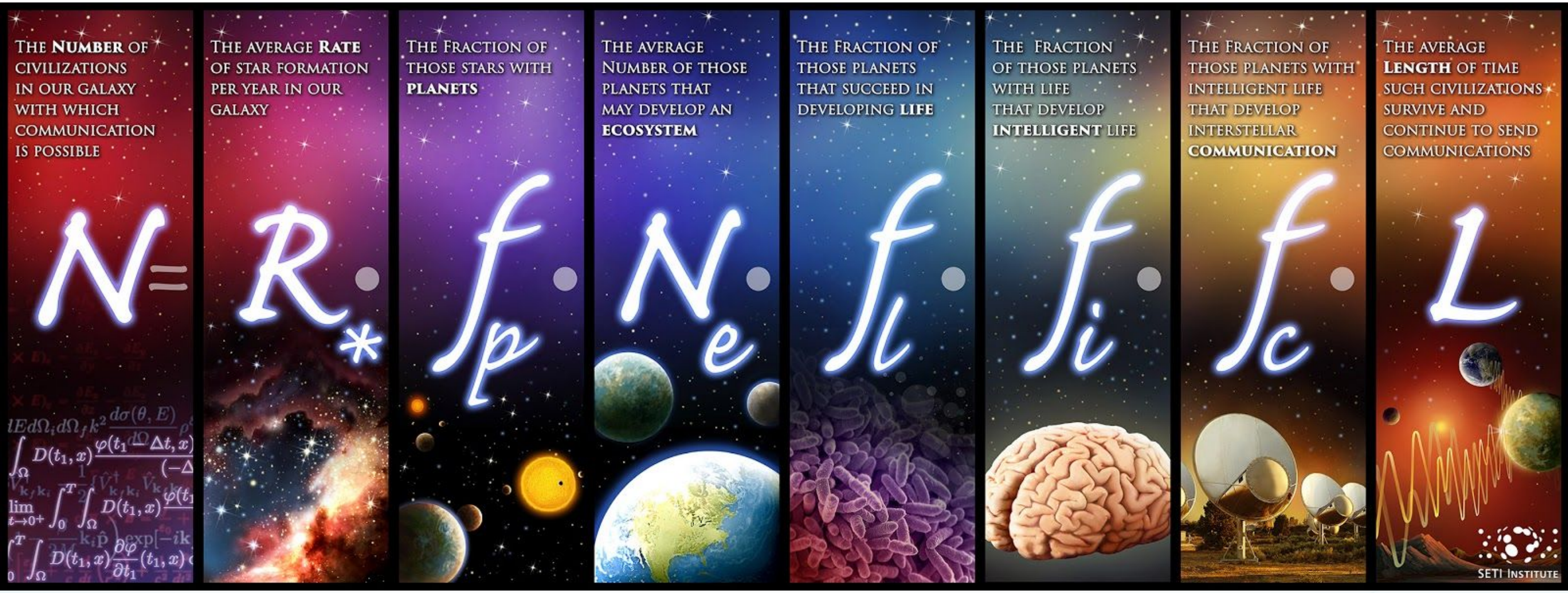
Are we alone in the Universe…?

Into The Universe With Stephen Hawking

"Are We Alone?"

https://www.youtube.com/watch?v=KBAgfwliUlA

Are we alone in the universe?
"Drake Equation"



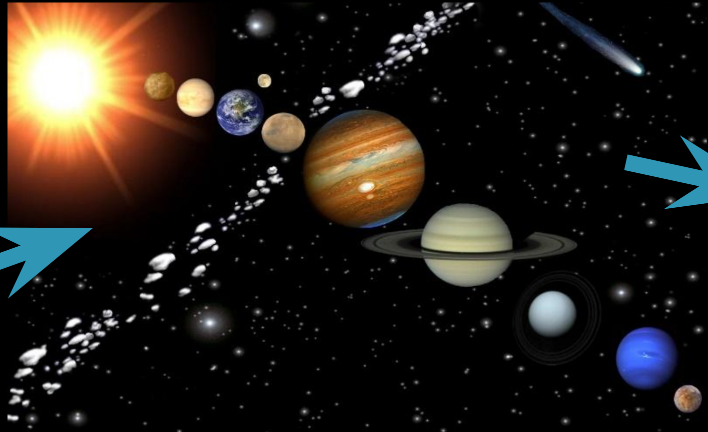
We will explore some of the factors that affect our probability of finding **intelligent** life in **our Galaxy**

Interactive Drake Equation Calculator
http://www.bbc.com/future/story/20120821-how-many-alien-worlds-exist

EARTH

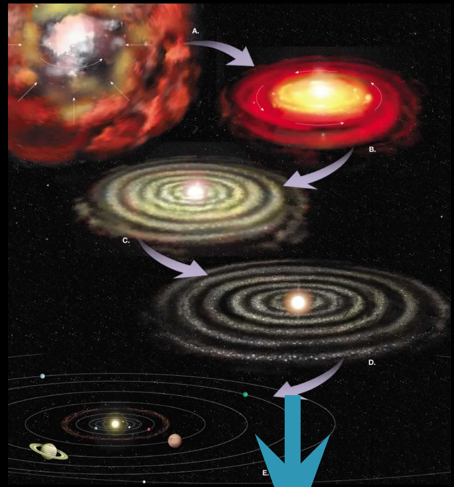
Home sweet home

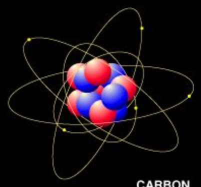
Week1: What is life? Where do we come from? Our planet and the Solar system



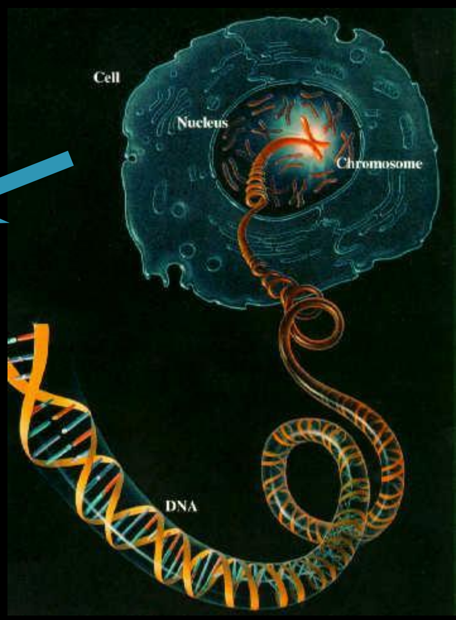
Week2: What makes planets go around the Sun? What holds the Solar system together?

Week3: How did the Solar system form? Is it unique?

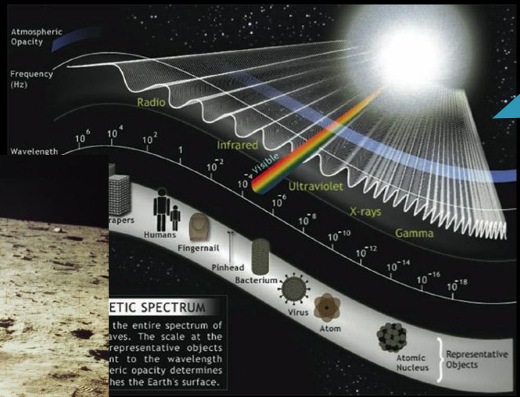




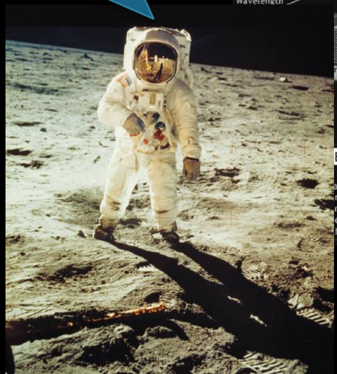
Week4: How did life on Earth begin? Building blocks of life, first form of life on Earth



Week5: How can we look for ET life? Atom and EM spectrum



Hello?
Is there
anybody out
there?

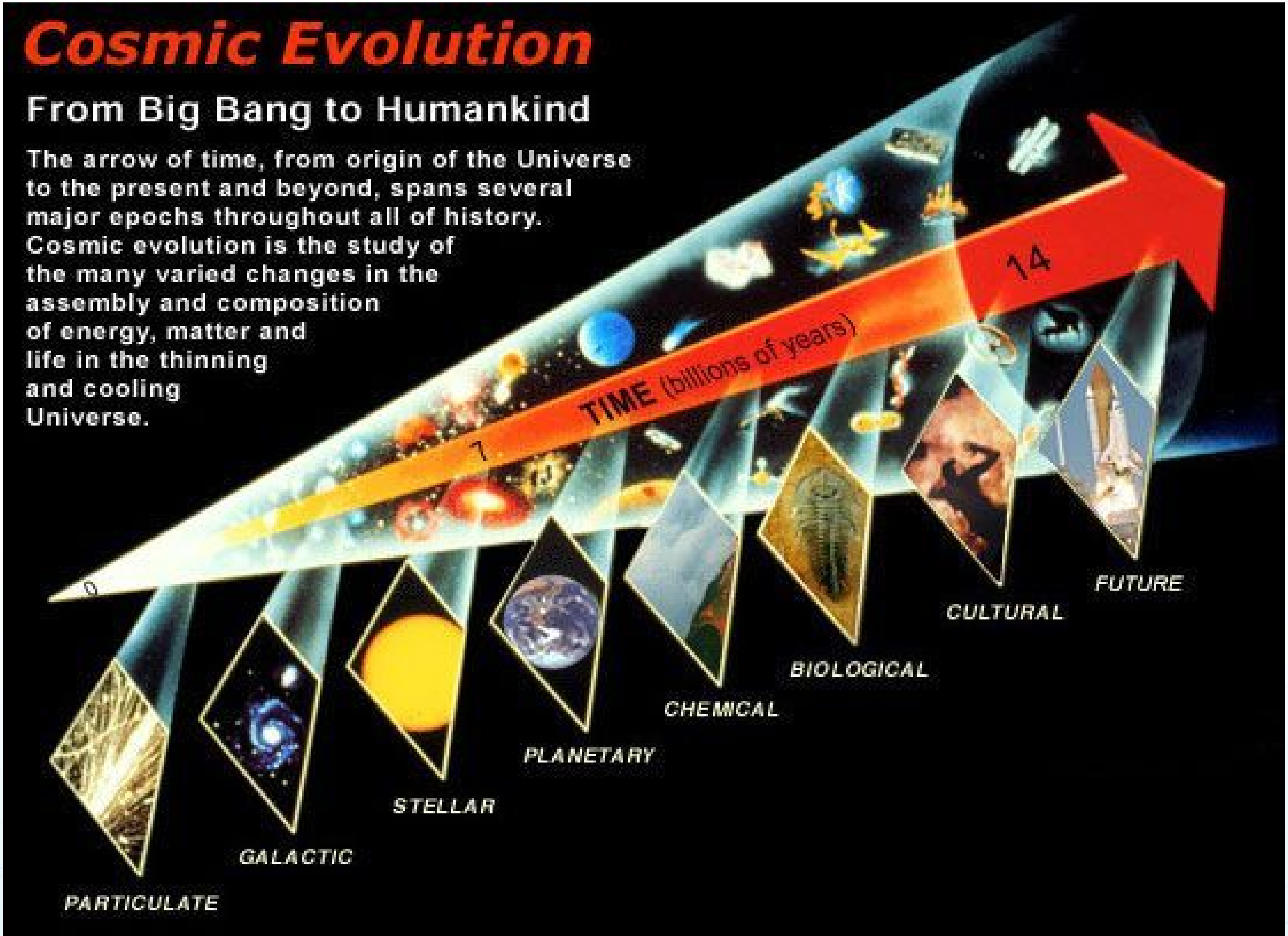


Week6: What form of life would you look for and how? Possibility of life on other planets

Virtual Lecture

2. Phases of cosmic evolution

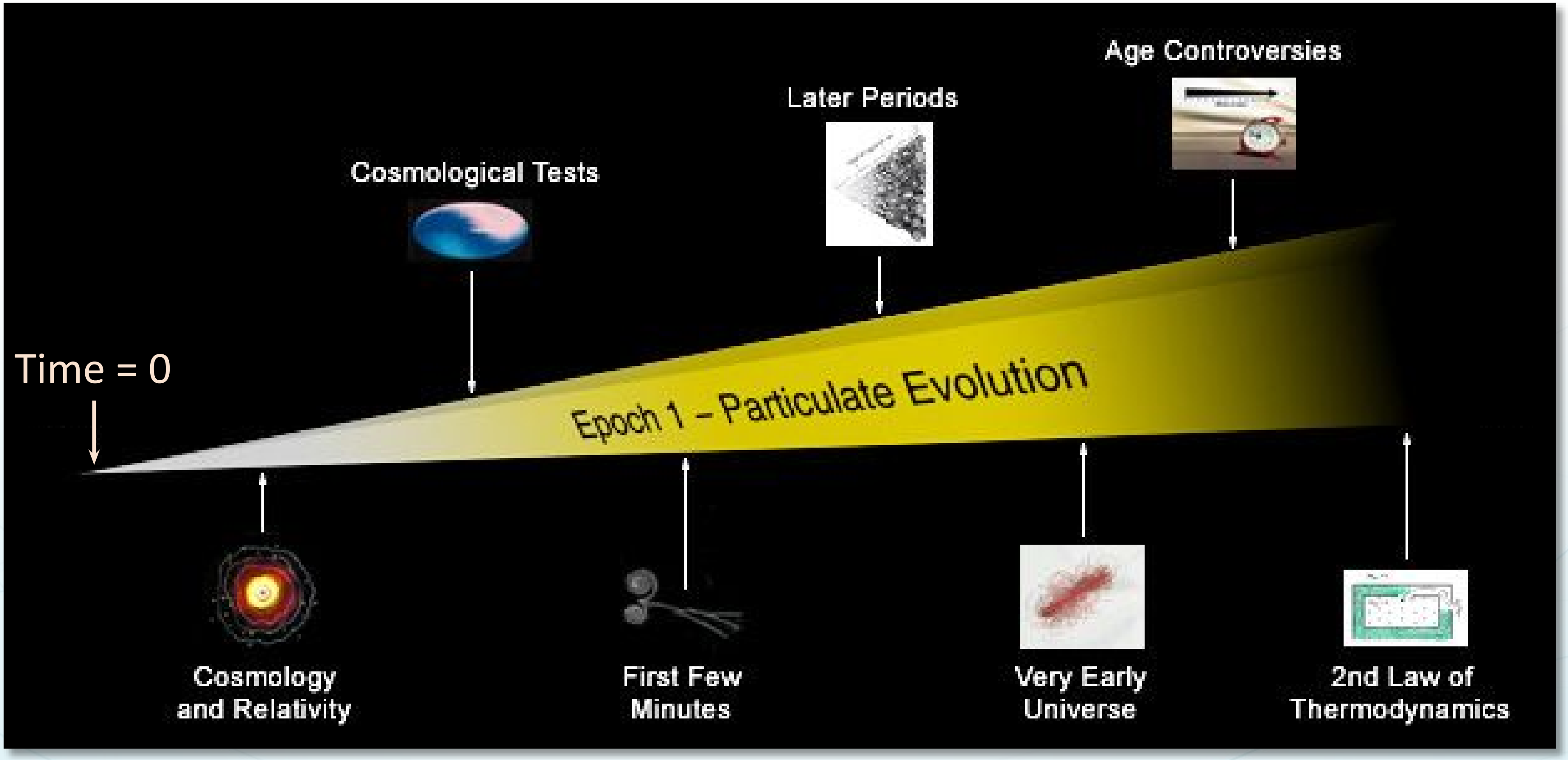
How did life and technology emerged on Earth?



