Astrobiology in Science and the Arts

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Abstract. The search for life in the universe has reached a pivotal stage. After centuries of pure speculation, a breakthrough came with the first detection of an exoplanet in 1995. Since then, the number of exoplanets has soared to nearly 6000 and hundreds of Earth-like planets have been discovered. The projection is ten billion habitable worlds in our galaxy alone, each with the potential to host biology. Research now centres on the challenging task of detecting the global alteration of an exoplanet atmosphere caused by microbial life. Meanwhile, the search for extraterrestrial intelligence continues by searching for evidence of advanced technology on remote worlds. The first detection of life beyond Earth would be the most profound scientific discovery of the century. The science of astrobiology involves understanding the extent and origin of life on Earth and pursuing strategies to detect life off-Earth. Astrobiology permeates popular culture through depictions of aliens in books, television, and films, and with a widespread public belief that UFOs represent visits from aliens. Astrobiology in the Arts runs the gamut from fanciful aliens in science fiction and fantasy to realistic representations of exoplanets by astronomical artists. This paper focuses on creative responses to the search for life in the universe that capture important elements of the science of astrobiology. Examples are taken from literature, film, television, music, and the visual arts. Imaginative renditions of life beyond Earth should be taken seriously, because everything from a fungal spore to a redwood tree to a blue whale is the result of a single biological experiment. Life on any of the myriad exoplanets in the cosmos might be stranger than we can imagine.

Introduction

The search for life in the universe addresses one of the most profound questions in all of science. Since the Copernican Revolution, discoveries have conformed to the 'principle of mediocrity', where there is nothing special or atypical about our location in the universe.[1] It would therefore be surprising if the Earth were the only planet to host biology. Astrobiology is concerned with the origin and evolution of life on Earth, in addition to the prevalence of habitable exoplanets, which are planets orbiting stars

[1] Alexander Vilenkin, 'The principle of mediocrity', *Astronomy & Geophysics* 52, no.. 5 (October 2011): pp.5.33–5.36, https://doi.org/10.1111/j.1468-4004.2011.52533.x.

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beyond the Solar System. The current research emphasis is identifying the best strategies in the search for life beyond Earth.[2] Life has not yet been discovered beyond Earth, but astrobiology took a huge leap forward with discovery of exoplanets in 1995,[3] leading to the award of a Nobel Prize in 2019.[4] The rapid pace of exoplanet discovery reveals that there are as many planets as stars in the Milky Way galaxy. Earth-like planets are common, some of which are in the habitable zones of their stars.[5] Habitable locations also exist elsewhere in the Solar System, such as the sub-surface of Mars and the giant planet moons Europa, Titan, and Enceladus.[6]

Even without evidence for life beyond Earth, there are logical reasons to expect that it exists. Figure 1 shows indirect lines of evidence indicating that biology might be common in the universe. The building blocks of life can form easily from simple chemicals, in nature and in the lab, as shown in famous experiments by Stanley Miller and Howard Urey in 1952.[7] Also, those chemical ingredients are widely available in the universe across time and space, suggesting that biochemistry is universal.[8] Furthermore, biology started almost 4 billion years ago, when conditions on the Earth were very inhospitable.[9] Terrestrial life tolerates and even thrives in a very wide range of physical and chemical conditions, such as pressure, temperature, water content, and pH.[10] Finally, using a simple definition of

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[2] Charles Cockell, *Astrobiology: Understanding Life in the Universe* (Hoboken, NJ: Wiley-Blackwell, 2020).
[3] Michel Mayor and Didier Queloz, 'A Jupiter-Mass Companion to a Solar-Type Star', *Nature* 378 (1995): pp. 55–59.
[4] Michel Mayor, 'Nobel Lecture: Plurality of Worlds in the Cosmos: A Dream of Antiquity, a Modern Reality of Astrophysics', *Reviews of Modern Physics* 92 (2020): pp.1–12.
[5] Steve Bryson, et al., 'The Occurrence of Rocky Habitable Zone Planets Around Solar-Like Stars from Kepler', *The Astronomical Journal* 161 (2021): pp.36–49.
[6] Karen Ollson-Francis, et al., 'Editorial: Habitability Beyond Earth', *Frontiers of Microbiology* 9 (2018), https://doi.org/10.3389/fmicb.2018.02645.
[7] Leroy Cronin and Sara Walker, 'Beyond Prebiotic Chemistry', *Science* 352 (2016): pp.1174–75.
[8] Norman Pace, 'The Universal Nature of Biochemistry', *Proceedings of the National Academy of Science* 98 (2001): pp.805–08.
[9] Martin Van Kranendonk, 'Volcanic Degassing, Hydrothermal Circulation and the Flourishing of Early Life on Earth: A Review of the Evidence from c. 3490-3240 Ma Rocks of the Pilbara Supergroup, Western Australia', *Earth-Science Reviews* 74 (2006): pp.197–240.
[10] Pabulo Rampelotto, 'Extremophiles and Extreme Environments', *Life* 3 (2013): pp.482–85.

