Re: Essay: What is Life?

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> From: "Perplexed in Peoria" <jimmenegay@xxxxxxxxxxxxx>

(Responding to your earlier "flip" article first:)

RM> But they don't satisfy the thermodynamic critera I defined above! [snip]
RM> Maybe you can suggest a good wording for my second criterion, the one
RM> which distinguishes living systems from flamelike ...

JM> Hmmm. How about "self−producing" or "self−creating".

What a living system does is make more of itself. Some of itself is aready there at the start, while other of itself is made later by its own actions. Create implies that *none* of itself was pre−existing, which is clearly misleading. Self−producing is possibly OK as a term. But self−agrandizing or self−enhancing or self−incrementing is more accurate. Self−enlarging is not correct because it misleadingly implies the physical size is enlarged, when in many cases all the change is internal, with already−consumed food, already part of the total volume of the creature, getting digested and converted to body tissue, replacing the same volume rather than adding new volume. Unfortnately self−agrandizing has psychological derogatory insinuation, and self−enhancing sounds like the typical male body part spam, and self−incrementing sounds too computer−jargonish. Maybe somebody on alt.usage.english can read this and think of a better term?

> It doesn't much matter to me as long as you don't describe a candle
> flame as at equilibrium, near equilibrium, or getting closer to
> equilibrium. It is none of those things. It is a (dynamic) steady
> state far from equilibrium.

I agree, but on the other hand a flame merely rushes in a free−fall toward equilibrium, converting fuel and oxygen to carbon dioxide and water vapor and thermal energy as fast as possible, making no effort to maintain any particular structure or chemical species away from equilibrium. Even the shape of the flame isn't maintained in the face of arbitrary supply of new food. For example, set a curtain next to the candle flame, and the flame makes no effort to prevent being converted from a candle flame to a curtain fire, and the curtain fire then makes no effort to prevent being converted into a full house−fire, and the house−fire makes no effort to prevent being converted to a full neighborhood fire and then to a full city fire (a la SFO or Chicago). The only thing in common between the original candle fire and the subsequent full−city fire is the presence of lots of heat above a threshold for igniting new cumbustable material, and the equilibrium products of CO2 and H2O etc. There is not a single specific chemical species that is maintained. There's vaporized candle wax in the original flame, but vaporized wood resins in the city fire, not a chemical match. All the non−equlibrium chemicals in the flames are correlated with the food (combustable material) available, not with the type of fire that started it all.

By comparison, even with a single chemical replicator that consumes all the food in the whole ocean, the product of that replicator is highly correlated with the logical bitmask that says which particular species of replictor it was that started the chain reaction, and on a different planet if by chance a different replicator got started, the product would be *that* species of replicator rather than the one on Earth.

And a 500−pound obese human is still recognizable as a humanoid with arms and legs and a gut etc., unlike a candle flame that has grown by consuming a curtain. Even that largest living thing, the fungus that has spread a hundred miles in diameter, still maintains micro−structure just about the same as it did when it was tiny baby fungus.

But if a fire started on another planet, it'd be the chemistry of the food, not the chemistry of the fire, that determined the non−equilibrium chemicals within the flames at any given moment, and a large flame that covered a wide set of fuels would have non−equilibrium chemicals that varied with location to match the local fuel.

So to say that true life, even my hypothetical just barely life (simple replicator i.e. auto−catalytic chemical set or catalytic cycle or catalyst−type cycle), maintains its own specific non−equilibrium chemicals, whereas fire doesn't do that, would seem to be adequate to distinguish the two. To extend the defintion to Cairnes−Smith clay crystal patterns, we might say "species of atomic−arrangement pattern" instead of "species of chemical". To include computer viruses, we might just say "species of pattern".

I think generally we need to make this a two−step definition. First we define "energy system" to be any local collection of particles which by group action maintain a local condition statistically distinguishable from the nearby surroundings. That definition would include candle flames and hurricanes, as well as all forms of life. For example, the different atoms within an auto−catalytic molecule would work together to make the catalytic action that maintains the numbers of that molecule in the local area (before they drift away). Take away a few of those atoms and the group effort no longer achieves that result, thereby proving it was group effort rather than just the sum of all the single contributions. Likewise the whole flame, or a significant part of it, is needed to maintain a flame. Take away 90% of a candle flame and the resultant portion dissipates its heat faster than it can ignite new material to build the heat back up, thereby proving it was group effort that maintained the flame.