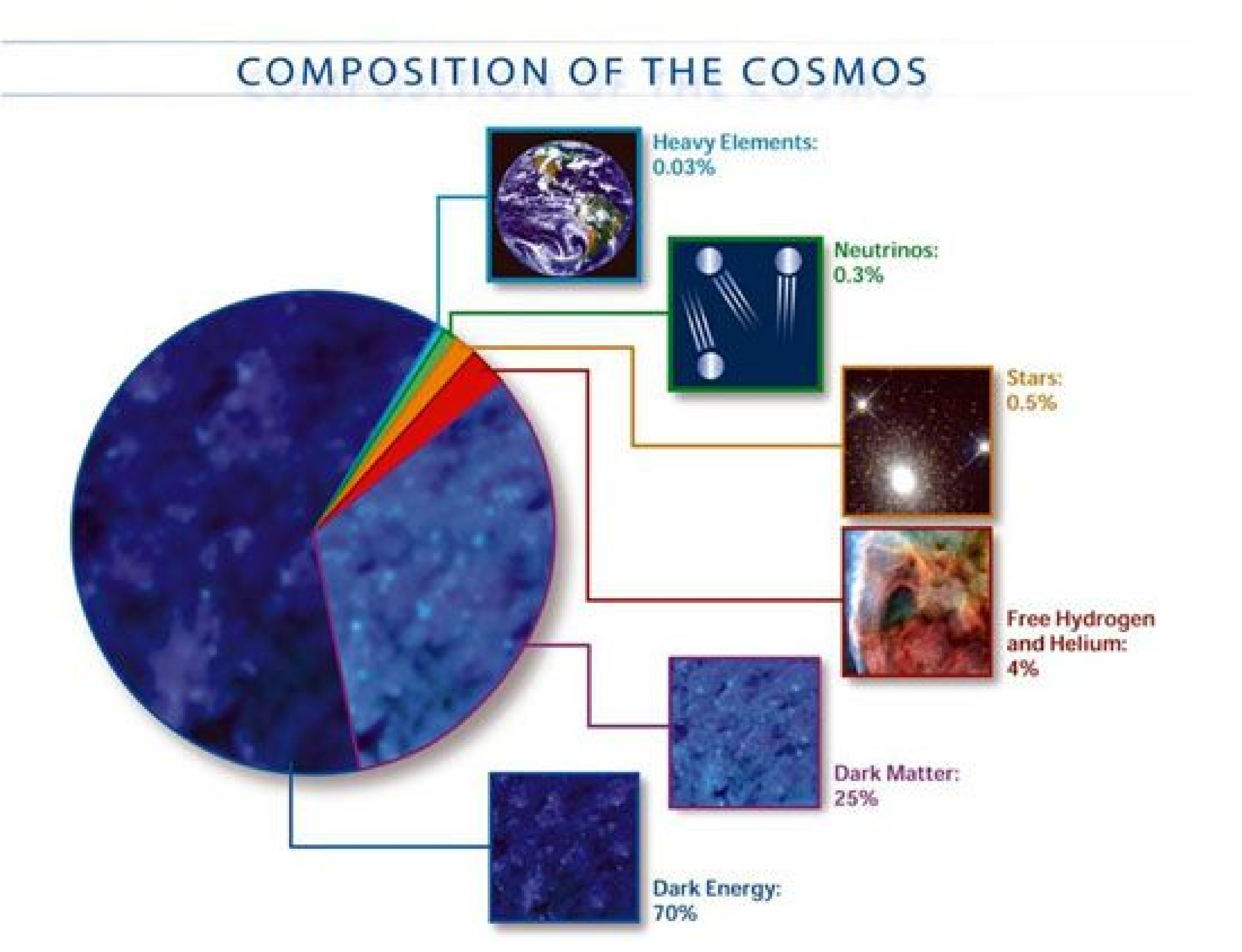
https://www.cfa.harvard.edu/~ejchaisson/cosmic_evolution/docs/splash.html

Epoch 1 - Particulate epoch (the early universe)

Our knowledge of the early universe is uncertain. The earliest moments of existence are gone with the expansion, perhaps forever lost to the march of time. Yet virtually all the cosmic data thus far accumulated imply an extremely hot and dense early Universe, growing cooler and thinner with time.



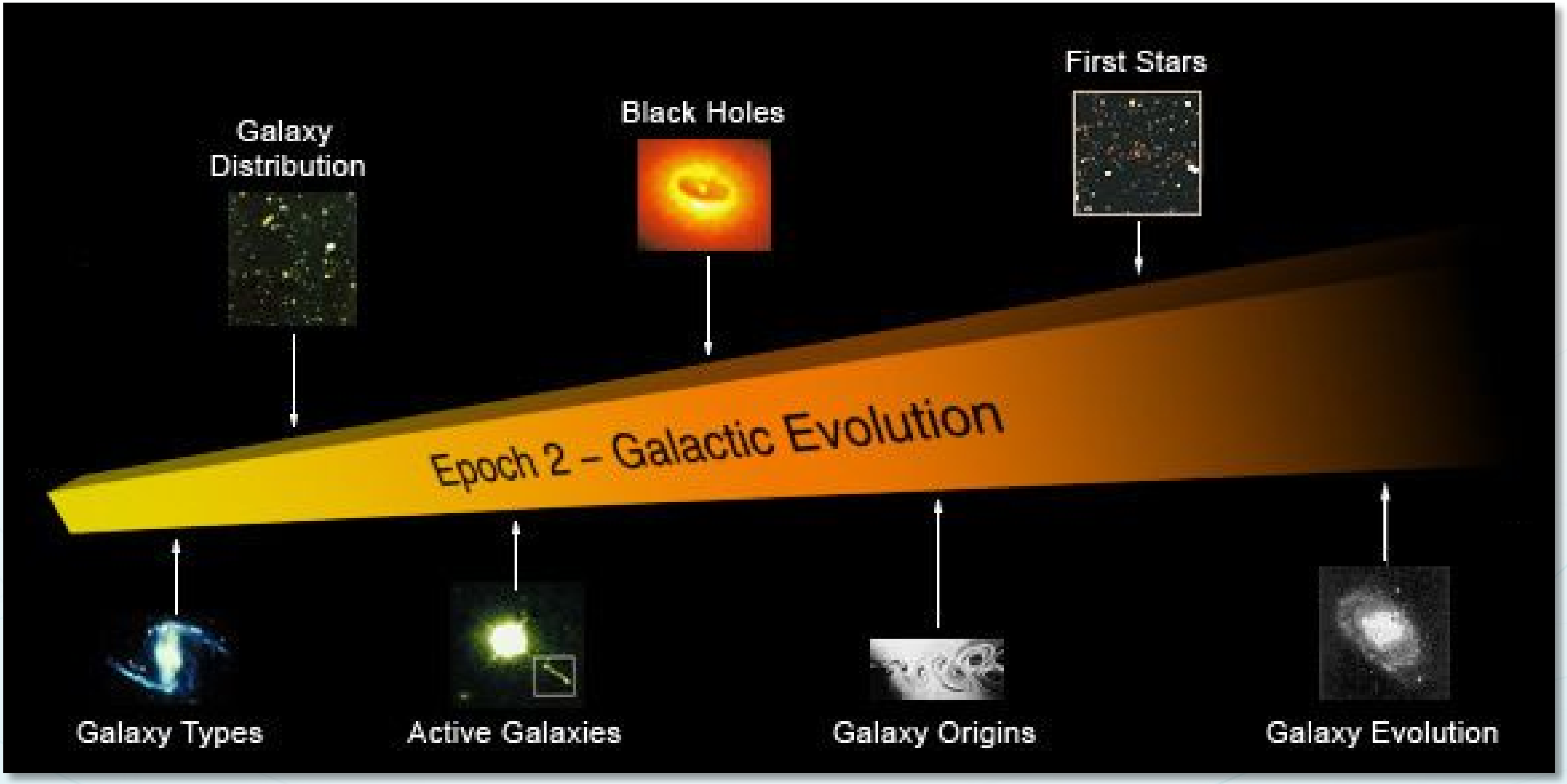
Cosmic composition



* We do NOT know what constitutes %95 percent of the universe...

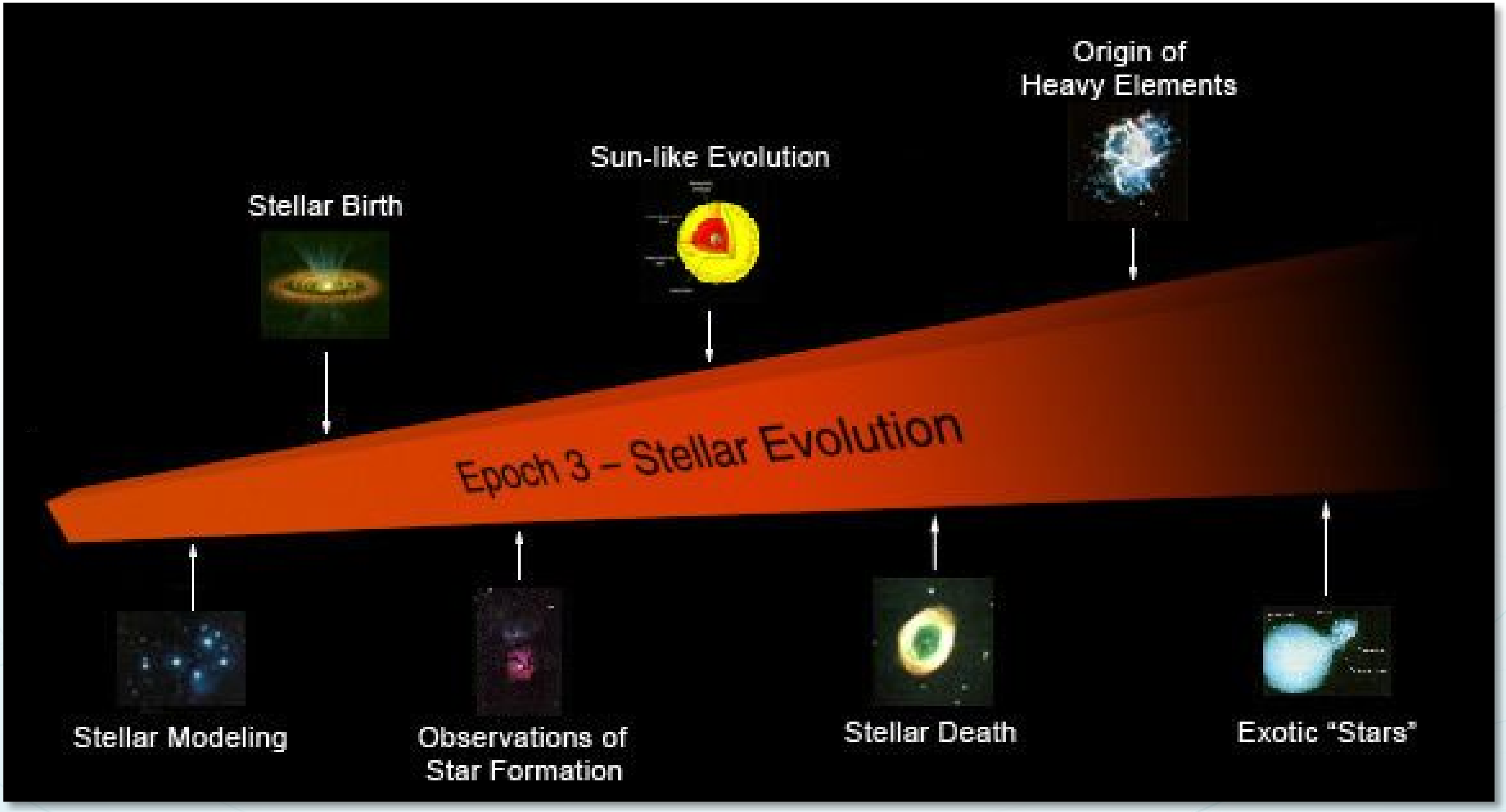
Epoch 2 - Galactic Evolution

Aside from the creation of atoms, the formation of galaxies was the first great accomplishment of the Matter Era. However, our knowledge of the galaxies, especially their origin and evolution is clearly inadequate. The subject of galaxy formation is the biggest missing link in all of cosmic evolution.



