Life in our Universe: How did it come about?

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Popular Science Talks,

NCL-IISER Pune,

July 14th, 2013

Our Universe

Cosmology
The astrophysical study of the history, structure, and dynamics of the universe.

Universe
Everything that exists, including the Earth, planets, stars, galaxies, and all that they contain; the entire cosmos.

Galaxy
A component of our universe made up of gas and a large number (usually more than a million) of stars held together by gravity.

Mankind's deepest-ever view of the universe

http://www.nasa.gov/images/content/690958main_p1237a1.jpg

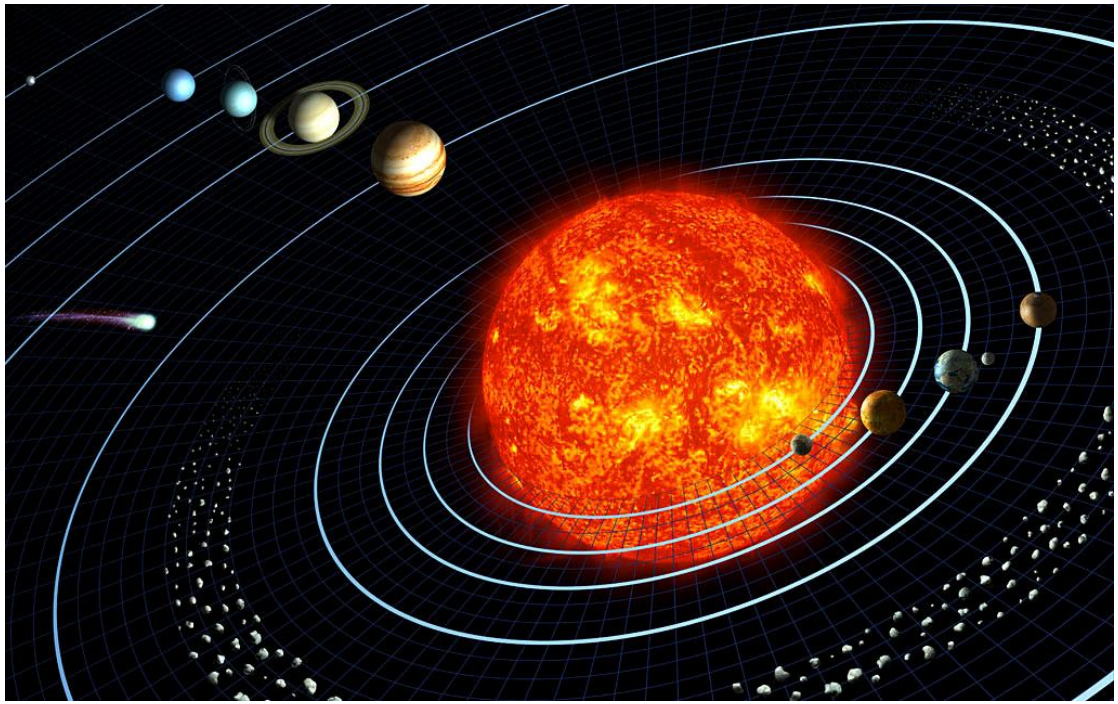
The Andromeda galaxy

Robert Gendler/NASA

http://imagine.gsfc.nasa.gov/docs/dictionary.html#S, http://starchild.gsfc.nasa.gov/docs/StarChild/solar_system_level1/planets.html#

Star

A large ball of gas that creates and emits its own radiation.



Star forming pillars in the Eagle Nebula, as seen by the Hubble Space Telescope

Check below videos:

1. **Birth of the Universe**
2. **2. Introduction to our solar system**

Planet

A planet is a large space object which revolves around a star. It also reflects that star's light. Eight planets have been discovered in our solar system. Mercury, Venus, Earth, and Mars are the planets closest to the Sun. They are called the inner planets. The inner planets are made up mostly of rock. The outer planets are Jupiter, Saturn, Uranus, and Neptune. Jupiter, Saturn, Uranus, and Neptune are large balls of gases with rings around them. All eight planets travel around the Sun in a different orbit.

