

## Comment

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### Defining Life: Products or Processes?

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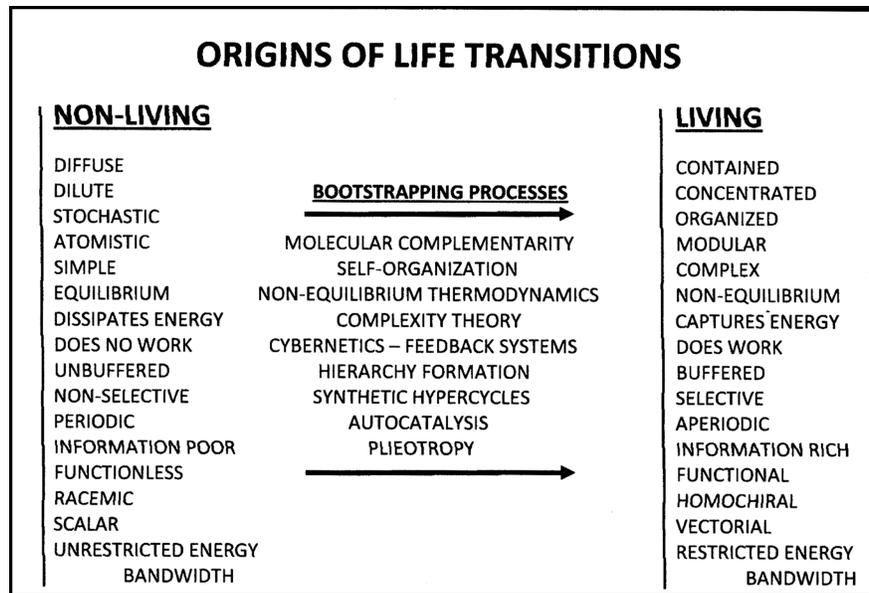
Trifonov's study of the language used to describe living systems (1) is an eye-opening glimpse into the assumptions underlying much of origins of life research today. Unfortunately, for someone with a putative interest in words, Trifonov's attempt to create categories of words often suffers from a lack of sensitivity to the precise meanings of words, as becomes evident in the meta-categories he invents for analyzing his findings. Evolution and change are not the same thing as any embryologist will tell you. Many things change without evolving. Any physicist would cringe to see "force" subsumed under "energy": The equation  $f = ma$  has no energy term! These misunderstandings are not, of course, all Trifonov's, but undoubtedly represent fundamental problems in how biologists misunderstand the principles applicable to describing living processes. Such misunderstandings are themselves troubling.

Unfortunately, these misunderstandings extend beyond words to fundamental principles as well. Trifonov's definition of life as given by Darwin and Oparin are both incomplete and misrepresent both men's actual theories. Darwinian evolution requires not just "reproduction with variations" or "replication with mutation" but also – critically! – non-random selection. If there is no selection or selection is random, there can be no evolution. Discovering the selection processes operant during prebiotic evolution is an unexplored area of great importance.

A second major problem with Trifonov's approach, which to be fair is inherited by him from his sources, is that it focuses on properties instead of processes. The problem of understanding life is not simply describing a system that can replicate and evolve through non-random selection. If these criteria were sufficient, then all human inventions evolve. Indeed, we even have AI systems which employ entities that can acquire computer resources, use them to replicate, change through mutation, and be non-randomly selected. The real problem of understanding life, as Darwin and Oparin understood full well, is how it evolved without a designer or programmer. Thus, the issue of what characterizes the properties of a living system is subservient to the problem of how to evolve such properties through natural processes that existed before any of the properties unique to life had themselves yet evolved. Clearly, whatever this process was, it had to be employ a series of bootstrapping steps in which each new form of organization was able to perform newly emergent functions. Describing and testing such an emergent process is a fundamentally different, and far more difficult, problem than describing the characteristics of living systems that resulted from it (2-4).

Indeed, restating the problem as one of processes rather than properties yields a very different set of criteria for what it means to understand life and consequently a very different set of terms for describing it. Some of these criteria are listed in the following table, which I published recently (5). Notably, very few of

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the terms in the Table occur in any of the lists summarized by Trifonov, demonstrating how very different the process approach to understanding life is as compared with the properties approach.

The processes approach to understanding life also sheds a very different light on current attempts to engineer living systems. We must remember that even in the building of human edifices and inventions, we often make use of scaffolds that leave no traces on the final products they make possible. Imagine trying to explain how to build a skyscraper without knowing about cranes, bulldozers or cement mixers! Any account of the evolution of life must leave open the possibility, and even the likelihood, that life itself benefited from metaphorical “scaffolds” that have long been discarded yet were essential to permitting living organizations to emerge. So even if we could manufacture in a laboratory each and every component of a cell from its membranes to its metabolic machinery and its chromosomes, and then mix these engineered components together to produce a functional cell, this would tell us nothing about how life evolved. Even if we keep deleting genes until we reach some apparent minimum without which a cell

cannot function, this tells us nothing about how that minimal set was elaborated, integrated, and selected from the set of molecules and genes that nature elaborated on its random walk toward life. So in defining life, we have to be clear about why we want to define life: is the purpose to be able to make and modify life, or is it to understand how life itself came into existence? Do we want to engineer life’s products or recapture the processes of evolution itself? These are two very distinct questions that will require very different approaches. Unfortunately, too much of recent research in origins of life has confused or even conflated the two. Perhaps Trifonov’s study will prompt us to reconsider which questions are of most interest.

#### References

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