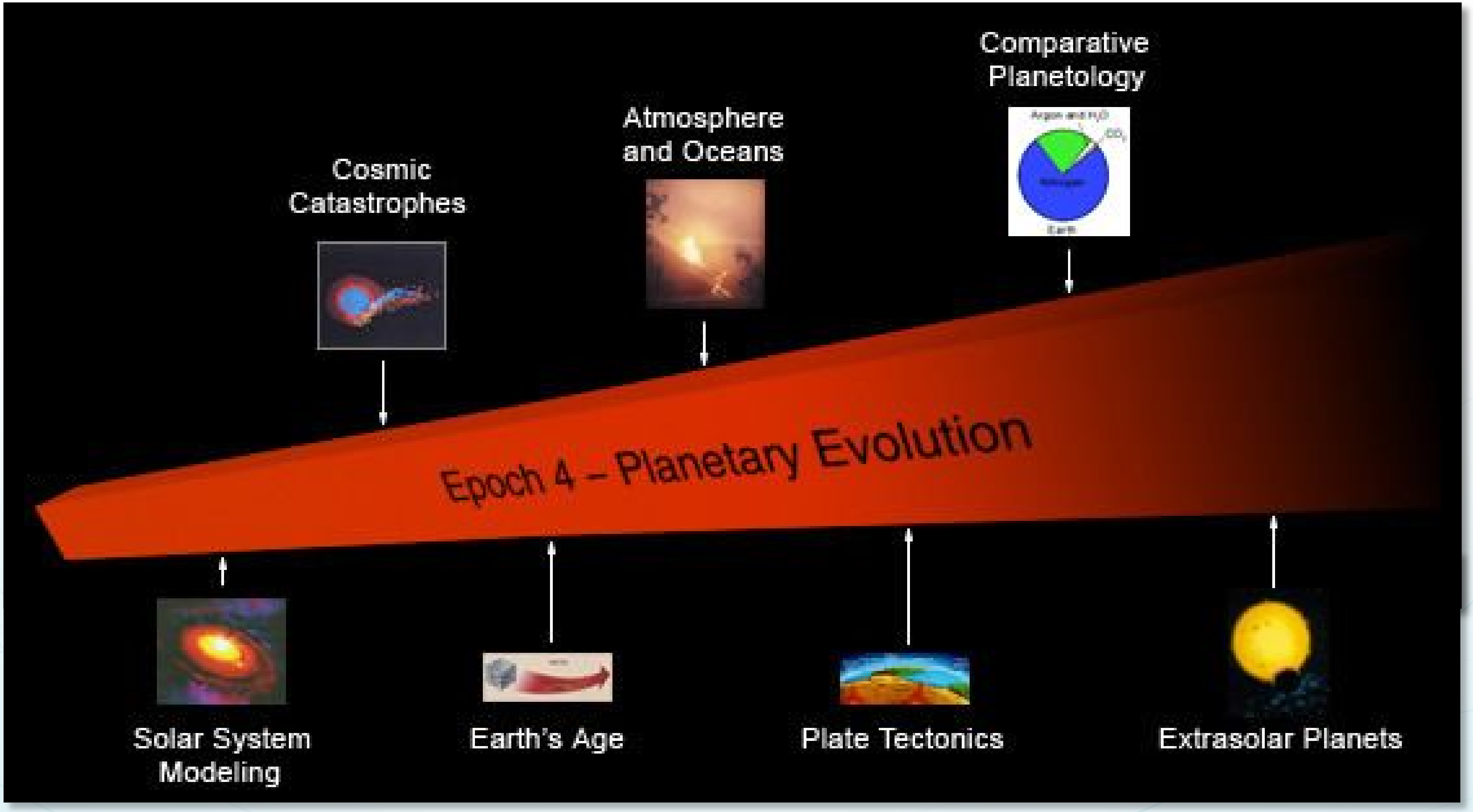
Epoch 3 - Stellar evolution

In recent years, astronomers have gained a reasonably good understanding of how stars proceed through their various evolutionary paces, from birth to maturity to death. In contrast to our lack of knowledge of galaxy evolution, we know quite a lot about stellar evolution, including the creation of the elements of which we are made.



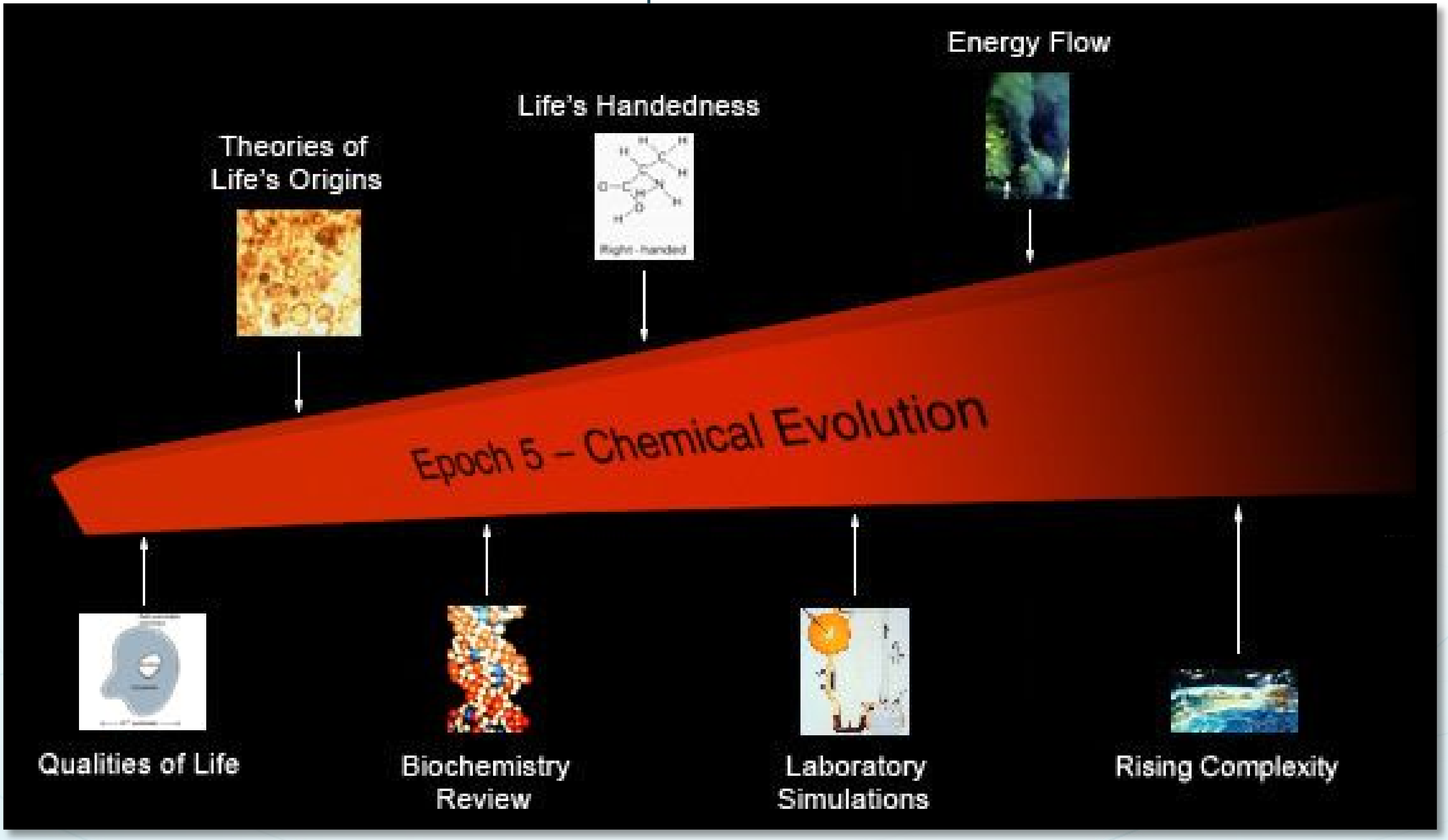
Epoch 4 - Planetary Evolution

Viewed from the broad perspective of Earth photographed in space and imagined over the eons, not much is stable on our planet. Virtually everything evolves, although more often subtly than dramatically, and on time scales long compared to the duration of a human lifetime or a typical civilization.



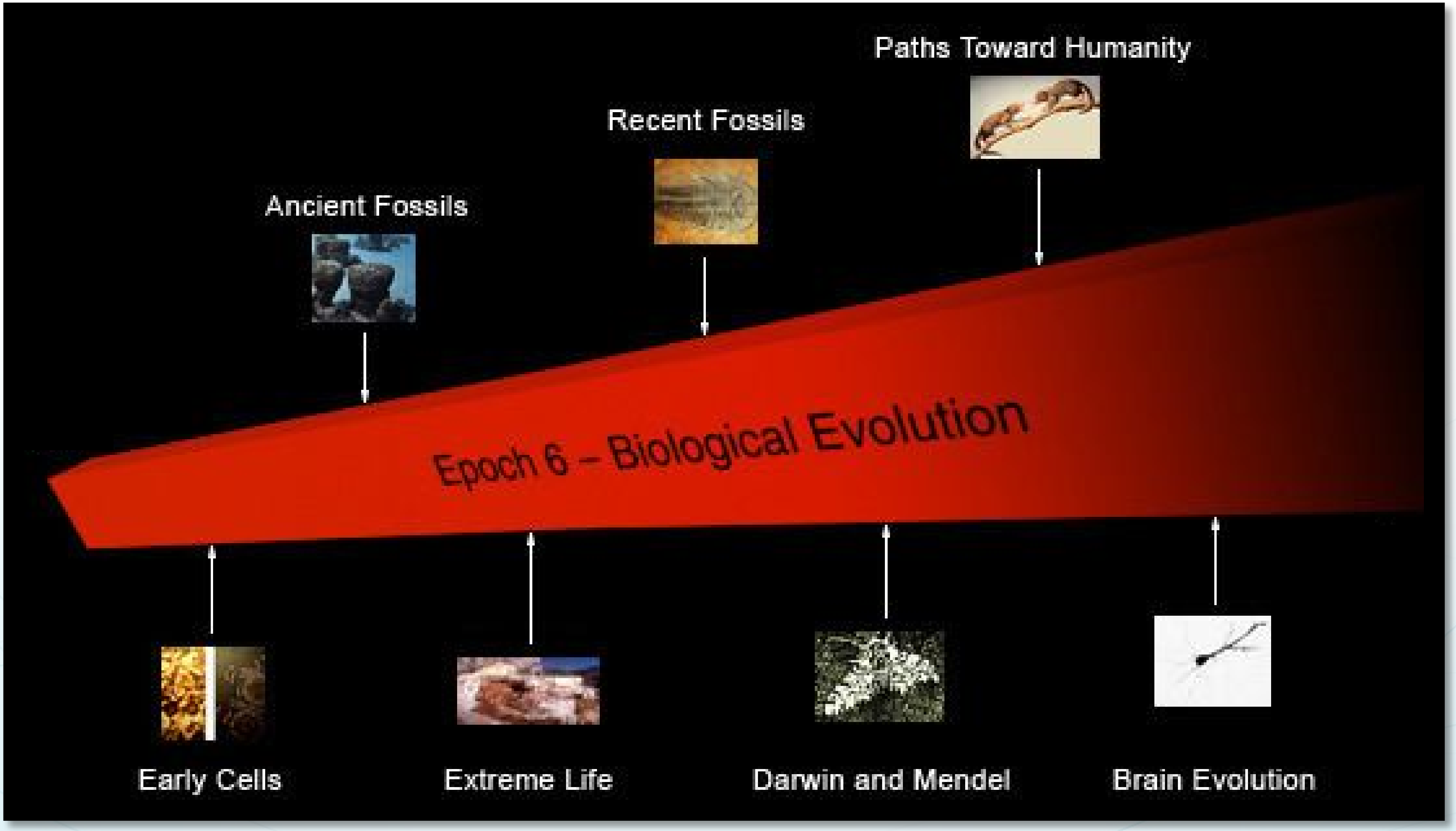
Epoch 5 - Chemical Evolution

Theoretical considerations and experimental simulations suggest that life is a logical result of known physical and chemical principles operating within the atomic and molecular realm. Furthermore, the origin of life itself seems to be a natural consequence of the evolution of that matter on the microscopic level.



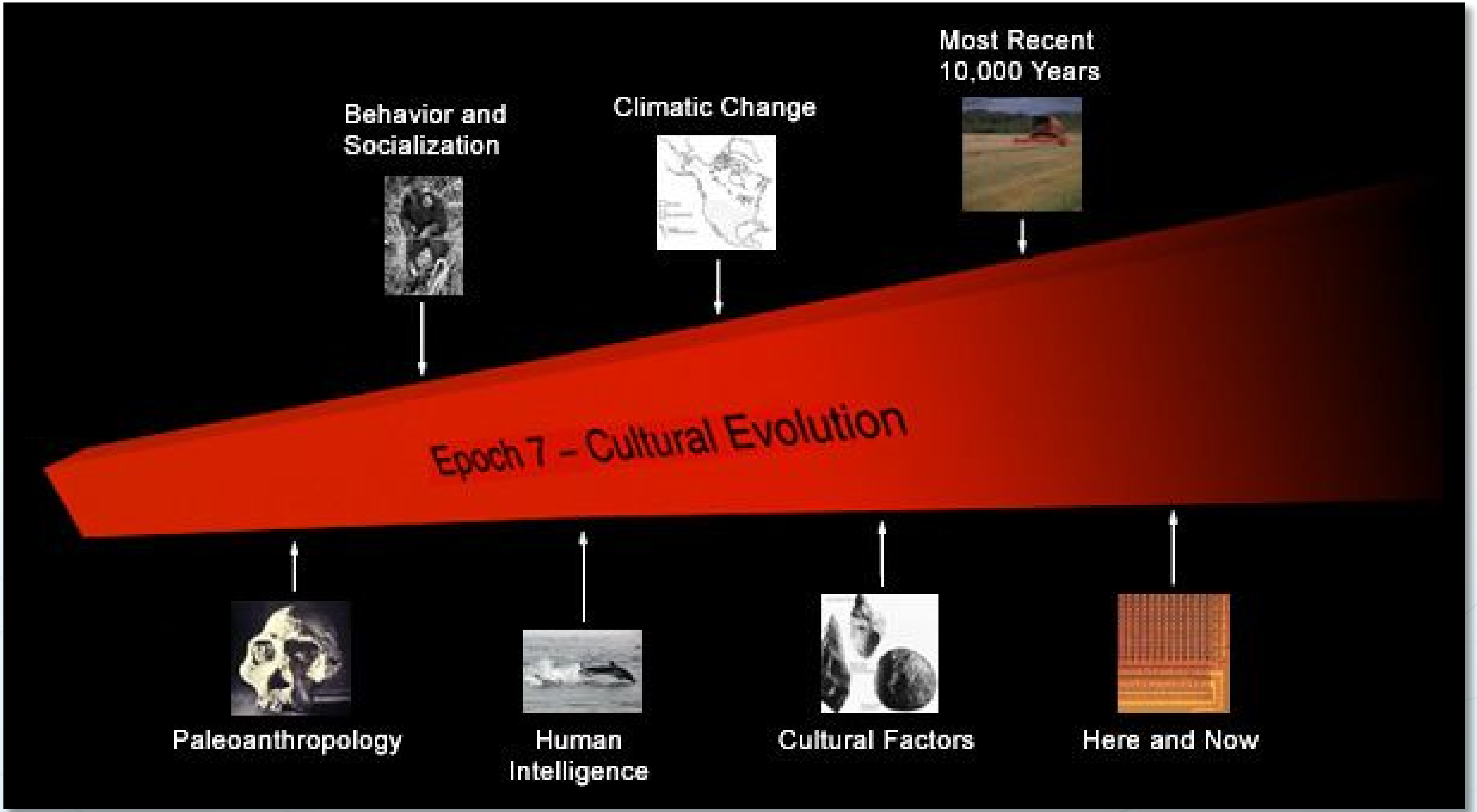
Epoch 6 - Biological Evolution

The most remarkable heavy-element assemblage on Earth is life itself. Plants and animals are widespread on the land and in the sea, and both are well adapted to our planet yet experience never-ending change. Of particular interest, men and women have existed within only the last 0.1 percent of Earth's history.



