Astrobiology as an Emerging Science: What does it tell Philosophers?[i]

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> "The known is finite, the unknown infinite; intellectually we stand on an islet in the midst of an illimitable ocean of inexplicability. Our business in every generation is to reclaim a little more land." A Quote from T. H. Huxley
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> (Quoted in Alan Guth's *Inflationary Universe*,
> Addison-Wesley Publishing Company, New York, 1997.)

Astrobiology is an emerging science, which both intersects and overlaps with numerous disciplines like physics, astronomy, biology, geology, paleontology, chemistry, and biochemistry. Intersections with several disciplines have helped this new disciple to propose theories of origin of life (TOL) in the development of this new discipline. We will discuss how theories in an emerging science like astrobiology provide an opportunity for philosophers of science to examine whether their celebrated criteria of theory choice could be applied to TOL. We contend that the criteria of theory choice are not applicable to astrobiology with regard to the TOL.

Philosophy of science offers a meta-theory of *all* scientific theories. Depending on one's stance toward theories, a philosopher adopts a specific philosophy of science toward all theories. Her key jobs, as a philosopher, are (i) to ask questions about anything including scientific methodology, & (ii) if possible make recommendations to scientists regarding what should be done about their methodology. Previous good theories of science teach philosophers about what features of a theory should be considered good. Philosophers then recommend them to the next generation of scientists. Some examples of good theories are Newton's theory of gravitation and Einstein's theory of relativity. They are good theories in the sense that they are able to unify diverse phenomena under one rubric. They are both testable and make surprising predictions. To explore this point, we will first compare Newton's theory with Einstein's theory and then discuss why and in what sense the latter is clearly better than the former. What we learned from these theories is that some of the criteria of theory-appraisal are, (i) the role of unifications, (ii) the testability criterion, (iii) the feature of predictability, and (iv), the feature of consistency

When we apply these features of theory choice to the theory of double helix, we find that the latter satisfies the features of a good scientific theory. We observe that in the case of the theory of double helix it is able to unify biology and chemistry together along with obeying three key features of theory choice. (I) The theory is testable because of the X-ray diffraction of DNA crystals showed that DNA has a helical structure. (II) It is able to predict, among other things, the sequence of bases in the DNA strand that will complement the single strand DNA shown. 5'-C-

G-A-A-T-C-C-T-A-3'.(III) It is consistent with the contemporary knowledge of science. However, there arises a problem for the application of the criteria of theory choice to the emerging science. By an "emerging science," we roughly mean, it to be a promising research area which often has several anomalies to solve and is in constant flux due to the impact of new data. Note that like any science, in astrobiology, hypotheses are proposed, experiments constructed, theories refined, according to the data, and subsequently new experiments developed. However, some parts of astrobiology are speculative and rest on incomplete data as it is expected because it is an emerging field of science. These parts of astrobiology of both being speculative and resting on incomplete data are the ones that both pose a challenge for and test the celebrated criteria of theory choice.

We will consider two emerging theories in the origin of life issues: (i) The RNA World Theory (RWT) & (ii) the Metabolism First World Theory (MWT). The RWT adopts the major function RNA plays in the study of the origin of life. It proposes, based on several experiments, that RNA molecules could perform both catalytic properties similar to enzymes called "ribozymes". In theory, since RNA could store genetic information and act as catalysts, they would make proteins unnecessary for simple life. Hence, a simpler "RNA world" could have preceded the DNA-plus-protein world of today. The MWT, in contrast, lays emphasis on the minerals' role in protecting, supporting, selecting and doing catalysis on its way to generating the first life. There are, however, two drawbacks with the RWT. (i) The reaction sequences in the RNA world have been conducted in labs and they are found to be inefficient. Creation of the RNA itself is a sticking point, and the question arises, "Who did create the RNA (Shapiro, 2007)?" (ii) The RNA has been doing double duty: (i) catalyzing all of the reactions within a reproducing system and (ii) storing the genetic information to complete this replication. We don't have any remnants of RNA occupying all of these roles in today's earth nor do we see such a role left in the fossil records. (Alberts et. al. 2002).

We also notice that there are two defects for the MWT. They are, (i) it sounds good in paper if complex cycles analogous to metabolic cycles could have operated before the appearance of enzymes since it would have solved the material difficulties associated with the origin of life. However, it is *not* a point of *logical possibility*. It is rather a *point* about chemistry. (Orgel, 2008) (ii) Those complex cycles have to be very efficient because each reaction relies on its previous input for its subsequent reaction. It would take eons longer to carry out those reactions with low concentrations than they take in a lab in which molecular concentrations are synthetically raised. (Orgel, 2008, Ross, 2008) Early earth might not share the same molecular concentrations as lab experiments would describe them to be in the MWT.

What we have learned so far from an emerging science like astrobiology is that none of the TOL clearly predicts several phenomena, which are testable. RNA cannot replicate an entire cell, nor can complex anabolic metabolic systems cycle without the use of enzymes. We have yet to talk about unifications with regard to these theories because we don't know which diverse phenomena to be unified under either of these theories. Our take home lesson is that the criteria for theory-choice don't fit nicely with the theories of TOL at this present stage. Our analysis provides us with a better grasp of how to characterize an emerging science. In addition to what we have already noted about emerging sciences, we state also that they are often inconsistent with the existing knowledge and lack three features of a good theory evidenced by astrobiology. For example, they lack (i) surprising predictions, (ii) substantial testable results, (iii) and finally, unifying power.

We then compare the state of the TOL with theories in neuroscience, which is another emerging science. We find that emerging sciences have gradations of development that could be understood in terms of a scale from 0 to 1 on a real number line. Even though, the TOL *not* exactly like theories (better conjectures) in neuroscience, they are further from some full-blown theories of sciences like the theory of double helix or even the Newtonian theory. We consider possible objections to our argument and then dispense with them because of a lack of good reason.

Russell worries that when a disciple gets specialized, it becomes science leaving the domain of philosophy forever (Russell, 1912, reprinted 1997). Thus, the domain of philosophy gets shrunk. In astrobiology several specialized disciples converge into one by becoming a less specialized discipline giving room for philosophers to speculate. Recall Huxley's quote: "our business in every generation is to reclaim a little more land." Our paper is an example how philosophers are able to speculate about the status of astrobiology as an emerging science. Thus, philosophers are, however, able to gradually reclaim the land that was lost to the scientists of the previous century, dispelling Russell's century old worry.

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