

Astronomy 330



This class (Lecture 13):

Life in the Solar System
Danielle Campanella
Bryan White

Next Class:

Life in the Solar System

HW 5 is due today
Midterm is next week

Oct 18:
Timothy Noffke
Se Hee Jang

Music: *Venus as a Boy* – Björk

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Midterm



- 80 minute exam in this classroom.
- It will cover material up to, but not including, “Life in the Solar System”
- Will consist of ? multiple choice/ true-false questions (worth 40 points) and 2 essay questions (25 and 40 points each) .
- A total of 105 points, so 5 extra credit points.
- You can bring a normal-sized sheet of paper with notes on both sides.

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HW #3



- **Sean White:** <http://www.astro-tom.com>
- **Joe Krischon:**
<http://www.astro.ucla.edu/~astro7/exlife/exlife.html>
- **Mike Johnson:** <http://mufor.org>

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Presentations



- **Danielle Campanella:** [ET and Religion](#)
- **Bryan White :** [Interstellar Travel](#)

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Outline

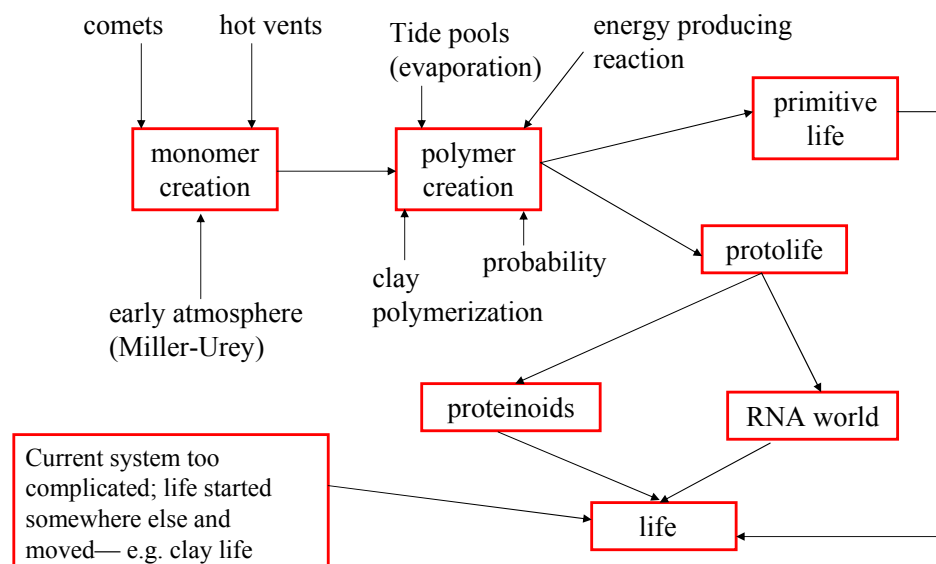


- Simple alternative to life
- Estimate of f_l
- Life on Venus or Mars

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Pathways to Life on Earth



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Silicon Based Life?



- Silicon makes 4 bonds like Carbon
- It is 135 times more abundant than carbon on Earth.
- But there are 4 arguments against it:
 - C-C bonds are twice as strong as Si-Si
 - Si-O or Si-H is stronger than Si-Si, so harder to make long stands
 - Si does not usually make multiple Si bonds
 - C with O makes CO_2 , but Si with O makes silicates (SiO_2), which are large solid crystals.
- Still it is a possibility that can not be ruled out.



<http://www.decipher.com/startrek/cardlists/mirrorimage/images/horta.gif>
<http://soundways.trekkieguy.com/25.html>

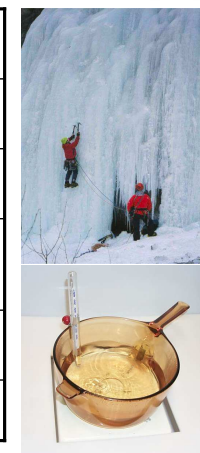
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Other Solvents



<i>Molecule</i>	<i>Freezes (K)</i>	<i>Boils (K)</i>
Water (H_2O)	273	373
Ammonia (NH_3)	195	240
Methyl alcohol (CH_3OH)	179	338
Methane (CH_4)	91	109
Ethane (C_2H_6)	90	184



Water is about twice as good as ammonia or methyl alcohol.
 Water also has a high energy of vaporization, so it is very good at evaporative cooling (sweat).