A TIMELINE of **LIFE'S EVOLUTION**

Drag the red marker to learn about important events in the history of life on Earth

4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0

BILLIONS of YEARS AGO

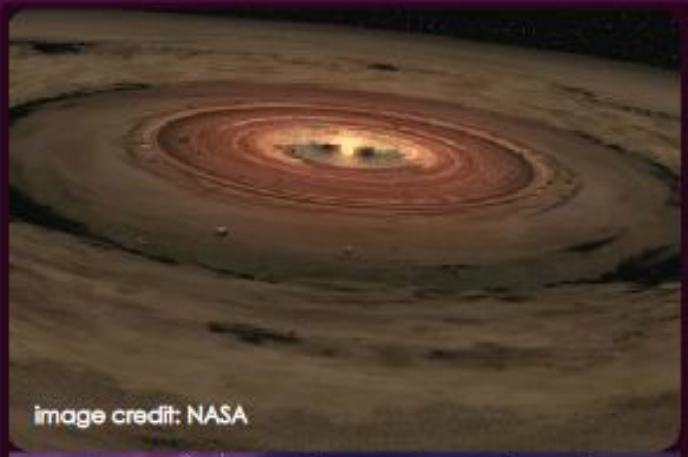


image credit: NASA

FORMATION OF THE SOLAR SYSTEM

circa 4.57 billion years ago

Our Solar System is thought to have formed from a giant rotating cloud of gas and dust, known as a protoplanetary disc. The Sun formed at the center of the disc, and the planets gradually formed around the Sun in a process known as accretion. The image on the left shows an artist's version of an accretion disc.

image credit: Joe Tucciarone

FORMATION OF THE MOON

circa 4.53 billion years ago

According to the "Giant Impact" hypothesis, the Moon formed as a result of a collision between Earth and a Mars-sized body called Theia. The impact caused a portion of the combined mantle of Earth and Theia to be expelled into space, eventually forming the Moon.

http://exploringorigins.org/timeline.html

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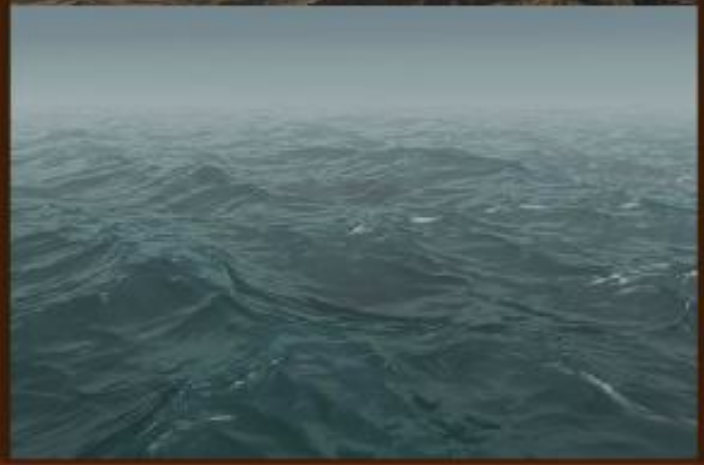
BILLIONS of YEARS AGO

LATE HEAVY BOMBARDMENT

circa 4.1 - 3.8 billion years ago

Based on observations of impact craters on the Moon, many astronomers believe that the Earth endured a violent period of near-constant collisions with large asteroids and comets.

Could early forms of life have survived the Late Heavy Bombardment, or was it only after this tumultuous time that the first cells formed?



FORMATION OF THE EARTH'S CRUST & OCEANS

circa 4 billion years ago?

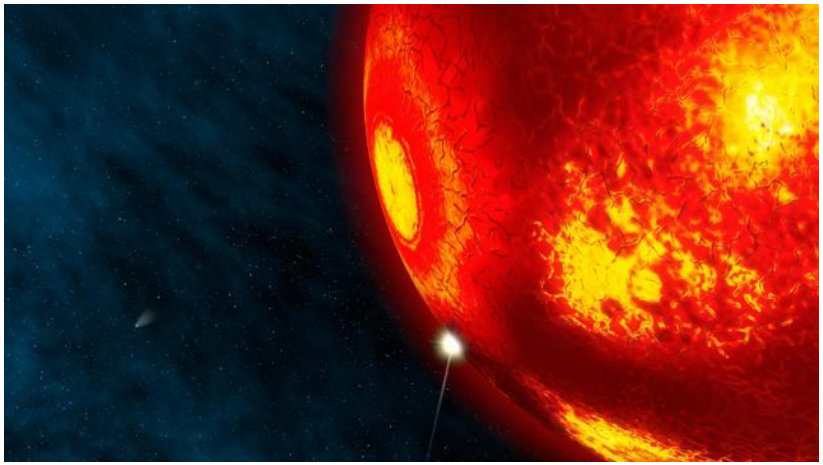
The cooling of the Earth allowed for crust formation and the condensation of water present in the atmosphere, forming the Earth's oceans.