Epoch 7 - Cultural and technological evolution

The precise path of human evolution during the past few million years is tricky to unravel in detail. The causes of recent evolution include not only biological factors but cultural and technological ones as well. The result is a central nervous system or sentiment brain enabling us to reflect back upon the Universe that gave us life.



Virtual Lecture

3. The Solar System

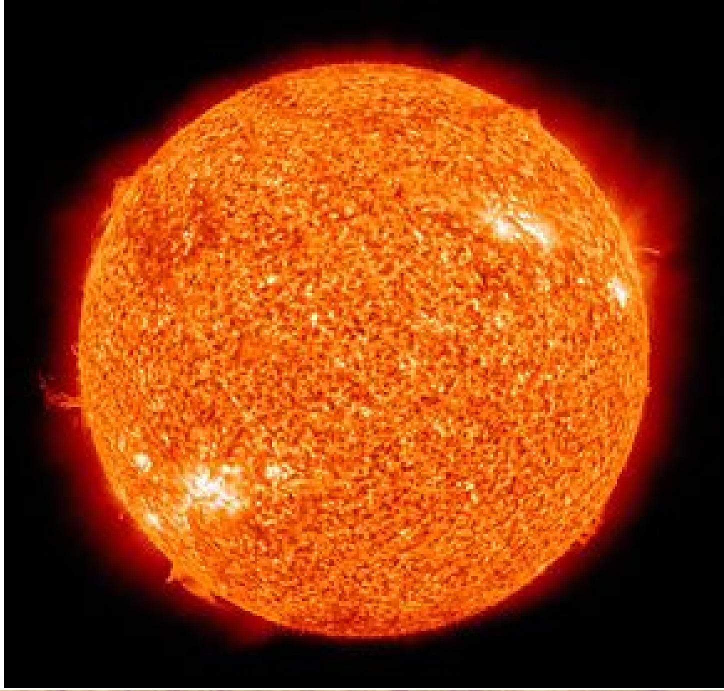
Is the Earth so special?

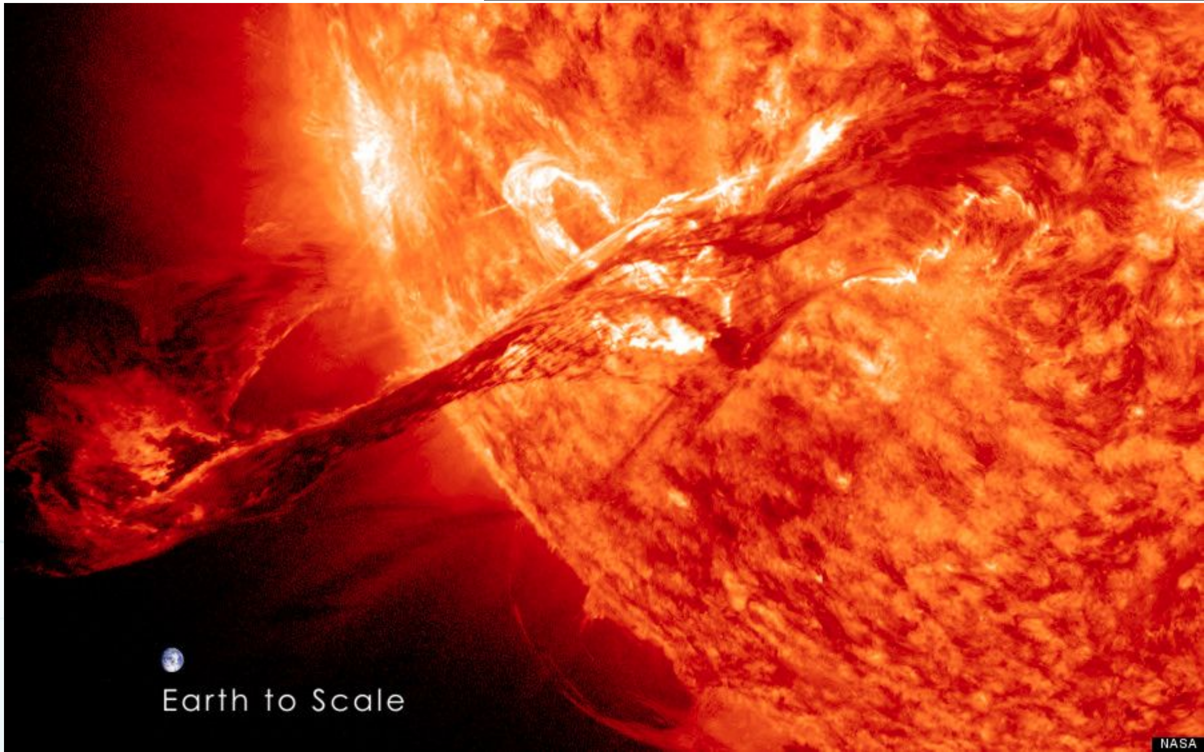
* The Earth is part of the solar system: bunch of large and small bodies, all rotating around the nearest star, the SUN!
* Check out the solar system facts:
  http://solarsystem.nasa.gov/planets/solarsystem

The SUN

* Spherical hot gas held by its own **gravity**.
* The inner parts have a temperature of 15 x 10^6 degrees, whereas the surface is around 6000 degrees Celcius.
* Radius: $7x10^8$m
* Check out facts:

https://solarsystem.nasa.gov/planets/sun/indepth

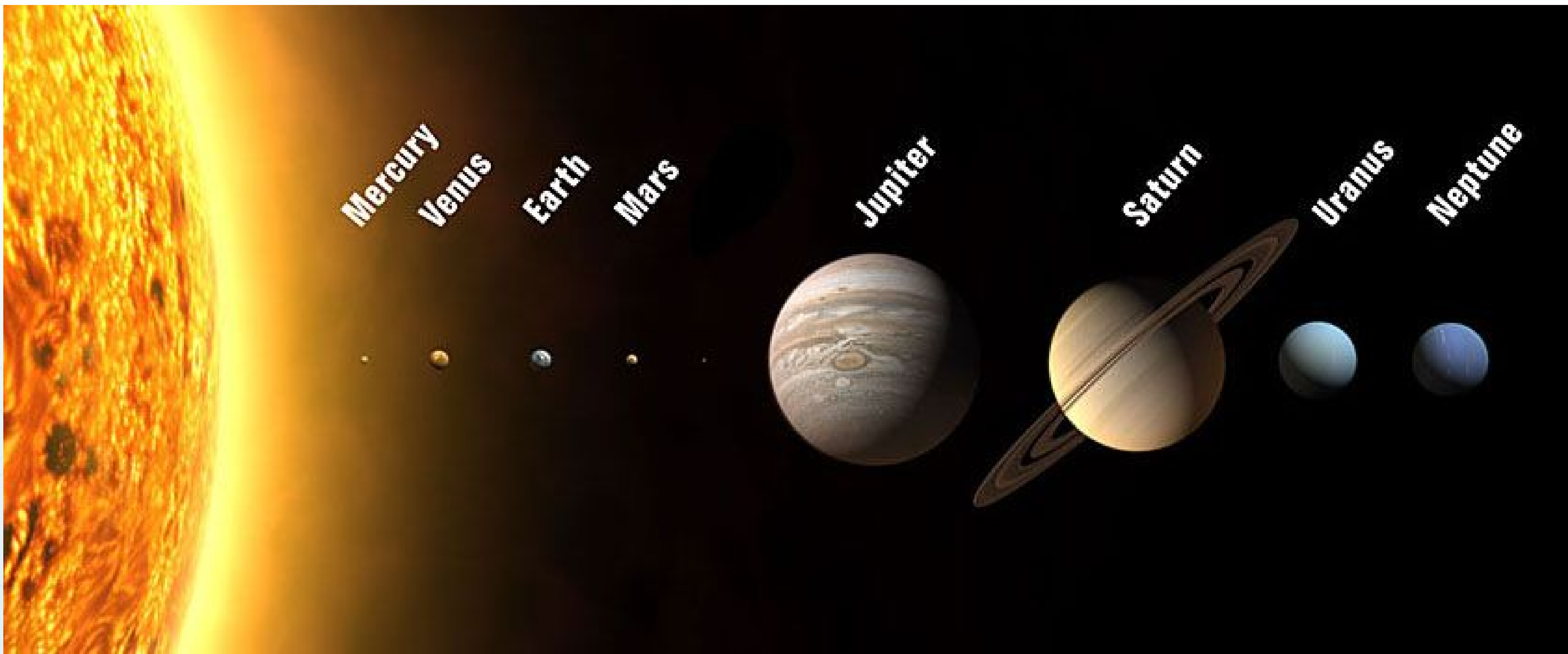




PLANETS

What is a planet?

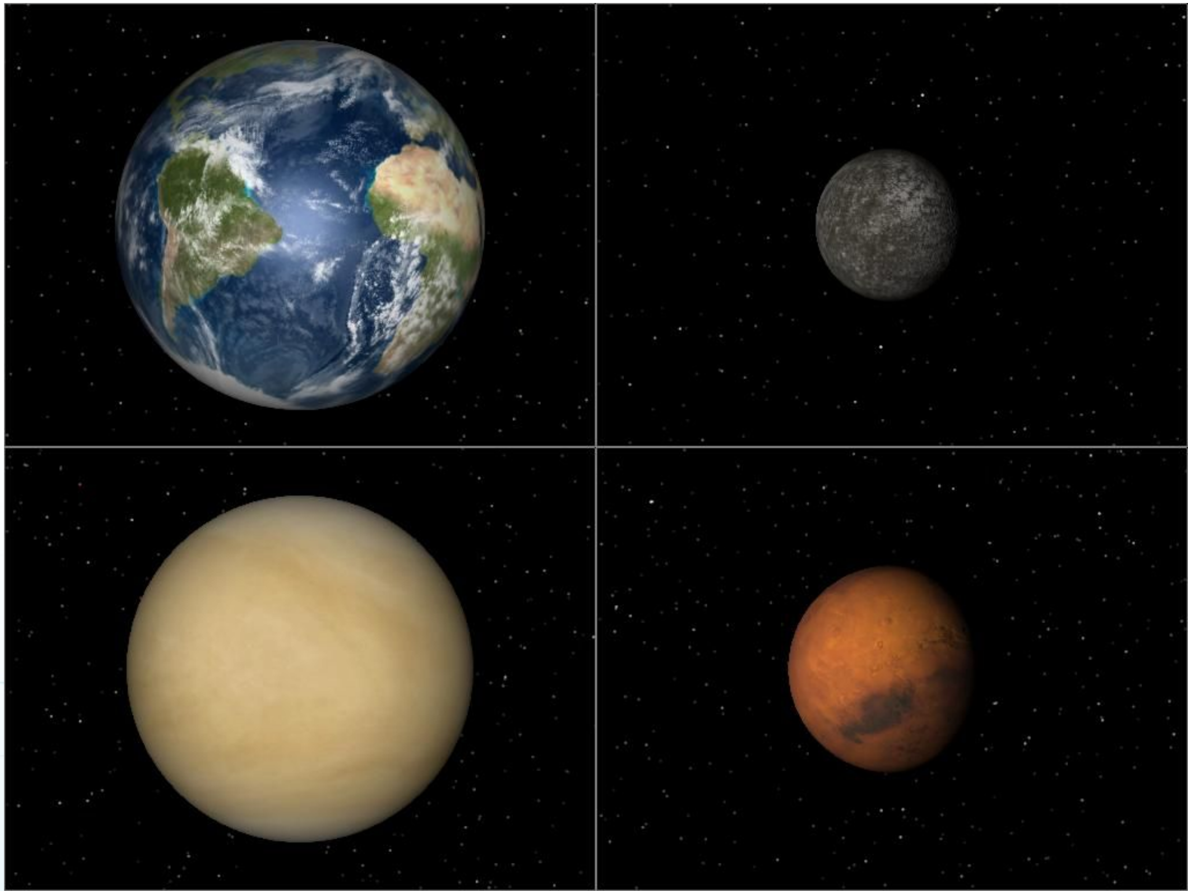
http://solarsystem.nasa.gov/planets/whatisaplanet.cfm



