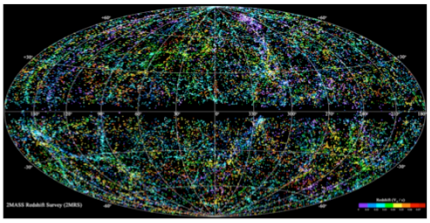


History of Universe, the Sun and Earth

Dennis Baldocchi

ESPM 2

Fall 2017

This lecture covers the origins of the Universe, Sun and our planet, giving us the foundation upon which the biosphere is based, including its elements, source of energy and environmental conditions.

https://www.cfa.harvard.edu/sites/www.cfa.harvard.edu/files/images/pr/2011-16/1/hires.jpg

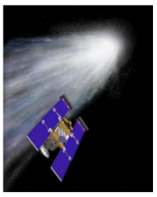
Interesting readings

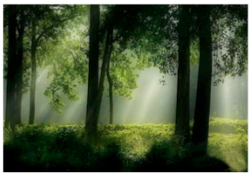
https://www.bighistoryproject.com/chapters/1#
http://www2.glos.ac.uk/gdn/origins/earth/earth.pdf

Outline

- Origins Theory/Creation Myth
- Big Bang
- Star and Galaxy Formation
- Formation of the Sun and Solar System
  - Formation of Elements of the Periodic Table
- Formation Earth
- Early Earth History

https://www.bighistoryproject.com/chapters/1#; http://www2.glos.ac.uk/gdn/origins/earth/earth.pdf





'Our bodies are stardust;
Our lives are sunlight'

Oliver Morton, 2008 Eating the Sun: How Plants Power the Planet

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I grew up hearing 'bread is the staff of life'.. But in reality is it sunlight. The world about us would not function as well as it does without the capture of sunlight and its conversion to chemical energy by plants. Eating the Sun is a Wonderful book describing the connections of sun, energy and life. If you have time to read for pleasure and curiosity sake I recommend this book for all biospherians.

Origin Theories/Creation Myths

- Ancient Greeks/Romans
  - Out of **Chaos** formed the Cosmos, and sprang, Mother Earth, Gaia, or Terra
- Judeo-Christianity, '**creatio ex nihilo**'
  - 'And God said, Let there be light: and there was light', Genesis, 1.3
- Other recurrent themes
  - World Parent, Earth Diver, Emergence

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http://www.physicsoftheuniverse.com/cosmological.html

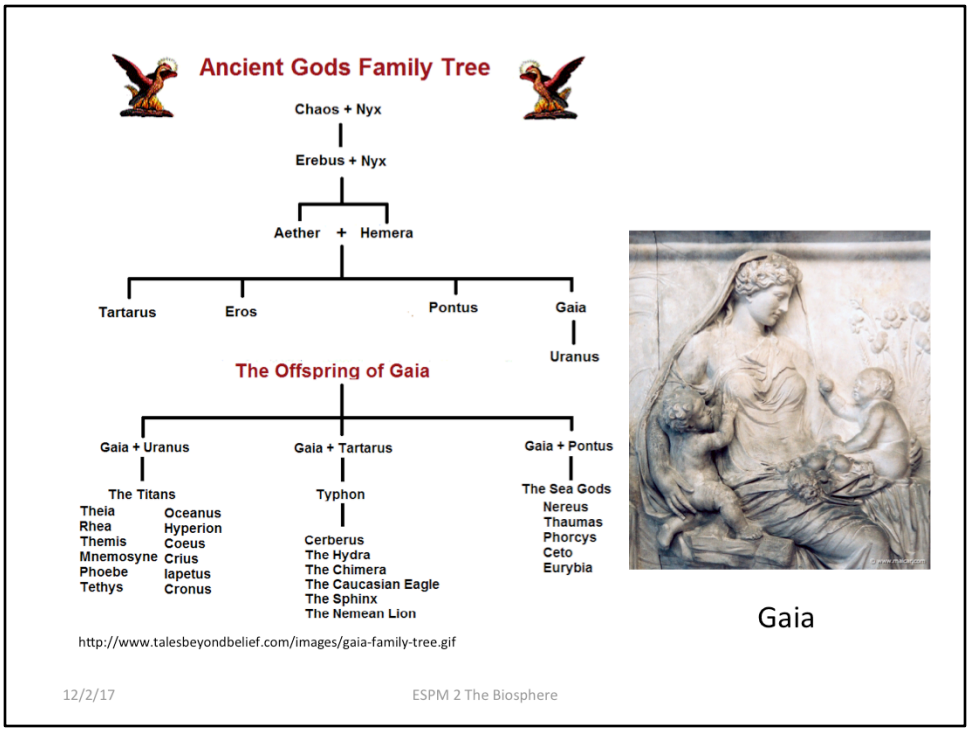
Mankind has been curious and crafted creation stories for millennia, across cultures. So creation theories and myths are common across many, if not most, cultures. Some actually have some grains of truth in our current scientific understanding of the birth of the Universe.

Earth diver, Supreme Being sends bird or amphibian to Earth. It dives into the primordial sea and brings up mud to form land.

World parent, Sky and Earth are joined; creation occurs when they are pulled apart

Emergence, mankind springs from the womb of Mother Earth

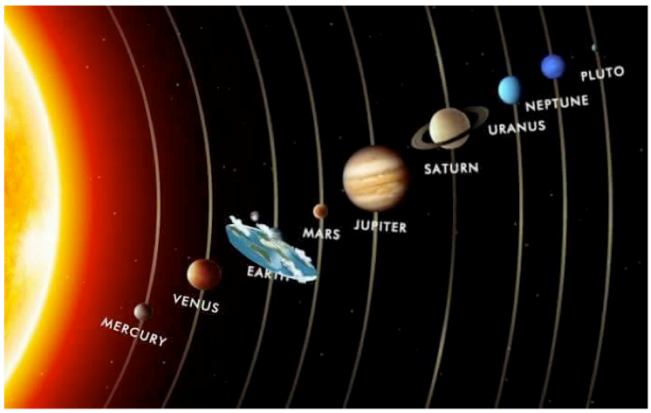
But also note that these myths have not withstood the test of time and have been falsified with scientific inquiry, methods, observations, theories and models. As you will see there is abundant scientific evidence supporting the concept of the Big Bang.



Gaia, mother Earth, was one of the offspring of Chaos. Gaia bore Uranus (sky). Note that Gaia, mother Earth was pre Olympian and mother of the Titans, who begat the Olympians. It is important to have some sense of Greek Cosmology as the Gaia Theory, we will discuss later derived its name from this family tree.

http://www.maicar.com/GML/000Images/gim/gaia8838detail.jpg

Sadly in this era of 'Fake News' there has been a resurgence of Flat Earth Theory



http://i0.kym-cdn.com/photos/images/original/001/205/102/61a.jpg

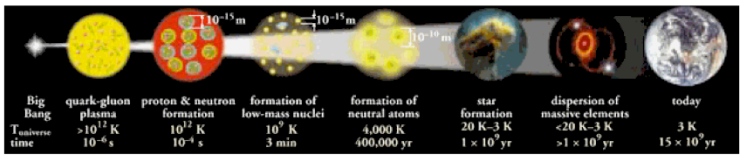
How it all Started:
The Big Bang

13.798 ± 0.037 billion years ago

The Universe is about 13.8 Billion (13.8 times 1,000,000,000 or 13.8 10^9) years old. It started with a Big Bang. We do not or cannot know the state of the Universe any farther back in time. All clocks start with the Big Bang.

The Big Bang to Now, in a Nutshell

Event	Time
Big Bang	0
Inflation	10^{-32} s
Quarks form	10^{-6} s
Protons and Neutrons forms	10^{-4} s
Low Mass Nucleii form	3 min
Hydrogen forms; limit to visible light	380,000 years
Stars form	1 billion years
Galaxies and Stars	> 1 billion
today	13.8 billion years



There are the highlights in the time line of the evolution of the Universe

http://www2.lbl.gov/abc/wallchart/chapters/10/graphics/Image1.gif

Edwin Hubble, Astronomer

Edwin Hubble (1889-1953) observed that distant galaxies are moving away from us faster than nearby galaxies; this is occurring in all directions.

This infers that long ago galaxies were closer together.