The atmospheric composition of the early Earth and the timing of crust and ocean formation have been topics of controversy within the scientific community. Resolving these questions is crucial to understanding the early steps in life's evolution.

http://exploringorigins.org/timeline.html

Our Planet - Earth

3.8 - 4.1 billion years ago (4000000000 years)!!!



Artwork showing the early Earth by Walter Myers/SPL

Illustration by Peter Sawyer © Smithsonian Institution

Today

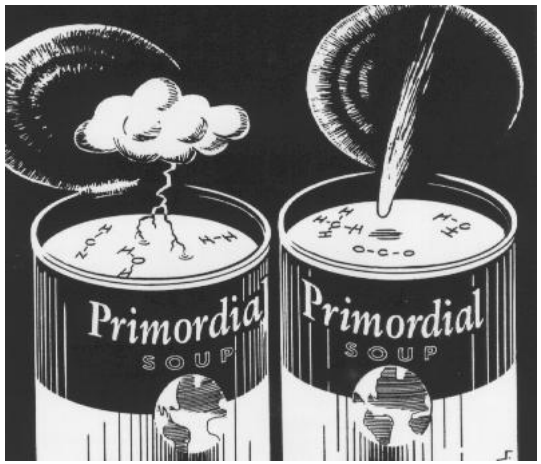
http://eoimages.gsfc.nasa.gov/images/imagerecords/57000/57723/globe_east_2048.jpg

Oparin-Haldane Theory

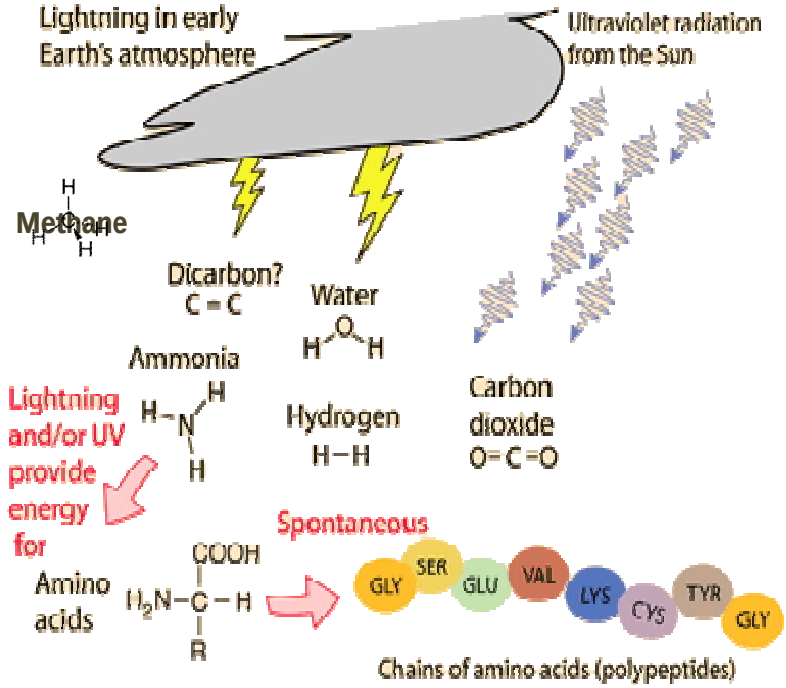
The ideas of these two men were simple, elegant, and almost identical!

Basic hypothesis: Early Earth's atmosphere was reducing. This means that the atmosphere had an excess of negative charge and could cause reducing reactions by adding electrons to compounds. Under these conditions, organic molecules could have formed from simple inorganic molecules.

"Primordial Soup": Haldane proposed that the primordial sea served as a vast chemical laboratory powered by solar energy where the atmosphere was oxygen free. The host of organic compounds formed under these conditions became a 'hot dilute soup' containing large populations of organic monomers and polymers.