Rocky planets, Mercury, Venus, Earth and Mars

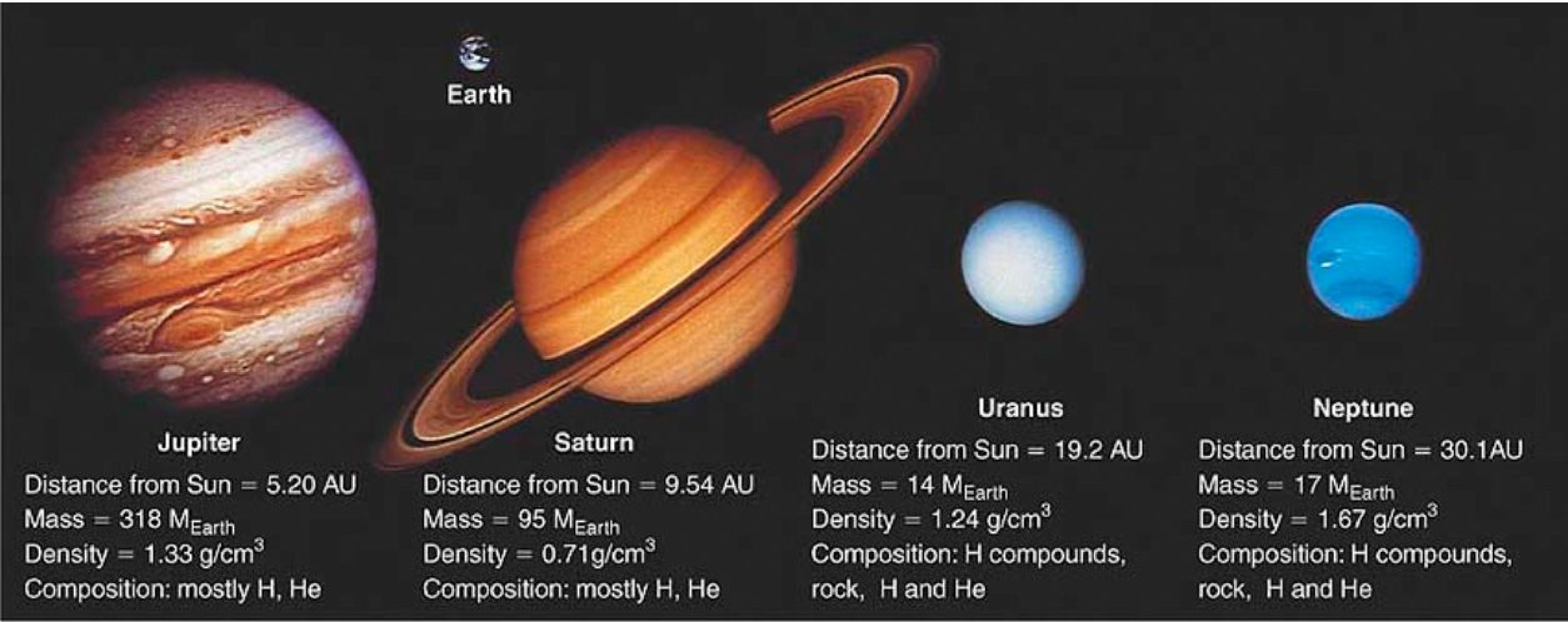
* Rocky planets are also known as a terrestrial planet, with a solid and dynamic surface of mountains, valleys, canyons, plains.

* What is the biggest difference between the Earth and the other terrestrial planets?



Gaseous planets
Jupiter, Saturn, Uranus, Neptune

* Gaseous planets do not have solid surfaces, but they may have solid cores.



Pluto and dwarf planets

* After the discovery of planets at the outer parts of the solar system as large as pluto, a decision had to be made!
* In 2006 IAU demoted Pluto to be a dwarf planet, rather than a planet.

http://solarsystem.nasa.gov/planets/dwarf

SPACE.com

www.SPACE.com

Dwarf Planets in the Solar System

In 2006, the organization responsible for classifying celestial bodies, the International Astronomical Union (IAU) decided that a new class of objects was needed. Pluto, considered a planet since its discovery in 1930, was reclassified into the new "dwarf planet" category. To date, five dwarf planets have been found, although some astronomers expect there may be as many as 50 in the solar system.

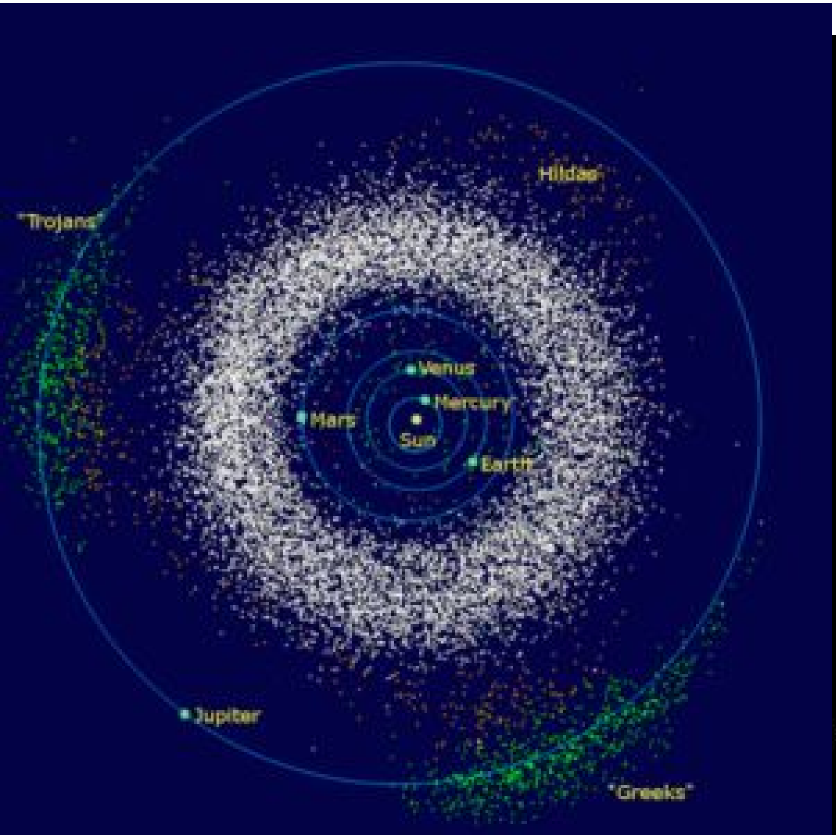
	ERIS	PLUTO	HAUMEA	MAKEMAKE	CERES
Year of discovery	2003	1930	2003	2005	1801
Diameter (mean)	1,445 miles 2,326 km	1,430 miles 2,302 km	892.3 miles 1,436 km	882 miles 1,420 km	591.8 miles 952.4 km
Orbital period (Earth years)	561.4	247.9	281.9	305.34	4.6
Distance from sun (times Earth's distance)	68	39.5	43.1	45.3	2.8
Orbital inclination (degrees)	46.9	17.14	28.2	29	10.59
Rotation period	25.9 hours	6.39 Earth days	3.9 hours	22.5 hours	9.1 hours
Moons	1	5	2	0	0

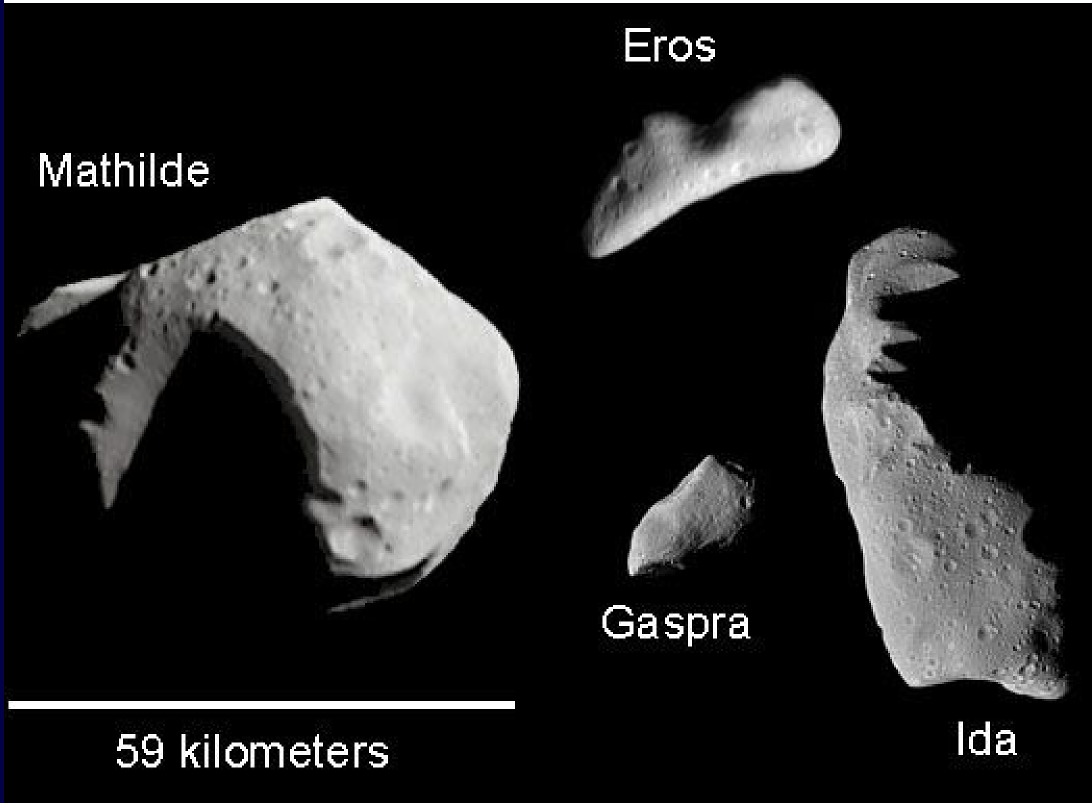
SOURCE: NASA

Asteroids

http://solarsystem.nasa.gov/planets/asteroids

Can asteroids be sources of complex organic molecules, even life on Earth?

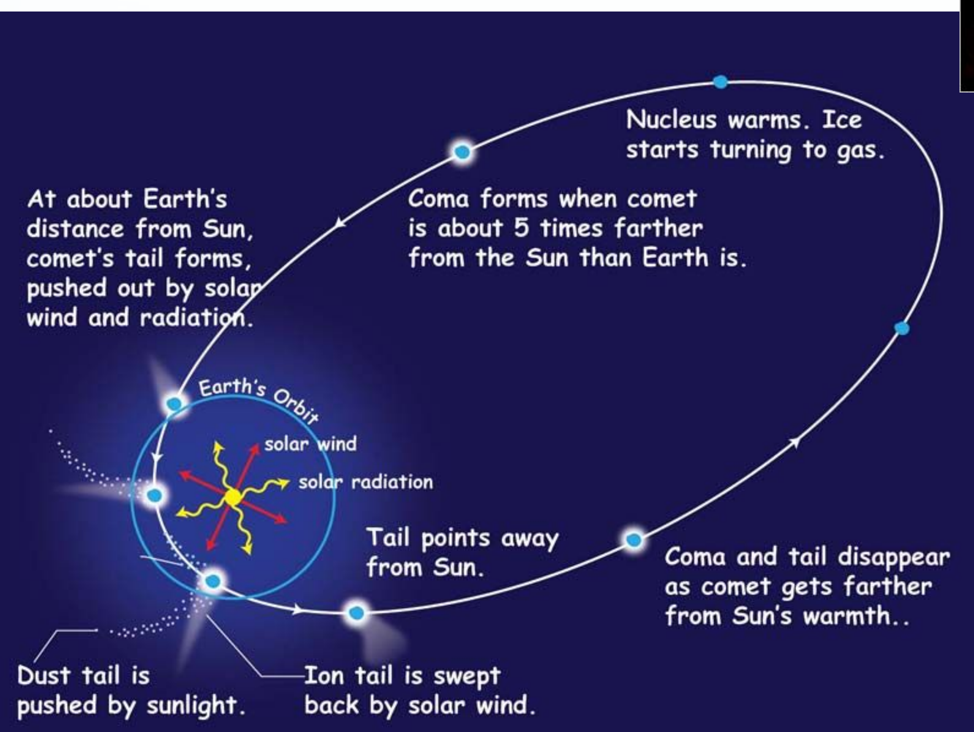


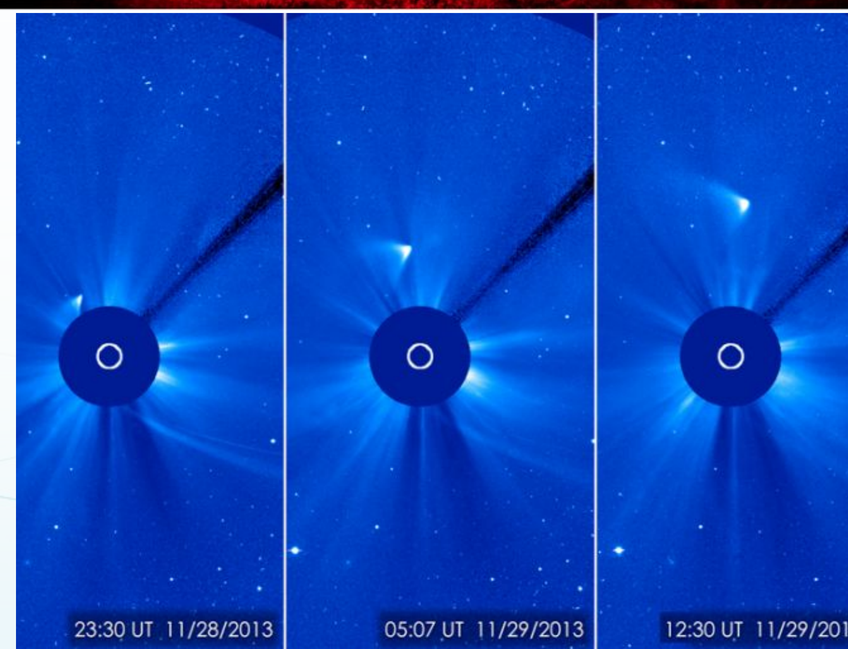


Match solar system

Comets

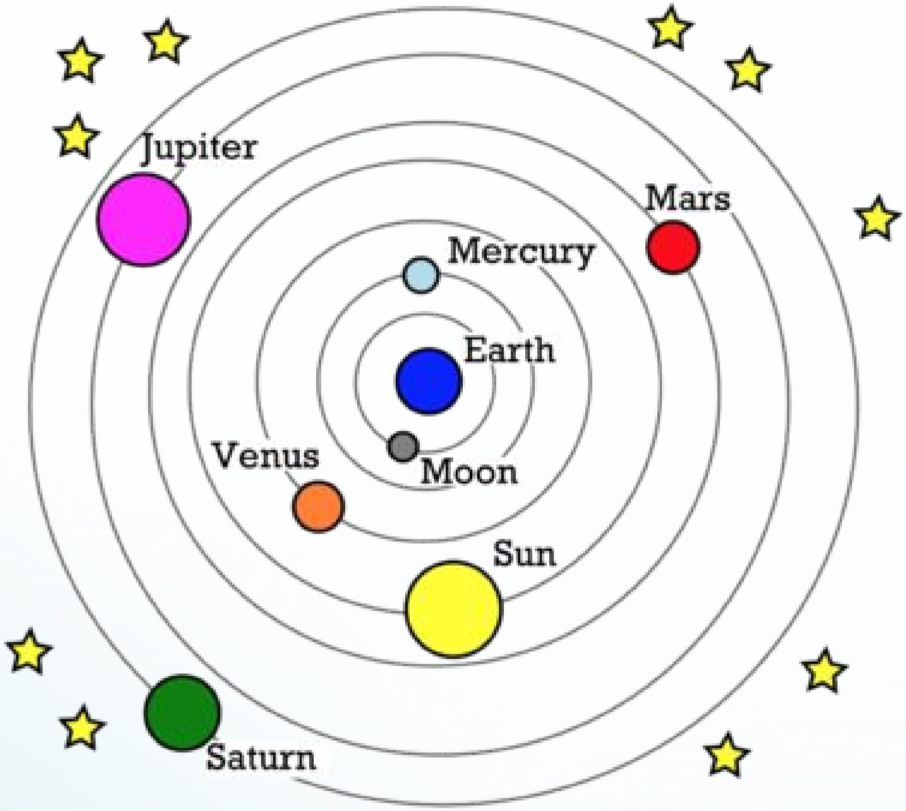
* http://solarsystem.nasa.gov/planets/comets
* Some fracton of water on Earth came with comets?



