The search for life and a new logic

Douglas Scott and Ali Frolop

Dept. of Physics & Astronomy, University of British Columbia, Vancouver, Canada

(Dated: 1st April 2020)

Exploring the Universe is one of the great unifying themes of humanity. Part of this endeavour is the search for extraterrestrial life. But how likely is it that we will find life, or that if we do it will be similar to ourselves? And therefore how do we know where and how to look? We give examples of the sort of reasoning that has been used to narrow and focus this search and we argue that obvious extensions to that logical framework will result in greater success.

I. INTRODUCTION

Motivations given for Solar System exploration missions, as well as for studies of exoplanets, often have the search for life at the very top of the list. Picking some examples, the stated science goals for the whole of NASA’s Mars Exploration Program are to “study Mars as a planetary system in order to understand the formation and early evolution of Mars as a planet, the history of geological processes that have shaped Mars through time, the potential for Mars to have hosted life, and the future exploration of Mars by humans”,[1] while in Europe “The goals of ExoMars are to search for signs of past life on Mars”.[2] Elsewhere in the Solar System, the aims of the Dragonfly mission to Titan are “to search for chemical signatures that could indicate water-based and/or hydrocarbon-based life”[3] and the Europa Clipper will “investigate whether the icy moon could harbor conditions suitable for life”. Moving further afield, “The Origins Space Telescope will trace the history of our origins from the time dust and heavy elements permanently altered the cosmic landscape to present-day life … How common are life-bearing worlds?”[4] and “The Habitable Exoplanet Observatory is a concept for a mission to … search for signatures of habitability such as water, and be sensitive to gases in the atmosphere possibly indicative of biological activity, such as oxygen or ozone”.[5]

Beyond these few examples, there are countless others. In general, astronomers cannot talk about planetary exploration or exoplanetary observational studies for more than a couple of sentences without mentioning the search for life.

Is this reasonable? Is there no motivation for studying a planet other than to search for life? While some cynical people might suggest that the reasons for this single-minded focus are sociological or political,[6] we are merely scientists, and so in this paper we will concentrate only on what rational thinking can say about this question. Let us turn to the most basic aspect of the scientific process, namely logic. There is a famous syllogism that illustrates how logical reasoning works:

• A All elephants are grey.
• B Mice are grey.
• C Therefore mice are elephants. [8]

The search for life elsewhere in the Universe follows a similar form of dialectical thinking:

• A The Earth has life.
• B Some other places are like the Earth.
• C Therefore these other places have life.

We will suggest that this is not only logically sound, but that extending such reasoning gives us a way to select specific places where life is much more likely to be found, as we will discuss in Section V.

II. HISTORICAL DIGRESSION

First, let us go back to the time of ancient Greece, when several philosophers, notably Leucippus[10], Democritus and Epicurus, argued that the Universe was large and contained a multitude of life-bearing worlds. This idea of “Cosmic pluralism” was continued by Middle Eastern scholars and was promoted in Europe by Giordano Bruno, among others. It was formalised in the 1686 book “Entretiens sur la pluralité des mondes”[11] by Bernard Le Bovier de Fontenelle. Deeply intertwined with religious thinking[12], the basic concept was that the Creator would surely not have made all these worlds without purpose, and hence each world must have been made for its inhabitants.

As Sir David Brewster[13] put it, when “we trace throughout all the heavenly bodies the same uniformity of plan, is it possible to resist the influence that there is likewise an uniformity of purpose; so that if we find a number of spheres linked together by the same bond, and governed by the same laws of matter, we are entitled to conclude that the end for which one of these was constituted, must be the great general end of all, – to become a home of rational and God-glORifying creatures”. To rephrase this argument:

• A The Earth was made for humans.
• B Other planets exist.
• C Therefore there are beings on all other planets.
This “plurality of worlds” and cosmic-abundance-of-life concept was popular in the 17th, 18th and 19th centuries. It was promoted by such luminaries as Adams, Herschel, Huygens, Locke, and Newton. Camille Flammarion’s 1862 book specifically devoted to the topic, “La Pluralité des mondes habités” [14], went through 33 editions in 21 years and includes statements such as “we who inhabit this world are only a few out of all the worlds”.

In 1837, popular astronomy author Reverend Thomas Dick [15] went through a series of five arguments for life on other worlds in the Solar System, leading to an estimate that there were 21,894,974,404,480 inhabitants in total [16]; he did not include the Sun in his calculation, although he acknowledged that its surface area would allow for a larger number of inhabitants than all of the planetary bodies. However, William Herschel had already stated that “we need not hesitate to admit that the sun is richly stored with inhabitants” [17]. Moreover, astronomer Johann Bode [18], describing the inhabitants of the Sun, stated: “Who would doubt their existence? The most wise author of the world assigns an insect lodging on a grain of sand and will certainly not permit . . . the great ball of the sun to be empty of creatures and still less of rational inhabitants who are ready gratefully to praise the author of life”.

