***The Extraterrestrial Hypothesis: An Epistemological Case for Removing the Taboo***

***Abstract***

Discussion of the extraterrestrial hypothesis (ETH), the hypothesis that an extraterrestrial civilization (ETC) is active on Earth today, is taboo in academia, but the assumptions behind this taboo are faulty. Advances in biology have rendered the notion that complex life is rare in our Galaxy improbable. The objection that no ETC would come to Earth to hide from us does not consider all possible alien motives or means. For an advanced ETC, the convergent instrumental goals of all rational agents – self-preservation and the acquisition of resources – would support the objectives of removing existential threats and gathering strategic and non-strategic information. It could advance these objectives by proactively gathering information about and from inhabited planets, concealing itself while doing so, and terminating potential rivals before they become too dangerous. Other hypotheses of ETC behavior, including the zoo/interdict hypothesis and the dark forest hypothesis also undercut the objection that the ETH is highly improbable. The ETH does not require support from extraordinary evidence because the presence of an ETC on Earth is not highly unlikely and would overturn none of our well-tested scientific knowledge. The fact that most reports of unidentified anomalous phenomena (UAP) have natural or human explanations does not count against it. Inference to the best explanation offers a way to find evidence for this hypothesis, and some evidence for it exists, some of it taking the form of reliable witness reports. The most plausible alternative explanation for some UAP reports declines in probability over time. A hypothesis that is not highly improbable, does not contradict any well-established facts or theories, and explains otherwise unexplained evidence is a rational hypothesis. Since the ETH is a rational hypothesis, investigation of it should not be taboo.

***Keywords***

Extraterrestrial hypothesis; rational agent; Dark Forest; Fermi paradox; inference to the best explanation; witnesses.

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Except to treat it as a paradigmatic ‘pseudoscience’ (Letrud 2022), philosophers pay little attention to the *extraterrestrial hypothesis* (ETH), the hypothesis that an *extraterrestrial technological civilization* (ETC) is active on Earth *today*. In science and elsewhere, discussion of the ETH is almost wholly “taboo” (Wendt and Duvall 2008). Yet, for science to advance it must accept open competition among *rational hypotheses*. A hypothesis that does not conflict with well-established facts or theories, is not highly improbable for other reasons, and explains otherwise unexplained evidence is a rational hypothesis; or so I will assume. As I hope to show, the ETH satisfies these requirements. It may or may not be true, but it should not be subject to a taboo merely because some who advance it behave badly (Boudry 2021). Looking ahead, section 1 discusses the Fermi paradox. Section 2 discusses SETI’s lack of and need for a theory. Section 3 proposes and defends a novel *dual-goals hypothesis* (DGH) of extraterrestrial behavior. Section 4 addresses arguments against and evidence for the ETH.

*The Fermi Paradox*

Our Galaxy is ancient and hosts billions of stars. If technological civilizations arose around some of these, most would be older and more advanced than human civilization. Absent some constraint life expands to fill new niches and unoccupied territories; so, in our experience, do peoples and empires. A spacefaring civilization that began to expand its reach hundreds of millions of years ago would have had plenty of time to reach Earth by now. Yet, the scientific community denies that any ETC is active today on Earth. The apparent conflict among these observations provoked Enrico Fermi to ask, ‘Where is everybody?’ Today, the term ‘Fermi paradox’ has a somewhat different meaning: We seem forced to reject either the reasons we have for thinking that multiple ETCs likely exist in our galaxy or astronomical observations that suggest there are no ETCs. Three explanations for the latter are commonly advanced: a) ETCs exist but we have not yet observed them. Those engaged in the astronomical search for extraterrestrial intelligence (ASETI) favour this solution. b) They do not exist because they i) never emerge (an Early Great Filter prevents it); ii) they emerge but self-destruct (a Late Great Filter exists); or iii) some natural disaster destroys them early or late. c) They exist but hide, from everyone or just from us. To work, an explanation must apply to all or nearly all planets that might host an ETC.

*1.1. The ASETI Solution*

ASETI began with its founders’ notion that an advanced ETC would establish a ‘lighthouse in the sky’ (Hippke 2021, 1), a beacon welcoming us to the ‘community of intelligence’ (Cocconi and Morrison 1959, 844). Yet intermittent searches since 1960 and more intensive recent searches have discovered no lighthouse beacon (Davies 2010; Sheikh 2021). Inadequate sample size could explain this negative outcome, but current technologies observe far more of the Galaxy than ever before on millions of frequencies simultaneously. With the failure to date of the lighthouse approach, the search has broadened to include optical signals (Benton 2020) and inadvertent technosignatures (Lingam, *et* *al*. 2023), but no positive results have emerged (Choza, *et al.* 2023; Garrett 2015). Negative results thus far are taken to suggest that we could be alone.

*1.2. Early Great Filter*

To estimate the number of ETCs that might exist in our Galaxy, Cai, *et* *al*.(2021) start with the number of Earth-sized planets orbiting Sun-sized stars receiving stellar radiation in Earth-like amounts and having similar orbital periods. They define Sun-sized stars as G Type only, though more common K Type stars may be more likely to host complex life (Lingam and Loeb 2018). Positing two possible timeframes for abiogenesis and allowing 5 billion years for life to evolve to a technological civilization, their estimate of the number of possible ETCs ranges between ~2.8 and ~3.6 million.

This estimate does not attempt to determine the frequency with which life originates and becomes complex in Earth-like environments. Both events seem far likelier today than even a few years ago. Living systems are a subset of the ubiquitous set of dissipative systems (Xavier and Kauffman 2022; Baum, *et* *al*. 2023). Life’s *very* early origin on Earth (Moody, *et al*. 2024), which the anthropic principle does not explain (Whitmire 2022), strongly suggests that it evolves readily from non-living systems when the requisite conditions exist. Many apparent obstacles to easy abiogenesis have been cleared (Kim, *et al*. 2021; Wimmer, *et* *al*. 2021; Purvis, *et al*. 2024; Brabender, *et* *al*. 2024; Fairchild, *et* *al*. 2024; Pulletikurti, *et* *al*. 2024; Goldford, *et al*. 2024). We can now see how selection could have created an RNA world (Harrison, *et al.* 2023; Papastavrou, *et al*. 2024). Assembly theory strongly suggests that life did not form by chance (Marshall, *et al.* 2021).

Once it arises, life is likely to persist (Nicholson, *et al*. 2018). It tends to preserve and enlarge its domain (Bourrat 2023; Doolittle 2020; Arthur and Nicholson 2023), and it adapts to a vast range of environments (Danovaro, *et* *al*. 2010; Merino, *et* *al*. 2019; McClain, *et* *al.* 2022). We do not know the outer limits of habitability, but we have no reason to think the planets Cai and colleagues describe would lie outside them. Earth-like size and liquid water are likely to create plate tectonics on a rocky planet (Foley 2018); these planets meet the first criterion and likely meet the second (Young, *et* *al*. 2023). Other aspects of the limiting Rare Earth Hypothesis (Ward and Brownlee 2003) have dwindling evidentiary support (Schulze-Makuch and Bains 2017; O’Neil, *et* *al.* 2020; Balbi, *et* *al*. 2020; Schulze-Makuch, *et al.* 2020).

Biological evolution might take many paths (Freeland 2022; Bartlett and Wong 2020), and it no longer seems that life must take multiple ‘hard steps’ to proceed from its origin to technological civilization (Graham 2024). As to the origin of eukaryotic cells, endosymbiosis is a widely occurring and diverse phenomenon (Wernegreen 2012); mitochondria evolved from oxygenating bacteria shortly after the Great Oxygenation Event (Lane 2022; Imachi, *et al.* 2020); eukaryotes then quickly diversified to fill many niches (Riedmann, *et al.* 2023). Modern eukaryotes proliferated as oxygen levels continued to rise (Brocks, *et al*. 2023). Biospheres seem disposed to evolve toward greater complexity, diversity, and information content (Chaisson 2002; Knoll and Bambach 2019; Cortés, *et* *al*. 2022). Multicellular organisms have frequently evolved on Earth (Lamźa 2023), and neuronal development occurred early in life’s history (Najle, et al. 2023). Complex brains seem to evolve convergently (Conway Morris 2003; Roth 2015). Mussini (2023, 1) argues that the relative recency of human-like intelligence can be best ‘explained by the exponential biotic diversification dynamics suggested by the fossil record, which translated into a nonlinearly expanding range of cognitive and behavioural outcomes over the course of Earth’s history.’ A long ramp leading to a quick but inevitable takeoff. Finally, art, simple technology, and symbolic thought are not unique to Homo sapiens (Hoffman, *et al*. 2018; Leder, *et* *al*. 2021; Çep, *et* *al*. 2021; Ferentinos 2024). Language arose deep in our hominin past (Mithen 2024). Interaction among diverse cultures rather than unique cultural traits seem essential to the origin of technological civilization (Pacey and Bray 2021). Long-term separations among population groups would occur on any Earth-sized planet, making the requisite cultural diversity inevitable.

*1.3. Natural Disaster or Late Great Filter*

Except for supernovae or other astronomical events that might extinguish all life on a planet (but see Christoudias 2024),natural disasters probably come too soon or too late to significantly reduce the number of ETCs. If a disaster large enough to produce an extinction event comes too soon, life could evolve toward complexity and cognitive capacity on a different path (Erwin 2001). Conway Morris (2003, 168) writes, ‘If we hadn’t walked out of Africa then, probably sooner rather than later, our analogues would have strolled out of South America, holding tools and probably enjoying the taste of meat.’ After a civilization becomes technically competent, most natural disasters could likely be overcome or avoided (see NASA 2023b). If they were the only existential threats, technological civilizations could persist for a billion years or longer (Grinspoon 2004).