This infers that the Universe is expanding; velocity of galaxy moving from Earth is the product of its distance times a constant H

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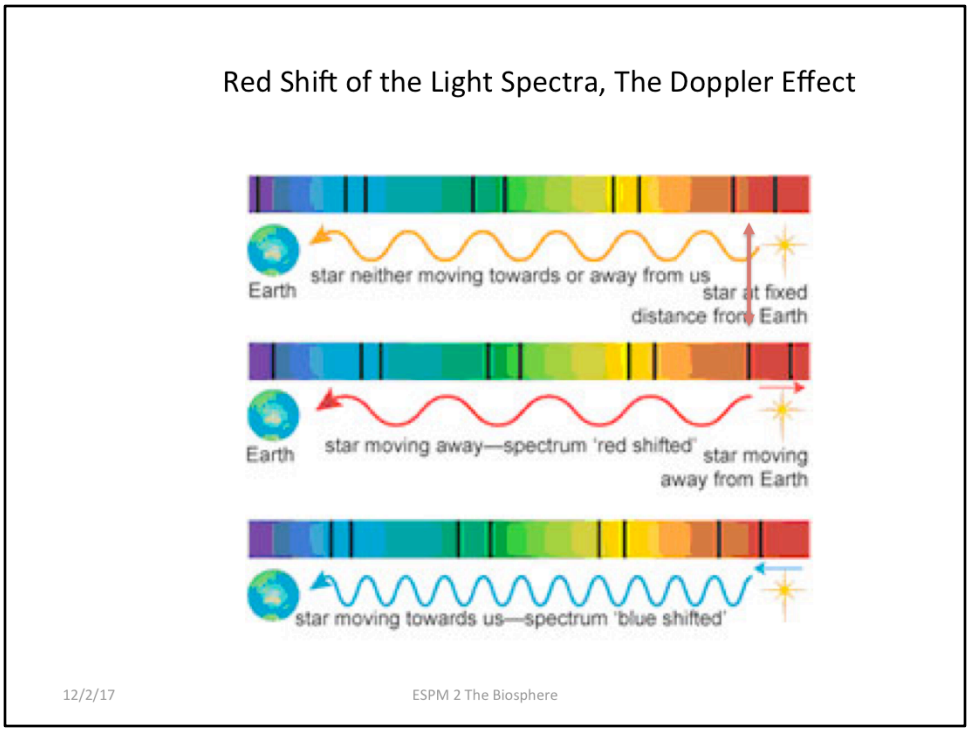
First evidence for the Big Bang, came from Hubble's observations; Worked with the Mount Wilson Telescope (2.5 m) near Pasadena and later the Mount Palomar' 5 m Hale telescope. Prior to 1919 astronomers thought the Milky Way Galaxy was the Universe.
He found that the greater the distance between any two galaxies, the greater their relative speed of separation, using red shift and standard candle stars.

Information by red shift helped provide evidence

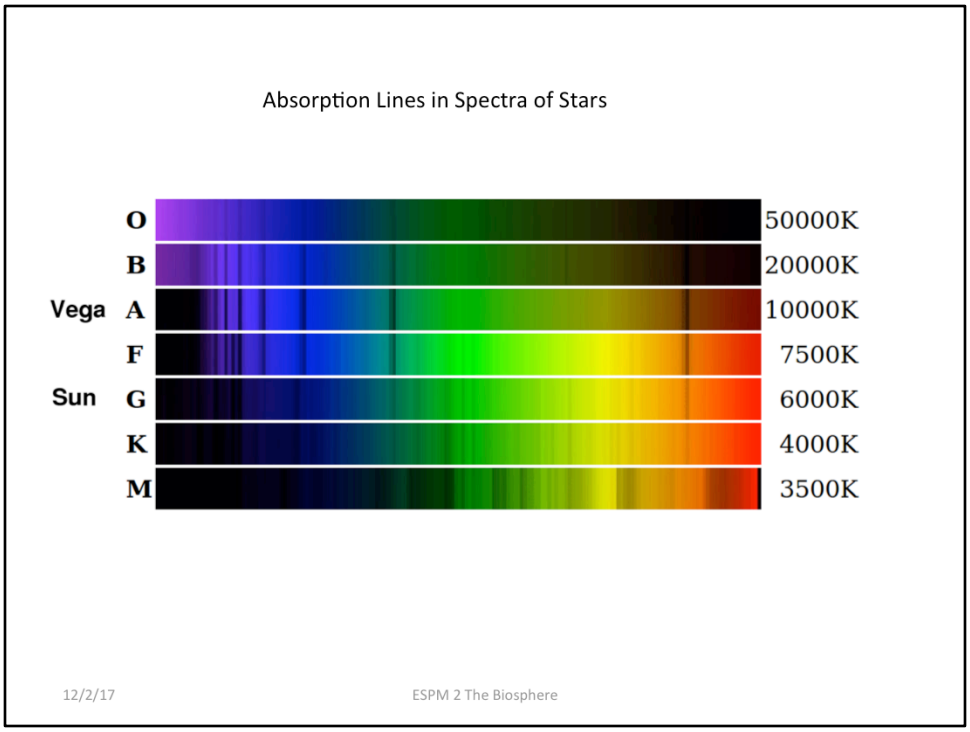


http://wps.pearsoned.com.au/wps/media/objects/8331/8531591/_images_/ch8b.jpg

Think of the change in pitch as a whistling train approaches then passes you. One can quantify the red shift by looking at the relative differences in the elemental absorption lines of light emanating from a distant star vs those associated with our sun. In the case above the second absorption band from the right of the middle color spectrum appears more red when observed on earth as that star is moving away from us.

According to spectroscopy, the color, or wavelength of light, from a star should have a known and well defined spectra given its temperature and the elements. It is the shift in the spectra of these well characterized spectral lines that help us detect the speed the star or galaxy is moving.

Example of marks on a balloon move apart as the balloon inflates.

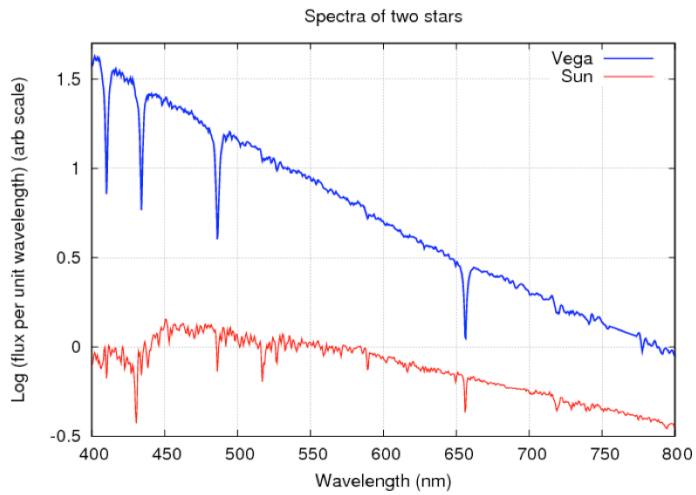


http://spiff.rit.edu/classes/phys301/lectures/spec_lines/rainbow_spec_label.png

Absorption lines from an element will appear if there are atoms of the element present the atoms are in a low-density gas the atoms spend most of their time in a particular low-energy level the gas lies between us and a source of contiunous light (of all wavelengths)

http://spiff.rit.edu/classes/phys301/lectures/spec_lines/spec_lines.html

Red Shift is 0.03 nm, implying Vega is moving away from us at 13.7 km/s



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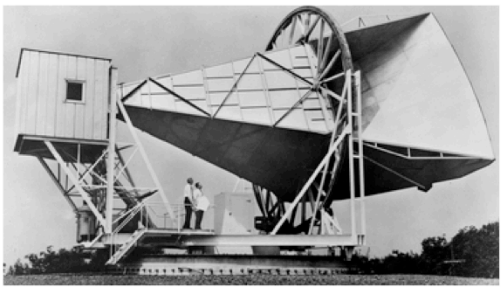
http://spiff.rit.edu/classes/phys301/lectures/spec_lines/comp_vega_sun.png

Mathematically speaking vrad/c = (λshift – λrest)/ λrest

Example: If observe Hα spectral line (normally at 656.285 nm) from the star Vega at 656.255 nm, then Vega is moving at: vrad/c = - 4.57 10-5 or 13.7 km/s away from us

https://www.ifa.hawaii.edu/users/shadia/lectures/habbal_astro110-01_spring2009_lecture15.pdf

Proof of the Big Bang



https://www.bighistoryproject.com/assets/images/chapter1/holmdel-horn-antenna.jpg