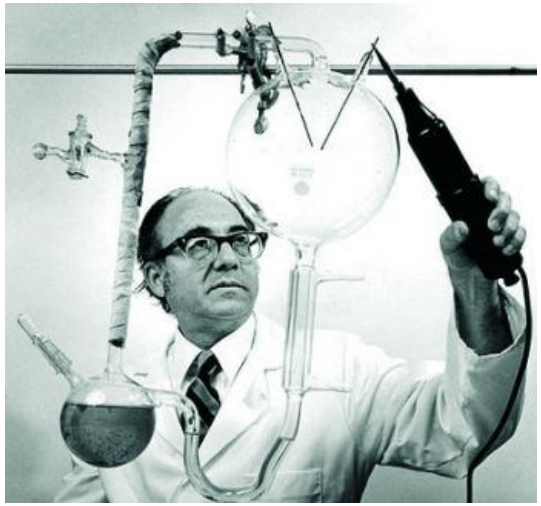


http://www.cbs.dtu.dk/staff/dave/roanoke/primsoup.jpg



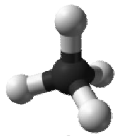
http://hyperphysics.phy-astr.gsu.edu/nave-html/faithpathh/lifelab.html

The Miller-Urey Experiment (1953)



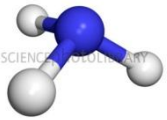
Movie-1

Movie-2

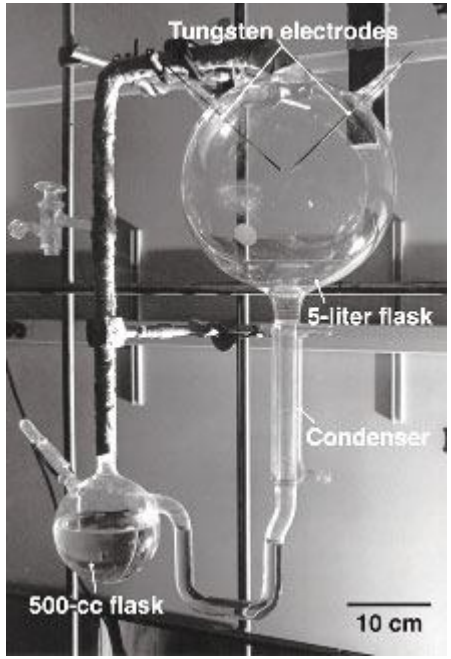


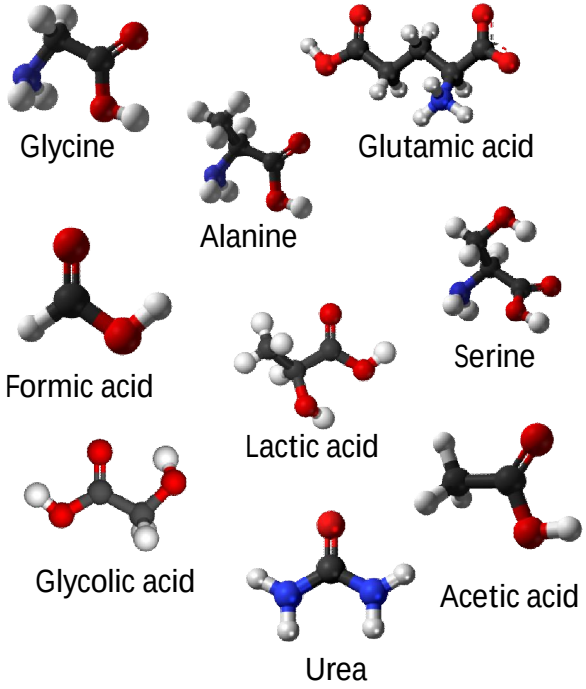
Methane

Water

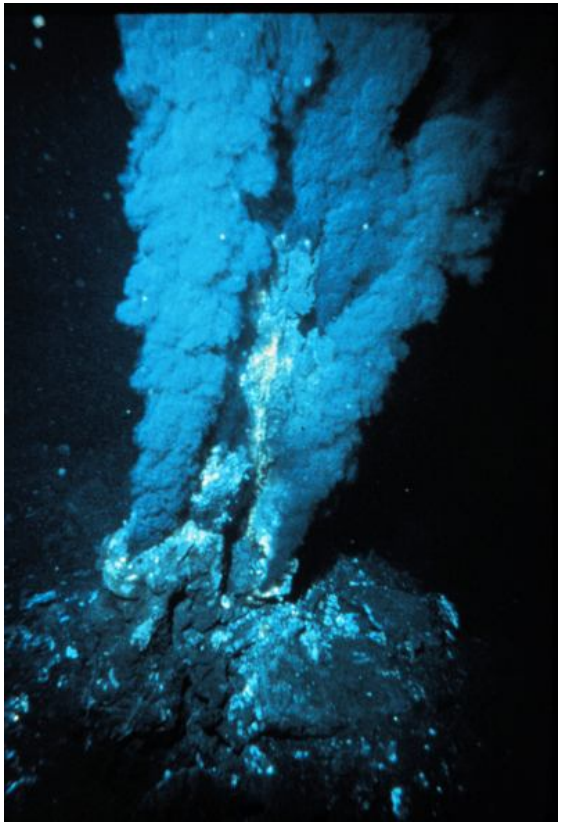


Ammonia





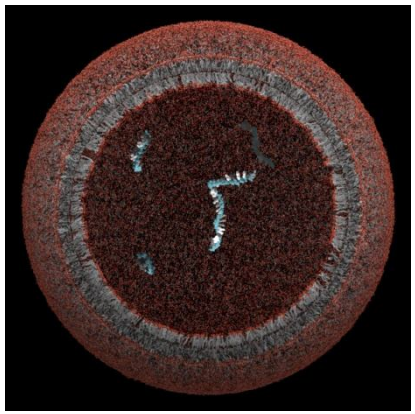
Environments that would have supported life-producing chemical reactions



http://www.photolib.noaa.gov/htmls/nur04506.htm

David Deamer, Bumpass Hell, Mount Lassen, CA, USA

What might have the earliest possible life forms looked like?



Protocells: Lipid membranes encapsulating RNA that can grow, replicate and evolve
http://molbio.mgh.harvard.edu/szostakweb/exploringOriginsDownloads/protocell.jpg

LUCA (Last Universal Common Ancestor)

***Gloeocapsa* (Cyanobacteria)**
© 2007 John Giezentanner

Don't forget to visit the following site: http://exploringorigins.org/index.html