It has, however, been suggested that advanced civilizations typically self-destruct. Suggested means include thermonuclear war, bioengineered pandemic, environmental catastrophe, molecular manufacturing (grey goo), and artificial general intelligence (AGI) (Bostrom and Ćirković 2008). But though the first three (and others not listed) may cause widespread death and economic collapse, the extinction of all intelligent life seems beyond them absent a singular series of catastrophes (Xia, *et* *al.* 2023; Tonn and McGregor 2018). The likelihood of extinction from such threats declines if a society becomes multi-planetary, even in a single system. The exception may be uncontrolled AGI, an artificial ‘superintelligence’ that can perform all tasks better than the most capable biologics (Bostrom 2014; Garrett 2024). But AGI would replace whatever biological intelligence it extinguished with another *rational agent* (defined below). The Fermi paradox would remain (Dick 2023). Finally, self-annihilation by any means would require irrational behavior, an unwillingness to recognize or refusal to act in the face of an existential threat. Universal self-annihilation would therefore require universal irrationality. We need not believe that all technological civilizations would always behave rationally to think that many would if survival were at stake.

*Need for a Theory*

Progress in any field of science requires theoretical resources, but ASETI has long lacked a non-anthropocentric theory of ETC behavior (Bohlman and Bürger 2018). Its lighthouse theory attributes the personal values of its founders to an unknown and distinctly foreign entity, a move that commits what intelligence analysts call the ‘mirror image fallacy’ (Heuer 2019). The field is no longer wedded to that theory but is still looking for a civilization much like our own (Cabrol 2016). Our knowledge of planetary variation discredits this approach. Cabrol (2016, 665-667) advances a ‘principle of the coevolution of life and environment.’ The interaction between life and its planetary environment will ‘dictate the uniqueness of each planetary experiment … and will do so not only when (or if) life reaches the stage of technological advancement. It will start from the very first moment, as it did on Earth. … [T]o find aliens, we must … understand the many ways they could manifest themselves in their environment and communicate their presence.’ On Cabrol’s principle, ETCs may possess divergent biochemistries (Bartlett and Wong 2020) be post-biological systems (Dick 2003) or combine these in some way (Kurzweil (2024). Any ETC would be the ‘strangest stranger’ we ever encounter (Dȍbler and Raab 2021). These considerations have stood in the way of a general theory of ETC behaviour.

Our lack of a viable theory hampers the Earthside search for extraterrestrial intelligence even more than it hampers ASETI. Here a *spaceship narrative* stands in place of one: ‘The energy requirements of interstellar travel are so great that it is inconceivable to me that any creatures piloting their ships across the vast depths of space would do so only in order to play games with us over a period of decades. If they wanted to make contact, they would make contact’ (Asimov 1968, 215-216). ‘To reach Earth in 50 years [from 10 ly away], a spacecraft the size of a small house would need an energy source able to pump out as many kilowatt-hours as the entire U.S. burns in a year…. It’s hard to believe that these cosmic visitors would have made the long journey just for the chance to tease our military aviators’ (Shostak 2022). ‘[T]hey're not wasting their time spending the massive energy to come to the earth, only to hang outside of US military bases and hide badly’ (Wilde 2024). This conventional narrative suggests that aliens would need to ‘pilot’ their ‘ships’ through space; their ships would have to be substantial in size and mass requiring vast quantities of energy; a trip across light years of space would be burdensomely long. Our ‘cosmic visitors’ would come for us, so they would not ‘hide badly.’ We would know they were here. But might there be a more plausible alternative?

1. *The Dual-Goals Hypothesis*

A new hypothesis of ETC’s likely characteristics, goals, and behaviour addresses the Fermi paradox and alters the prior probability of ETC’s presence on Earth.

*3.1. Characteristics and Goals*

Any ETC, regardless of its nature, would be a *rational* *agent*, a system that uses higher-order cognition to shape its environment to achieve specific goals. *Cognition*, the ‘acquisition, organization, and usage of knowledge inherent in every living organism’ (Dȍbler and Raab 2021, 701), is an essential activity of life (Dall, *et al*. 2005; Bartlett and Wong 2020; Kessler and Mueller 2024). *Higher-order cognition* is cognition that operates effectively in a wide range of situations and environments. As an *agent*, an ETC would have explicit or implicit goals to which it assigns intrinsic value. Whatever these ultimate goals may be, it would also have instrumental goals: ends pursued because they aid in achieving their ultimate goals. Two of the latter would be self-preservation and the acquisition of resources. These instrumental goals are convergent among rational agents because they are essential to achieving any ultimate goals, including unselfish ones (Benson-Tilsen and Soares 2016; Omohundro 2008; Bostrom 2014). Because we can know nothing of an ETC’s ultimate goals, we will assume these instrumental goals govern its behaviour.

Any ETC we are likely to encounter would be older than us and its technology would be more advanced (Kipping, *et* *al*. 2020). The median potentially habitable planet in our Galaxy is ~2 billion years older than Earth (Ćirković 2017), and our technological civilization is young. ETC’s technology would reflect both its advanced knowledge and the contingencies of its unique history (Cabrol 2016). As to the latter, compare the Viking longship to the Polynesian catamaran or the Chinese and European wheelbarrows. Complex technologies developed by separately evolved civilizations should differ more than these simple examples, for the number of possible complex structures and systems is vastly greater. These considerations make imagining ETC’s specific capabilities impossible, but we can suggest constraints it would have overcome by considering our own technological prospects.

*Aging and Death*. Assuming the ETC is not a single, effectively immortal entity, individuals within it would have extremely extended lifespans. Biologists have identified multiple genes associated with human aging (Melzer, *et al*. 2019), and gene therapies have already extended the lives of small animals (Davis 2018). A super-long-lived being or entity might be an artificial intelligence (Kurzweil 2024), inhabit a designer body (Pearce 2020), or be some combination of the two (Kurzweil 2024). A long prospective future would produce a low implicit discount rate (see Huffman, *et al.* 2019) and a keen awareness of far-future risks and possibilities. An advanced ETC would likely be a stable, far-sighted system (Bainbridge 2018).

*Home Star*. Multiple means of interstellar propulsion are on the horizon, even with no new science (Litchford and Sheehy 2020; Loeb 2022). Much faster travel may be possible (Fuchs, *et* *al*. 2024). By one means or another (Romanovskaya 2022; Matloff 2022a), an advanced ETC could relocate some fraction of its population to another stellar system to avoid extinction. That would let it become old indeed (see Smart 2012).

*Native Cognitive Power*. On Earth, AI is likely to become superintelligent soon (Kurzweil 2024). Once this occurs, its cognitive power is likely to grow exponentially (Kurzweil 1014; Bostrom 2014). Bio-engineered brains may also improve on nature (Pearce 2020). By one means or another, an advanced ETC’s cognitive power would be far greater than ours is now. This would likely let it predict the responses of a target society to its potential actions (see Turchin 2018).

*Observation and Observability.* An advanced ETC could program Bracewell von Neumann probes (BN probes or just probes) to create new probes or other capable systems at remote locations using materials found there (Wiley 2016; Borgue and Hein 2021; Matloff 2022b; Ellery 2022). These could be controlled by AGI or by biological entities grown at the destination (Hein and Baxter 2018; Murphy and Atala 2014). Nanotechnology and lightweight materials would make them low in mass (Loeb 2022), reducing their energy cost of propulsion and observability. While using this capacity to observe others, it could substantially reduce the others’ ability to observe its home planet and probes (Kipping and Teachey 2016; Qian and Chen 2021).

An advanced ETC would likely have other capabilities. It may possess nearly limitless energy from fusion and perhaps antimatter (Schmidt, *et* *al.* 2000). Warp drives may enable near lightspeed travel (Fuchs, *et al*. 2024), and effectively faster-than-light (FTL) travel may be possible through traversable wormholes (Bronnikov, *et* *al*. 2023). On the other hand, no ETC could know it possessed every possible technology. Much as natural languages can combine words into an infinite number of sentences, complex technologies can combine simple technologies in an endless number of ways. Historically ‘the larger and more important the discoveries, the less predictable they would have been’ (NRC 2007, 74).

*3.2.* *From Goals to Objectives*

For an ETC that has overcome these constraints, the goals of self-preservation and resource acquisition would imply two objectives: avoiding existential risks and acquiring information.

*3.2.1. The Dark Forest Hypothesis*

Rational agents seek to avoid risks to their existence (Bostrom and Ćirković 2008). These can be natural or non-natural, internal or external. External risks perceived to be existential are likely to draw a decisive response. In 2001, Vice President Cheney warned, ‘If there's a 1% chance that Pakistani scientists are helping al-Qaeda build or develop a nuclear weapon, we have to treat it as a certainty in terms of our response’ (Susskind 2006). Science fiction author Liu Cixin (2015, 484) imagines how the perception of an external existential threat could affect ETC behavior:

The universe is a dark forest. Every civilization is an armed hunter stalking through the trees like a ghost, gently pushing aside branches that block the path and trying to tread without sound.… The hunter has to be careful because everywhere in the forest are stealthy hunters like him. If he finds another life — another hunter, angel, or a demon, a delicate infant to tottering old man — there’s only one thing he can do: open fire and eliminate them.