habitability, where biology is possible if a planet is at a distance from its star where surface water could exist, habitable locations beyond the Solar System are known to be abundant.[11]

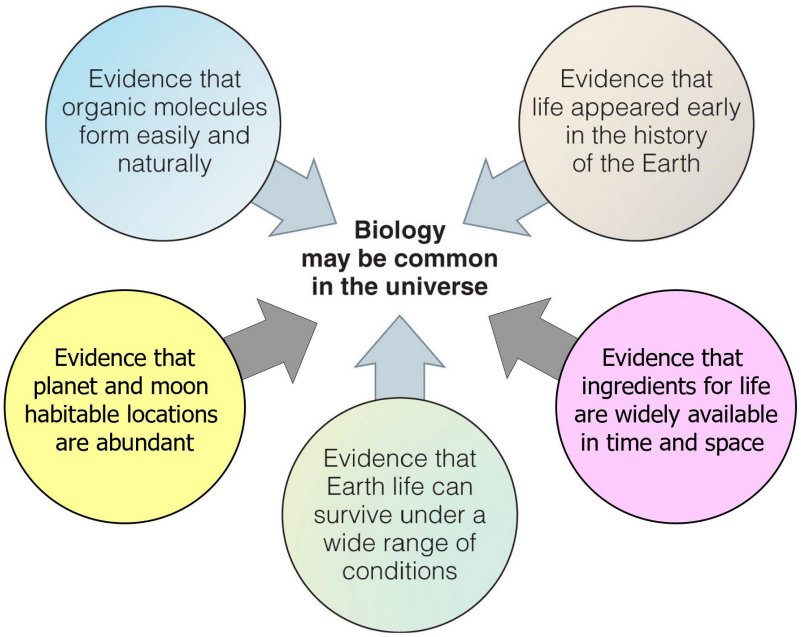

Fig. 1. Indirect arguments indicating that biology might be common in the universe, although no life beyond the Earth has yet been detected (Credit: Chris Impey).

The arguments just made apply to microbial life, which is the dominant form of life on Earth. Public interest tends to focus on advanced forms of life with intelligence and technology. Decades before the first exoplanet was detected, the expectation that biology might be abundant beyond Earth led physicist Enrico Fermi to wonder why intelligent aliens had not been found or made their presence known[12]. With a myriad of planets out there, many of them habitable, and a lot of time for intelligent species to evolve, there must be many of them, he reasoned. He framed the simple question: '"Where are they?' As one explanation for their apparent absence, the idea

[11] Sara Seager, 'Exoplanet Habitability', *Science* 340 (2013): pp.577–81.
[12] Eric Jones, 'Where is Everybody? An Account of Fermi's Question, Technical Report LA-10311-MS', Los Alamos National Laboratory, U.S. Department of Defense (1985).

of a "Great Filter" was proposed.[13] A Great Filter is a hurdle in biological evolution that prevents most, or all, forms of life from evolving to travel through space and become a cosmic species. The filter might operate near the beginning, so that it's exceptionally rare for life to originate even when all the ingredients are in place. It might be at major evolutionary transitions such as forming cells with nuclei or multicellular organisms, or the hurdle of developing technology may be very hard to clear. For example, on Earth, dolphins and elephants are undoubtedly intelligent, but they will never build telescopes or spacecraft. The most ominous filter would be one that lies in our future, instability due to technology. That filter would suggest that intelligent life in the universe is rare, and we are operationally alone.