The team behind the above site state: "the goal of this project is to use molecular illustration and animation to help describe origins of life research and theories to broad audiences."

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BILLIONS of YEARS AGO

image credit: Paul Harrison

image credit: Virtual Fossil Museum

OLDEST GEOLOGICAL EVIDENCE OF LIFE

circa 3.5 billion years ago

The pillow-like rock formations shown in the image on the left, called stromatolites, are formed as a byproduct of microbial life. During the formation of stromatolites, sheets of microbes, such as cyanobacteria, capture sedimentary particles. Successive layers of microbes and sediment result in the striated pattern of growth as seen in the lower image on the left.

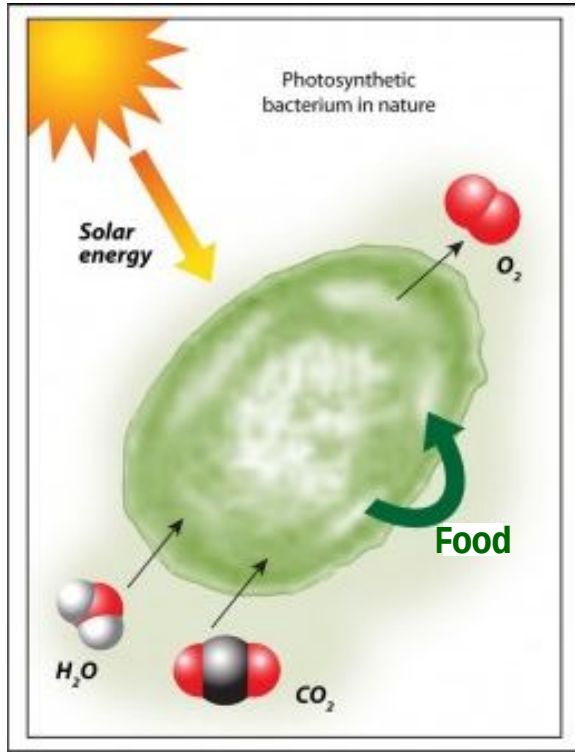
Recent studies on stromatolite samples suggest that microbes may have existed on Earth as early as 3.5 billion years ago. Additional stromatolite samples that have clear evidence of microbial life have been dated to 2.7 billion years ago.

From this evidence, it appears that life evolved within a short billion years after Earth's formation.