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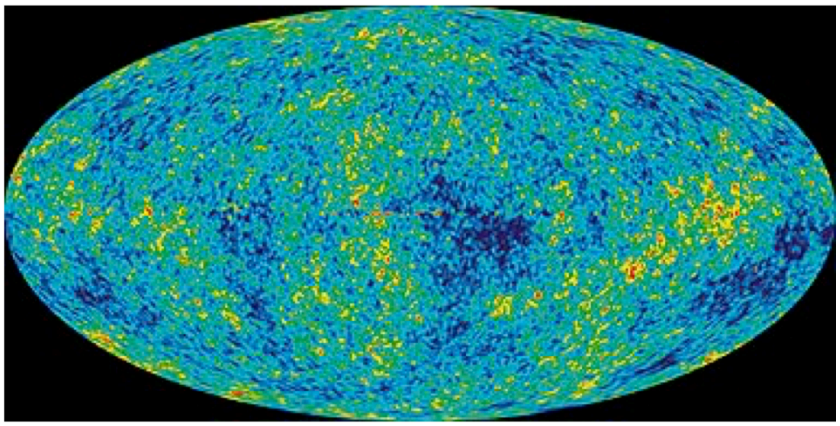
Penzias and Wilson, working at Bell Labs near Princeton, they were annoyed with the background noise they were seeing with their giant radio telescope. It was microwave radiation with a 3 K signal. Everywhere they pointed it existed. They tried to find all sorts of artifacts that may explain it like bird poop on the system, etc. In the end it was real, they had proof of the big bang and won the Nobel Prize for this effort. This is a good example of the serendipity of science and the ability to see something when others don't or can't. And example of Consilience. Being able to see the distance connections between observations and new theories. It is part of the motivation of this class, on why the scope of the topic is so broad. I want you to see connections and where you fit in the world, today, and in your future. Who knows what YOU may Discover.

More recent work on the accelerating expansion of the Universe by Saul Perlmutter and colleagues netted Cal, yet another Nobel Prize.

Cosmic Background
Microwave (7.35 cm) Radiation, ~3 K



http://www.dlr.de/en/DesktopDefault.aspx/tabid-5089/8554_read-16260/gallery-1/gallery_read-Image.1.8365/

Today with the Cosmic Background explorer (COBE) http://lambda.gsfc.nasa.gov/product/cobe/ scientists can map the cosmic radiation of the Universe in greater detail. Do note the Cosmo has lots of granularity. But in general its temperature is about 3K

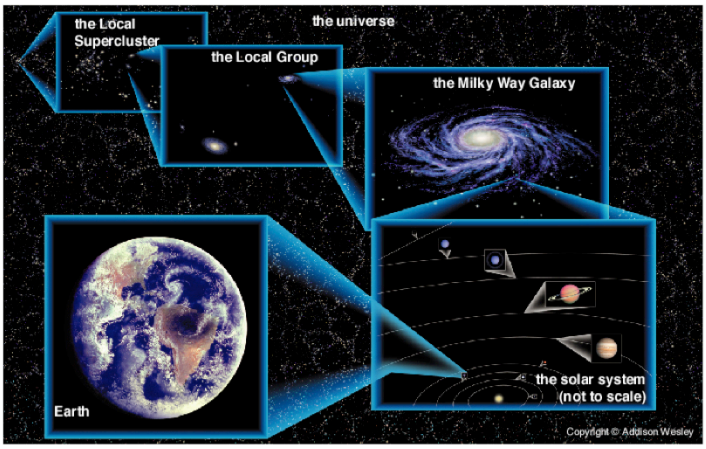
The Futures of the Universe

- Oscillating Universe
  - Curved space causes expanding universe to collapse under its own gravity, form a big crunch, then explode again, and again
- Steady-State Universe
- Multiverse
  - Our Universe is one of a potentially infinite number of cosmic bangs; I have an affection for this one
- Inflationary Universe
  - Perlmutter, Cal Prof, 2011 Nobel Prize

What is the fate of our Universe? http://www.physicsoftheuniverse.com/cosmological.html

More recent work on the accelerating expansion of the Universe by Saul Perlmutter and colleagues netted Cal, yet another Nobel Prize. Personally, I like the idea of multiverses.. But I'll let the physicists tell us what they know

And, our location in Deep Space



http://cse.ssl.berkeley.edu/bmendez/ay10/2002/notes/bt2lf0101_a.jpg

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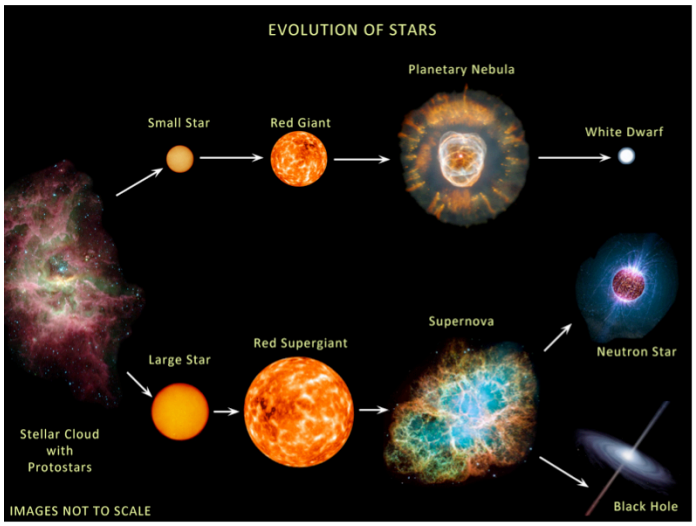
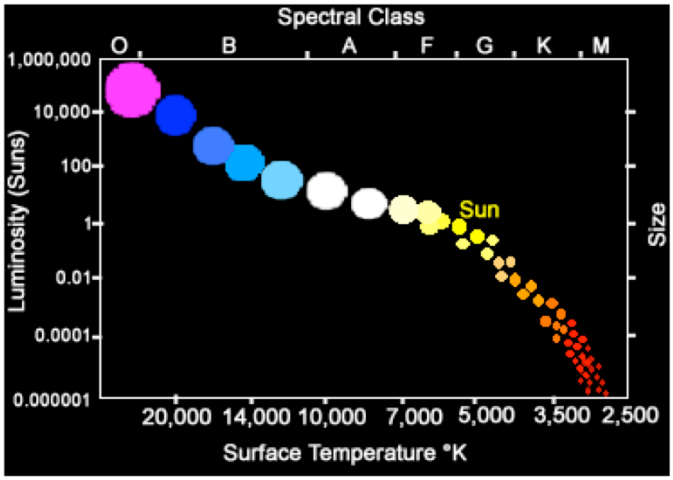
Knowing our position within the Universe, our galaxy and our solar system are important for giving us perspective. We are not the 'center of the Universe', something your Mom may have told you or reminded you about, too.



http://4.bp.blogspot.com/-uEXrXiclwxY/UdfEzQdXDII/AAAAAAAAPxc/6sU_rgtZmd4/s1600/se1.jpg

Our Sun, Not too Hot, nor too Cold



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The universe is full of stars of different sizes and luminosity. The brightest are the Hottest and with the Most Mass.

Not all Sun's are hospitable for life, as we know it. Some are too bright, others too dim. According to Wein's displacement Law the color of an emitting object shifts to shorter wave lengths as the surface temperature gets hotter and hotter.