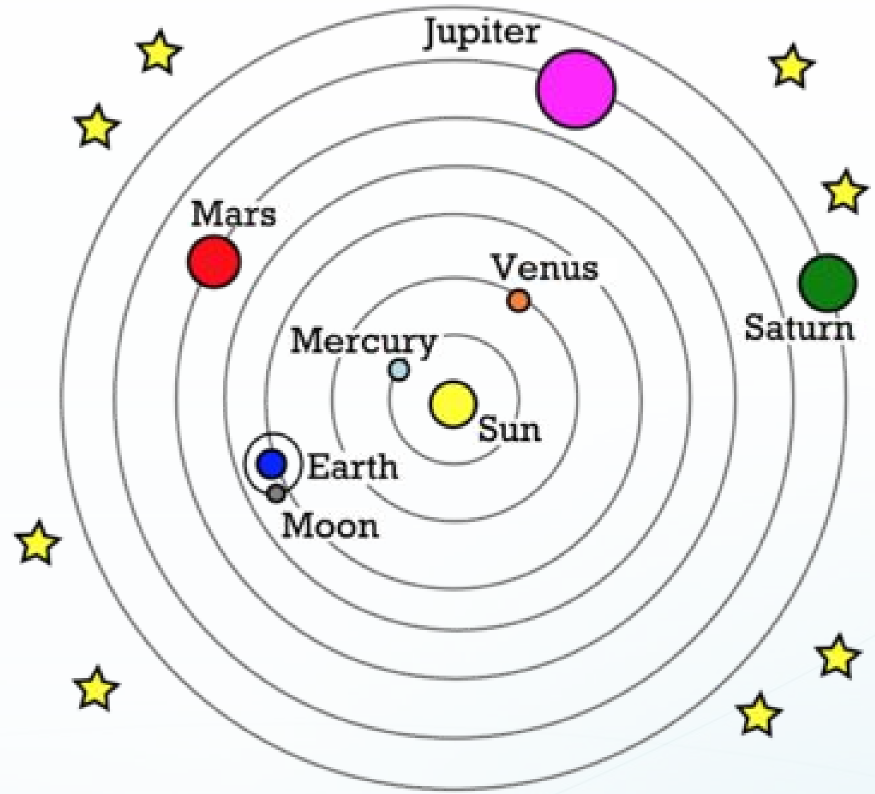


Virtual Lecture

4. Describing Motion

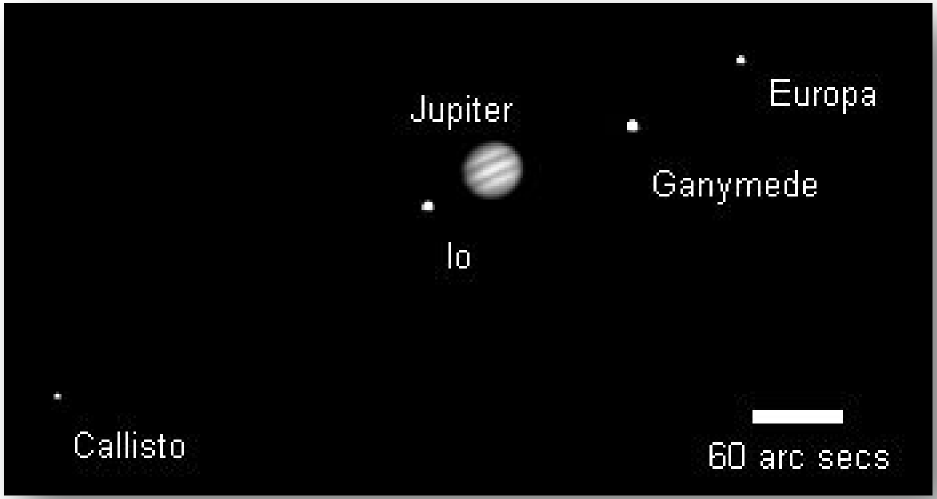


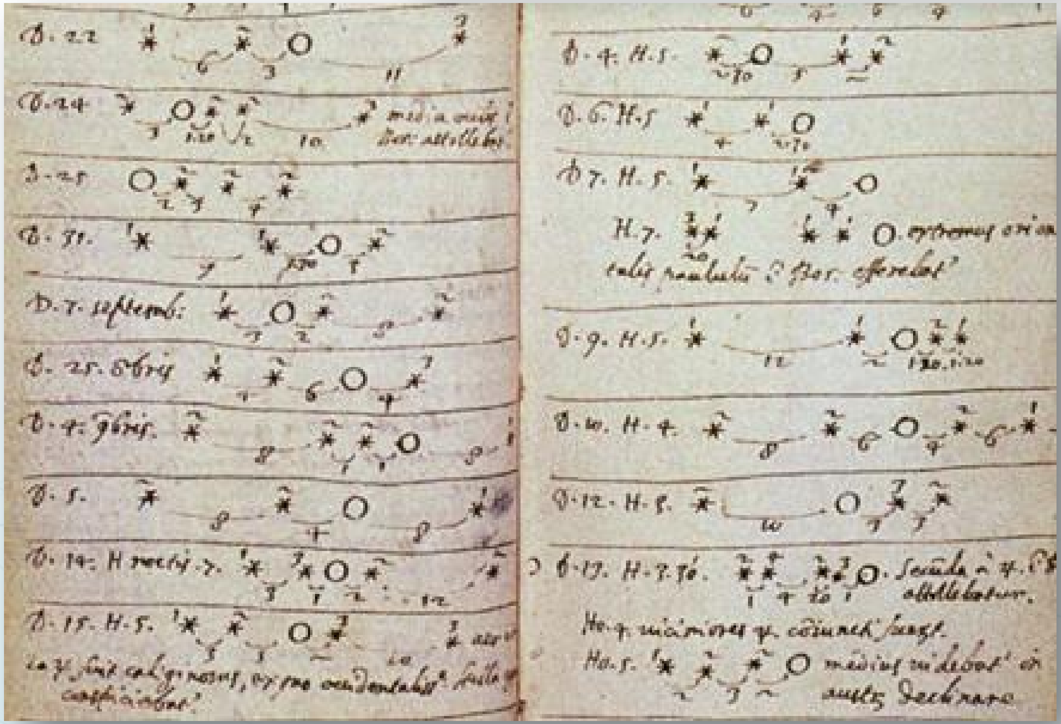
Earth at the Center

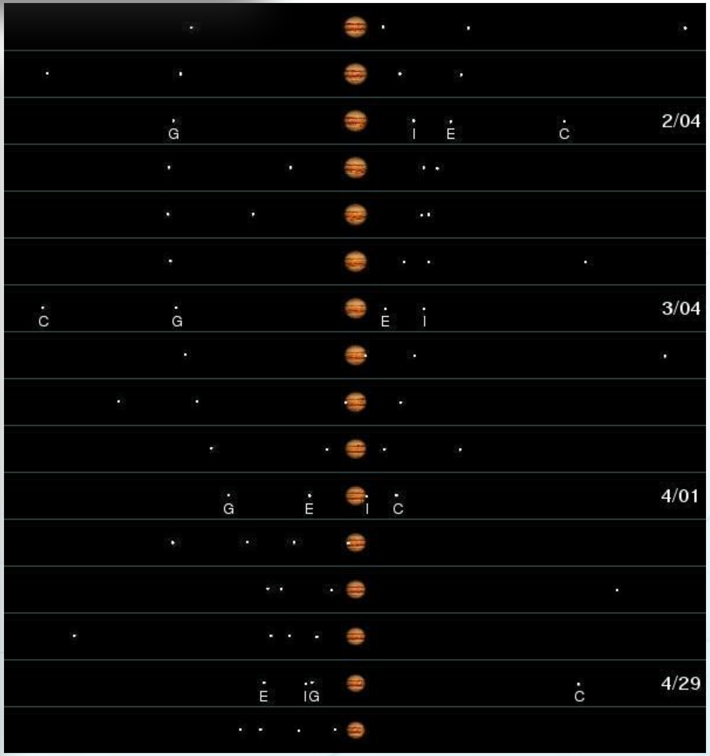


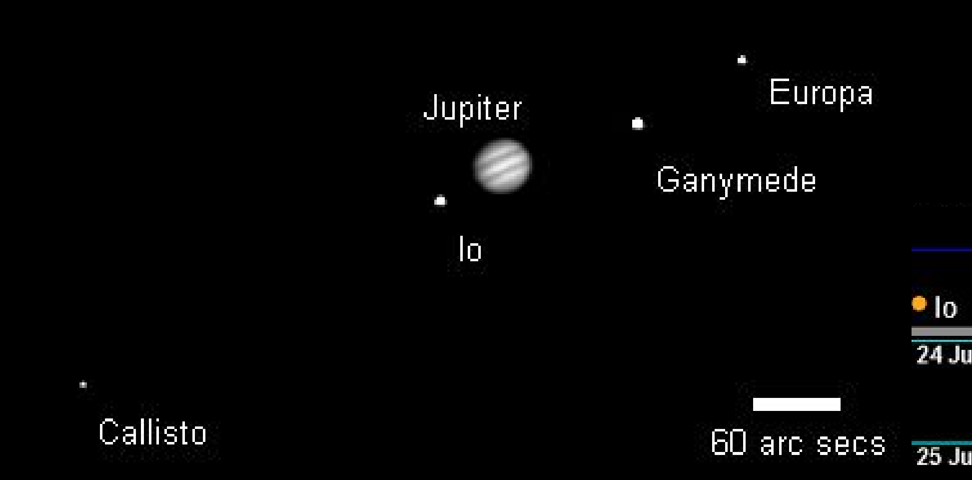
Sun at the Center

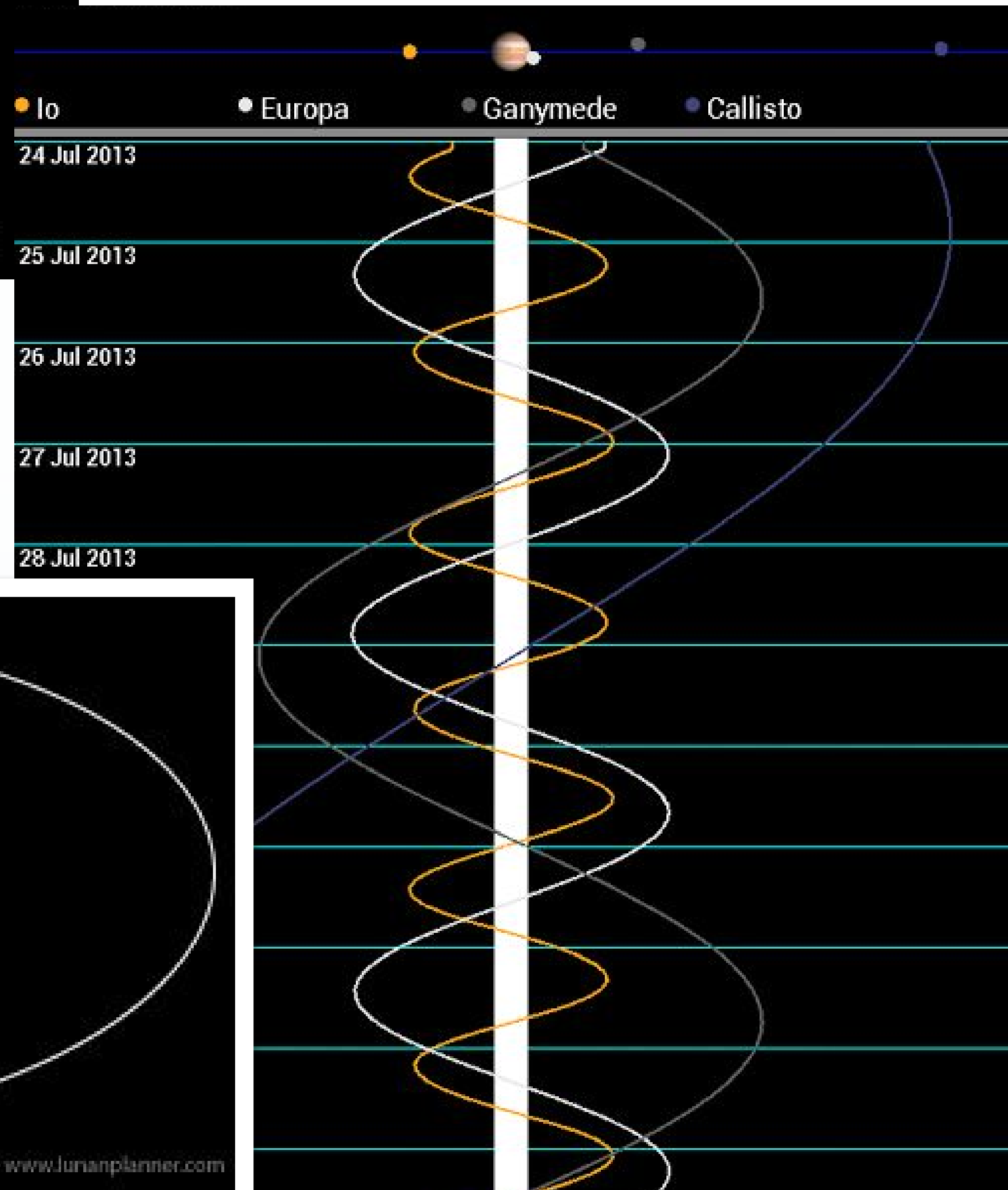
Observations: What do we see?