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<http://www.talisman-activities.co.uk/winter/images/ice%20climbing.jpg>
<http://web.media.mit.edu/~fletcher/tags/boiling.jpg>

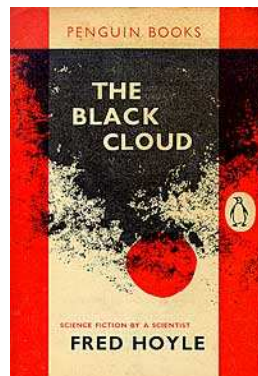
Non-Chemical Life



Life is based on chemical energy. Thinking is an electrochemical activity. What about a life form that uses electromagnetic energy instead, perhaps without a body.

The Black Cloud (1957) by Fred Hoyle

The story describes a small interstellar molecule cloud that is alive. The organism is half a billion years old, as big as the orbit of Venus, and as massive as Jupiter. The brain is a complex network of molecules. Once it discovers the Earth it communicates with us:



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The Black Cloud Speaks

Paraphrased "badly"



- It is most unusual to find animals with technical skills inhabiting planets
- Living on a planet, greatly limits your size, thus the scope of your neurological activity.
- Living on a planet, forces you to possess muscular structures to promote movements.
- Your very largest animals have been mostly bone and muscle with very little brain.
- One only expects intelligent life to exist in a diffuse gaseous medium. At the moment, I myself am building basic chemicals at about 10,000,000,000 times the rate as your whole planet.

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Cloud Problems



- How would such a cloud evolve?
- The most dense clouds are 10^{13} times less dense than our atmosphere, which makes molecule interactions very rare.
- In space, interstellar clouds are torn apart in about 10^7 years. It took 10^9 years for intelligent life to form on Earth.
- Still it is a cute idea.



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Other Voices, Other Energies



- Life based on nuclear energy (put forward by Drake)
 - Life on the surface of a neutron star?
 - Gravity and temperature too high for normal life.
 - Life made of closely packed nuclear matter instead of molecules
 - They interact quickly 10^{-21} seconds, much faster than chemical reactions.
- It has been fictionalized by Robert Forward in *Dragon's Egg*
 - Talking to these beings would be difficult.
 - Their Biology uses the strong nuclear force.
 - A time difference of a million to one.
 - In the time it takes to say "Hello" - would be the equivalent of a week to a star creature. It would hear "He . . ." on Sunday and ". . . lo" on the following Saturday.

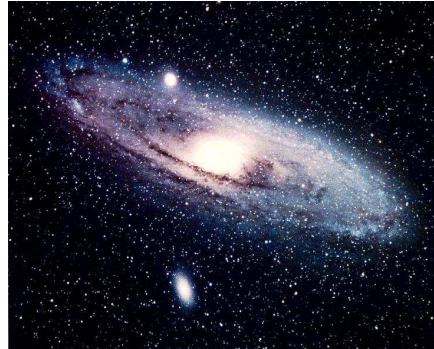
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Or Too Big



- Life based on gravitational energy?
- In this creature, the gravity force would dominate— very large!
- The monomer of life would have to be a star.
- Perhaps individual stars play the role of individual atoms or molecules in Earth life.



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Or Too Big



- Could galaxies be alive?
- Stars interact with one another on a time scale of many millions of years, so if life is to originate from such interactions it would take longer than the age of the Universe.
- If life is occurring, it is only at the stage where life was when the Earth was a few years old.



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<http://www.astro.cz/cz/wallpapers/index.php?id=15>

Summing Up



- Existence of organic molecules in space implies that amino acid complexity is common.
- Fact: On Earth polymers arose and evolved to life.
- Life it seems evolves naturally through a number of intermediate steps if conditions are right and $f_1 = 1$
- But how often are the conditions right?
- Nonetheless, even with only a vague notion of how life on Earth evolved, it seems that there are possible pathways that take the mysterious polymerization to transition to life steps.
- Still a number of questions:

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Summing for f_1



- Is life a natural occurring consequence of the laws of nature?
- Will each planet from n_e outgas and produce water?
- Will it have a reducing atmosphere?
- Will it have the right energy sources to produce life's monomers?
- Monomers from space?
- Will polymerization occur?
- Are tides necessary to wash polymers back into liquid water?
- Will basic life occur? Protolife or life?
- Alternative life?
- Maybe the conditions that produced life on Earth are unusual or maybe common.
- That means f_1 can range from small numbers 0.0001 to 1.

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