Then we add some restrictions that exclude things we don't want counted as "life". For example, we exclude gross thermal energy, and we exclude equilibrium chemicals, and we require that the "life" itself determines the non−equilibrium pattern more than the happenstance of food available, and in the case of a candle flame there's nothing left to satisfy the definition, so the flame fails the definition. For a hurricane, it might be a bit harder to exclude it as a life form.

Side remark: With so many definitions of "life" or "living system" floating around, it'll be difficult to know which definition we're using later. Here's an idea: First we work out a really good definition most of us can agree upon. Then we publish that on a newsgroup. Then we get a Google−Groups−alpha URL for that article, and submit it to tinyurl, and get back a very short alphanumeric string which identifies that article. Then when we want to specify that particular definition of our term we suffix it with the tiny URL string. One problem: As Google−Groups−Alpha sites convert to broken−beta, our URLs become invalid. I don't know any solution to this dilemma except to concoct very short message−IDs for such special purposes, post articles to Usenet using these very short message−IDs, and use the message−ID itself as the suffix for the term defined in that article. We might even make the message−id contain as a sub−string the word being defined!
Imagine Message−ID: 1@xxxxxxxxxxxx for example!
I did a check just now and got back:
Message id or article number 1@xxxxxxxxxxxx not found.
so clearly such short message−IDs aren't all taken yet.

That's the end of my reply to:
http://www.google.com.gr/groups?selm=d9o3n9%241c2%241%40darwin.ediacara.org
Now moving ahead to your not−flip article:
http://www.google.com.gr/groups?selm=d9o3nd%241hr%241%40darwin.ediacara.org
> My other answer was a bit flip, and doesn't really address your
> argument. Let me give a more thoughtful response:

Thank you.

> Trying to separate out an "increase in entropy" in "the chemicals"
> (taken in or already present) strikes me as impossible. You can
> only measure an increase in entropy in the system as a whole. The
> "chemicals" you refer to are continuously being consumed and recreated.

Although the system as a whole always increases in entropy, living systems partition the system into waste portions and self portions, with the the increase in entropy mostly going to the waste portions, while the self portions are kept far from equilibrium. I think this may be a useful distinction between living systems and everything else.

A zircon makes no effort to get rid of entropy, rather it merely impedes entropy from leaking in, but over billions of years a little entropy does leak in from time to time, via dislodging of one or a few molecules of the crystal each time, and the zircon makes no effort to get rid of that that entropy that leaked in, nor to get rid of other entropy to achieve a total of zero increase in entropy.

By comparison an elephant does consume food to make useful energy to get rid of entropy it has slowly accumulated.

> You may be onto something with that "uncontrolled". But all chemical
> reactions, everywhere, run toward equilibrium.

Globally, considering the system as a whole, yes they do, but a living system makes sure the living part does *not* run toward equilibrium, by coupling respiration with chemosynthesis, so that resperation runs toward equilibrium but chemosynthesis doesn't. My hypothetical first chemical replicator likewise overall runs toward equilibrium in the sense of increased entropy, but that portion of the reaction product which is the replicated self clearly does *not* run toward equilibrium, only the "waste" products head in that direction.

> Well, first of all, there is no such thing as a plasma consisting of
> carbon dioxide and water vapor. A plasma, by definition, consists
> of ions (charged particles). There are some ions in the flame, but
> it mostly is a simple hot gas, except that it contains a lot of free
> radicals.

Oops, because candle flames are yellow, I mistakenly assumed that was blackbody radiation, indicating they were about as hot as the surface of the Sun, in which case there'd be no CO2 or H2O as entitites, rather just free ions of C and O and H which later when cooled a bit would recombine to form the usual CO2 and H2O. When I spoke of plasma consisting of CO2 and H2O I actually meant all the atoms of those chemicals which later recombine to form actual molecules, sloppy wording. But as you point out the flame isn't that hot to ionize the chemicals to atoms, rather it's just hot enough to push chemical reactions over their threshold for rearrangement, typically 451 degrees Fahrenheit for book paper to ignite for example, a bit hotter once the flame gets going, but still nowhere near the full−ionization threshold, right? So I stand corrected.

Now what's the situation in an acetyline/oxygen flame as used by welders? Is that actually hot enough to ionize the fuel and oxygen and keep it all ionized for a while before it starts to cool which then releases heat to sustain the temperature? Or is it likewise way below the full−ionization threshold, merely above the activation thereshold?

