

Our Cosmic History*

Lecture #4 - April 29, 2010

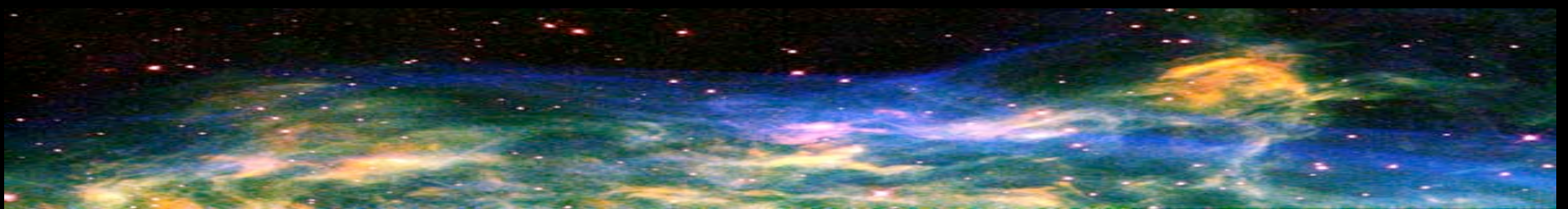
“The Emergence of Life”

Todd Duncan

duncan@scienceintegration.org

<http://sites.google.com/site/toddstardust/>

** Lecture series sponsored by the PSU Center for Science Education & the Science Integration Institute, and made possible by a generous grant from the Oregon Dept. of Education*



Themes of the series...

- Reflecting on what it means to be *you*, in this moment, within the context of the universe as we currently understand it. What is the cosmic *story* we are part of?
- Gaining perspective on how we connect to the universe: we are children of the *whole cosmos*, not just our immediate surroundings
- Framework for teachers and students to see how the details of science fit into a big picture that gives meaning and context to those details



Series Web Site...

...for schedule, resources, & continuing discussion...

<http://oregonteacherscholars.pbwiki.com/Our-Cosmic-History>

(or link from www.scienceintegration.org)

Upcoming...

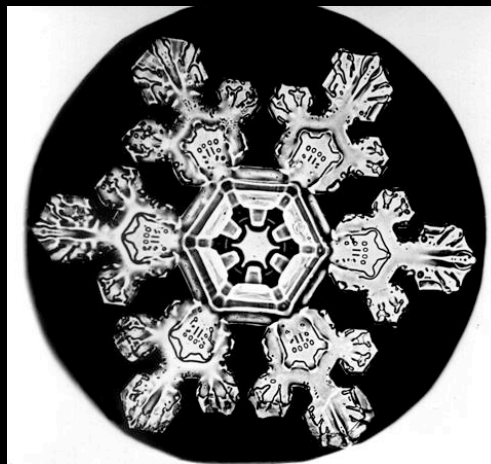
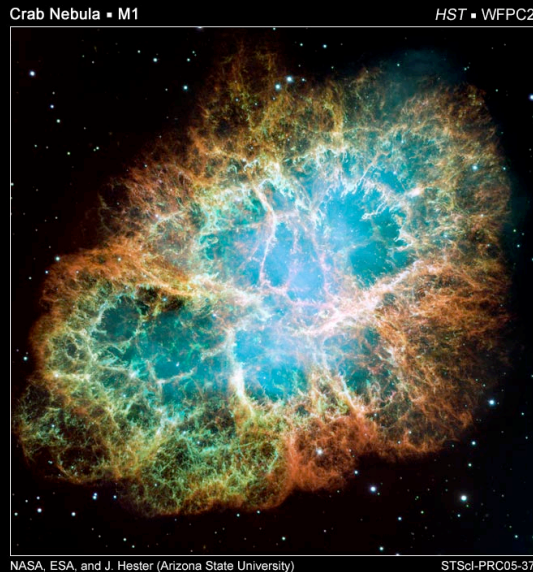
Lecture #5:
“Humanity”

April 29nd at 7 pm
(same location - 71 Cramer)



“This same spectacular transformation continued into the future, carrying these atoms into the form of the galaxies, and then into that of the molecules and cells, and then into the form of the human and the elephant and the blue spruce and the Mississippi River.”

— Brian Swimme



“Sometimes I think we’re alone in the universe, and sometimes I think we’re not. In either case the idea is quite staggering.”

— Stanley Kubrick
(apparently quoting Arthur C. Clarke)

Questions to keep in mind...

Is life another natural stage in the development of complexity in the universe?

What IS life?!?

Does life appear throughout the universe, or are we unique here on Earth?