A central question in the search for extraterrestrial life is: how do we know that biology is the same on an alien world? Life's origin on the Earth involved processes and physical conditions that apply to other planets and moons.[14] Even if the chemical ingredients and biochemical building blocks are similar, higher levels of organization might be radically different. We cannot reasonably expect to find bees or whales or mushrooms or roses on another planet. To use a homely analogy, kitchens may all have ovens and cupboards with similar ingredients, but the meals that get served could vary wildly. Astronomers are constrained to look for extraterrestrial life that has a similar biochemical basis as terrestrial life. If biology is expressed in radically different ways off-Earth, astronomers don't know how to build an experiment to detect it. The open-ended nature of astrobiology sparks the imagination, and it has attracted the attention of artists and others in creative fields. Figure 2 gives one example, where the Kepler spacecraft has yielded a cornucopia of exoplanets with widely varying properties. The rest of this article presents a selection of responses to astrobiology in the media and the arts.

[13] Robin Hanson, 'The Great Filter – Are We Almost Past It?' 1985, http://hanson.gmu.edu/greatfilter.html [accessed 20 October 2024].
[14] David Deamer, *Assembling Life: How Can Life Begin on Earth and Other Habitable Planets?* (Oxford: Oxford University Press, 2019).

Fig. 2. Artistic rendition of the impact of the Kepler spacecraft, which discovered several thousand exoplanets, hundreds of which are Earth-like (Credit: NASA Astrobiology/Aaron Gronstal).

Imagining Mars

Mars has had a grip on the population imagination for over a century.[15] The scientific understanding of Mars and its likelihood of hosting life has also evolved. It was known in the eighteenth century that Mars had ice caps that grew and shrank with the seasons, but it was not appreciated that the ice was in fact frozen carbon dioxide rather than frozen water. American astronomer Percival Lowell sparked intense interest in the red planet with his claims of canals, which he argued were the work of a dying civilization trying to transport water from the poles to the equator.[16] Drawings accompanying his writing were as much the work of his imagination as the results of his observations (see Figure 3). The public was excited, but astronomers were sceptical. Even as Lowell published his popular book on Mars in 1895, data showed that the atmosphere contained neither water nor oxygen.[17] But the idea of life on Mars was irresistible. In 1898, H.G. Wells wrote his iconic science fiction novel telling of the invasion of Earth by Martians fleeing their dying planet.[18] Early in the twentieth century, Edgar

[15] Matthew Shindell, *For the Love of Mars: A Human History of the Red Planet* (Chicago, IL: University of Chicago Press, 2023).
[16] Robert Crossley, 'Percival Lowell and the History of Mars', Massachusetts Review 41, no. 3 (2000): pp.**297318**.
[17] Paul Chambers, *Life on Mars: The Complete Story* (London: Blandford, 1999).
[18] Herbert Wells, *War of the Worlds* (London: Heinemann, 1898).

Rice Burroughs amplified the mythology with the Barsoom series of books. Burroughs was a prolific pulp fiction writer best known for creating the Tarzan character, but in a dozen books written over thirty years, he spun tales of the heroic John Carter romancing a Martian princess and slaying Martian monsters.[19] By mid-century, Mars featured prominently in the class science fiction of Isaac Asimov, Ray Bradbury, and Robert Heinlein.[20] By the year 2000, the number of works of fiction dealing with Mars exceeded five thousand.[21] A recent standout is Kim Stanley Robinson's Red, Green, Blue Mars trilogy, evoking the terraforming and colonization of the red planet.[22]

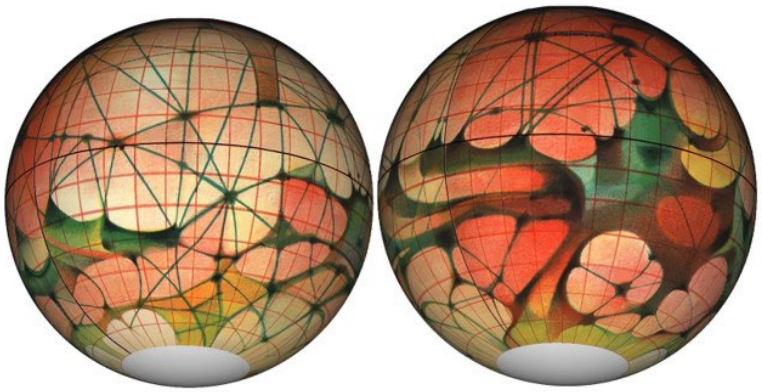

Fig. 3. The canals of Mars, hand-drawn by Percival Lowell in 1895 based on his observations with a telescope. In fact, the features are not linear and there is no evidence of a Martian civilization (Credit: Public Domain).

