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ASTR 4800



# Astrobiology

...if it is just us... it seems like an awful waste of space.

## What is Life?






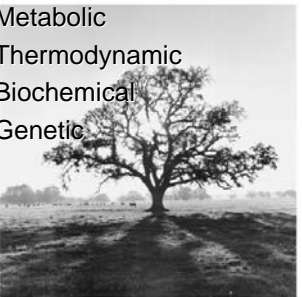
Your thoughts?




Is it a problem that we only have "one" example?

### Carl Sagan's Five Categories of Definitions


1. Physiological
2. Metabolic
3. Thermodynamic
4. Biochemical
5. Genetic

Source: www.phys.lsu.edu

Source: artfiles.net.com

## Physiological

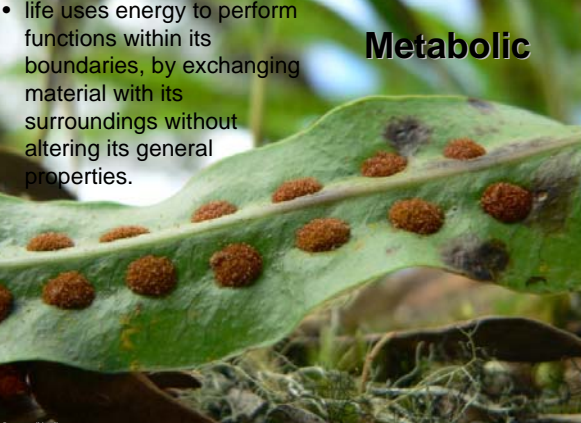


- life is defined as a system capable of performing a number of functions including eating, metabolizing, excreting, moving, growing, reproducing, breathing, and responding to stimuli.

Source: wikipedia.com

- life uses energy to perform functions within its boundaries, by exchanging material with its surroundings without altering its general properties.


## Metabolic



Source: wikipedia commons

## Thermodynamic

- components of life are contained within definite boundaries (for example, cells) and results in locally increased order.



Source: unc.edu

## Biochemical

- life has a distinctive chemistry and contains coded hereditary information (ex. DNA) that is passed to the next generation.



## Genetic

- life is capable of evolution by natural selection.



## NASA's working definition of life:

Life is a self-contained chemical system capable of Darwinian evolution.



## NASA's working definition of life:

Life is a self-contained chemical system capable of Darwinian evolution.

Explanation:

"Self-contained" goes further than the metabolic definition, and excludes viruses.

"Chemical" excludes machine-life.

"Darwinian evolution" implies:

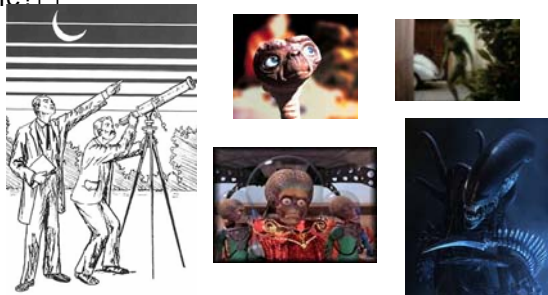
- 1). Continuity over a historical lineage
- 2). Individual genetic variation
- 3). Struggle for survival (natural selection)

Basically, this definition just incorporates all of Sagan's categories.



Life is complicated...

we can't decide on a set definition...  
so what should we look for in the search for life? □

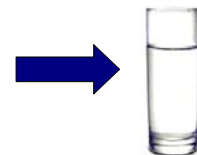


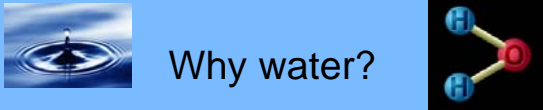
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## FOLLOW THE WATER!

The search for life, as we know it, is the search for WATER!

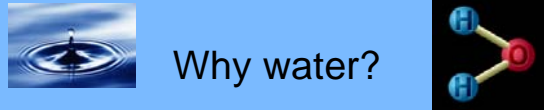




## Why water?

1. It's what we *know*. All life as we *know* it needs water.
2. It's a universal solvent.
3. It stays liquid over a wide range of temperatures.
4. Ice floats.
5. Water is a polar molecule.
6. It quenches thirst.

Source: www.amyoceco.org Source: americanhistory.si.edu



## Why water?

Water as a universal solvent:

- It dissolves organic molecules enabling chemical reactions in cells
- It allows transport of chemicals in/out of cells
- It is directly involved in many metabolic reactions

Could another liquid fulfill water's role?

Source: www.amyoceco.org Source: americanhistory.si.edu

### Could another liquid fulfill water's role?

- Most other candidates have small temperature ranges
- Chemical reactions go very slowly at colder temps.

Substance	Freezing Temperature	Boiling Temperature	Width of Liquid Range
Water (H <sub>2</sub> O)	0°C	100°C	100°C
Ammonia (NH <sub>3</sub> )	-78°C	-33°C	45°C
Methane (CH <sub>4</sub> )	-182°C	-89°C	18°C
Ethane (C <sub>2</sub> H <sub>6</sub> )	-183°C	-89°C	94°C

Plus, we don't know how life based on these liquids would look like. So we'll stick with water.

Source: library.thinkquest.org Source: whifiles.org

## BACK TO MARS

We won't rest!

### Viking Experiments

- Did we give up too quickly?

When we go back, either with humans or robots, what should we test for?

Source: forum.nasa.gov



## Extremophiles

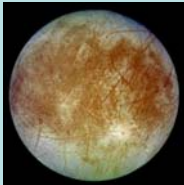

- They really make it hard to define life.
- But they also make it much more likely that life exists elsewhere in our solar system!

Hyperthermophile = high temp.  
Halophile = salt  
Lithophile = rock  
Piezophile = pressure



Source: library.thinkquest.org Source: whifiles.org

## Europa and Enceladus

- Water vapor plume
- Sub-surface ocean
- Strong tides
- Could tidal heating result in hydrothermal vents?

Source: http://vpl.ipac.caltech.edu Source: http://ai.jpl.nasa.gov

**What would be definitive proof?**

What would YOU need to be convinced?


What would the public in general need to be convinced?

How long would it take for overall acceptance, given definitive proof?

**Let's Be Hypothetical**

- If there is proof-positive evidence that there is life on Mars, should we send humans there?
- Sanctity of life argument
- Is the existence of life on Mars important enough for us to get there before 2050?

Three kinds of life on Mars!



A photograph showing three LIFE magazine covers lying on a reddish, sandy surface that resembles the Mars surface. The covers feature various images and the word 'LIFE' in large letters. A green arrow points from the text 'Three kinds of life on Mars!' to the magazines.

Source: borromini@nypost.com