I doubt life could evolve near a bluish planet because it would emit lots of ultraviolet energy that would break bonds. A planet too red may not emit photons with enough energy to drive photochemical reactions.

http://www.teachastronomy.com/astropedia/article/Main-Sequence-Lifetimes

http://migall.fastmail.fm.user.fm/astronomy/stars_and_nebulae/stars_detail/Main_sequence.gif

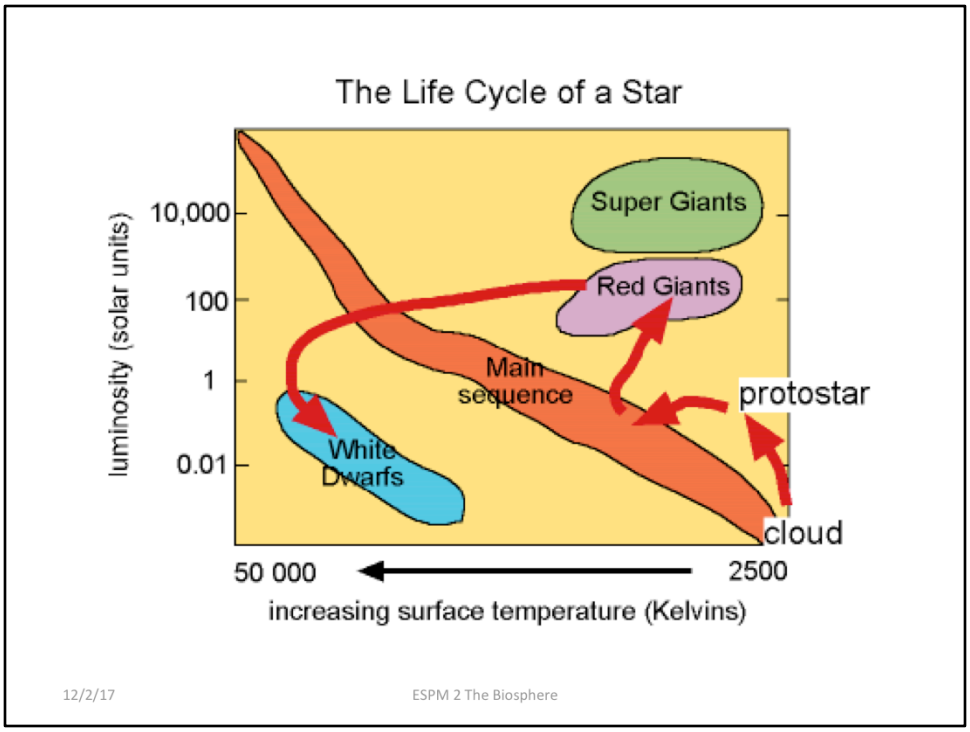
Main Sequence Stars

Energy produced by Nuclear Fusion of Hydrogen into Helium

In Hydrostatic Equilibrium:
Thermal Pressure from Convection Balanced by Inward Pressure of Gravitational Collapse

More Massive, Shorter Lifetime

The luminosity of other stars, relative to our sun, scale with the ratio of their mass, relative to our sun, to the 3.5 power



Stars follow main sequence until all the hydrogen fuel is consumed. Fates can be white dwarfs, Red Giants and eventually Black Holes or super nova
http://www2.glos.ac.uk/gdn/origins/images/hrannot.gif

What is the Lifetime of a Star?

The main sequence lifetime is given by the amount of fuel divided by the rate at which fuel is consumed.

The Sun consumes 2×10^{19} kilograms of hydrogen per year. If a star has luminosity L in solar units, the rate of fuel consumption is 2×10^{19} L.

The mass of the Sun is 2×10^{30} kilograms, but not all of that mass is available as nuclear fuel.

Fusion can only occur in the hot core that contains 10% of the Sun's mass, so the available fuel is $0.1 \times 2 \times 10^{30} = 2 \times 10^{29}$ kilograms. If a star has mass M in solar units, the available fuel is 2×10^{29} M. Now divide to get the lifetime:

$t = (2 \times 10^{29}\ M) / (2 \times 10^{19}\ L) = 10^{10}\ (M/L)$ years

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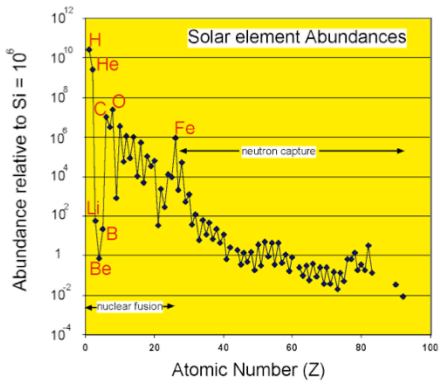
http://www.teachastronomy.com/astropedia/article/Main-Sequence-Lifetimes

I think we don't have to worry about the sun extinguishing in our lifetime.

Mass (solar masses)	Time (years)	Spectral type
60	3 million	O3
30	11 million	O7
10	32 million	B4
3	370 million	A5
1.5	3 billion	F5
1	10 billion	G2 (Sun)
0.1	1000s billions	M7

Nucleosynthesis
Origin of Matter in the Universe

We are Star Dust



- Universe is mostly Hydrogen.
- Fusion in Stars formed Helium.
- As Hydrogen is consumed, Star heats up and contracts. This leads to fusion reactions that can form carbon ,nitrogen and oxygen
- As helium is consumed additional fusion reactions can form Silicon and Iron
- Heavier elements formed by Neutron capture

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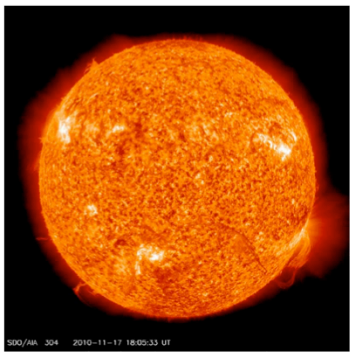
http://www2.glos.ac.uk/gdn/origins/earth/ch2_4.htm

The Sun: Source of Our Energy



1 of 100 Billion Stars in the Milky Way

Sun is 4.56 billion years old

It will Expand into a Red Giant with a radius engulfing Earth in 5 billion years

Surface Temperature:5770 K

Luminosity: 3.846 e26 J s^{-1}

Sun was formed by gravitational collapse of slowly rotating, interstellar molecular cloud; called the solar nebula, it was formed of dust and gases, mostly hydrogen and helium

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We are a planet in the Sun's solar system. It is the energy from this Star that is central to the functioning of Life on Earth and you being able to listen to this lecture and learn!!! We eat Sunlight. This is a theme you will hear repeatedly in this course. The life cycles of stars in general are also responsible for the elements upon which life is based.

Earth Formation, the Hadean, by Accretion
4.55 Billion years ago

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http://www.wonderwhizkids.com/wwkimages/Know_Why/earth_formation.jpg

Earth formed following the gravitational collapse of the gas cloud that formed the sun, dust and gases then accrete to form planets. As their mass grows they accumulate more planetismals.

Age of earth based on $^{207}Pb/^{206}Pb$ dating

Kasting and Catling DOI: 10.1146/annurev.astro.41.071601.170049

Moon formed in Early years of Earth's Formation
Moon is ~4.51 Billion years old

Both Earth and the Moon were bombarded until
4.0- 3.8 Billion years ago

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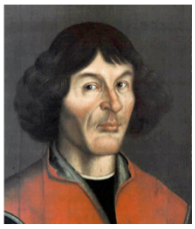
Why does the moon have craters and there are few on Earth? The Earth is 'Alive'! Actions of life, water, weather, weathering and continental drift all erase evidence of early craters from the great bombardment period.

Moon brings stability to the Earth obliquity. Without it, causing it to change from 0 to 85 degrees on time scales of millions of years, raising havoc on climate and life

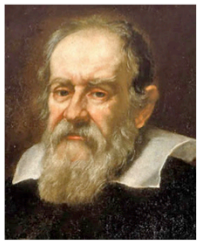
Look at craters on the Moon as evidence of the Bombardments. Why are craters still seen on the Moon and not on Earth?

16th and 17th Centuries Paradigm Shift:
Earth Was Not the Center of the Universe, or Solar System



Copernicus

Kepler



Galileo

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These scientists were key for proposing and developing Heliocentric theory (Copernicus, Galileo) and the Laws of Planetary Motion (Kepler), overthrowing the Geocentric view of the Church and Society. Developments of telescopes by Galileo helped provide evidence for the ideas of Copernicus.