> the flame (and I am including the darker areas near the
> center of the flame)

I'd like to exclude those darker parts where there's nothing except vaporized partially−decomposed wax, which hasn't yet reached the oxygen−diffusion front, so it hasn't even begun to undergo oxidization yet. By analogy, that vaporized/decomposed non−oxidized−wax part is rather analagous to the food inside our stomach which is merely being stored (with some preliminary decomposition such as saliva turning starch to sugar) but not yet starting to be truly digested (proteins broken into amino acids etc.) nor oxidized (Kreb's cycle) nor used as components for chemosynthesis (new proteins, nucleic acids etc.). The food we've eaten but not yet digested, and the candle wax the flame hasn't yet oxidized, aren't a proper part of our bodies or the flame yet. If the body or flame is converting dissimilar chemicals to like−self chemicals, these are the still−dissimilar chemicals not yet converted to like−self chemicals.

> contains many things besides the end products CO_2 and H_2O. It
> contains vaporized paraffins

I'll exclude that part from discussion, but:

> and partially oxidized parafins, O_2, N_2, hydroxyl and atomic oxygen
radicals, PAHs, and a "Beilstein" of other things.

I'll exclude the O_2 and N_2 which are input rather than converted, but the rest you list there is sufficient to establish your point.

(This suggests that you might wish to distinguish the candle flame from a living entity by characterizing a "Beilstein". The living entity contains "specific" chemicals; the flame doesn't. Among other things, the flame is racemic.)

Racemic is, in my opinion, irrelevant to this question. I can imagine an A.I. lifeform that discovers how to do photosynthesis and decides that since there's a lot more CO_2 than silicon and cadmium available on the surface of the Earth, and storage of hydrogen is harder than storage of sugars, it should store energy as organic sugars instead of in metallic chemical batteries or fuel−cell hydrogen tanks. But to avoid being "appetizing" to potential preditors, it might deliberately synthesize a racemic mix of sugars, and likewise deliberately synthesize a racemic mix of enzymes to run Kreb's cycle.

However a living system not just having but actively maintaining a specific set of chemicals is close to what I said on this topic, so I think we're converging on agreement as to what distinguishes the two kinds of energy systems, living and non−living. Actively maintaining a specific set of far−from−equilibrium chemical or physical or other patterns as "self", while driving the resporation by discharging entropy in "waste" chemicals, characterizes life.

At a finer level of distinction, life could be divided into autotrophic, heterotrophic, and obligatory parasitical (such as computer viruses).

> A molecule, on its own, cannot be placed on a spectrum of closeness
> to equilibrium. A molecule is near or far from equilibrium only in
> the context of an environment of things that it might react with.

Hmm, I suppose that's true if you ignore the gross statistics of the planet's ecosphere. In an enviornment with lots of hot carbon, CO2 is unstable, tending to react with the carbon to form CO. In an environment with lots of free oxygen, CO is unstable, tending to react with the oxygen to form CO2. The same goes between ferrous and ferric iron surrounded by lots of hot hydrogen sulfide or oxygen. So we must look to the global environment to say what is near equilibrium in that environment and what is far from equibrium. In our current 20% oxygen atmosphere, CO is unstable whereas CO2 is stable. In the primordial environment, with no free oxygen, but lots of free H2 and H2S in addition to the usual CO2 and H2O, a few chemicals would become stable or unstable compared to the current environment. However at any particular time, with a big ocean sloshed by tides and wind and convection and meteor/astoroid crashes and volcanism, I think the question of close to equilibrium (stable) or far from equilibrium (unstable or meta−stable) would be pretty much the same worldwide, with just a few local variations. An unstable chemical might survive very long in one part of the environment where there was a local scarcity of it's opposite with with to react, while it might be very unstable and short−lived most anywhere else where there was lots of its opposite chemical locally present. But still, any chemical would be circulated around to encounter its opposite chemical within a few thousand years, so there wouldn't be any chemicals that survived over geological time just because their opposites weren't locally available all that time.
(The one exception would be deep inside rock/crust/mantle where there's virtually zero mobility over medium−geological time. I'm ignoring the iron/nickel/sulfur core of the Earth which is totally irrelevant to OOL discussions.) Is my estimate far off here?

> > There is virtually no coupling where
> > increase in entropy one place causes decrease in entropy somewhere
> > else.
> Sure there is "coupling". There are convective flows, for example.