Jupiter
Europa
Ganymede
Io
Callisto
60 arc secs


Io
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24 Jul 2013
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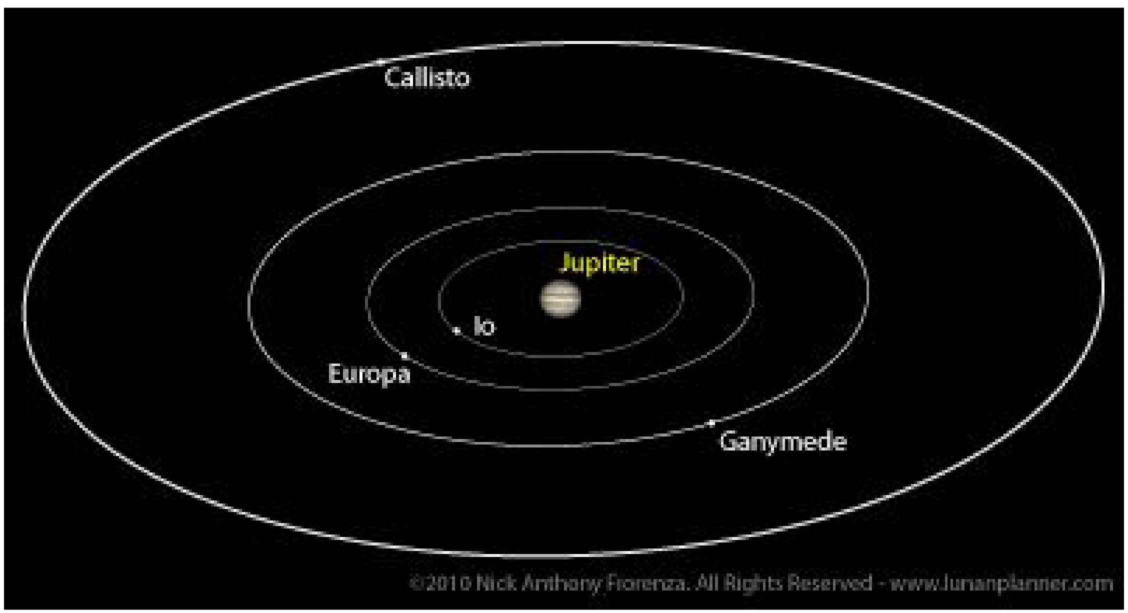
Callisto
Jupiter
Io
Europa
Ganymede
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WHAT makes planets orbit around the SUN?

* **Kinematics**
  * Mathematical description of **motion** of bodies (objects) and systems (groups of objects)

    = **HOW** it moves
* **Dynamics**
  * What is causing such motion?

    = **WHY** it moves

Describing motion

* Where the object is at a certain moment

  → **Position** ($\vec{x}$ in 1-dimensional motion)

* How fast the object is moving, in which way

  → **Velocity** ($\vec{v} = \Delta\vec{x}/\Delta t$)

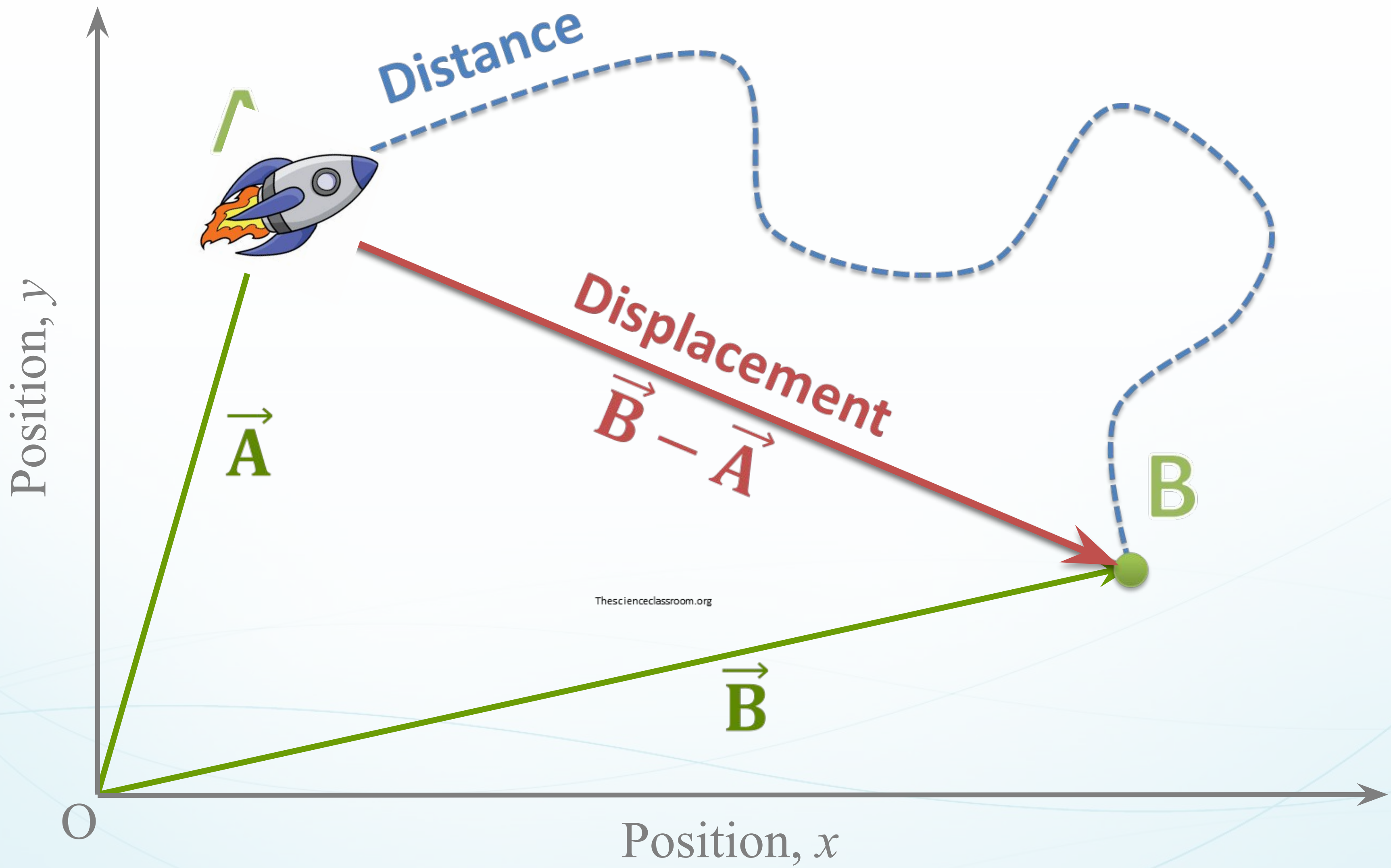
* How the object's speed and direction change in time

  → **Acceleration** ($\vec{a} = \Delta\vec{v}/\Delta t$)

Terms for describing motion

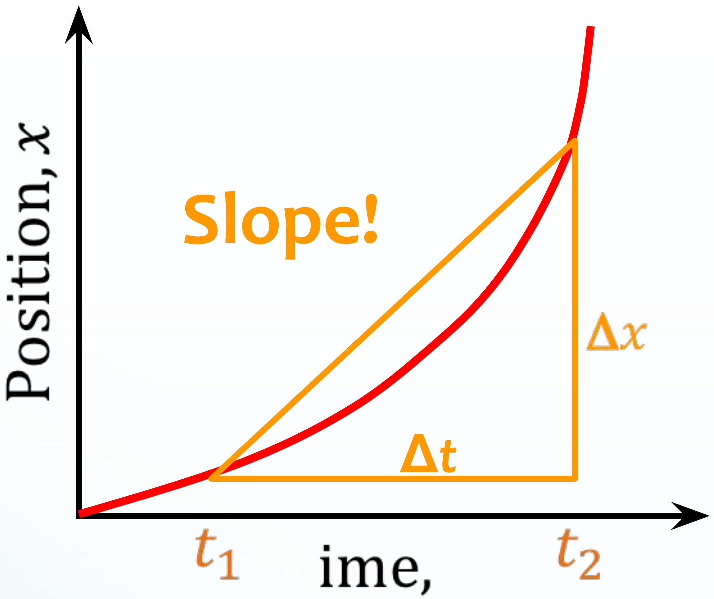
Quantity	Definition	Vector/ Scalar	SI Unit
Position ($\vec{x}$)	The vector from a reference point (origin) to the location of the object.	**Vector**	m
Distance	Length of path travelled by the object	Scalar	m
Displacement ($\Delta\vec{x}$)	Change in position [$\Delta\vec{x} = \vec{x}_f - \vec{x}_i$] (vector from the initial to the final position)	**Vector**	m
Speed (v)	*Distance* traveled per unit time	Scalar	m/s
Velocity ($\vec{v}$)	Change in position vector per unit time [= dx/dt]	**Vector**	m/s
Acceleration ($\vec{a}$)	Change in velocity per unit time [=d$\vec{v}$/dt]	**Vector**	m/s^2

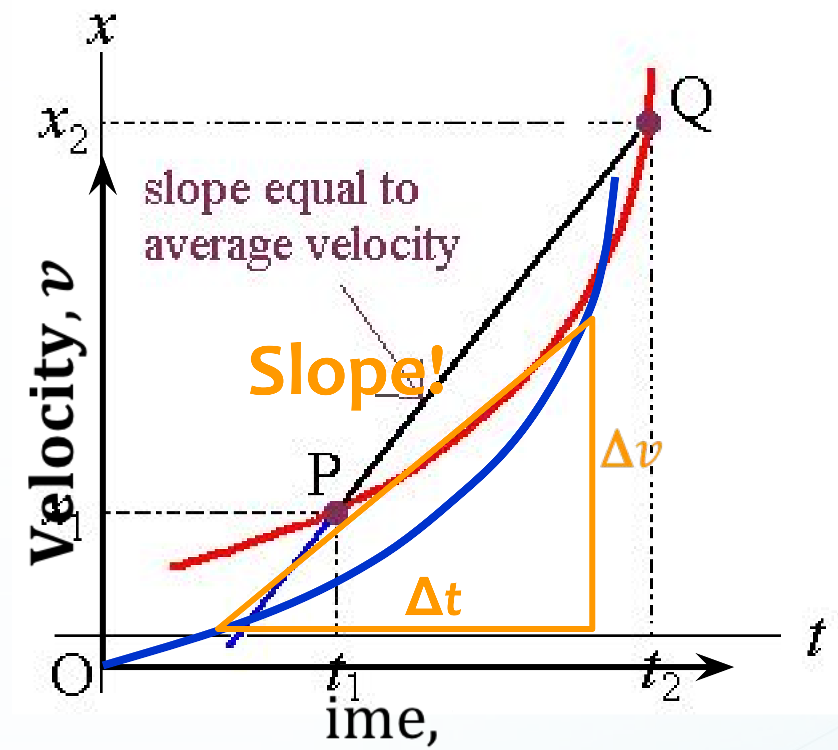
Distance vs. Displacement



What Δ*t*?

Velocity ($\vec{v} = \Delta\vec{x}/\Delta t$)





"Instantaneous" velocity

$$\mathbf{v}_{\text{ave}} = \frac{\Delta \mathbf{x}}{\Delta t}$$

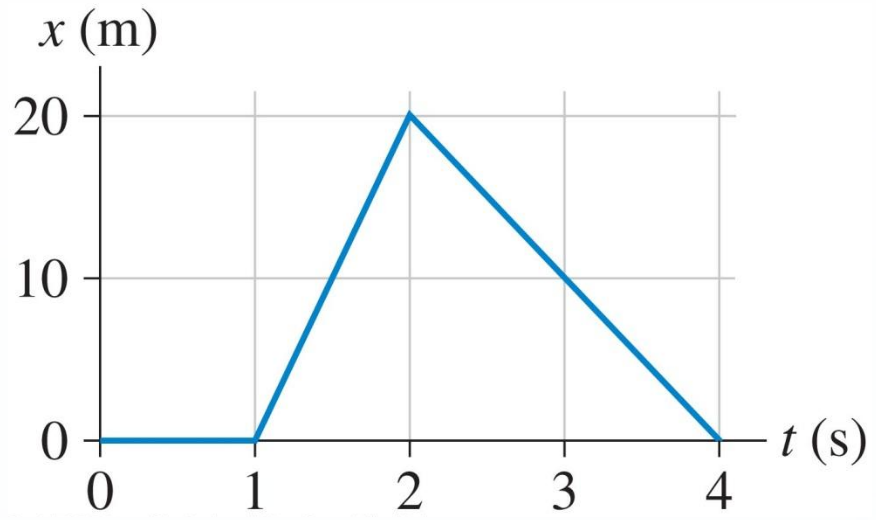
$$\mathbf{v}_{\text{inst}} = \lim_{\Delta t \to 0} \frac{\Delta \mathbf{x}}{\Delta t} = \frac{d\mathbf{x}}{dt}$$

$$\mathbf{a}_{\text{ave}} = \frac{\Delta \mathbf{v}}{\Delta t}$$

$$\mathbf{a}_{\text{inst}} = \lim_{\Delta t \to 0} \frac{\Delta \mathbf{v}}{\Delta t} = \frac{d\mathbf{v}}{dt}$$

QuickCheck 2.6

Here is a position graph of an object:



At t = 1.5 s, the object’s velocity is

A. 40 m/s.
B. 20 m/s.
C. 10 m/s.
D. –10 m/s.
E. None of the above.

How about the velocity at t = 3 s?