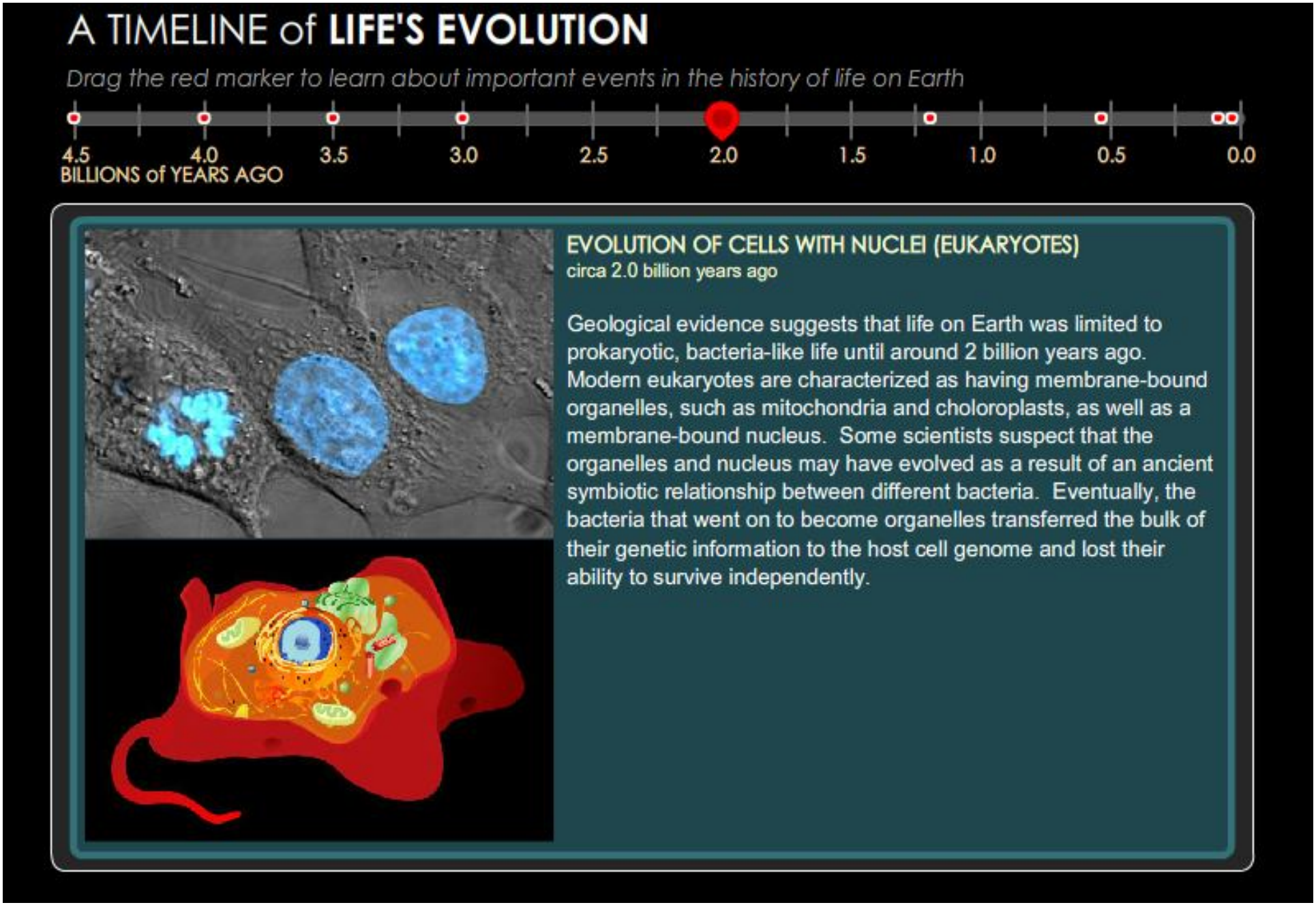
http://exploringorigins.org/timeline.html

Oxygenation of the earth's atmosphere – How did bacteria do it?