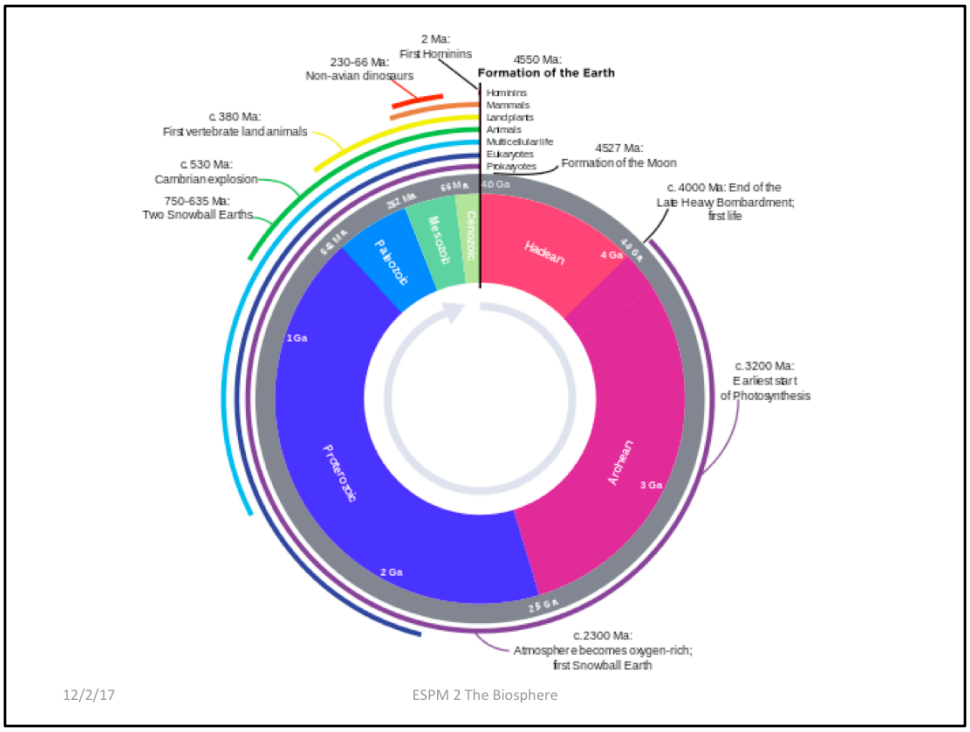
Earth is at the Center of the Universe, Plato, Aristotle, Ptolmy

Held until the late 1500s and early 1600s

Superseded by the Scientific work of Copernicus, Kepler, Galileo and Evidence of a Heliocentric solar system

Key Moments in Early Earth History, part 1
The Manger for Life

Event	Geological Eons/Era	Time
Sun Forms		4.57 Gy
Earth Forms, Accretion and Bombardment	Hadean	4.56 Gy
Moon Forms	Hadean	4.51 Gy
Earliest minerals, zircon	Hadean	4.4 Gy
End of Heavy Bombardment	Hadean	4.0 Gy
1st Life, prokaryotes	Hadean/Archaean	4.0 Gy
Continental crust and first rocks	Hadean	4.0 Gy
1st photosynthesis, cyanobacteria	Archean	3.5 Gy
Iron Banded Formations		
Great Oxygenation of the Atmosphere		2.48 Gy
1st Snowball Earth	Proterozoic	2.4 Gy
Eukaryotes Emerge		
Super Continents	Proterozoic	



https://upload.wikimedia.org/wikipedia/commons/thumb/7/77/Geologic_Clock_with_events_and_periods.svg/750px-Geologic_Clock_with_events_and_periods.svg.png

Early Earth History, Hadean (4.6-4 Billion years ago)

- Formed ~4.56 Billion years ago by accretion of debris from solar disk
- Much of Earth was extremely hot; molten conditions due to bombardment and volcanism
- Early atmosphere and oceans formed by volcanism; no oxygen in early atmosphere
- Moon formed, 4.51 Billion years ago
  - Stabilizes Earth's Obliquity and its Climate
- No Life

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The Earth is formed out of debris around the solar protoplanetary disk. There is no life. Temperatures are extremely hot, with frequent volcanic activity and hellish environments. The atmosphere is nebular. Possible early oceans or bodies of liquid water. The moon is formed around this time, probably due to a protoplanet's collision into Earth.,,,wikipedia

http://www.ucmp.berkeley.edu/precambrian/archean_hadean.php

Earth 4.56
Allègre, C. J., G. Manhès, and C. Göpel. 1995. The age of the Earth. Geochimica et Cosmochimica Acta **59**:1445-1456.

Moon 4.51 billion years
Barboni, M., P. Boehnke, B. Keller, I. E. Kohl, B. Schoene, E. D. Young, and K. D. McKeegan. 2017. Early formation of the Moon 4.51 billion years ago. Science Advances **3**.

Kasting and Catlin
Presence of a moon could affect their subsequent climate evolution

Early Earth, Archaean: 4.0 to 2.5 Ga

- Bombardment Ceases, Earth Surface Cools
- Faint Sun Paradox, brightness was 30% less than today
  - Yet Earth remained warm enough for life to evolve
  - Ocean and Liquid water present
  - Carbonate-silicate/CO2-climate feedbacks, inorganic and geological path to a warm enough atmosphere
  - Atmosphere composed of volcanic and greenhouse gases
- First life, prokaryotes, formed towards end of heavy bombardment, 4 Ga; demarking the beginning of the Archaean
- Earliest photosynthetic life forms, cyanobacteria, 3.4-3.5 Ga; stromatolites
  - Oxygen is produced but concentrations remain low as O2 is reacts with Fe and is removed by rust (Iron oxides), Banded Iron Formation

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See Canfield Oxygen

https://en.wikipedia.org/wiki/Geological_history_of_oxygen

Stromatolites a calcareous mound built up of layers of lime-secreting cyanobacteria and trapped sediment, found in Precambrian rocks as the earliest known fossils, and still being formed in lagoons in Australasia

Walter, M. R., R. Buick, and J. S. R. Dunlop. 1980. Stromatolites 3,400-3,500 Myr old from the North Pole area, Western Australia. Nature **284**:443-445.
stromatolites 3,400–3,500-Myr old from the Pilbara Block of Western Australia.

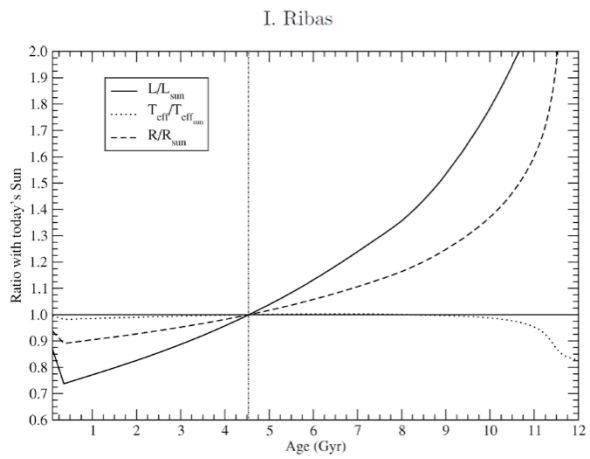
http://www.ucmp.berkeley.edu/precambrian/archean_hadean.php

Kasting argues that early methane ammonia atmosphere is unlikely. He argues for a CO2, N2 atmosphere, weakly reducing

Review by Kasting and Catlin..

The most important part of the carbon cycle in terms of long-term climate

Time History of Sun's Brightness



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It is important to recognize that life on Earth, dependent upon the Sun, evolved as the brightness of the sun increase. So it was not hunky dory like today, several billion years ago. We have to consider the change in solar lumination and the possible climate of our planet when thinking about the trajectory for the evolution of life.

Carbonate-Silicate Cycle/Climate Cycle

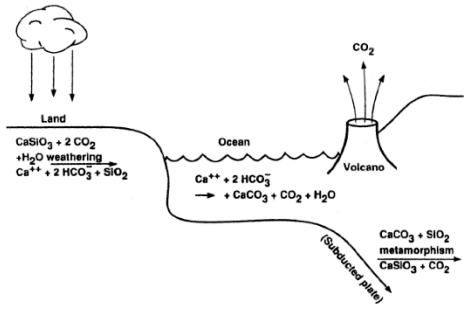


Figure 3 Diagram illustrating the modern carbonate-silicate cycle, also referred to as the inorganic carbon cycle.