The mass media has embraced Mars for extraterrestrial storytelling. In 1938, Orson Welles made waves and caused a regional panic with the Halloween episode of his 'Mercury Theater on the Air' radio broadcast. He adapted H.G. Wells' novel and presented the invasion as a series of

[19] Thomas Clareson, *SF: The Other Side of Realism* (Madison, WI: Popular Press, 1971).
[20] Robert Crossley, *Imagining Mars: A Literary History* (Middletown, CT: Wesleyan University Press, 2011).
[21] Gary Westfahl, 'Reading Mars: Changing Images of Mars in Twentieth-Century Science Fiction', *The New York Review of Science Fiction* 148: p. 1.
[22] Robert Markley, 'Falling into Theory: Terraformation and Eco-Economics in Kim Stanley Robinson's Martian Trilogy', in *Dying Planet: Mars in Science and the Imagination* (Durham, NC: Duke University Press, 2025).

news bulletins, interrupting a show of dance music. On the cusp of World War II, there was a widespread anxiety that Welles tapped into. His artful deception fooled many people into thinking the Earth was being invaded.[23] There have been at least 40 movies featuring Mars since 1910. Many are forgettable, such as the lurid 'Devil Girl from Mars' in 1954, and 'Mars Needs Women' from 1967. In terms of Internet Movie Database ratings, the best are 'The Martian' in 2015, the anime 'Cowboy Bebop' in 2001, 'Watchmen' in 2009, and 'Total Recall' in 1990. In worldwide gross revenue, 'The Martian' wins with $630 million, 'John Carter' is a distant second at $284 million, and 'Total Recall' and its 2012 remake come in third at around $200 million each.[24] Mars features less prominently on TV, but four series that give a sense of the range of styles are 'My Favorite Martian', a gentle 1960's sitcom, 'Martian Chronicles', a 1980 miniseries based on Ray Bradbury's book, 'Biker Mice from Mars', a 1993 animated series, and 'Mars," a 2016 series with high production values created by National Geographic.

Music can be the backdrop for updating the scientific view of Mars. 'War of the Worlds' was still selling strongly in early 1914, and the world was anticipating war, when Gustav Holst wrote his orchestral suite 'The Planets'. After toying with presenting the planets in their order from the Sun, Holtz opted for the drama of leading off with 'Mars, the Bringer of War'.[25] The prog-rock band King Crimson borrowed this theme in their live performances, and John Williams was heavily influenced by Holst in 1977 when he wrote the 'Imperial March' for Star Wars.[26] David Bowie recorded 'Life on Mars' in 1971, with his band, the Spiders from Mars, as Mariner 9 was on its way to becoming the first spacecraft to orbit another planet. Mariner 9 revealed Mars to be a frigid, arid desert, dashing the fever dream of life on the surface. Bowie's song is not actually about Mars, but

[23] John Gosling, *Waging the War of the Worlds: A History of the 1938 Radio Broadcast and Resulting Panic* (Jefferson, NC: McFarland, 2009).
[24] Marspedia 2022, https://marspedia.org/Mars_Movies [accessed 20 October 2024].
[25] Richard Greene, *Holst: The Planets* (Cambridge: Cambridge University Press), p.19.
[26] Simon Tebbutt, 'This Classical Music Inspired John Williams During the Scoring of Star Wars', *Culture Slate*, https://www.cultureslate.com/explained/this-classical-music-inspired-john-williams-during-the-scoring-of-star-wars [accessed 20 October 2024].

it powerfully captures a sense of youthful alienation.[27] Other bands have used the planet in a similar way, such as the Canadian group Klaatu's 'Maybe I'll Move to Mars' in 1981, and Alice Cooper's 'Might as Well Be on Mars' in 1991. What Bowie and Mars share is the metaphor of being chameleons. David Bowie changed his persona and reinvented himself many times during his career. Meanwhile, the pendulum has swung back and forth on the likelihood of life on Mars. Liquid water and the chemical conditions required for biology are now thought to exist in sub-surface aquifers.[28] Carl Sagan aptly summarized the mystery and the appeal of our planetary neighbour: 'Mars has become a kind of mythic arena onto which we have projected our Earthly hopes and fears'.[29]