Herschel also talked about the Moon, stating in 1780 that there was a “great probability, not to say almost absolute certainty, of her being inhabited” [19] and in 1795 he added that “the analogies that have been mentioned are fully sufficient to establish the high probability of the moon’s being inhabited like the Earth”. [20] It had already been known since the time of Galileo, that the Moon possessed seas and volcanic craters. However, further evidence of life appeared in a series of articles published in The Sun newspaper in New York in 1835 [21], based on new observations by William Herschel’s son John. These articles discuss how forests, fields and beaches could be seen on the lunar surface, and with a little more scrutiny, bisons and sheep, as well as bipedal beavers, blue goats, unicorns and man-bats. [22]

Hence we see that, during the 19th century, the Solar System was understood to be teeming with a great variety of living creatures, and presumably the rest of the Universe also. Following the usual logic, William Herschel’s final conclusion was that “if stars are suns, and suns are inhabitable, we see at once what an extensive field for animation opens itself to our view”. [23]

III. MARS

Proponents of the study of the biota of Mars are in good company, since they are following the same lines of reasoning as the champions of “cosmic plurality”, namely

- A Earth has life.
- B Mars is similar to Earth.
- C Therefore Mars has (or did have) life.

Since the 17th century, we have known that the rotational period of Mars is approximately the same as the Earth’s. Over time, improvements in the measurements grew along with the ideas of “cosmic plurality”. Hence, as it became clearer that a Mars day is very similar to an Earth day, there was growing obsession with the question: is there Life on Mars? [24] This quest was also encouraged by apparent evidence for water on the planet, including the famous canals seen by Percival Lowell. [25] Thus followed decades of Martians appearing in books, motion pictures and radio broadcasts. [27]

More recently, many missions to Mars have focused on the search for evidence of biological activity. Although there are continuing claims that such evidence has been found, the general consensus is that Mars might be barren today. But since Mars is so similar to Earth, and the logic is so unassailable, then if Mars has no life now, it must be that it had life at some other time. Hence attention has focused on looking for evidence of water on ancient Mars.

IV. WATER

Our home planet is about 70 % covered with water and swarming with living organisms (if not necessarily intelligent living organisms [28]). By the now-familiar logic, it is obvious that liquid water is necessary for the development and sustainment of life. In other words:

- A The Earth has water.
- B The Earth has life.
- C Therefore, where there is water there must be life.

“Habitability” then equates to the presence of H2O, not as ice or steam, but in its liquid form. [29] A planet in a habitable region is also referred to as being in the “Goldilocks Zone”. [30]

But how do we know we are looking in the right places for life? We simply defer to the so-called “streetlight effect”, which states that usually the light has been placed in just the right place for you to be able to see the thing you are looking for. This follows the same exacting rules of deduction that we have described above.

V. THE NEW LOGIC

To further extend this line of reasoning, might we not expect that bodies sharing further attributes with the Earth will have a higher chance of harbouring life?

Our planet has several characteristics that make it special. For example, Earth’s orbital inclination is very close to zero [31]—hence we should look for life on planets with almost no orbital inclination. Perhaps we should always focus our attention on the third planet from the star in any exoplanet system, or on the fifth largest planet?

Earth is also the greenest place in the Solar System, suggesting that we should search for life on planets with
the same colour as the Earth. Additionally we only have a single, large moon, which may be beneficial for life, and hence we can ignore planets with too few or too many moons.

A particularly fruitful search may be in any planetary systems we find that initially look like they have nine planets but turn out to have only eight.

However, we have only been considering the obvious reasons that the Earth is special. Following the thinking described earlier in this paper, it is clear that any characteristic similar to Earth’s should make life compulsory, according to pure logic. Hence other bodies whose names also start with the letter “E” should be good bets. In fact this has already been confirmed in the Solar System, where Europa and Enceladus have been highlighted for future searches for life.

Another popular place to look is Titan, and, while it does not start with an “E”, it has the same number of letters as “Earth”, making it another obvious target. Moreover, it starts with the same letter as “Terra”, the Latin name for Earth.

Maybe we should concentrate on places with lots of NaCl, while avoiding those with almost none? As a last suggestion, perhaps planets whose names mean “dirt” in one of their native languages are likely to host life?