How did life begin?

Did Earth-based life originate on Earth, or somewhere else?

What is life?

One definition -

“Life is a self-sustaining chemical system capable of Darwinian evolution.”

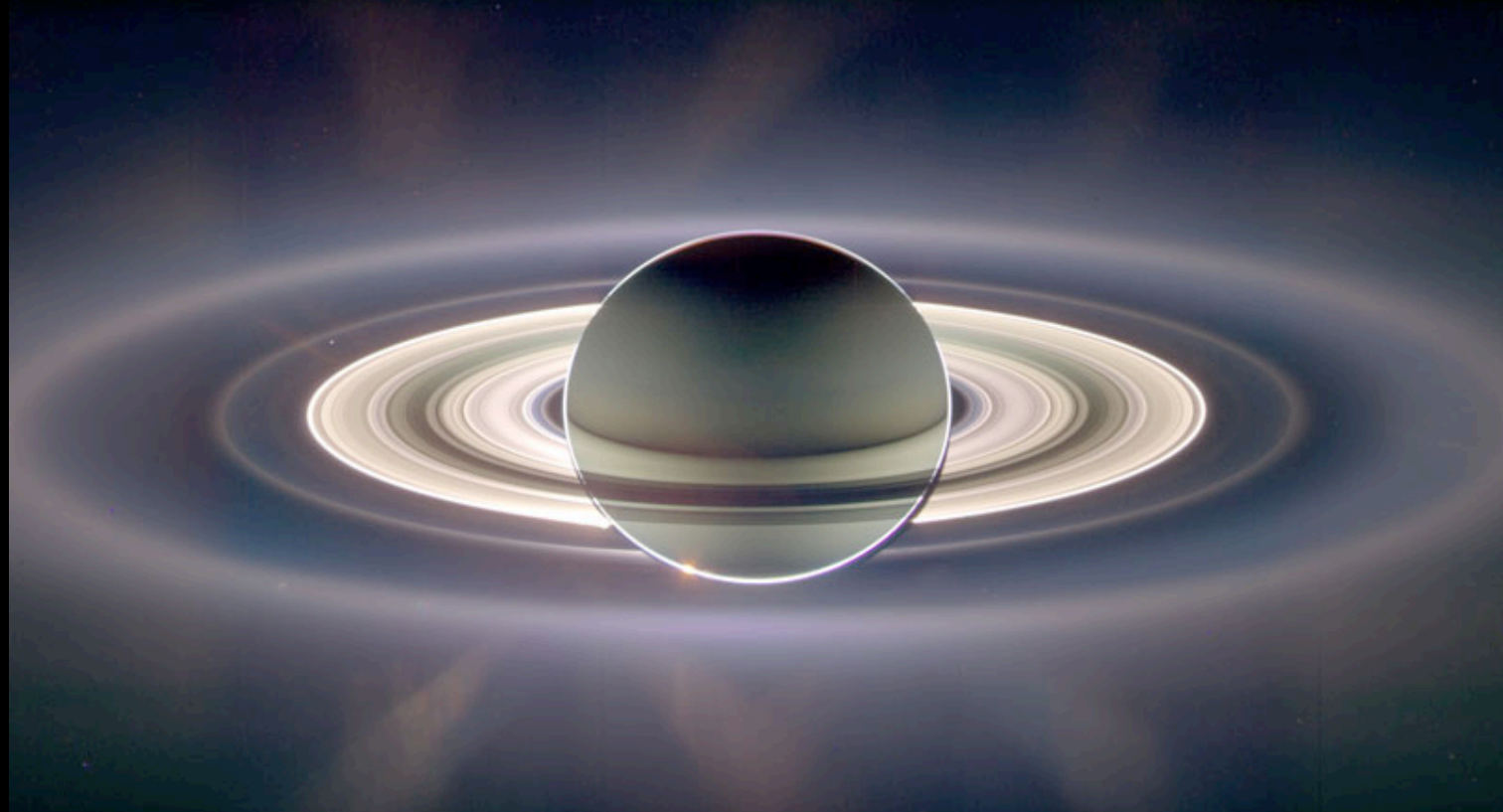
(Gerald Joyce/NASA committee)

EXERCISE 13.1 Creepy Thought Experiment

Imagine that you had a machine that could disassemble someone, atom by atom, and keep a record of where each atom goes. Then you could put the person back together later with the same machine. Assume that it all happens in about a minute, so that your guinea pig person dies from being disassembled, rather than from hunger or suffocation. Pick someone that you'd like to have out of the way for a while, but you don't necessarily want to kill, and run this thought experiment with him or her in mind. The question is, When you reassemble the person, will he or she be alive again? Answer in four parts:

- (a) What's your immediate instinctual answer? And what's the first reason that pops into your head?
- (b) Now give the problem a little more thought. Give your answer, and justify it. For example, if you say yes, then explain how the reassembled collection of atoms starts functioning again. If you say no, then explain what prevents the reassembled person from functioning again.
- (c) Does it make it any easier to consider something simpler than a human being? Try one or more alternatives, like a cat, or a tree, or a single-celled organism.
- (d) Change the question so that you're no longer disassembling the person first. Instead, you're simply assembling a person or a tree from a collection of all the correct atoms, which you put in all the correct places, but these particular atoms have never been in a living thing before.

There is no correct answer to any of this. We don't have the technology to perform this experiment (yet!). Just try to flesh out what you *think* would happen, and try to understand why you think whatever you think.



Video on synthetic life -

<http://www.pbs.org/wgbh/nova/sciencenow/3214/01.html>

Website on life's origins -

<http://exploringorigins.org/index.html>

the non-life-to-life transition at 4.0 +/- 0.1 billion years ago

a “dead” bag of
chemicals

???

an “alive” bag of
chemicals



**Lehman: “*the origins of life is a chemical problem
in a biological context*”**

the stuff of life

- proteins (amino acids)
- lipids (alcohols & fatty acids)
- carbohydrates (sugars)
- nucleic acids (nucleotides)
- small molecules (water, metals, ions, etc.)

all are polymers formed by condensation reactions
...IN THE "PRIMORDIAL SOUP"?

the elements of life

s-Block		d-Block										p-Block						He			
H																					
Li	Be																			Ne	
Na	Mg																			Ar	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn									Kr	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd									Xe	
Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg									Rn	
Fr	Ra	Lr	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub										
		f-Block																			
		* La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb						
		** Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No						

sum = about 22 elements

small molecule precursors

Found in space:

- hydrogen cyanide (HCN)
- acetylene ($\text{HC}\equiv\text{CH}$)
- formic acid (HCOOH)
- formaldehyde (H_2CO)
- acetic acid (CH_3COOH)
- ammonia (NH_3)
- water

Found in comets & meteorites:

- amino acids
- lipids
- PAHs
- water

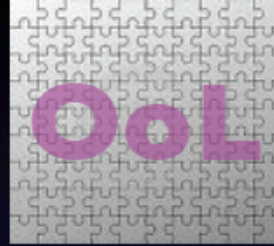
abundant on early Earth: hydrogen sulfide, CO, water, methane, salts, etc.

Organic Molecules in Space :)

<http://www.abc.net.au/news/newsitems/200604/s1607840.htm>

<http://www.comedycorner.org/1.html>

piecing together the jigsaw puzzle through experimentation



- Stanley Miller (1953) – *made proteins from inert gasses*
- Juan Oró (1961) – *made adenine from hydrogen cyanide*
- Jerry Joyce (1991) – *evolved RNA molecules in a test tube*
- Jim Ferris (1996) – *used clay to make RNA*
- Dave Bartel (2001) – *evolved an RNA replicase*
- Jack Szostak (2003) – *made artificial cells*

Darwin's “Warm Little Pond”

“It is often said that all the conditions for the first production of a living organism are now present, which could ever be present. But if (and oh! what a big if) we could conceive in some warm little pond with all sorts of ammonia and phosphoric salts, light, heat, electricity, etc., present, that a protein compound was chemically formed ready to undergo still more complex changes, at the present day, such matter would be instantly devoured or absorbed, which could not have been the case before living creatures were formed.”



Darwin, 1871,
unpublished letter

References/Suggested Reading

- Niles Lehman & Stacey Halpern lectures from last year - <http://www.beavton.k12.or.us/media/district/psu/index.html>
- Christian, *Maps of Time*, ch 4 (2004)
- Duncan & Tyler, *Your Cosmic Context*, ch 13 (2009)
- Carroll, *Remarkable Creatures* (2009)
- * Collected resources: <http://www.scienceintegration.org>
(click on “our cosmic history series” link)

Video - Stacey Halpern's lecture from last
year

“Emergence of Complex Life”

Thanks to...

- Oregon Dept. of Education Math/Science Partners Grant
(primary funding for this lecture series)
- Portland State University Center for Science Education
- Beaverton and Hillsboro School Districts
- Pacific University
- Science Integration Institute