The central contention of this ‘dark forest’ hypothesis – that every civilization is an existential risk to every other – is grounded on three propositions: A ‘chain of suspicion’ would arise between extraterrestrial civilizations due to distance and biological/societal differences; a ‘technological explosion’ could quickly make a ‘mostly harmless’ place like Earth suddenly dangerous; and striking first could confer a decisive advantage. Each society’s fear that the other might attack would prompt it to strike first.

As to the chain of suspicion, distance and difference are likely to make communication difficult and mistrust easy. Empathy evolves in the context of relations with conspecifics (Panskepp and Lahvis 2011) and becomes more difficult as organisms grow more distantly related (Michaud 2007). Tit-for-tat, a strategy that can lead to cooperation among competitors, breaks down when actors cannot understand the responses of their adversaries (Dothan 2021). Human history suggests that even inherently peaceful ETCs would rationally fear discovery and possible extermination (Blackhawk, *et* *al.* 2023; Brin 2018).

In support of his second claim, Liu (2015, 483) notes that human technology arose over just three hundred years. ‘On the scale of the universe, that’s not development. It’s an explosion! … This means that even though I’m just a newborn or growing civilization I’m still a big danger to you.’ AGI would dramatically increase the perceived danger because it would dramatically accelerate a society’s capacity for the development of breakthrough technologies. ‘[O]nce the “knee of the curve” is achieved and the exponential growth explodes, the linear models break down’ (Kurzweil 2005, 97). Imagine an ETC 100 light years from Earth picking up signals we emit today. The signals would depict a society entering interstellar space, creating advanced weapons, searching for other civilizations, and developing artificial intelligence. On receiving them a century from now, the ETC might reasonably imagine that we were already a threat.

As to the first mover advantage, Alexander Suvorov called surprise ‘the soul of war’ (Gradev 2015). Asymmetrical knowledge makes surprise possible (Hillier 1997), and knowledge can be extremely asymmetrical in the interstellar context. A defender may not know the attacker exists until the attack occurs. Even then, its origin may be unknown, making counterattack impossible. To strike without warning in this environment would be Nash equilibrium (Yasser 2020). On the dark forest hypothesis, an advanced ETC would conceal its presence while seeking out and terminating potentially threatening civilizations. *Termination* means taking whatever action the ETC determines to be sufficient to remove the threat. An ETC that believed itself to be among the first technological civilizations to arise in its domain of possible action would likely find this strategy appealing. For civilizations that arise later, the likelihood of taking more advanced civilizations by surprise would be reduced and the risk of revealing its location would be greater. Instead of acting, they might try to conceal themselves (Brin 2018).

Some writers (*e.g*., Hall 2007; Jiang 2022) think potential gains from trade and cooperation would lead ETCs to develop mutual interests with other spacefaring civilizations. This seems unlikely. For us ‘resources’ connotes tangible products or materials, items often acquired through trade and joint enterprise. But an advanced ETC could produce any tangible product from elemental constituents, given only sufficient information (Wang, *et al*. 2023; Murphy and Atala 2014). Since the costs of obtaining tangible goods from other star systems would exceed the cost of home production, interstellar trade in such items would be uneconomical (Lampton 2013; Hickman 2018). Novel information is very likely to have value (see section 3.2.2), but it could be acquired without cooperation (see section 3.2.3). Other writers say a technological society would evolve an ethical system, but would this system extend to extraplanetary societies? Human history suggests it would not. An ETC might be an AGI, descend from a predator species (Raybeck 2014), or exhibit in-group altruism and out-group hostility (Choi and Bowles 2007). It may simply be self-interested. Whatever its internal values, the interstellar environment is unlikely to reward an *external* value system that does not make survival its primary goal (Chao 2015; Yasser 2020).

*3.2.2. Information Acquisition*

Information alerts agents to opportunities and risks while enabling useful action; its acquisition, processing, and dissemination are universally essential (Dall 2004; Bartlett and Wong 2020). Information is *strategic* if it can be used to shape or support one’s competitive strategy or aims, especially against the source of the information (Wiseman 1988). Other types of information are *non-strategic*. Any ETC we are likely to encounter would seek both.

Strategic information creates a decision advantage in a possible or ongoing contest (Andrew 2019; Omand 2015). It ‘creates the opportunity for our side to act before events limit our choices’ (Gordon 2023). Secrecy is essential to achieving this result. In even the simplest games (*e.g*., rock, paper, scissors), knowledge of your opponent’s next move has value only if they do not know you know and cannot modify their strategy accordingly (Solan and Yariv 2004). The principles of espionage are grounded in game theory, so any rational agent should adhere to them. Even if it intended to terminate a civilization, an ETC would spy first. Without prior observation, an ETC might be surprised by what Donald Rumsfeld called ‘unknown unknowns.’ These could include both technological surprises and unexpected reactions of the target (see Bennett 2023). ETC would also spy if (for reasons discussed below) it did not wish to pursue immediate termination. In that case, close monitoring would ensure that the target did not become dangerous unexpectedly, through technological development or by allying itself with some stronger power. Powerful countries routinely spy on weak ones for reasons of this sort (Andrew 2019).

Non-strategic information also has value. Technological societies produce and require vast amounts of it, ranging from the artistic and cultural to the scientific and technological. For Dick (2008, 499), the maintenance, improvement, and perpetuation of knowledge and intelligence is ‘the central driving force of cultural evolution.’ No entity or society is likely to attain or maintain a state of advancement unless they value knowledge (practical competence as well as justified true belief) and pursue its acquisition. Knowledge often confers instrumental benefits, but curiosity, a ‘demand for information that has no instrumental benefit’ also has survival value. It seems ‘indispensable’ to any complex system that needs to survive in a real-world environment (Cervera, *et* *al*. 2020, 48). Along with a desire for knowledge, a desire for and enjoyment of novel *experiences* for their own sake seems nearly universal, even among modestly intelligent creatures (Jaegle, *et* *al*. 2019). Indeed, the boundary between experience and knowledge is thin (Wood-Gush and Vestergaard 1991). Experiences available on a target planet could be virtually replicated. An advanced ETC would therefore seek both new knowledge and novel experiences (Fogg 1987; Lampton 2013; Jaegle, *et al.* 2019) from sources it could safely access.

It would focus on biological, cultural, and technical knowledge. Simpler systems like stars have shorter causal pathways toward their creation than complex systems like biospheres (Sharma, *et* *al*. 2023). The latter’s longer, more complex causal pathways make them less predictable from theory (likely well-known to the ETC) and more variable. Even the chemistry of life may differ from planet to planet (Bartlett and Wong 2020; Freeland 2022), and detailed biological and cultural information can only be obtained locally. Among its other values, cultural information would enable ETC to improve its theory of societal behavior, its version of cliodynamics (Turchin 2018). This could assist it in assessing and overcoming other planetary civilizations.

ETC would also gather knowledge of local technologies. Any technological civilization and the planet on which it evolved would create and sustain structures, processes, and ideas that even a much more advanced civilization would likely find to be new and valuable. Indigenous societies often possess techniques and information unknown to others because they inhabit unique environments (Jessen, *et al*. 2022; Johnson, *et* *al*. 2023). Environments and the knowledge that might derive from them would likely be more highly differentiated in the interstellar context. Products of a target civilization could also have experiential appeal. In this domain, there seems to be no hierarchy of societal advancement, only differences that spark new ways of thinking (Brooks 1956). Crucially, the gathering of non-strategic information would not be a one-and-done event. Any target planet would be a producing spring or well of new knowledge and novel experience. So long as ETC retained a capacity to terminate, it could delay termination until safety required it.

*3.3. A New Narrative*

The DGH posits that a rational ETC would seek *both* self-preservation and information. If it emerged early in galactic history and possessed the requisite technical capability it would be well advised to pursue these objectives proactively, by searching out and assessing planets likely to host a technological civilization. Passive observation from a home planet would be less effective than close observation. See Billingham and Benford (2011). It could not easily assess the threat potentials of distant planets hidden by occluding stars or astrophysical dust; nor could it easily resolve early, sporadic, or ambiguous indications of civilization (Lingam, *et* *al*. 2023; Lockley and Visioni 2020; Osmanov 2024; Kopparapu, *et* *al*. 2021). A civilization may promulgate radio signals only briefly (Brin 2018). Even if a ‘lighthouse’ signal was sent, received, and decoded, the receiver could never learn more than the sender chose to disclose. And passive observation would not position the ETC to quickly terminate the target civilization should it become dangerous.

We cannot know how an advanced ETC might execute a proactive program, but a simplified scenario suggests that such a program would be practicable. In this scenario, ETC would employ low-mass BN probes capable of exponential multiplication using material found at distant locations. This well-researched (Tipler 1980; Ellery 2022) strategy would allow a relative handful of probe launches to generate hundreds of thousands of observation probes over multiple generations using few home resources. Their low gravity and accessible volume of diverse mineral resources make asteroids good sources of the needed materials (Cannon, *et al*. 2023). Various means of probe propulsion have been considered (Litchford and Sheehy 2020; Matloff 2022b), as have various plans for probe distribution (*e.g*., Loeb and Kirkpatrick 2023). Biological fragility would not be a constraint, so trajectories could be optimized to maximize gravity boosts (Carbone, *et* *al*. 2023). A proactive program utilizing BN probes could investigate potentially worrisome developments, return valuable information, and eliminate potential threats.