Planetscapes

There are many artistic renditions of exoplanets (see Fig. 2), but the science of exoplanet detection is lagging behind such visualizations. Most exoplanets have been discovered by one of two methods. Spectroscopy of the parent star reveals a periodic Doppler shift caused by the planet tugging on the star, which gives the mass of the planet. Alternatively, photometry of the star shows a periodic dimming caused by the planet transiting across the face of the star, which gives the size of the planet.[30] Both methods are indirect; the exoplanet is not seen but it is detected by its effect on the star it orbits. Imaging exoplanets is challenging because their reflected light is hundreds of millions of times fainter than the light of the host star, so they are 'lost in the glare' of the nearby star. Easiest to detect are giant planets on wide orbits. No exoplanet was imaged until 2004, and fewer than 100 of the 6000 confirmed exoplanets have been imaged.[31] Even with the best images, the exoplanet is little more than a few pixels across. Occultations have been used to map the thermal or infrared emission of giant planets, but Earth-like exoplanets will be no more than 'pale blue dots' for the

[27] Mayer Nissim, 'Life on Mars by David Bowie: The Making of the Surreal Glam Masterpiece, *Gold Radio UK*, https://www.goldradiouk.com/artists/david-bowie/life-on-mars-lyrics-meaning-facts-video/, [accessed 20 October 2024]
[28] Aditya Kuller and Phillip Christensen, 'Evidence of Exposed Dusty Water Ice within Martian Gullies', *Journal of Geophysical Research: Planets* 126, no. 2 (2021), https://doi.org/10.1029/2020JE006539
[29] Carl Sagan, *Cosmos* (New York: Random House, 2008), p.106.
[30] Jonathan Lunine, Bruce Macintosh, and Stanton Peale, 'The detection and characterization of exoplanets', *Physics Today* 62, no. 5 (2009): pp.46–51.
[31] Gael Chauvin, et al., 'A giant Planet Candidate Near a Young Brown Dwarf', *Astronomy and Astrophysics* 425, no. 2 (2004): pp.L29–L32.

foreseeable future.[32] Nevertheless, astronomers can use the mass, size, and orbital properties of an exoplanet to characterize it as rocky or icy, predict the thickness of its atmosphere, and infer whether it has oceans or plate tectonics. Many exoplanets have extreme properties. The Kepler spacecraft found a planet with lethal glass rain whipped by 9000 kilometre per hour winds, a planet being torn apart by its host star, a planet made of diamonds, a planet almost as dark as a black hole, and a planet so hot that it has iron and titanium vapor in its atmosphere.[33] This information has inspired the imaginations of space artists and illustrators.

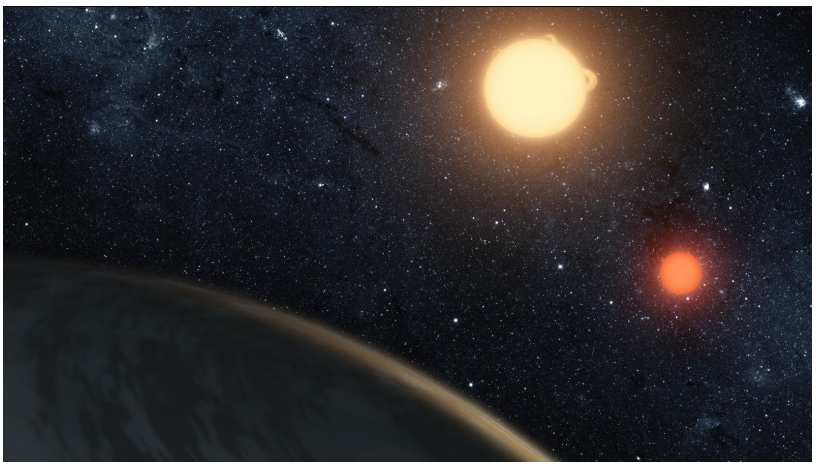

Fig. 4. The Kepler 16 binary star system creates a double sunset on its planet, like the one experienced by the fictional Star Wars character Luke Skywalker on Tatooine (Credit: NASA/JPL-Caltech/J. Pyle)

Space art has a long history that predates the discovery of exoplanets. It emerged as a distinct genre in the 1950's, often associated with science fiction magazines, with subject matter that ranged from astronauts in space to the planets and moons of the Solar System to imagined alien worlds.[34]

[32] Nicolas Cowan and Yuka Fujii, 'Mapping Exoplanets', in *Handbook of Exoplanets* (Berlin: Springer, 2021): pp.1–18.
[33] Jess Wilder, '13 of the Weirdest, Strangest Exoplanets in the Universe', *BBC Sky at Night* (2024), https://www.skyatnightmagazine.com/space-science/weirdest-exoplanets-universe [accessed 20 October 2024].
[34] Ron Miller, *The Art of Space: The History of Space Art, from the Earliest Visions to the Graphics of the Modern Era* (Minneapolis, MN: Zenith Press, 2014).