I was referring to chemical and other local patterns. Of course if you include gross physical entropy then convection is an example of coupling, where one unit of fluid falls thereby gaining entropy while another unit is displaced and thereby buoyed up thereby losing entropy, with overall a very slight increase in total entropy. (Did I get the math right in that explanation?)

Can you think of a life−form that somehow maintains its lofty position on a mountain top, by leveraging off rain falling down, or wind blowing by, but which does *not* maintain any physical structure such as mechanical "machines" (levers, inclined planes, etc.) by which to achieve such convection−like maintainance of high position? Clearly it'd have to be an emergent property that was obligatory parasitical upon some other artifact of life, like a computer virus, but even such a parasitical form is hard for me to figure out without it also somehow collecting physical material from the host to use to build machines to maintain the lofty position.

> Candle flames turn over their contents fairly rapidly. Living things
> do so more slowly. But there are no molecules in living things that
> "avoid the fall indefinitely". Certainly not in the OOL scenarios
> that motivate your attempt to define "life".

Hey, I'm not Tom Hendricks, who considers absolute stability, like a zircon, resisting the intrusion of entropy, as the key to OOL. I'm Robert Maas, the guy who dismisses absolute stability as a criterion, considering instead fecundity to replace that which is lost faster than it's lost. No individual molecule can survive indefinitely. But a *species* of molecule can synthesize replacements of the same species faster than the old ones are lost, thereby maintaining the *quantity* of the species as immortal even while any individual molecule is mortal.

A candle flame doesn't maintain any particular species of molecule, except near−equilibrium waste such as CO_2, whereas living systems do maintain specific (*1*) far−from−equilibrium chemical species, not by holding tight against decomposition, but instead by fabricating replacements fast enough to replace those decomposed. (Shit, this reminds me of the Islamic Jihad policy of maintaining armies of suicide−bombers, not by protecting the soldiers it already has, but instead by recruiting new members faster than the old ones kill themselves. Same strategy as for soldier ants in an ant colony. Hmm, I wonder if we can appeal to Islamic pride, that they have lowered themselves from humanhood to anthood, to shame them into stopping their suicide bombings?)

> There is no "maintenance" of molecules away from equilibrium. All
> biochemicals are in a dynamic steady state in which creation
> and destruction are balanced. I am aware of only one biochemical
> that is actively "maintained" − DNA. There are repair processes for
> DNA. Everything else is being continually turned over.

(No, I'm not going to pull that William Windom line from StarTrek−TOS Doomsday Machine: "Don't you think I know that!?!")

Repeating my point: Each individual molecule (except some DNA) are mortal, it's the species of molecule that is synthesized fast enough to replace loss to thereby avoid depletion of the total quantity of that species of molecule, thereby achieving immortality for that species. The quantity of such members of any such maintained species is far from equilibrium and is forcibly maintained far from equilibrium. It's like you have a bunch of wooden ducks in an arcade, and people are occasionally shooting them down, but the manager of the booth is setting them back up fast enough that the overall situation of wooden ducks (or bowling pins) is maintained far from equilibrium.

> ISTM that your attempt to use your second criterion to exclude
> candle flames fails.

The forced (entropy−Ieveraged/coupled−reaction) maintainance of a set of chemical species far from equilibrium? What's wrong with that??

> 1. Give a good thermodynamic characterization of a "Beilstein".
> Candle flames are Beinsteins, living things are not.

So just add your word "specific" to what I said before, yielding the statement above, which I've flagged as (*1*) now before posting. OK?

> 2. Distinguish based on "control". Living things use enzymes
> which can be "turned on and off". (I could live with a definition
> of OOL which calls a metabolism based on uncontrolled enzymes
> "pre−life" and only calls it "life" when one of the enzymes
> becomes sensitive to the state of the environment).

Computer viruses/trojans have virtually nil control. They run rampant as fast as resources become vulnerable and known. I wouldn't want to exclude them from the definition. How about we distinguish between "just barely life" such as my auto−catalytic cycle or computer viruses/trojans run amok, and "fully−regulated life" which evolves much later after trapped−in−micro−ecosystem results in the evolution of endosymbiotic cooperation and biochemical pathways?

> 3. ... 4. ... 5. ...

(We agree those aren't very good ideas, so I'll just drop them now.)

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- Prev by Date: ***Re: Speciation News...***
- Next by Date: ***Re: entropy and bio−evo***
- Previous by thread: ***Re: The shape of inbreeding/outbreeding depression***
- Next by thread: ***Re: History of genetic elements?***
- Index(es):
    - ***Date***
    - ***Thread***