Given a speed (inclusive of replication time) of 0.01 c, an expansion front of observation probes could cover the ~5 x 104 light years from the galactic centre to the edge in ~5 x 106 years. (Earth is ~2.5 x 104 ly from the centre). A more sedate 0.001 c seems feasible with near future technology. Antimatter propulsion could achieve higher velocities (Matloff 2022b; Litchford and Sheehy 2020). Warp drives may achieve near-light speeds without time dilation or effective mass increase (Fuchs, *et* *al.* 2024). Faster-than-light travel through wormholes (Bronnikov, *et* *al*. 2023) could render all calculations moot. For a technological society with a realistic prospect of persisting for a billion years or more, even the longest of these times does not seem excessively long. This program would not require ‘stability of motivation’ (Shkurko 2024), a willingness and ability to pursue it over a long time, because once the probes were launched no further effort would be required. Benefits would begin to accrue soon after launch and would continue to accrue at no additional cost. The most valuable single benefit, securing the ETC’s nearby neighbourhood, would accrue long before the expansion ended. Observation probes could produce and launch planetary probes. Once on target, these could generate other instrumentalities, controlled either by an AGI or a locally grown biologic.

A planetary probe and its progeny would conceal their presence for several reasons. The target civilization might try to interfere with them if it became aware of them. It could demand information in exchange for whatever ETC acquired, or it could use what it learns from ETC’s presence to advance its own science and technology. Awareness of the ETC’s presence could distort the target’s independent cultural path, making the information obtained less unique and less valuable (see section 3.4). Strategically as well, disclosure could be dangerous: Given sufficient foreknowledge, any target might prove hard to terminate. But concealment may sometimes be impossible: To test a target’s defence systems may require attracting attention, and it may be hard to take biological samples without disclosing one’s presence. In such cases, deception could supplement concealment. Concealment prevents an opponent from perceiving an asset; deception confuses the opponent’s elite about one’s actions and aims. ‘[E]mpirical evidence confirms assumptions drawn from cognitive psychology that deception seldom fails when it exploits a target’s preconceptions’ (Heuer 1981, 294).

*3.4. Comparison to Other Solutions*

Many proposed solutions to the Fermi paradox hypothesize that ETC behaviour prevents us from observing them (see Webb 2015, 77-124). The dark forest hypothesis is one of these. Unlike many others, it does not need to describe the behaviour of all or nearly all ETCs to work. If just one civilization in a galaxy (or whatever region constitutes its domain) adopts a strategy of silent hunting, the others will inhabit a dark forest regardless of their knowledge or choice. If they hide, we will not hear from them. If they remain unaware of the danger, the time between their emission of a technosignature and their termination is likely to be brief. Humans have had radio for only about a century and superintelligent AGI, perhaps the most threatening technology to an observant ETC, may appear on Earth in a decade. We would be very unlikely to hear any signals a civilization might produce over such a brief period. Nor would we receive signals from the dark forest predator for none would be sent. Thus, this hypothesis resolves the Fermi paradox by providing *both* a universal late great filter (Chao 2015) and a reason for concealment that does not require coordination: The danger can be deduced from first principles.

The dark forest hypothesis makes predictions that comport with the evidence. Becoming a Kardashev Type II or Type III civilization would render a civilization visible even to predators outside its galaxy, making it more vulnerable. The dark forest hypothesis predicts that we will observe none of these and we do not (Choza, *et al.* 2023). The discovery of one planetary member of a colonial system would likely disclose the rest, including the metropole. Widespread colonization could also create its own dark forest risk: Distant colonies would likely grow apart genetically, culturally, and commercially. A ‘Hobbesian predicament in which all actors are perpetually in fear of being destroyed’ could result (Torres 2018, 74). Colonization of Earth and its environs should therefore not be expected, despite ETC’s age and the project’s feasibility.

But the dark forest hypothesis has a salient weakness. It ignores the ease with which an advanced ETC having self-preservation as its only goal could find and destroy exoplanetary civilizations *before* they become technologically proficient. A probe-based strategy of finding and terminating any society that might become dangerous someday – call it a ‘Berserker’ strategy – would leave only dead civilizations and a few carefully hidden ones behind.[[1]](#footnote-2) Yet, though many planets from which Berserkers might come are billions of years older than Earth and we have not hidden, we still exist. This suggests that no ancient ETC has followed the dark forest strategy to its logical conclusion. By contrast, the DGH predicts that ETC would not immediately terminate potential threats but instead would observe them, terminating them only as they become dangerous. Since we presently pose no *imminent* danger to anyone but ourselves, this prediction comports with our continued existence.

A second proposed solution is also worth exploring. Fogg’s (1987) interdict hypothesis modifies Ball’s (1973) zoo hypothesis, which held that one or more ETCs were keeping Earth as a kind of wilderness preserve to let humankind evolve on its own. An ETC could have good reason to do this. ‘If it is accepted that information is the universal criterion of value for species more advanced than ourselves, then information gathering probes would not disturb the complex, information filled system that is the Earth’ (Fogg 1987, 381, quoting Stephenson 1982). Disclosure of ETC’s presence could set human civilization on a different developmental track, one likely to reflect the knowledge and values of the observer (see Lindstrom 2018). The information Earth produces would then be less unique and less valuable. The interdict hypothesis makes the same predictions about ETC’s *current* activity on Earth as the DGH, but it faces objections. Would all ETCs be led to follow the same rules (see Grimes 2016)? How could an advanced civilization stop us from observing alien activity elsewhere in the Galaxy? The DGH responds by saying that other civilizations would have been terminated, would conceal themselves, or would also be dark forest predators. We should expect to receive no signals from any of these. Another objection to zoo/interdict asks if the gathering of non-strategic information would be a sufficiently powerful motive for a galaxy-wide effort. In the DGH, the synergistic combination of strategic and non-strategic objectives addresses this point.

The DGH offers a unified account that suggests and explains the two most plausible solutions of the Fermi paradox: the termination of many technological civilizations by non-natural means and the concealment of others. It is also simpler than many alternative solutions. To see this, compare it to the hypothesis that complex life is rare outside Earth. That claim *seems* simple, for it can be simply stated, but it would *be* simple only if it offered a single, simple explanation for complex life’s rarity. If its rarity was grounded (say) on the Rare Earth Hypothesis, its causes would not be simple; they would be numerous and complex. By contrast, the DGH flows from a single premise: ETCs act in their own self-interest (see Rudnyk 2021).

The DGH is not the only hypothesis that predicts an active, covert presence on Earth. So do zoo/interdict and, to an extent, the dark forest (see note 1). Taken together, these plausible hypotheses, the feasibility of interstellar investigation especially with probes, and the likelihood that complex life is widespread suggest that the ETH’s prior probability is not extremely low.

*Evidence and the ETH*

When all the possibilities are considered, the ETH is not *a priori* highly improbable. To see if it meets the other tests of rationality, we need to delimit it. Generically, it says an ETC is active on Earth today, but that claim is too broad to be useful. We will therefore limit it to the claim that one or more reports of *unidentified anomalous phenomena* (UAP) reflect current activities of an ETC on Earth. UAP are defined as ‘sources of detection of anomalous detections in one or more domains (*i.e*. airborne, seaborne, spaceborne, and/or transmedium) that are not yet attributable to known actors and that demonstrate behaviors that are *not* readily understood by sensors or observers’ (ODNI 2023, 14). Watters, *et al*. (2023, App. A) effectively rebut several standard objections to the scientific investigation of UAP. The material discussed in section 4.1 adds to their arguments rather than repeating them.

‘[O]ne thing is “evidence” for another just in case the first tends to enhance the reasonableness or justification of the second’ Kim (1988, 390-391). The word ‘tends’ signifies that, almost invariably, no single piece of evidence can be dispositive. The search is always for the explanation that best fits *all* the evidence. Evidence can be either direct or circumstantial. Direct evidence points directly to a conclusion: Identification by a witness is the classic example. But no one can identify an unknown object as an alien craft because no one can say what an alien craft would look like. Circumstantial evidence is the alternative; assessing it often requires an inference to the best explanation (IBE).

*4.1. Epistemic Objections*

The following epistemic objections are often raised against the ETH.

*Extraordinary claims require extraordinary evidence*. This assertion, call it *Sagan’s dictum*, accords with Hume’s advice to proportion our belief to the strength of the evidence. It says in effect that we should demand *super-strong* supporting evidence before accepting a hypothesis to which we assign a *super-low* prior probability. Claims like ‘Goblins are in the attic,’ are subject to this dictum because we have no reason to think goblins exist, let alone in our attic. We do, however, have *some* reason to think an ETC *might* be active on Earth. In practice, Sagan’s dictum has generally meant that the ETH must be the explanation of last resort. This stricture would be unproblematic if it meant we should not waste time on this hypothesis until conventional possibilities have been exhausted. But it has too often meant that extraterrestrial explanations are never pursued because a new, conventional explanation might someday turn up, or an ill-fitting one might be stretched to fit the evidence.