CO2 is emitted into atmosphere by volcanos

CO2 is dissolved in water and forms weak carbonic acid

It dissolves silicate rocks through weathering

Calcium carbonate are precipitated

They are subducted and return by volcanoes

0.5 Million year return cycle

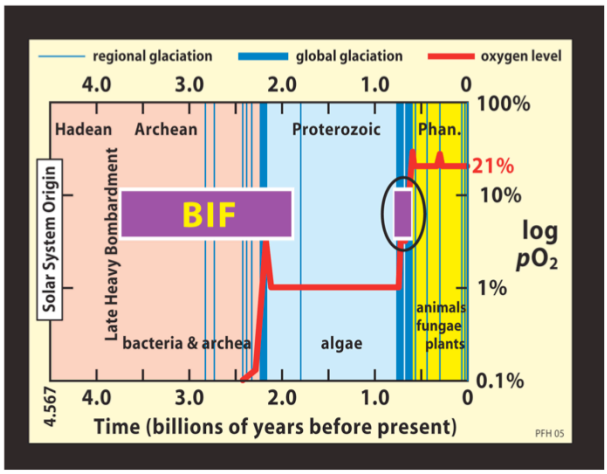
Weathering increases with Temperature, so CO2 decreases as T increases and vice versa

Kasting and Catlin

CO2 dissolves in rainwater to form carbonic acid (H2CO3),
which is a weak acid, but when it acts over long timescales, it is strong enough to dissolve silicate rocks. For illustrative purposes, we use the simplest silicate mineral, wollastonite (CaSiO3), to represent all silicate rocks. The products of silicate weathering, including calcium (Ca2C) and bicarbonate (HCO¡
3) ions and
dissolved silica (SiO2), are transported by streams and rivers to the ocean. There, organisms, such as foraminifera, use the products to make shells of calcium carbonate
(CaCO3). Limestone is the commonly preserved form of calcium carbonate. Other organisms such as diatoms and radiolarians make shells out of silica

carbonate sediments are carried
down to depths where the temperatures and pressures are much greater. Under these conditions, carbonate minerals recombine with SiO2 (which by this time is the mineral quartz) to reform silicate minerals, releasing CO2 in the process. This reaction is termed carbonate metamorphism. The CO2 released from carbonate metamorphism makes its way back to the surface and re-enters the atmosphere by way of volcanism, thereby completing the carbonate-silicate cycle. This

Connections between life, formation of oxygen,
banded iron formation, plate tectonics and snowball earth



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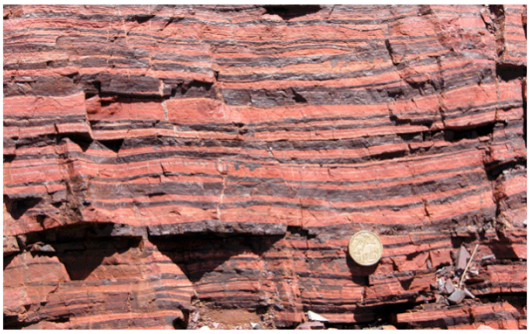
http://www.snowballearth.org/slides/Ch13-2.gif

The early production of oxygen by cyanobacteria, as viewed by the development of stromatolites, was rapidly removed from the atmosphere as this O2 reacted with iron on the earth's crust. Iron oxides were formed as noted by the banded iron formation

Rapid rise in O2 over 2 Ga could have reacted with methane and reduced the greenhouse effect of the atmosphere, allowing the earth to undergo cooling, with positive albedo feedbacks.

Iron Banded Formation:
Before Oxygen could build up in the Atmosphere it had to Rust the Iron Rocks



Oxygen combined with dissolved Iron to form Iron Oxides, Magnetitie (Fe_3O_4) or hematite (Fe_2O_3)

Evidence of Early Life

Stromatolites 3,400–3,500-Myr old from the Pilbara Block of Western Australia.; Stromolites a calcareous mound built up of layers of lime-secreting cyanobacteria and trapped sediment, found in Precambrian rocks as the earliest known fossils

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https://upload.wikimedia.org/wikipedia/commons/thumb/1/1b/Stromatolites_in_Sharkbay.jpg/1024px-Stromatolites_in_Sharkbay.jpg

Stromolites
a calcareous mound built up of layers of lime-secreting cyanobacteria and trapped sediment, found in Precambrian rocks as the earliest known fossils, and still being formed in lagoons in Australasia

Walter, M. R., R. Buick, and J. S. R. Dunlop. 1980. Stromatolites 3,400-3,500 Myr old from the North Pole area, Western Australia. Nature **284**:443-445.
stromatolites 3,400–3,500-Myr old from the Pilbara Block of Western Australia.

Cyanobacteria, photosynthetic, 3.5 billion years ago

Photosynthetic lichen

Early Earth, Proterozoic
2.5 Ga to 541 Ma

- Cyanobacteria continue to produce oxygen
  - Atmosphere becomes Oxygen Rich
  - ''great oxidation event'' (GOE) at 2.4 Ga
- Snowball/Slushball Earth occurred at the beginning and towards the end of this eon
  - The rise in O2, consumed methane and reduced greenhouse warming, followed by ice-albedo feedbacks
- Eukaryotes form, cellular and multi-cellular

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Falkowski, 2011 Photosynthetic Research

The inference of ozone and the timing of this so-called ''great oxidation event'' (GOE) at 2.4 Ga comes primarily from analyses of sulfur isotopes in the rock record…up until 2.4 Ga, the isotopic fractionations in the geologic record are mass independent. SO2 has a UV absorption cross section, peaking at *200 nm. Breaking of bonds by high energy photons does not lead to mass dependent isotopic fractionation. Hence, one interpretation of the mass independent fractionation is that short wave UV radiation reached the Earth's surface prior to *2.4 Ga, but subsequently that radiation was quenched. Stratospheric ozone absorbs short wave UV radiation on the contemporary Earth, and the source of ozone is O2. Hence, the loss of the mass independent isotopic fractionation of sulfur at 2.4 Ga suggests a change in the oxidation state of Earth's atmosphere. ..the concentration of oxygen that arose during the GOE is extremely poorly constrained. Formation of stratospheric ozone is not limited by O2 above ca. 0.1% of the present atmospheric level.

In a simple geochemical sense, net production of oxygen on Earth implies the burial and sequestration of reductant. The reduced equivalents are primarily in the form of organic matter. Organic matter in the ocean is depleted in 13C by *20% relative to the (arbitrarily chosen) standard, carbon from fossil (extinct) marine

Snow Ball Earth and Banded iron formation, Conventional Theory

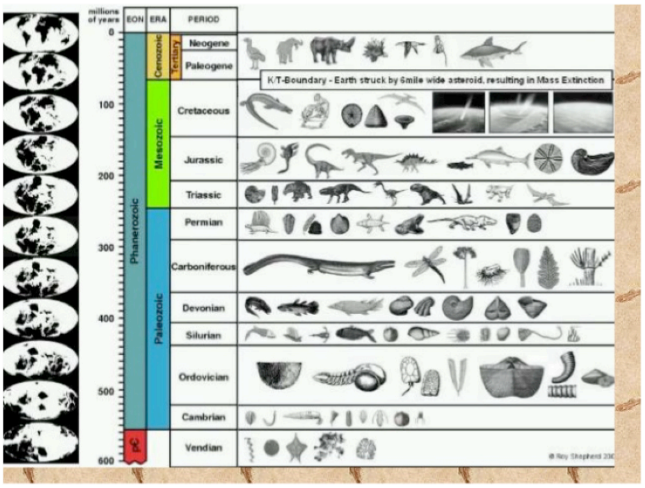
During SnowBall Earth, dissolved iron builds up in the sea, as ice prevents exchange of oxygen with oceans

With melting of ice photosynthetic cyanobacteria is active, stimulated by dissolved iron and produces oxygen

This new source of oxygen combines with dissolved iron in the ocean and forms insoluble iron oxides that precipitate and form layers in the rocks that formed

Bands form due to the availability, or unavailability of oxygen

Phanerozoic, Eon of Visible Life



http://image.slidesharecdn.com/prehistoryearlylife2-110114143819-phpapp01/95/prehistory-1-geologic-timeline-notes-on-the-geologic-life-history-of-earth-from-precambrian-to-the-present-cenozoic-era-10-638.jpg