Four years after its inception, NASA started its Space Art program, often featuring the work of the pioneer Chesley Bonestell.[35] As exoplanets were being discovered in large numbers, artists responded with scientifically-informed visualizations.[36] More recently, the exoplanet 'zoo' has been visualized in exquisite detail by the artist Martin Vargic, with the planets grouped by temperature from Neptune-like ice worlds to temperate Earth clones to blazing hot Jupiters.[37] He has compiled them into a book, along with an array of astronomy graphics covering the universe and everything in it.[38] Exoplanets have been rendered in film and on television for decades, often with great artistic license and scant regard for scientific principles. Sometimes, however, art anticipates astronomy. The 'Star Wars' universe includes eight planets that were subsequently discovered, not in a galaxy far, far away, but right here in the Milky Way. They include the lava world Mustafar, the icy super-Earth Hoth, the ocean world Kamino, and Luke Skywalker's home planet, Tatooine, roasting under the glare of twin stars (Fig. 4).[39] Finally, for a sonic exposition of exoplanet discovery, there are the tight harmonies and crisp visuals of A Capella Science performing 'Whole New Worlds'.[40]

UFOs and Aliens

Astrobiology has permeated public consciousness through reports of UFOs and depictions of aliens in the media. The largest global survey of beliefs about life in the universe was done by Glocalities, a marketing consulting

[35] Lois Rosson, 'The Art of Air and Space', *Smithsonian National Air and Space Museum* (2016), https://www.airandspace.si.edu/stories/editorial/art-air-and-space [accessed 20 October 2024]

[36] Ray Villard and Lynette Cook, *Infinite Worlds: An Illustrated Voyage to Planets Beyond Our Sun* (Berkeley, CA: University of California Press, 2005); Micheal Carroll, *How to Draw and Paint Planets, Moon, and Landscapes of Alien Worlds* (New York: Watson-Guptill, 2007).

[37] Robert Lea, 'With real scientific data, artist Marin Vargic has visualized hundreds of alien planets', *Space.com* (2024), https://www.space.com/exoplanet-art-martin-vargic-interview [accessed 20 October 2024].

[38] Martin Vargic, *Vargic's Curious Cosmic Compendium: Space, the Universe, and Everything Within It* (London: Michael Joseph, 2019).

[39] NASA Science Editorial Team, 'Meet 8 Star Wars Planets in our Own Galaxy', *NASA*, https://science.nasa.gov/universe/exoplanets/meet-8-star-wars-planets-in-our-own-galaxy/ [accessed 20 October 2024].

[40] A Capella Science, 'Whole New Worlds: An Aladdin history of Exoplanets', *YouTube*, https://www.youtube.com/watch?v=gai8dMA19Sw [accessed 20 October 2024].

company based in Amsterdam[41]. They polled over 26,000 adults from 24 countries in 2016 with questions about life in the universe, the existence of extraterrestrial intelligence or ETI, the advisability of making contact, and the panspermia hypothesis. About 60% believe in some form of life on other planets, and 47% think intelligent alien civilizations exist. Belief in ETI is highest in Russia and lowest in the Netherlands, with no obvious geographical or other trend underlying large variations. According to the survey, believers are characterized being as open-minded, tolerant, having an anti-authoritarian mindset, being politically engaged, and having faith in technology. A survey of over 24,000 adults in 36 countries asked if it's likely that aliens would visit Earth in 2023. Globally, 18% said yes, with the highest percentage in India (43%), the United States near the average (17%), and Japan at the low end (8%). Despite a continuing flurry of UFO reports, no alien visit occurred, however the public seems primed for it to happen.[42] In the United States, most people are confident that ETI exists. In a 2020 poll of 1000 adults, 66% said there is life on other planets, while a slightly smaller 57% said there is intelligent life and civilizations beyond Earth. Nearly half (45%) said UFOs exist and have visited the Earth and a quarter (26%) thought that alien and human societies would be similar.[43]

Another layer of the American belief system is revealed by a Politico survey of registered voters. Among the 62% of respondents who believed in the existence of extraterrestrial life, 82% said that their government has concealed the existence of UFOs.[44] Clearly, the public is not a 'blank slate' when it comes to alien expectations. In the United States, UFO sightings are part of a web of conspiracy theories that includes crop circles and alien abduction, to the point where belief in aliens is a form of religion.[45]

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[41] Glocalities, 'A survey in 24 countries published on the occasion of the Last Jedi Star Wars movie', *Glocalities* (2024), https://glocalities.com/reports/majority-of-humanity-say-we-are-not-alone-in-the-universe [accessed 20 October 2024].