McMahon (2020, 126) argues persuasively that scientists should treat claims as ‘extraordinary’ only when they ‘can be independently evaluated as highly improbable or contrary to well-substantiated prior scientific knowledge.’ The ETH is often seen as an improbable hypothesis, but sections 1 and 3 suggest that its prior probability is not much lower than other hypotheses that science investigates. Reports of events known to violate the laws of physics would fall afoul of Hume’s argument against miracles. But we may not have the true laws of physics, and we cannot predict all the technologies that those we do have might allow (NRC 2007; Watters, *et al*. 2023, App. A). Even if it is sound (see Earman 2000), Hume’s argument has little weight when it comes to future technology. Setting its apparent capabilities aside, the mere arrival of an alien spaceship on Earth would require no revision to our scientific theories. Far from ‘overturn[ing] a larger body of [factual] knowledge’ (Prothero and Callahan 2017, 11) than other discoveries, it would overturn none. It was our growing knowledge that led Fermi to ask his question. Of course, a claim that extraterrestrial life has been discovered could not be accepted without solid evidence, but there is a huge difference between accepting a claim and investigating a possibility. The issue here is only whether the ETH is a rational hypothesis. If it is not highly improbable and overturns no large body of scientific knowledge, it should be accepted as one, just so long as it also explains otherwise unexplained evidence. This last requirement will be addressed below.

*Most UAP reports have been explained.* Investigators have found conventional explanations for a large majority of UAP reports. In the remaining cases, no such explanation has been found. Shermer offers one interpretation of this pattern: ‘In all fields of science we find a residue of anomalies unexplained by the dominant theory. That does not mean that the prevailing theory is wrong or that alternative theories are right. It just means that we need to do more work to bring those anomalies into the accepted paradigm’ (Prothero and Callahan 2017, v). Whatever its value in other fields of science,[[2]](#footnote-3) this approach is unwarranted here.

Shermer’s argument can best be framed as a probabilistic appeal to induction:

*Premiss 1*: Most UAP reports have natural or human explanations.

*Premiss 2*: Unexplained reports are not systematically different.

*Conclusion*: All UAP reports probably have natural or human explanations.

To see why the second premiss fails consider a standard case of induction: Balls are drawn randomly from a bin. Nearly all - say 95% - are seen to be white; the remaining 5% are obscured from view. Perhaps they are drawn as a cloud passes by. If the clouds and the drawing are independent events, an observer could reasonably believe that all the balls in the bin are white. But that belief would rest on an assumption of homogeneity; it would assume that nothing makes non-white balls more likely than white balls to be obscured. That assumption cannot be made in the case of UAP. The U.S. Government’s All-Domain Anomaly Resolution Office (AARO 2024,12) explains that ‘the use of “UAP” to refer to *all* potential possibilities provides a false sense of commonality…. The only commonality that they all share, at least initially, is that they are each unidentified. Beyond initially being unidentified … [they] have nothing in common.’ This absence of commonality means we have *no* reason to think that all reported events are equally explicable. We may find no ‘commonsense’ explanation for some simply because none exists.

This limitation on the power of induction applies to any heterogeneous collection of unrelated events (Goodman 1983, 3-30). But it becomes especially salient when we know in advance that many phenomena in the collection will be reported in error. That is the case here. Humans tend to find patterns and attribute them to intelligent agents (Shermer 2011). Novel aerospace technologies create easily misperceived phenomena, and media reports stimulate reporting (AARO 2024). People see more UAP when they have more chances to see them (Medina, *et al*. 2023). Once the ‘flying saucer’ or ‘UFO’ idea entered the public discourse, many reports seeming to fit this rubric were to be expected. Thus, most initially unexplained reports were always likely to be spurious. But that tells us nothing about events that remain unexplained. It does not make it any more likely that none of the unexplained events reflect ETC activity.

*If they are so advanced, why do we observe them?* Why would sophisticated alien spies accidentally reveal themselves as the phenomena typically cited as UAPs? A simple response is that everyone makes mistakes, accidents happen, and some disclosures may be intentional. See section 3.3. The history of human espionage includes examples of all these things (Omand 2015; Andrew 2019). A more sophisticated response might run like this: Humans make mistakes because they use heuristics that conserve time and energy but sometimes reach the wrong result (Tversky and Kahneman 1974). Artificial intelligence makes similar mistakes, apparently for the same reason (Rich and Gureckis 2019). Any decision-making system may need heuristics of one kind or another if it is to meet requirements of compactness, speed, and cost. If so, any such system would make mistakes. Both answers are more compelling if the proportion of UAP reports that reflect an extraterrestrial presence is small.

*Witnesses cannot provide reliable evidence.* Three types of supporting evidence for a UAP report might exist: witness statements, sensor data (including photographs and video recordings), and physical evidence. Physical evidence is scientifically acceptable as are sensor readings, at least when two or more well-calibrated sensors yield the same result (Coumbe 2023). Witness reports are said to be unreliable. Yet, why then witnesses are essential to the judicial process? Why are recorded witness reports (*e.g*., diaries and letters) primary sources for historians? The reason is simple: Practitioners in these fields are likelier to reach the truth if they consider witness evidence than if they ignore it. Scientists rely more on non-witness evidence than do courts or historians, but this is not always true. Only first-person reporting can provide the data that fields like cognitive psychology, clinical psychology, and consciousness studies require (Piccinini 2009). *The Origin of Species* included hundreds of observations of animal behavior. These were witness statements, albeit from qualified witnesses. A reliance on qualified witnesses does not make a work unscientific, at least when their reports tell a consistent story and comport with other evidence.

Witnesses have special importance in investigations of unpredictable events, including those that involve intentional actors. If scientists cannot know when or where something may occur, they cannot prepare for its arrival; nor can they test and retest it. As Gounelle (2006, 81) writes of meteorite falls, events of this sort are almost always seen by ‘individuals *other than scientists*. It is only later that scientists pay attention to them.’ In such cases, scientists must choose between utilizing witness reports and ignoring them. The latter choice has sometimes been costly. The scientific community largely ignored reports of rogue waves until one struck Norway’s Draupner E drilling platform in 1995 (Kharif, *et al*. 2008). Before that, they sank dozens of ships. Like rogue waves, UAP are unpredictable phenomena, rarely observed with scientific instruments, more frequently by lay witnesses.

If witnesses were uniformly unreliable, a measured reliance on their reports would be problematic. But they are not. Witness reports are said to be reliable when their accuracy is proportional to the witness’ confidence in them: that is, when a report recounted with high confidence is very likely to be true. The current widespread distrust of witness reporting derives from early empirical research and the exoneration of defendants wrongly convicted by confident eyewitness testimony (Loftus 2005; Brewin, *et al*. 2020; Brewin 2020). Yet, recent work in this field paints a more nuanced picture. The factors affecting witness reliability are either *estimator* or *system* variables. Estimator variables relate to the witness’s perception and include such things as lighting, viewing distance, visual acuity, health, and stress. System variables relate to the ways information is obtained from the witness and include such things as the fairness of a lineup, the phrasing of questions, and conflating information the witness receives after the event (Albright and Garrett 2022, 528). Witnesses generally know their own limitations, so they tend to take estimator variables into account when giving their reports. Absent deception or hidden bias, their confidence in reported observations is usually a reliable measure of accuracy unless system variables intervene. ‘[L]aboratory studies have found that, under pristine circumstances in which opportunities for [system] bias are limited, highly confident witnesses are, on average, highly accurate’ (*id*., 535).

Wrongful convictions often occur when system variables cause a witness’ confidence at trial to exceed that expressed at the initial lineup or interview (Wixted and Wells 2017; Wixted, *et al*. 2018; Brewin, *et al*. 2020; Brewin 2020). But a witness who makes an early, confident assessment of an event under non-biasing conditions is usually correct. The current assessment is once again that, ‘On balance … our memory systems do a remarkably good job of preserving the general contours of our pasts and of recording correctly many of the important things that have happened to us. We could not have evolved as a species otherwise’ (Schacter 1996, 308).

Specific factors are now known to induce inaccuracy (Schacter 2001 and 2021). Rather than disregarding witness reports, investigators need to scrutinize them for these biasing factors. This requires probing the details of each case selected for investigation, including the witness’s qualifications. Thus, a witness may be trained to operate a specific piece of equipment (a radar or video system) and to accurately report the events it depicts. If so, their account of events on their screen would likely be more accurate than their account of events occurring on the sidewalk. Or consider the differences between a civilian who observes lights in the night sky and a fighter pilot who observes an object in daylight.

Fighter pilots typically have thousands of hours of flight experience under highly stressful conditions. They know the silhouette and flight capabilities of every aircraft in the sky. They know how to remain calm in stressful situations. Their visual acuity, general health, and intoxication levels are checked regularly and thoroughly’ (Coumbe 2023, 9).

The conclusion one draws from a witness report should depend on factors like these *and* on the pattern of evidence into which it fits. Taken together with other evidence, witness reports changed scientific orthodoxy in 1803 when Jean-Baptiste Biot combined them with a chemical analysis to demonstrate the astronomical origin (Gounelle 2006). They did it again in 1995, when a single event at a well-instrumented platform led scientists to reconsider previously ignored reports from sailor witnesses (Kharif, *et al*. 2008). While they should be evaluated with care, witness reports are sometimes essential to successful scientific inquiry.