We hope that some of these ideas will be pursued by future targeted exoplanet observations, as well as SETI searches. Following the same rigorous logic that has been applied by centuries of researchers of extraterrestrial life, we hope that readers of this paper will come up with visionary ideas of their own.

---

1. mars.nasa.gov
2. www.esa.int/exomars
3. dragonfly.jhuapl.edu
4. www.jpl.nasa.gov/missions/europa-clipper/
5. asd.gsfc.nasa.gov/firs/
6. www.jpl.nasa.gov/habex/mission/
7. Or financial.
8. [We shouldn’t be distracted by the fact that neither elephants nor mice are actually always grey. Notwithstanding, the logic is irrefutable.]
9. [A common way to start explaining physics: “It’s a warm summer evening in ancient Greece . . .”, Cooper S., in “Big Bang Theory”, Ser. 3, Ep. 10.]
10. [Often called the Father of Atomism. If he existed, that is.]
11. “Conversations on the Plurality of Worlds”.
12. [Normally we try to avoid discussing religion in our papers, but, Lord knows, it’s sometimes hard to avoid.]
13. He invented the kaleidoscope. Just saying.
14. “The Plurality of Inhabited Worlds”.
15. Dick T., 1838, “Celestial scenery; or, The wonders of the planetary system displayed; illustrating the perfections of deity and a plurality of worlds”, Harper & brothers, New York, p. 305 and chapter IX.
16. [This number, nearly 22 trillion, has as its prime factors 2, 5, 19, 10067 and 178859. Dr. Frolop is studying the significance of this.]
17. See “The Scientific Papers of Sir William Herschel”, 2013, Cambridge University Press; Herschel was one of the pre-eminent astronomers of his day, being Court Astronomer and Fellow of the Royal Society.
18. [The guy who fit the distances of the six known planets using a function with five degrees of freedom.]
19. Herschel W., 1780, Phil. Trans. R. Soc., Vol. 70, “Astronomical Observations Relating to the Mountains of the Moon”, p. 508.
20. Herschel W., 1795, Phil. Trans. R. Soc., Vol. 85, “On the Nature and Construction of the Sun and Fixed Stars”, p. 66.
21. Reprinted from the Edinburgh Journal of Science. It may be significant that these discussions of the abundance of life appeared in “The Sun”.
22. See Goodman M., 2008, “The Remarkable True Account of Hoaxers, Showmen, Dueling Journalists, and Lunar Man-Bats in Nineteenth-Century New York”, Basic Books, New York.
23. Herschel W., 1795, Ibid., p. 68.
24. Bowie D., 1971.
25. [The linear features were first spotted by the astronomer Giovanni Schiaparelli and the fever was stoked by a mistranslation of his use of the Italian word “cannelloni”.
26. [It doesn’t take much imagination to consider the possibility that the canals of Lowell’s day had simply dried up by the time of the first Mariner flights of the 1960s.
27. [For something involving all three media, see “Who’s Out There?”, 1973, NASA documentary.
28. Python M., 1983, “And pray that there’s intelligent life somewhere out in space . . .”.
29. [Which we call “water”.
30. [Perhaps the name is because the porridge in some versions of the story is very watery.
31. [Some people claim that it’s exactly zero.
32. Seager S., et al., 2005, Astrobiol., 5, 372, “Vegetation’s Red Edge: A Possible Spectroscopic Biosignature of Extraterrestrial Plants”.
33. Asimov I., 1973, “The Tragedy of the Moon”, Doubleday, New York.
34. [Five letters are still good.
35. Which we call “water”.
36. Some people claim that it’s exactly zero.
37. Seager S., et al., 2005, Astrobiol., 5, 372, “Vegetation’s Red Edge: A Possible Spectroscopic Biosignature of Extraterrestrial Plants”.
38. Asimov I., 1973, “The Tragedy of the Moon”, Doubleday, New York.
39. Four letters are still good.
40. The salt of the Earth.
41. Since they’re like nothing on Earth.
42. Sanchez, R. & Smith M., 2015, Ser. 2, Ep. 10.
43. [See some earlier papers with related ideas: Scott D., Frolop A., 2006, astro-ph/0604011, 2007, astro-ph/0703783, 2008, arXiv:0803.4378, 2014, arXiv:1403.8145; Ali Frolop, Ali and Frolop. [arXiv:1504.00108]; Frolop A., Scott D., 2016, arXiv:1603.09703; Scott D., Frolop A., 2019, arXiv:1903.12412.
44. Any extraterrestrial lifeforms reading this paper who want to point out that their planet is nothing like Earth, should email the second author, Dr. Frolop.