[42] Ipsos, 'Global Predictions for 2023', *Ipsos*, https://www.ipsos.com/en/ipsos-global-predictions-2023 [accessed 20 October 2024].

[43] Ipsos, 'Majority of Americans Believe There is Intelligent Life and Civilizations on Other Planets', *Ipsos*, https://www.ipsos.com/en-us/news-polls/majority-believe-intelligent-life-exists-on-other-planets [accessed 20 October 2024].

[44] Politico, 'Most Alien Believers Think Government Has Kep UFO Existence from the Public', *Politico*, https://pro.morningconsult.com/instant-intel/ufos-extraterrestrial-life-government-secrets-survey [accessed 20 October 2024].

[45] Diana Pasulka, *American Cosmic: UFOs, Religion, Technology* (Oxford: Oxford University Press, 2019).

The science of aliens is still stuck in the starting gate. With thousands of exoplanets known, and hundreds that are like the Earth in size or mass, there is still no detection of life off-Earth. That's because life detection is a very difficult experiment. It requires the feeble reflected light from an exoplanet to be separated from the much stronger starlight and dispersed into a spectrum of high enough quality that atmospheric spectral features can be identified. The goal is to detect biomarkers, or gases that indicate microbial life.[46] On the Earth, oxygen is a good biomarker because it was created by microbes several billion years ago, and it's such a reactive gas that high concentrations cannot be produced by geology alone. Methane is another important biomarker, along with water vapor, since all life on Earth depends on water. With tools like the James Webb Space Telescope and upcoming large telescopes, the life detection experiment can be carried out on a dozen or more super-Earth exoplanets in the next 5 to7 years. Life detection on Mars or within the Solar System will take longer. The third approach is to vault over the uncertainty of the existence of microbial life and search for artificial radio or optical signals from extraterrestrial intelligence, an effort that has not succeeded after 70 years of listening.[47]

Astronomers are in an awkward position regarding aliens. With ten billion habitable worlds in the Milky Way, and billions of years for biology on any of them to advance to our level of technology or beyond, it's unlikely that we would be the first or the only species to advance to our level of technological sophistication. Therefore, it's logically plausible that space-faring aliens do exist.[48] However, the bar should be set high on evidence of their existence. UFOs are readily explained in ways that do not invoke extraterrestrial visitors, and verifiable physical evidence has never been provided.[49] Finding aliens is a scientific experiment that is most likely to succeed in terms of detecting microbial life on a nearby exoplanet.

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[46] Sara Seager and William Bains, 'The search for signs of life on exoplanets at the interface of chemistry and planetary science', *Science Advances* 1, no. 2 (2005), https://doi.org/10.1126/sciadv.1500047

[47] Chris Impey, 'Life Beyond Earth: How Will It First Be Detected', *Acta Astronautica* 197 (2022): pp.387–98.

[48] Jensine Andresen and Octavio Chon Torres, editors, *Extraterrestrial Intelligence: Academic and Societal Implications* (Cambridge: Cambridge Scholars Publishing, 2022).

[49] Andrew Fraknoi, 'Responding to Claims about Alien UFOs: A Brief List of Resources', (2024), https://www.fraknoi.com/wp-content/uploads/2021/05/Responding-to-Claims-about-Alien-UFOs-2.pdf [accessed 20 October 2024].

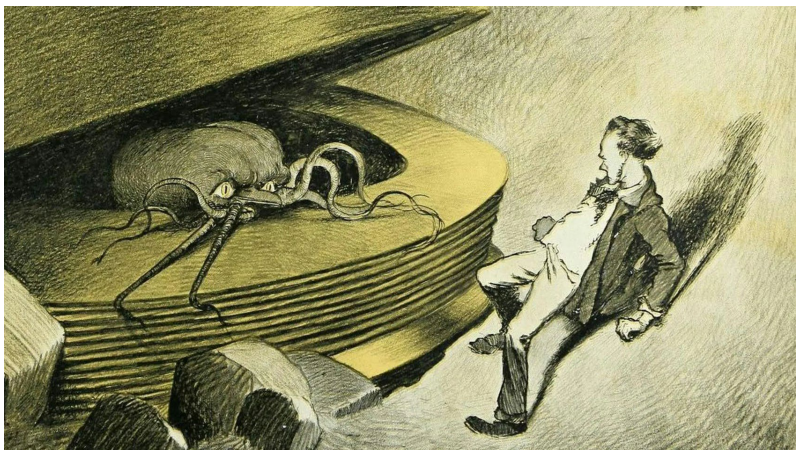

Fig. 5. Illustration for the 1906 edition of H.G. Wells' 'War of the Worlds' by Alvin Correa. Aliens have taken many different forms in fiction over the past century (Credit: Public Domain).