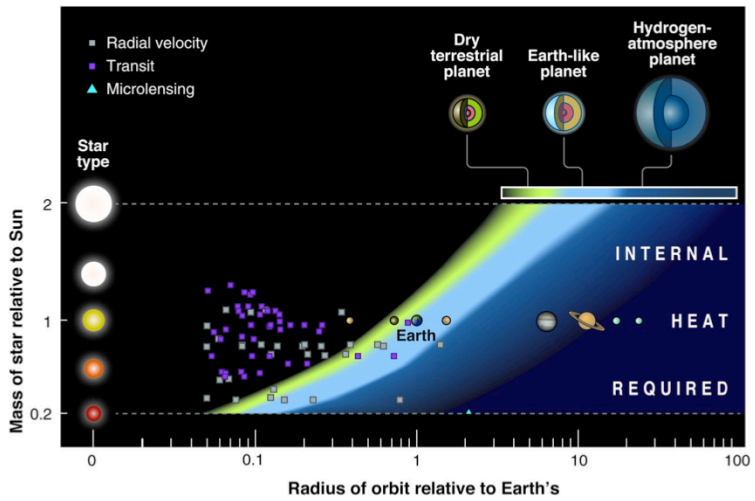
Synthesis and Summary

- Two pieces of Evidence for the Origin of the Universe
  - Hubble, Universe is expanding
  - Penzias and Wilson, background microwave radiation, remnant of 3 K, and birth of Universe
- Formation of Stars and Elements
  - Big Bang, Inflation, opaque universe of plasma (ionized gas) (t < 300,000 years)
  - H and He form as universe cools (4000 k), first light emitted
  - stars and galaxies form
  - heavier elements form
- Age of the Earth and its Early Developmental Steps
  - Development of Life, Rocks, and the composition of the air co-evolved
  - Planet formed by accretion
  - Life could not form until the planet cooled
  - Oxygen could not build up until dissolved iron precipitated
  - Oxygen consumes methane, Earth freezes
  - Banded Iron Formation, connected with Snowball Earth

Discussion Topics

- The Timeline from the Big Bang to the Formation of Earth
  - Think of the steps involved and the time between key steps
  - Formation of Atoms and Elements over numerous star lifetimes
  - Formation of our Star
  - Accretion of matter to form planetismals and planets.
- Look at craters on the Moon as evidence of the Bombardments.
- Why are craters still seen on the Moon and not on Earth?
  - Are they recent?
  - Did they not erode?
- What are the odds of Life elsewhere?

Habitable Zone



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http://www.sciencemag.org/content/340/6132/577/F2.large.jpg. Supergiants, dwarfs or binary or multiple stars tend not to be candidates for planets with life. Planets too close to stars will be hot and dry, those too far will be gas planets.

How Many Planets may have Life in the Universe?: Seager Equation

$N = N_* F_Q F_{HZ} F_O F_L F_S$

N = the number of planets with detectable signs of life
N_* = the number of stars observed
F_Q = the fraction of stars that are quiet
F_{HZ} = the fraction of stars with rocky planets in the habitable zone
F_O = the fraction of those planets that can be observed
F_L = the fraction that have life
F_S = the fraction on which life produces a detectable signature gas

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How many possible?

Drake's Equation (1961)

How Many are Able to Communicate with Us?

N = The number of civilizations in The Milky Way Galaxy whose electromagnetic emissions are detectable =

R^* = The rate of formation of stars suitable for the development of intelligent life (x)

f_p = The fraction of those stars with planetary systems (x)

n_e = The number of planets, per solar system, with an environment suitable for life (x)

f_l = The fraction of suitable planets on which life actually appears (x)

f_i = The fraction of life bearing planets on which intelligent life emerges (x)

f_c = The fraction of civilizations that develop a technology that releases detectable signs of their existence into space (x)

L = The length of time such civilizations release detectable signals into space.

What is the range of answers?

Hubble Space Telescope

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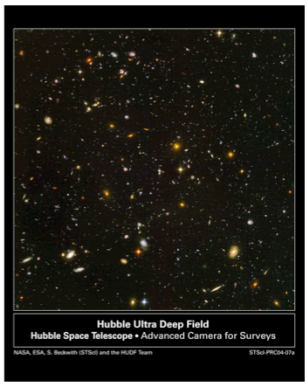
Our new eyes to the Stars. Launched 25 years ago. In early years it was near sited. Space walkers were able to correct its vision. This telescope is named in honor of Hubble and is revolutionizing how we see the distant universe. It is in orbit above the Earth's atmosphere to avoid the effects of clouds and distortion by the atmosphere, which plagues Earth bound telescopes, even those on high desert mountains like in Chile.

http://hubblesite.org/

Birth of a Star, Hubble Images

Deep Field Image



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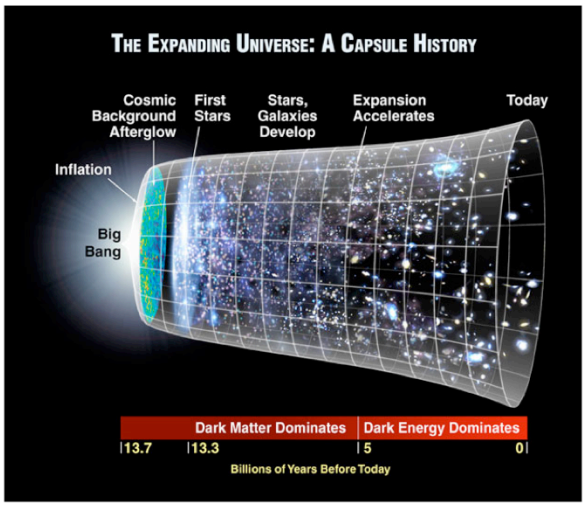
Some Really beautiful images being produced by the Hubble Space Telescope

http://cdn.theatlantic.com/static/infocus/hubble120112/s_h03_hs201013.jpg

Other key findings, gamma ray bursts associated with black holes; discovery of deep field galaxies of the early universe, never seen from Earth.
http://imgsrc.hubblesite.org/hu/hubble_discoveries/breakthroughs/assets/cosmo_large/HUDF.png

Timeline of the Early Universe



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Key periods, Big Bang, Inflation, opaque universe of plasma (ionized gas) (t < 300,000 years); H and He form as universe cools (4000 k), first light emitted; stars and galaxies form; heavier elements form

http://hetdex.org/images/dark_energy/expand_universe_capsule_history.jpg

Stars in the Sky

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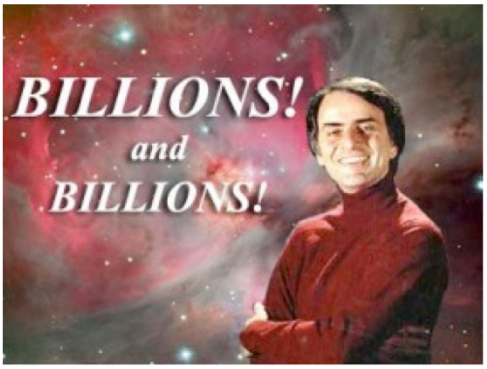
We tend to live in urban environments with lots of light pollution and have lost an appreciation for stars in the night sky. Growing up in the country I took it for granted until I brought a bunch of friends down from UC Davis for the weekend and they remarked 'look at all the stars'. More recently we like to spend time along the CA coast, where there is no light pollution across the western sky and even with my near sightedness I am amazed at the bright stars and how we can see the Milky Way on clear nights. And on trips to New Zealand and Australia I have been lucky to see such notable constellations as the southern cross.

http://en.es-static.us/upl/2015/09/Riding-the-roof-of-the-world-Jeff-Dai-e1441307245700.jpg

How Many Stars and Galaxies are in the Universe?



http://www.com.uri.edu/COM455/images/carl_sagan_billions.jpg

The universe is vast in size, space and numbers. Our sense of the night sky. The late Carl Sagan has often been satirized for his comments 'billions and billions'. But it has made the point that the universe is vast and full of many, many stars and galaxies. Remember at such far distances many of the stars we see are really galaxies with their own vast collection of stars.

On a Clear Night you can see the Milky Way

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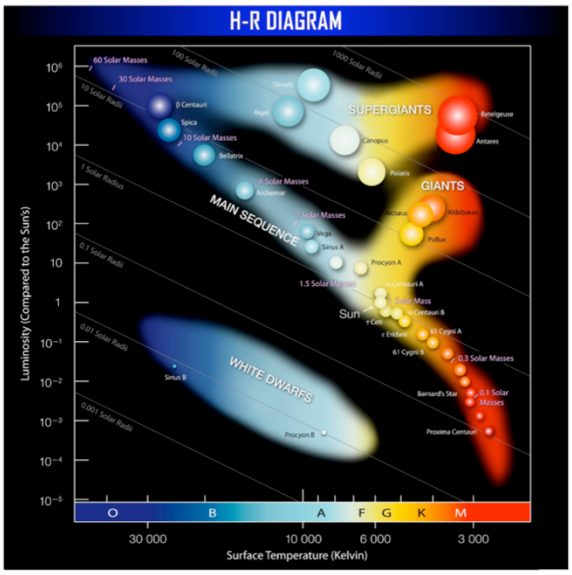
Try and look at the night sky on a clear night this semester and search for the Milky Way..

Our Location in our Galaxy, the Milky Way

Even within our galaxy we are on the outer edge.