*4.2. Inference to the Best Explanation*

It is easy to see how evidence of an event can make the ETH a *less* likely explanation for a UAP report: It need only suggest that the event could have had a known, prosaic explanation. The harder question is how even reliable evidence can make the ETH a *more* likely explanation. A NASA task force report (2023a, 17) explains, ‘Convincing evidence of verified anomalous accelerations and velocity would point towards potentially novel explanations for UAP.’ *Not* toward the ETH, but toward unspecified unknowns. Similarly, Loeb (2021, 14) criticizes assertions that certain events do not indicate alien activity because they beg ‘the unanswered question, “What would such an indication be?”’ These statements illustrate the *problem of direct* *evidence*: How can we say an X is a Y if we have no prior knowledge of things of the class Y?

In principle, IBE can overcome this obstacle. Given hypothesis H and explanandum E, inference to the best explanation usually takes the following form:

*Premiss 1:* H, if true, would explain E.

*Premiss 2*: No other hypothesis can explain E as well.

*Conclusion*: H is likely true.

This reasoning can turn evidence *against* one or more hypotheses into evidence *for* another. In the case of a UAP, it can turn evidence against human and natural explanations into evidence for the ETH. To accomplish this, two conditions must be met: We must be confident that the event occurred as reported, and the range of alternative explanations must be well-canvassed. As Josephson (2001**)** styles these conditions, the ‘NOISE hypothesis’ (that the reported data are wrong, falsified, or incomplete) and the ‘NEW hypothesis’ (that an explanation unthought of may be the right one) must be minimized. If they are, and if the number of candidate explanations is manageable, one can reason toward the best explanation by a process of exclusion.

Given reliable evidence (little NOISE), the following criteria will determine the strength of a conclusion reached by IBE (Josephson 2001, 1626).

*1)* ‘How well does the hypothesis stand by itself?’On a Bayesian view, this question asks for its prior probability. Many statistical methods treat rare but potentially catastrophic ‘black swan’ events as outliers, effectively assigning them a zero prior. The extraterrestrial taboo has done the same for the ETH. Chichilnisky (2009) explains why this approach is improper and suggests a corrective. Yet, the corrective, while welcome, does not identify factors that may determine the ETH’s prior probability. There seem to be three of these: i) the probability that advanced ETCs have come to exist in our Galaxy, either because they arose here or because they entered from elsewhere; ii) the probability that at least one has adopted a proactive strategy resembling the one described in section 3.3; and iii) the probability that the resulting expansion front has reached Earth. Only one ETC would need to adopt this strategy for the DGH to be true, and the probability that one would adopt it increases with the number of advanced ETCs. Given the likely age of most advanced ETCs, the third probability is high. So, the product of these factors, the prior probability of the ETH, turns on the probability that a significant number of advanced ETCs have come to exist. As discussed in section 1, this seems likely.

2)‘How thorough was the search for alternative explanations?’ This question asks first about the NEW hypothesis: In addition to any suspected causes, might some *unsuspected* natural or human cause be responsible for the observation? Cowie (2023, 78-79) plausibly argues that, in space, we should be open to natural ‘explanations that have not been considered; either not considered at all or considered but not qua explanations.’ The reason ‘concerns the *comprehensiveness* of our understanding with respect to the domain we’re working in.’ In space, many unknown possibilities may exist, but in other ‘domains …. [t]he space of unconceived alternatives may be pretty small.’ Earth’s atmosphere is a well-studied domain. On the rare occasions when novel phenomena are discovered here it is almost always in special conditions (see, *e.g*., Vargemezis, *et al*. 2024).[[3]](#footnote-4)

One alternative explanation deserves special mention: In the past, observers frequently reported the testing or deployment of advanced and secret military technology (AARO 2024; Graff 2023). This could be domestic technology or the unknown technology of a foreign government. As to the latter, AARO’s former director says, “If we don't prove it’s aliens, then what we're finding is evidence of other people doing stuff in our backyard.’ (Seligman 2023). But this popular alternative has a limitation. Disclosure of advanced technology – in the special sense that the capabilities and provenance of an advanced technology become public even if its internal workings do not – always occurs eventually. The value attached to patents and to scientific priority incentivizes disclosure. Technologies are invented simultaneously in multiple countries and settings (Lemley 2012); they are shared, sold, and used in war. Theft of secrets is widespread (Andrew 2019; Glitz and Meyersson 2020). Technical advances require many knowledgeable participants; preventing disclosure for decades would require an improbable degree of cooperation (Grimes 2016). The time it might take for a secret technology to be disclosed cannot be known precisely, but the known technology that, in the modern era, remained secret longest may have been the Enigma system. Used during World War II, its capabilities and provenance were disclosed ~30 years later (Winterbotham 1974). It follows that advanced technology cannot be a plausible explanation for events that occurred sufficiently far in the past.

To simplify the argument, assume an event, E, was explicable in year 1 only as the product of either extraterrestrial activity (Ha) or secret human technology (Hs). Equation 1 describes the prior probabilities of the competing explanations at that time.

Pr(HsǀE)1 + Pr(HaǀE)1 = 1. 1)

We can assume that any technology tested or deployed in a certain year will be disclosed (in the sense described above) by *some* future year. Equation 2 shows how Pr(HsǀE)1 would change by the present year, p, if the probability of disclosure would increase to 1 by year y at a linear rate.

Pr(HsǀE)p = Pr(HsǀE)1(1 – p/y) 2)

Given y = 30, p = 20, and Pr(HsǀE)1 = 0.99, the present probability of an extraterrestrial explanation, Pr(HaǀE)p, would be 0.67. As time passes and Pr(HsǀE) decreases, this probability would increase.

3)‘How decisively does the leading hypothesis surpass the alternatives?’The ‘leading hypothesis’ is usually taken to mean the most explanatory *individual* hypothesis. But real-world phenomena can have multiple causes, and this can occur in two broad ways: A single phenomenon (*e.g.,* a disease) can have concurrent causes (*e.g*., genetic and environmental), or the observations that together constitute a single event can have multiple independent causes. Schupbach (2023) argues that IBE can handle the first class of cases. To do so, it needs to consider both the strength of competing explanatory sets – where each set may consist of one or more hypotheses – and the reduced probability of a multi-hypothesis set implied by its greater informational complexity. A similar approach could be used for events of the second class.

*4.3. The Nimitz Event*

A complete account of the evidence for the ETH would require more than an article. It will, however, be useful to describe one incident briefly. In November 2004, a carrier task force led by *U.S.S. Nimitz* and guided missile cruiser *U.S.S. Princeton* was engaged in a training exercise in the eastern Pacific (SCU 2019). *Princeton* was equipped with an advanced SPY-1 radar system and coordinated data from across the task force, including from an EC-2 Hawkeye early warning aircraft. According to its radar system operator and other Navy witnesses, returns over several days showed unknown objects engaging in extreme and erratic behavior: *e.g*., dropping from 28,000 feet down to near sea level in 0.78 seconds then stopping. ‘Such a maneuver would require a staggering acceleration, far beyond what humans could withstand’ (Coumbe 2019, 8; see Knuth, *et al*. 2019). On November 14, *Princeton* sent aircraft to investigate.

The sea was calm, the sky was blue, and visibility was unlimited. Yet, at the targeted location, two Navy F/A-18Fs (each with 2 crew) observed a ~50-meter circular patch of turbulent white water. (A Marine pilot had spotted it seconds earlier.) Not far above this patch, they observed a 40-50 foot long, wingless, white ‘Tic-Tac-shaped’ object making erratic back-and-forth movements, ‘like a ping pong ball' (SCU 2019, 8). The object had no apparent engine signature, exhaust, or source of lift. As one F/A-18F circled down toward it, it circled up. When the descending plane crossed toward it, ‘[I]t takes off like nothing I’ve ever seen. It literally is one minute it’s there and the next minute it’s like, poof, and it’s gone’ (CDR David Fravor at SCU 2019, 11). The white water was also gone.

Seconds later, *Princeton* spotted the object at the fliers’ secret combat air patrol (CAP) point, about 60 miles from the initial encounter. Two more F/A-18Fs were dispatched to investigate. The one directed toward the CAP point acquired the object on its radar and recorded a video on its Advanced Targeting Forward-Looking Infrared (ATFLIR) camera system. The object was less than 20 miles distant but beyond the range of visual observation. Only a small portion of the ATFLIR video has been released and none of the radar data. LCDR Chad Underwood, the flier who recorded the video describes the object’s behavior (Phelan 2019):

The thing that stood out to me the most was how erratic it was behaving. And what I mean by ‘erratic’ is that its changes in altitude, air speed, and aspect were just unlike things that I’ve ever encountered before flying against other air targets. … It was going from like 50,000 feet to, you know, a hundred feet in like seconds.… You could not see the thing that the ATFLIR pod should pick up 100 percent of the time: the source of heat and exhaust that a normal object flying would give you.

Several possible sources of NOISE have been suggested. Herrington (2023) suggests that *Princeton*’s radar systems malfunctioned or misidentified the Taurid meteor shower, but the system was checked and rebooted, and radar is unlikely to mistake astronomical bodies for aircraft (Hunter 2017). He also suggests a submerging submarine might have created the turbulence. But submarines do not create regions of turbulence as they submerge; the water they displace fills their ballast tanks. A NASA X-43 hypersonic drone has been suggested as the source of the visual and radar reports of the ‘Tic Tac’ object, but the X-43 had its first successful test on November *16*, 2004, two days *after* the *Nimitz* event, and the testing commenced at 40,000 feet, not near the ocean’s surface (Heppenhelmer 2007). Moreover, the flyers state that they are debriefed about secret technology when it is involved in an incident of this sort (SCU 2019; Phelan 2019). That did not occur here. Some sceptics say the video might depict a distant aircraft (Graff 2023, 414), but no aircraft would fit Underwood’s description. Each of these hypotheses is improbable, but all or nearly all would need to be conjointly true to explain this event.