If we consider how aliens appear in movies or on television, many of them are almost laughably anthropocentric. Often humanoid, bipedal, and bilaterally symmetric, they are not radically alien. A hundred years of alien representations shows that they have evolved to become more sinister.[50] Perhaps the most plausible concept of aliens came from astronomers Carl Sagan and Ed Salpeter, who imagined an ecosystem of buoyant creatures in the temperate mod-levels of Jupiter's atmosphere. Their speculation was published in 1976 in a respected, peer-reviewed journal.[51] A light-hearted organizing framework for movie aliens is the 'Movie Alien Threat Matrix', which organizes movie aliens according to their size and how deadly or friendly they are.[52] The matrix ranges from large and deadly, such as the Xenomorph in "Alien" or the Martian in 'War of the Worlds', to small and friendly like the Aliens in 'Cocoon' or E.T. in 'E.T., the Extraterrestrial'.

[50] Bill Gourgey, '100 years of aliens: From Mars beavers to little grey men', *Popular Science* (2024), https://www.popsci.com/science/history-of-aliens/ [accessed 20 October 2024]
[51] Carl Sagan and Ed Salpeter, 'Particles, Environments, and Possible Ecologies in the Jovian Atmosphere', *Astrophysical Journal Supplement Series* 32 (1976): pp.737–55.
[52] Jason Concepcion and Shea Serrano, 'The Movie Alien Threat Matrix', *The Ringer* (2017), https://www.theringer.com/2017/5/19/16045594/movies-alien-covenant-scariest-movie-aliens-7fe44110e8c6 [accessed 20 October 2024].

We have only one example of biology to study, the single experiment on Earth where a common genetic ancestor 4 billion years ago led to lifeforms as diverse as a fungal spore, a poppy, and a blue whale. If any alternative biological experiments exist, they might be radically different from Earth life. Even if the base levels of genetic code and cell as a genetic container are similar, the higher levels of organization are impossible to predict. Put simply, we don't know how strange life elsewhere might be. In this light, and recalling Carl Sagan's quote earlier in this piece, it's natural to see alien life as a kind of mirror, reflecting our hopes and our fears, our dreams and our longings. Different writers have interpreted aliens in terms of social commentary,[53] the psychology of dreaming,[54] and through the lens of neo-Marxist theory.[55] Perhaps the most persuasive connection is with religion, where aliens represent entities with God-like powers, to which humans are subject.[56] This connection is quite literal in the case of the movie 'E.T., the Extraterrestrial'. Despite the protestations of director Steven Spielberg, the movie is a detailed retelling of the Christ story.[57] Science will eventually reveal whether aliens exist, and their true nature, but for humanity in its troubled adolescent as a technological species, they are avatars for our salvation and damnation.

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[53] Elaine O'Quinn and Heather Atwell, 'Familiar Aliens: Science Fiction as Social Commentary', *The Alan Review* 37, no 3 (2010), https://doi.org/10.21061/alan.v37i3.a.6

[54] Robert Reiber and Robert Kelly, *Film, Television, and the Psychology of the Social Dream* (Berlin: Springer, 2013), Chapter 2.

[55] Linda Billings, 'The Allure of Alien Life: Public and Media Framings of Extraterrestrial Life', in *The Impact of Discovering Life Beyond Earth*, edited by Steven Dick (Cambridge: Cambridge University Press, 2015), pp.308–23.

[56] Caron Ellis, 'With Eyes Uplifted: Space Aliens as Sky Gods', in *Screening the Sacred: Religion, Myth, and Ideology in American Popular Film,* edited by Joel Martin and Conred Ostwalt (Abingdon: Tayler and Francis, 1995).

[57] Bryce Rich, 'The Christological Symbolism of E.T. the Extra-Terrestrial', *BryceRich.net* (2017), https://brycerich.net/seminary-papers/th230/christology-of-et.html [accessed 2- October 2024].