http://www.cambridgecarbonates.com/downloads/small2/large2/StromatolitesWeb.jpg



Adapted from http://bioenergy.asu.edu/faculty/jones/research.html



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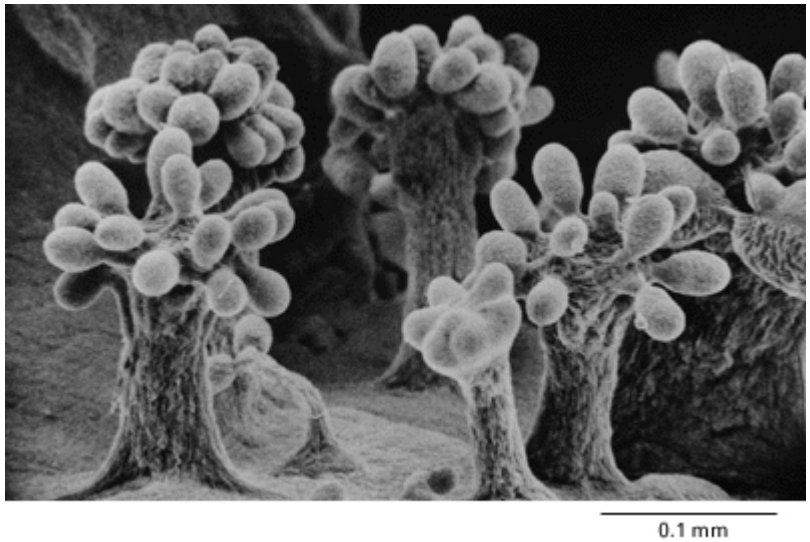
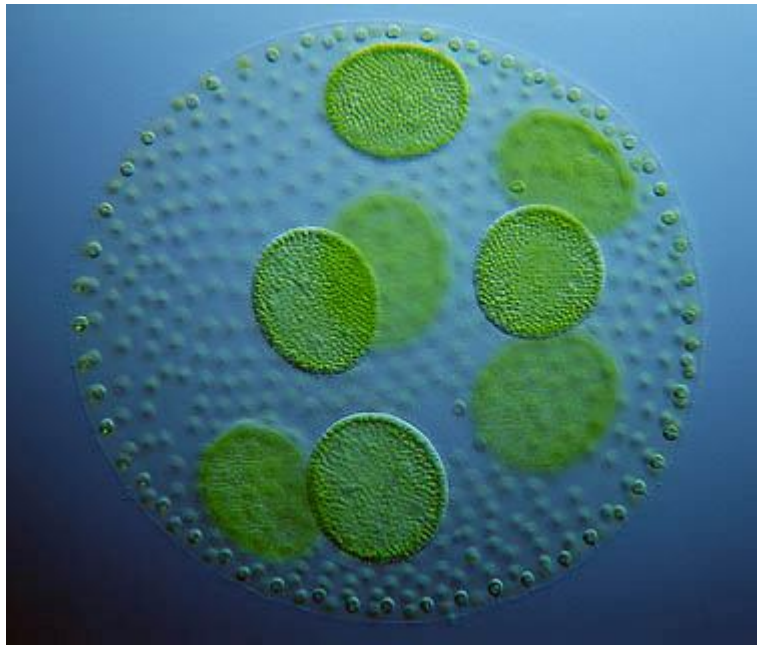
Evolution of multicellular organisms (1.2 billion years ago)

Fruiting bodies formed by a myxobacterium



P.L. Grilione and J. Pangborn, *J. Bacteriol.* 124:1558-1565, 1975.)

Volvox



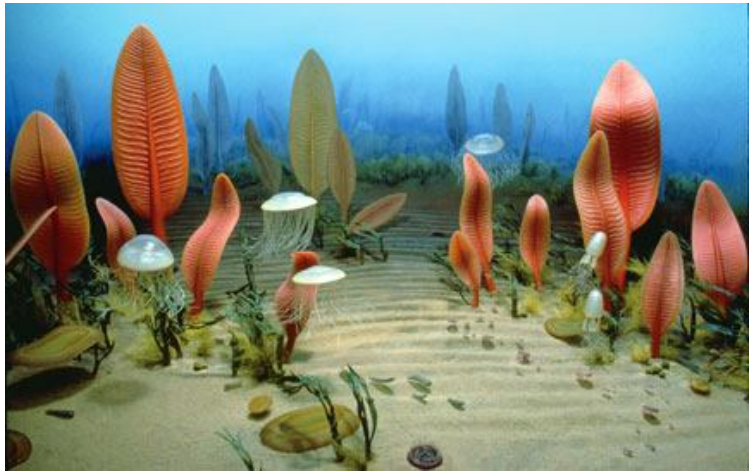
http://25.media.tumblr.com/tumblr_ltdt7pJauT1r3ajgyo2_400.jpg

The Ediacaran Period (~540 million years ago) was populated by some of the very first multi-cellular organisms.

http://www.bbc.co.uk/nature/history_of_the_earth/Ediacaran

Cambrian Explosion!

A menagerie of strange creatures emerged during the Cambrian explosion.