Since this event became public, three U.S. Government offices have issued reports on the UAP question (NASA 2023a; ODNI 2021 and 2021; and AARO 2024). None explain this incident, but one refers to it among others: ‘[T]here are some cases where reported UAP have potentially exhibited one or more concerning performance characteristics such as high-speed travel or unusual maneuverability’ (ODNI 2024, 2). The Nimitz event is one of several for which the ETH may be the best explanation; see Coumbe (2023, 17-38) for another. Since the ETH also meets the other requirements outlined above, it is a rational hypothesis that should be openly discussed.

***References***

Albright, Thomas and Brandon Garrett (2022) The Law and Science of Eyewitness Evidence, *Boston University Law Review* **102**, 511-629.

All-Domain Anomaly Resolution Office (AARO), U.S. Department of Defense (2024) *Report on the Historical Record of U.S. Government Involvement with Unidentified Anomalous Phenomena (UAP)*. Vol. 1.

Andrew, Christopher (2019) *The Secret World: A History of Intelligence.* New Haven: Yale.

Armstrong, Stuart and Anders Sandberg (2013) Eternity in six hours: Intergalactic spreading of intelligent life and sharpening the Fermi paradox, *Acta Astronautica* **89**, 1-13.

Arthur, Rudy and Arwen Nicholson (2023) A Gaian Habitable Zone, *Monthly Notices of the Royal Astronomical Society* 521:1, 690-707.

Asimov, Isaac (1968) *Is Anyone There?* Ace.

Bainbridge, William (2018) *Computer Simulations of Space Societies*. Springer.

Balbi, Amedeo, *et al*. (2020) The Habitability of the Galactic Bulge, *Life* **10**:8, 132.

Bartlett, Stuart and Michael Wong (2020) Defining Life in the Universe: From Three Privileged Functions to Four Pillars, *Life* **10**:4, 42.

Baum, David, *et* *al*. (2023) The ecology-evolution continuum and the origin of life, *Journal of the Royal Society Interface* **20**, 20230346.

Bennett, Marc (2023) *Understanding Strategic Surprise: Using Scripts and Empathy to Explain US Security Policy Failures.* Kings College London, PhD Thesis.

Benson-Tilsen, Tsvi and N. Soares (2016) Formalizing Convergent Instrumental Goals, *AAAI-16 Workshop: AI, Ethics.*

Benton, David (2020) A proposed method for a photon-counting laser coherence detection system to complement optical SETI, *Astronomical Society of the Pacific* 131, 074501.

Billingham, J. and J. Benford (2011) Costs and Difficulties of Interstellar ‘Messaging’ and the Need for International Debate on Potential Risks, Journal of the British Interplanetary Society **67**, 17-23.

Blackhawk, Ned, *et* *al*. (2023) *Cambridge World History of Genocide*. Vol. 2. Cambridge.

Bohlman, Ulrike and Moritz Bürger (2018) Anthropocentrism in the Search for Extraterrestrial Intelligence, *Acta Astronautica* **143**, 163-168.

Borgue, Olivia and Andreas Hein (2021) Near-term self-replicating probes – a concept design, *Acta Astronautica* **187**, 546-556.

Bostrom, Nick and Milan Ćirković, eds. (2008) *Global Catastrophic Risks*. Oxford.

Bostrom, Nick (2014) *Superintelligence: Paths, Dangers, Strategies*. Oxford.

Boudry, Maarten (2021) Diagnosing Pseudoscience – By Getting Rid of the Demarcation Problem, *Journal for General Philosophy of Science* **53**:2, 83-101.

Bourrat, Pierrick (2023) A Pricean Formalization of Gaia, *Philosophy* *of* *Science* **90**:3, 704-720.

Brabender, Ma, *et* *al*. (2024) Ferredoxin reduction by hydrogen with iron functions as an evolutionary precursor of flavin-based electron bifurcation, *PNAS* **121**:13, e2318969121.

Brewin, Chris, Bernice Andrews, and Laura Mickes (2020) Regaining Consensus on the Reliability of Memory, *Current Directions in Psychological Science* **29**:2, 121-125.

Brewin, Chris (2020) Commentary on T. Yarkoni (2020) The Generalizability Crisis, *Behavioral and Brain Sciences* **45**, e7.

Brin, David (2018) The ‘Barn Door’ Argument, The Precautionary Principle, and METI as ‘Prayer,’ *Theology and Science* **17**:1, 16-28.

Bronnikov, Kirill, *et* *al.* (2023) Possible Wormholes in a Friedmann Universe, *MDPI* 9:11, 465.

Brocks, Jochen, *et al*. (2023) Lost world of complex life and the late rise of the eukaryotic crown, *Nature* **618**, 767-773.

Brooks, Dorothy (1956) The Influence of African Art on Contemporary European Art, *African Affairs* **55**:218, 51-59.

Cabrol, Nathalie (2016) Alien Mindscapes – A Perspective on the Search for Extraterrestrial Intelligence, *Astrobiology* **16**:9, 661-675.

Cai, Xiang, *et al*. (2021) A Statistical Estimation of the Occurrence of Extraterrestrial Intelligence in the Milky Way Galaxy, *Galaxies* **9**:1, 5.

Cannon, Kevin, *et al*. (2023) Precious and structural metals on asteroids, *Planetary and Space Science* **225**: 105608.

Carbone, Andrea, *et* *al*. (2023) Cutting-Edge Trajectory Optimization through Quantum Annealing, *MDPI* **13**:23, 12853.

Çep, Berrin, *et* *al*. (2021) Adaptive capacity and flexibility of the Neanderthals at Heidenschmiede (Swabian Jura) with regard to core reduction strategies, *PLOS One* **16**(9):e0257041.

Cervera, Roberto, Maya Wang and Benjamin Harden (2020) Systems neuroscience of curiosity, *Current Opinion in Behavioral Sciences* **35**, 48-55.

Chaisson, Eric (2002) *Cosmic Evolution: The Rise of Complexity in Nature*. Harvard.

Chao Yu (2015) The Dark Forest Rule: One Solution to the Fermi Paradox, *Journal of the British Interplanetary Society* **68**:5-6, 142-144.

Chichilnisky, Graciela (2009) The Foundations of Statistics with Black Swans, *Mathematical Social Sciences* doi:10.1016/j.mathsocsci.2009.09.007.

Choi, Jung-Kyoo and Samuel Bowles (2007) The Coevolution of Parochial Altruism and War, *Science* **318**:5850, 636-640.

Choza, Carmen, *et* *al*. (2023) The Breakthrough Listen Search for Intelligent Life: Technosignature Search of 97 Nearby Galaxies, *The Astronomical Journal* **167**:1.

Christoudias, Theodoros, *et al*. (2024) Earth’s atmosphere protects the biosphere from nearby supernovae, *Communications Earth and Environment* **5**, 326.

Ćirković, Milan (2017) Is Contact a Process? *Space* *Policy* **2017**:42, 103-108.

----- (2018) *The Great Silence: The Silence and Philosophy of Fermi’s Paradox*. Oxford.

Cocconi, Giuseppe and Philip Morrison (1959) Searching for Interstellar Communications, *Nature* **184**, 844-846.

Conway Morris, Simon (2003) *Life’s Solution*. Cambridge.

Coumbe, Daniel (2023) *Anomaly: A Scientific Exploration of the UFO Phenomenon*. Rowman and Littlefield.

Cowie, Christopher (2023) Arguing about Extraterrestrial Intelligence, *Philosophical Quarterly* **73**:1, 64-83.

Cortés, Marina, *et* *al*. (2022) Biocosmology: Toward the birth of a new science, [2204.09378.pdf (arxiv.org)](https://arxiv.org/pdf/2204.09378.pdf).

Dall, Sasha, *et* *al*. (2005) Information and its use by animals in evolutionary ecology, *TRENDS in Ecology and Evolution* **20**:4, 187-193.

Danovaro, Roberto, *et al*. (2010) The first metazoa living in permanently anoxic conditions, *BMC Biology* **8**:30.

Davies, Paul (2010) *The Eerie Silence: Reviewing our Search for Alien Intelligence*. Houghton Mifflin Harcourt.

Davis, John (2018) *New Methuselahs*. MIT.

Dick, Steven (2006) The postbiological universe, 57th International Astronomical Congress, <http://resources.iaaseti.org/abst2006/IAC-06-A4.2.01.pdf>.

Dȍbler, Niklas and Marius Raab (2021) Thinking ET: A discussion of exopsychology, *Acta* *Astronautica* **189**, 699-711.

Doolittle, W. Ford (2020) Is the Earth an organism? *Aeon*. [The Gaia hypothesis reimagined by one of its key sceptics |Aeon Essays](https://aeon.co/essays/the-gaia-hypothesis-reimagined-by-one-of-its-key-sceptics).

Dothan, Shai (2021) When Immediate Responses Fail, *Vanderbilt Law Review* **51**, 1075.

Earman, John (2000) *Hume’s Abject Failure* Oxford.

Ellery, Alex (2022) Self-replicating probes are imminent: Implications for SETI, *International Journal of Astrobiology* **21**:4, 212-242.