Describing motion

$$\mathbf{v}(t) = \frac{d\mathbf{x}(t)}{dt} \quad \rightarrow \quad \mathbf{x}(t) = \int \mathbf{v}(t)dt$$

$$\mathbf{a}(t) = \frac{d\mathbf{v}(t)}{dt} \quad \rightarrow \quad \mathbf{v}(t) = \int \mathbf{a}(t)dt$$

* If we know:

a(*t*) **OR** ***v***(*t*) **OR** ***x***(*t*)

AND

The initial conditions of the motion ***x***(0), ***v***(0), ***a***(0),

WE KNOW EVERYTHING!

EXAMPLE

Integration constant

$$a(t) = 3t^2$$

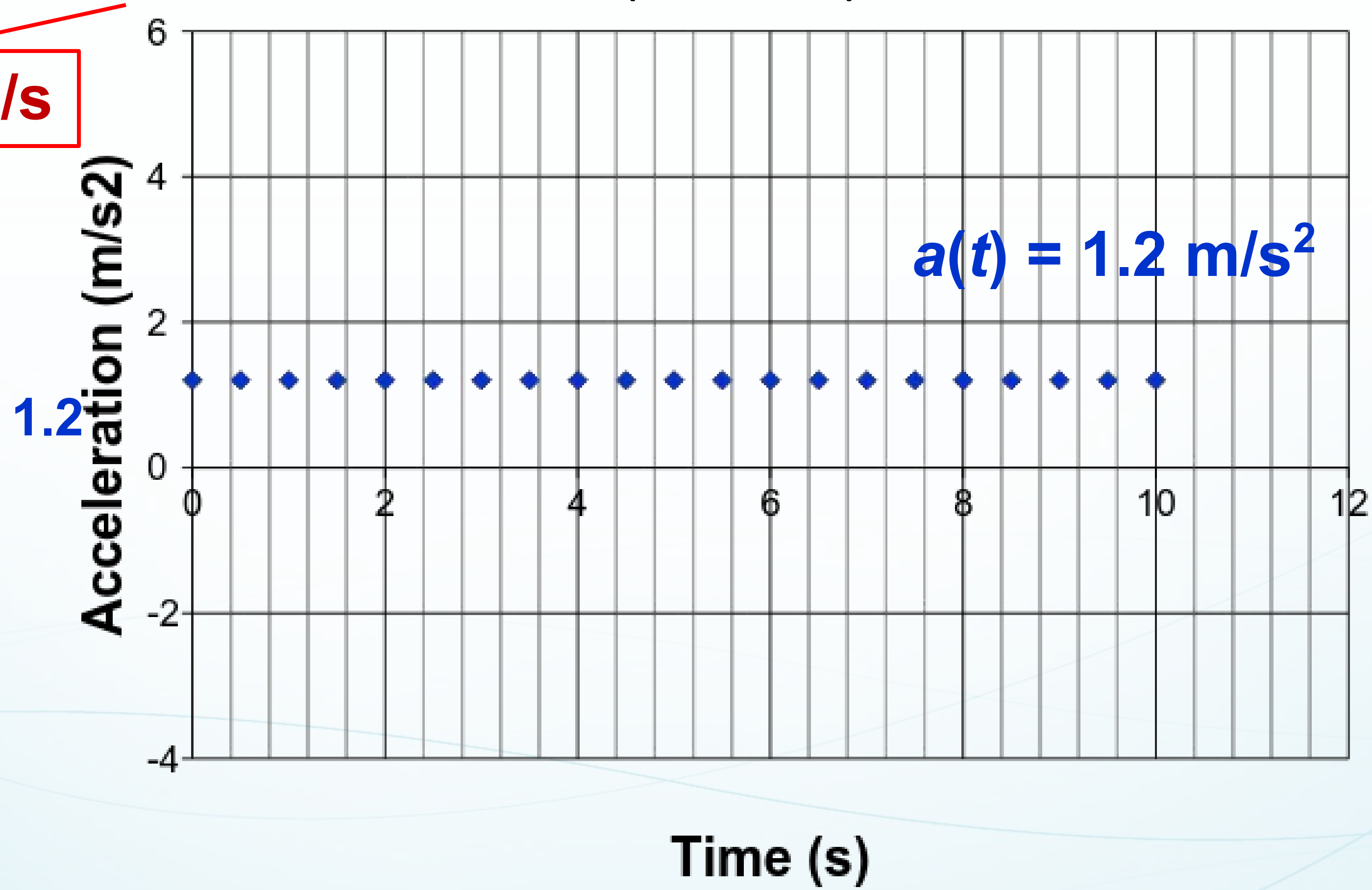
$$v(t) = \int 3t^2 dt = t^3 + C$$

$$v(0) = C = v_0$$ = Velocity at t = 0 (initial condition!)

Motion of an Astronaut with a Jetpack

To get back to the ISS, an astronaut accelerates to 12 m/s (43.2 km/h) in 10 s *from rest* with a constant (uniform) acceleration.

v_i = 0 m/s



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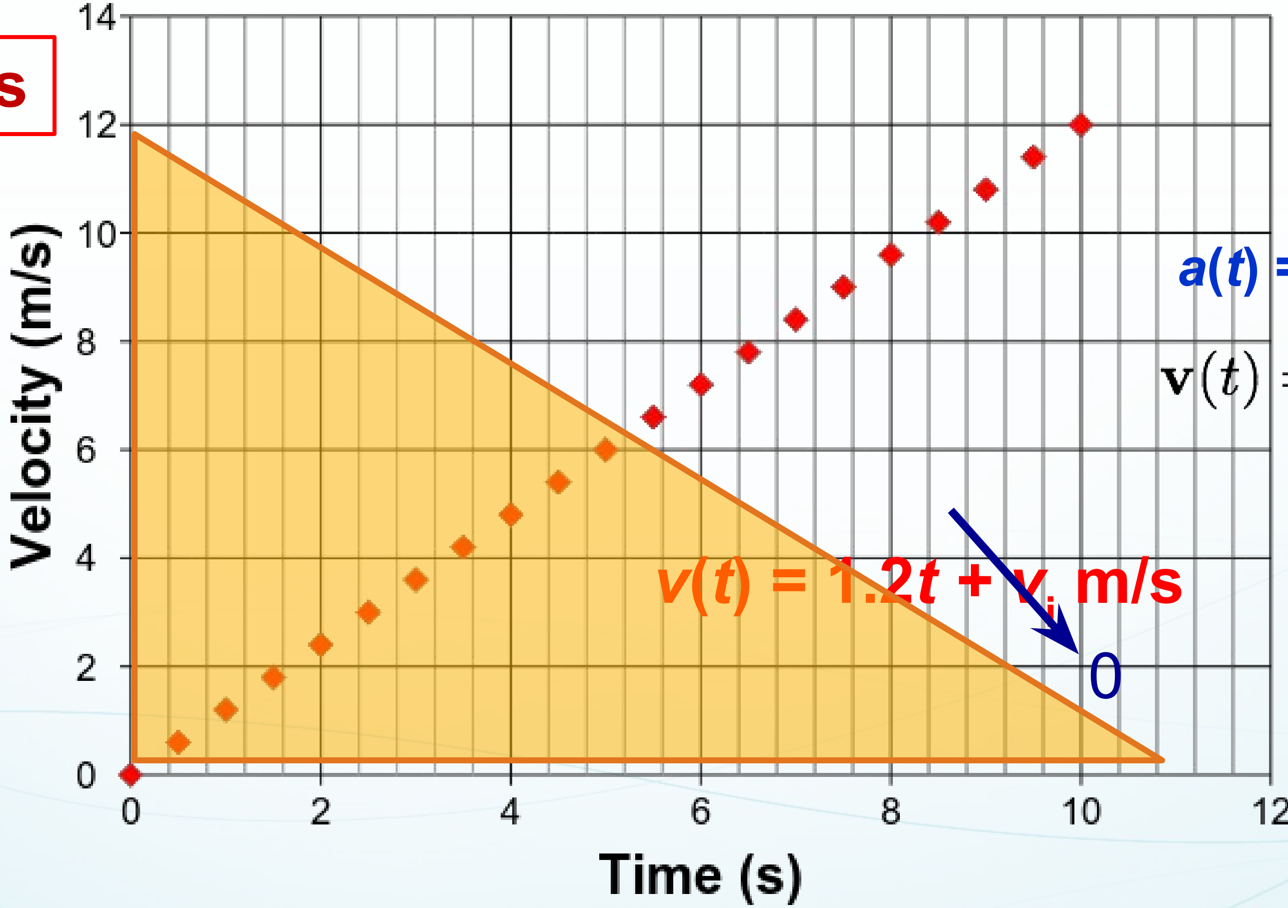
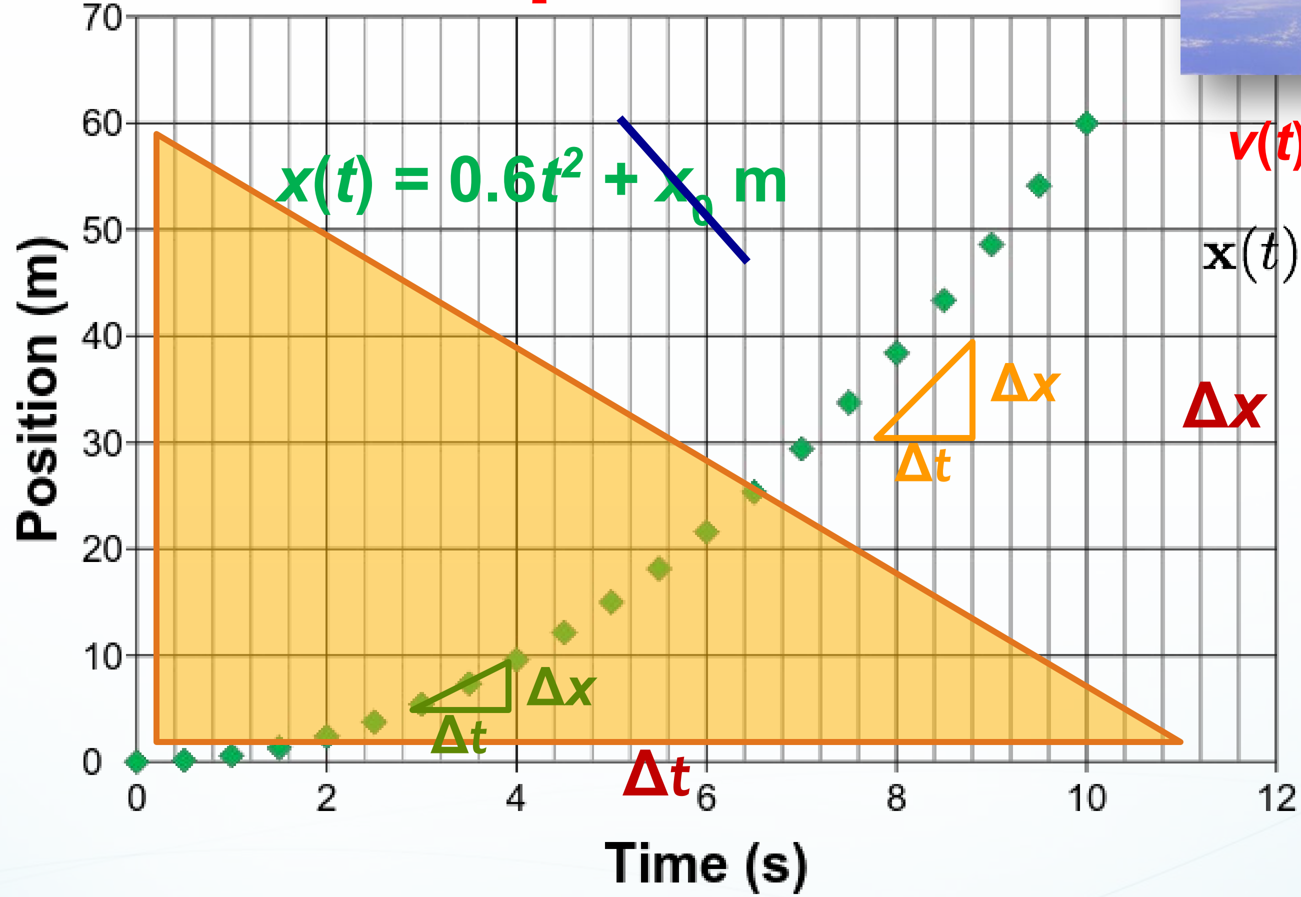


$a(t) = 1.2$ m/s^2

$$\mathbf{v}(t) = \int \mathbf{a}(t)dt$$

Motion of an Astronaut with a Jetpack



$v(t) = 1.2t$ m/s

$$\mathbf{x}(t) = \int \mathbf{v}(t)dt$$

Total Distance? $x(10) - x(0) = 0.6 \text{ m/s}^2 (10^2 \text{ s}^2) = 60$ m = area under V(t)

Average speed? $v_{avg} = \Delta x/\Delta t = 60$ m / 10 s = 6 m/s ≈ 22 km/hr

Speed at 3 s? $v(t) = dx/dt = 1.2t \rightarrow V(3) = 3.6$ m/s ≈ 13 km/hr

Math a bit rusty?

REVIEW

Derivative:

http://hyperphysics.phy-astr.gsu.edu/hbase/deriv.html#c1

For polynomial functions: $f(t) = Ct^n$

$df/dt = C\,nt^{n-1}$

Integral:

http://hyperphysics.phy-astr.gsu.edu/hbase/intdef.html#c2

See demonstration and further discussions
in Chapters 5 & 6 in "Science of Nature I" by M.A. Alpar
(PDF available on SUCourse)