National Museum of Natural History, courtesy of the Smithsonian Institution

http://www.astrobio.net/albums/origins/agb.jpg, D.W. Miller

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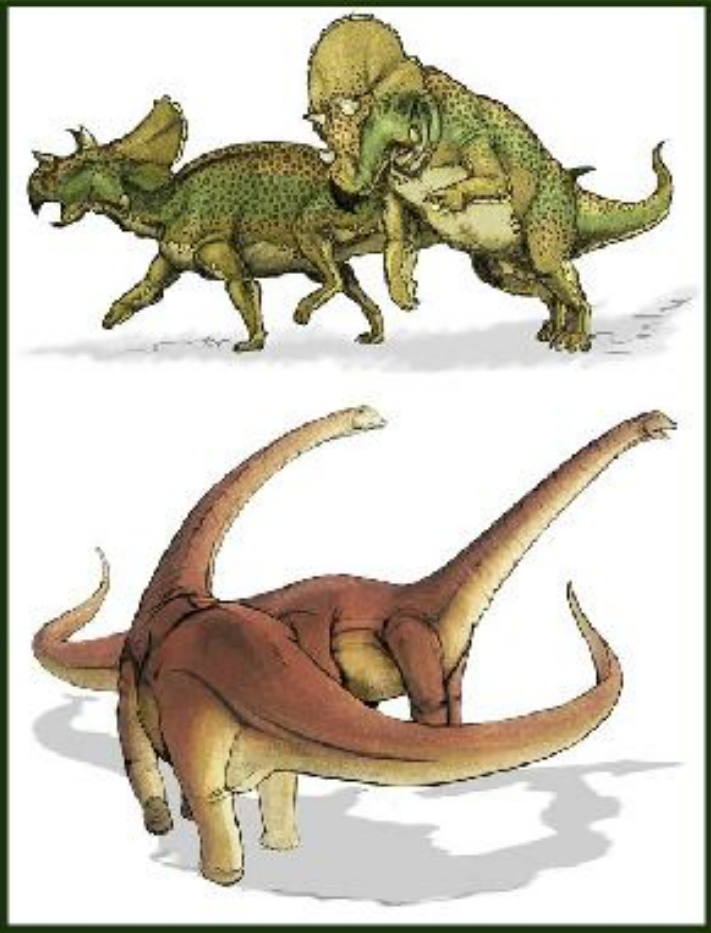


REIGN OF THE DINOSAURS

circa 230 - 65 million years ago

For over 150 million years, dinosaurs populated the Earth, eventually reaching every continent on the planet. Their sudden mass extinction, known as the Cretaceous-Tertiary Extinction Event, is thought to have been caused by a large asteroid impact or an increase in volcanic activity.

http://exploringorigins.org/timeline.html

Cretaceous-Tertiary mass extinction

+ Intense volcanic activity

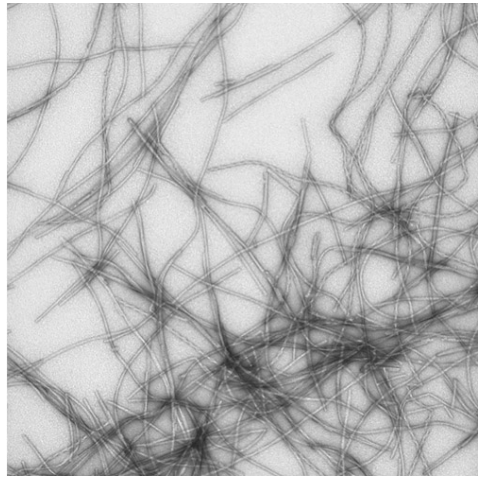
http://exploringorigins.org/timeline.html

What lead me to become a researcher and a teacher?

Answer: Plain curiosity....

To know how and why things are the way they are....

→ Fig 1: Sickle cell hemoglobin containing RBCs http://www.sicklecellinfo.net/images/understanding/sickles.jpg



→ Fig 2: Image of α-synuclein fibrils, a protein implicated in Parkinson's disease http://www.scripps.edu/kelly/photos/fig05.jpg

- My PhD work was on sickle-cell hemoglobin that causes sickle cell anaemia. To learn more about the disease please click here: http://www.nhlbi.nih.gov/health/health-topics/topics/sca/

- My first postdoctoral work was on understanding how and why Parkinson's disease happens. Click here for more info: http://www.ninds.nih.gov/disorders/parkinsons_disease/parkinsons_disease.htm

- In my current lab, we are trying to understand how the first biomolecules of life came about. This is important as it would have been a fundamental and crucial step in setting the stage for origin of life on Earth.