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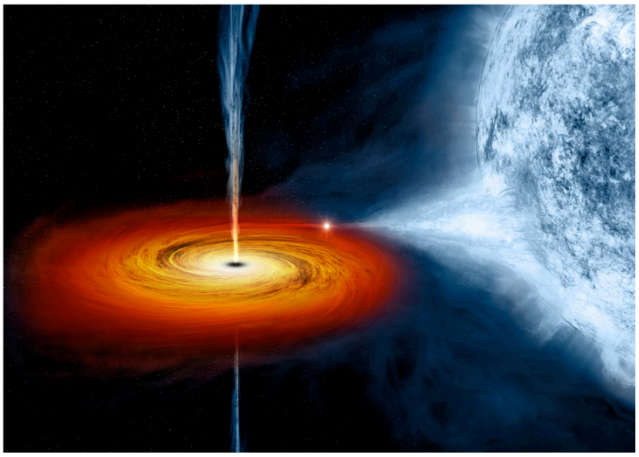
http://www.museumofflight.org/files/HRDiagram.jpg

Black Hole



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http://www.nasa.gov/sites/default/files/cygx1_ill.jpg

They are finding black holes at the center of many galaxies

Super Nova

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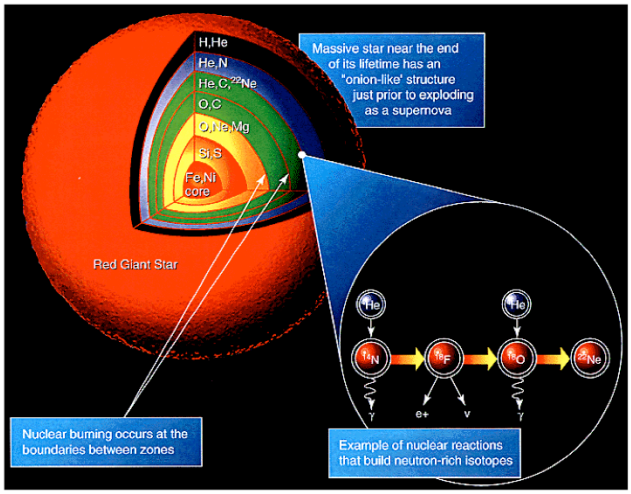
Explosions of super novae help populate space with new material for new stars…



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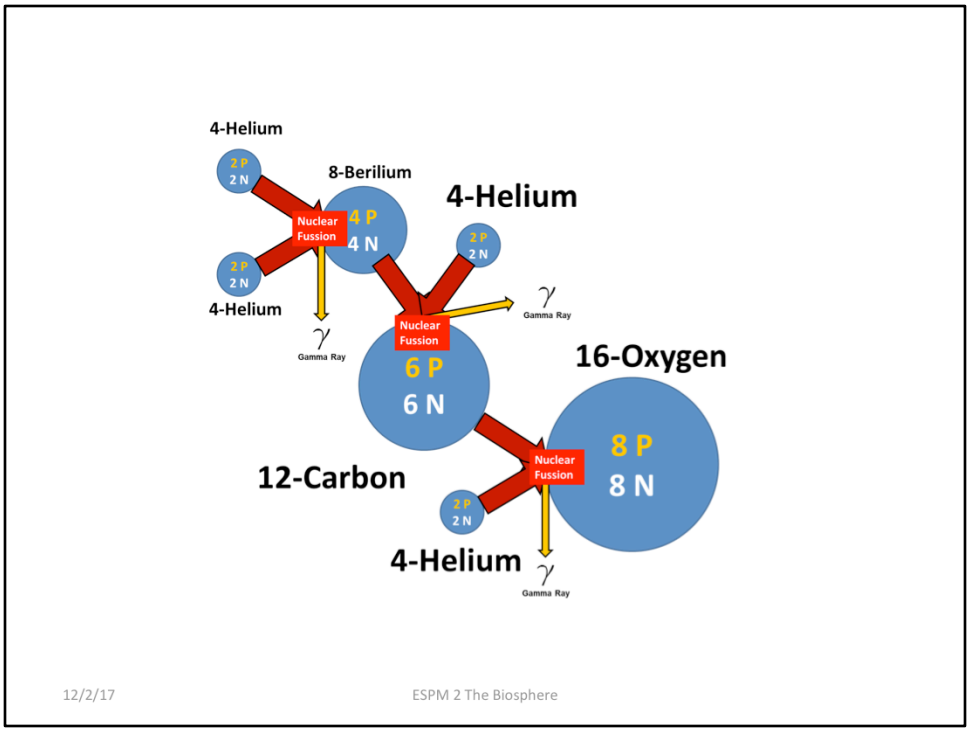
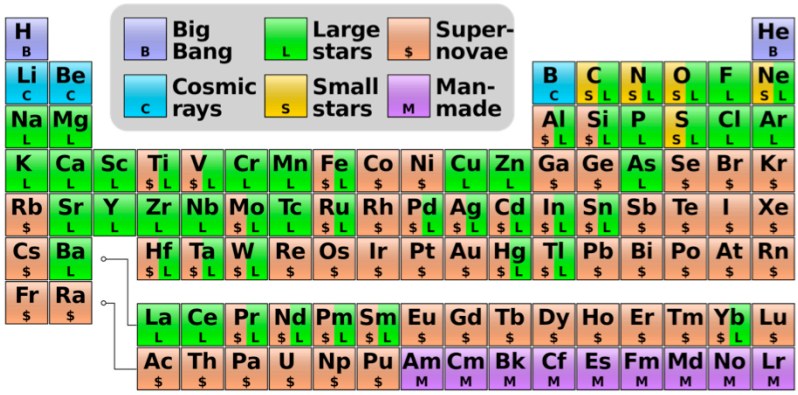
http://helios.gsfc.nasa.gov/onion.gif



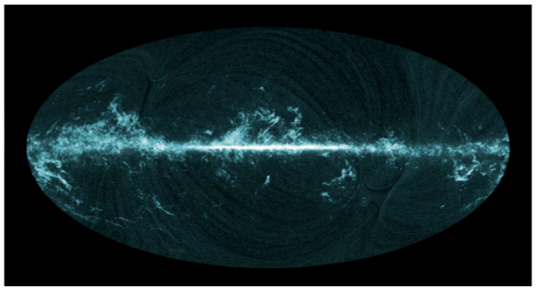
http://www.artinaid.com/wp-content/uploads/2013/04/Oxygen-Nucleosynthesis.png



https://upload.wikimedia.org/wikipedia/commons/thumb/3/31/Nucleosynthesis_periodic_table.svg/2000px-Nucleosynthesis_periodic_table.svg.png

How Many Atoms in the Universe?

~10^{80}



How did these atoms form?

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For context there are 10^{23} molecules per moles, so there must be about 10^{57} moles of matter in the Universe. How did this Matter Form?

http://www.esa.int/var/esa/storage/images/esa_multimedia/images/2012/02/all-sky_image_of_molecular_gas_seen_by_planck/10006278-2-eng-GB/All-sky_image_of_molecular_gas_seen_by_Planck_fullwidth.jpg

First Life on Earth

Rule of thumb is about 3.7 Billion years ago

Several piece of new evidence push life back to

4.1 – 4.2 Billion Years ago

photosynthetic life-form that created
the 3.7-billion-year-old microbial mats, called stromatolites.

Earliest undisputed life goes back to 3.5 Billion

http://www.sciencemag.org/news/2015/10/
scientists-may-have-found-earliest-evidence-
life-earth

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http://www.sciencemag.org/news/2015/10/scientists-may-have-found-earliest-evidence-life-earth

In the study,
Bell and her colleagues examined zircons from the Jack Hills in Western Australia, a site that has yielded more Hadean samples than anywhere else on Earth, searching for inclusions of carbon minerals like diamonds and graphite. The mere presence of these minerals does not prove biology existed when the zircons formed, but it does provide the opportunity to look for chemical signs of life. The team eventually found small bits of potentially undisturbed graphite in one 4.1 billion-year-old crystal. The graphite has a low ratio of heavy to light carbon atoms—called isotopes—consistent with the isotopic signature of organic matter. “On Earth today, if you were looking at this carbon, you would say it was biogenic,” Bell says. “Of course, that’s more controversial for the Hadean.”

http://news.nationalgeographic.com/2017/03/oldest-life-earth-iron-fossils-canada-vents-science/