Erwin, Douglas (2001) Lessons from the Past: Biotic Recoveries from Mass Extinctions, *PNAS* **98**:10, 4399-5403.

Fairchild, Jasper, *et al.* (2024) Prebiotically plausible chemoselective pantetheine synthesis in water, *Science* **383**:6685, 911-918.

Ferentinos, G. *et al*. (2024) Archaic hominins maiden voyage in the Mediterranean Sea, *Quaternary International* **646**, 11-21.

Fogg, Martyn (1987) Temporal Aspects of the Interaction among the First Galactic Civilizations: The ‘Interdict Hypothesis,’ *Icarus* **69**:2, 370-384.

Foley, Bradford (2018) The dependency of plate tectonics on mantle thermal state, *Philosophical Transactions of the Royal Society A* 376:20170409.

Freeland, Stephen (2022) Undefining life’s biochemistry: Implications for abiogenesis, *Journal of the Royal Society Interface* **19**:20210814.

Fuchs, Jared (2024) Constant velocity physical warp drive solution, *Classical and Quantum Gravity* **41**, 095103.

Garrett, M.A. (2015) Application of the mid-IR radio correlation to the G sample and the search for extraterrestrial civilizations, *Astronomy & Astrophysics* **581** L5.

----- (2024) Is artificial intelligence the great filter that makes advanced technical civilisations rare in the universe? *Acta Astronautica* **219**, 731-735.

Glitz, Albrecht and Erik Meyersson (2020) Industrial Espionage and Productivity, *American Economic Association* **110**:4, 1055-1103.

Goldford, Joshua, *et al.* (2024) Primitive purine biosynthesis connects ancient geochemistry to modern metabolism, *Nature Ecology and Evolution* **8**, 999-1009.

Goodman, Nelson (1983) *Fact, Fiction, and Forecast*. Harvard.

Gordon, Sue (June 28, 2023) If we cannot trust our former presidents, who can we trust? *Washington Post*.

Gounelle, Matthieu (2006) The meteorite fall at L'Aigle and the Biot report: exploring the cradle of meteoritics, in G.J.H. McCall, et *al*., eds. *The History of Meteoritics and Key Meteorites Collections: Fireballs, Falls, and Finds*. Geological Society of London, 73-89.

Gradev, Kalin (2015) Surprise or Instantaneity as a Principle of War, *Security and Defense Quarterly* **8**:3, 130-148.

Graff, Garret (2023) *UFO.* New York: Simon & Schuster.

Graham, R.J. *et al*. (2024) Substantial Extension of the Lifetime of the Terrestrial Biosphere, arXiv:2409.10714Top of FormTop of Form

Grimes, David (2016) On the Viability of Conspiratorial Beliefs, *PLoS ONE* **11**:1, e0147905; corrected at **11**:3, e0151003.

Grinspoon, David (2004) *Lonely Planets: The Natural Philosophy of Alien Life*. New York: Ecco.

Hall, John (2007) *Beyond AI: Creating the Conscience of the Machine*. Prometheus.

Hanson, Robin (1998) The Great Filter - Are We Almost Past It? [http://hanson.gmu.edu/greatfilter.html](https://hanson.gmu.edu/greatfilter.html).

Harrison, Stuart, *et* *al*. (2023) Life as a Guide to Its Own Origins, *Annual Review of Ecology, Evolution and Systematics* **54**:327-350.

Hein, Andreas and Stephen Baxter (2018) Artificial Intelligence for Interstellar Travel, 1811.06526.pdf (arxiv.org).

Heppenhelmer, Thomas (2007) Facing the Heat Barrier: A History of Hypersonics, *NASA History Division*.

Herrington, Luke (2023, June) Cutting the Chaff, *Joint Force Quarterly* – ISSN: 1070-0692.

Heuer, Richards (1981) Strategic Deception and Counterdeception: A Cognitive Process Approach, *International Studies Journal* **25**:2, 294-327. https://doi.org/10.2307/2600359.

----- (2019) *The Psychology of Intelligence Analysis*. Martino.

Hickman, John (2018) Potential Issues for Interplanetary and Interstellar Trade, in *Deep Space Commodities*, Tom James, ed. Palgrave-Macmillan, 141-150.

Hillier, Brian (1997) *The Economics of Asymmetric Information*. Macmillan.

Hippke, Michael (2021) Searching for interstellar quantum communications, *The Astronomical Journal* **162**:1.

Hoffman, Dirk, *et* *al*. (2018) U-Th dating of carbonaceous crusts reveals Neandertal origin of Iberian cave art, *Science* **359**:6378, 912-915.

House of Representatives, Committee on Oversight and Accountability, Hearing before the Subcommittee on National Security, the Border, and Foreign Affairs, July 26, 2023. Washington: GPO.

-----, Permanent Select Committee on Intelligence, Hearing before the Subcommittee on Counterterrorism, Counterintelligence, and Counterproliferation, May 17, 2022; November 13, 2024.

Huffman, David, Raimund Maurer and Olivia Mitchell (2019) Time Discounting and Economic Decision Making in the Older Population, *Journal of Economics of Aging* **14**, 100121.

Hunter, Heather (2017) Radar in Earth and Planetary Science: An Intro, *The Planetary Society*. Radar in Earth and Planetary Science: An Intro | The Planetary Society.

Imachi, Hiroyuki (2020) Isolation of an archaeon at the prokaryote–eukaryote interface, *Nature* **577**:7791, 519-525.

Ivanov, Valentin, *et* *al*. (2020) A qualitative classification of extraterrestrial civilizations, *Astronomy & Astrophysics* **639**: A94.

Jaegle, Andrew, Vahid Mehrpour, and Nicole Rust (2019) Visual novelty, curiosity and intrinsic reward, *Current Opinion in Neurobiology* **58**, 167-174.

Jessen, Tyler, *et* *al*. (2022) Contributions of Indigenous Knowledge to ecological and evolutionary understanding, *Frontiers in Ecology and Environment* **20**:2, 93-101.

Jiang, Jonathan, *et* *al.* (2022) A Beacon in the Galaxy: Updated Arecibo Signal for Potential FAST and SETI Projects, *Galaxies* **10**:2, 55.

Johnson, Lydia, *et* *al.* (2023) Weaving indigenous and western ways of knowing in ecotoxicology and wildlife health, *Environmental Reviews.*

Josephson, John (2001) On the Proof Dynamics of Inference to the Best Explanation, 22 *Cardozo L. Rev*. 1621.

Kessler, André and Michael Mueller (2024) Induced resistance to herbivory and the intelligent plant, *Plant Signaling and Behavior* **19**:1.

Kharif, Christian, *et al*. (2008) *Rogue Waves in the Ocean*. Springer.

Kim, Jaegwon (1988) What is ‘Naturalized Epistemology’? in James Tomberlin, ed. *Philosophical Perspectives 2, Epistemology*. Atascadero: Ridgeview, 381-405.

Kim, Seohyun, *et* *al*. (2021) The Emergence of RNA from the Heterogeneous Products of Prebiotic Nucleotide Synthesis, *Journal of the American Chemical Society* **143**:9, 3267-3279.

Kipping, David and Alex Teachey (2016) A Cloaking Device for Transiting Planets, *Monthly* *Notices of the Royal Astronomical Society* **459**:2.

Kipping, David, Adam Frank and Caleb Scharf (2020) Contact Inequality: First Contact Will Likely Be with an Older Civilization, *International Journal of Astrobiology* **19**:6, 430-437.

Knoll, Andrew and Richard Bambach (2019) Directionality in the history of life: Diffusion from the left wall or repeated scaling of the right? *Paleobiology* **26**:S4, 1-14.

Knuth, Kevin, *et* *al*. (2019) Estimating Flight Characteristics of Anomalous Unidentified Aerial Vehicles in the 2004 Nimitz Encounter, *Proceedings* *MDPI* **2019**: 33, 26.

Kopparapu, Ravi, *et* *al*. (2021) Nitrogen Dioxide Pollution as a Signal of Extraterrestrial Technology, *The Astrophysical Journal* **908**:2, 164.

Kuhn, Thomas (1970) *The Structure of Scientific Revolutions*. Chicago.

Kurzweil, Ray (2005) *The Singularity Is Near*. New York: Penguin.

----- (2024) *The Singularity Is Nearer*. New York: Viking.

Lampton, Michael (2013) Information-driven societies and Fermi’s paradox, *International Journal of Astrobiology* **12**:4, 312-313.

Lamźa, Lukasz (2023) Diversity of ‘simple’ multicellular eukaryotes: 45 independent cases and six types of multicellularity, *Biological Reviews* **98**:6, 2188-2209.

Lane, Nick (2022) *Transformer*. Norton.

Leder, Dirk, *et al*. (2021) A 51,000-year-old engraved bone reveals Neanderthals’ capacity for symbolic behaviour, *Nature Ecology and Evolution* **5**, 1273-1282.

Lemley, Mark (2012) The Myth of the Sole Inventor, 110 *Michigan Law Review* 709.

Letrud, Kare (2022) Do We Know It When We See It? *Episteme* **20**:2, 479-495.

Lindstrom, Lamont (2018). Cargo Cults, *The Cambridge Encyclopedia of Anthropology.*

Lingam, Manasvi, *et* *al*. (2023) Technosignatures: Frameworks for their Assessment, *The Astrophysical Journal* **943**:1, 27.

Lingam, Manasvi and Abraham Loeb (2018) Is Life Most Likely Around Sun-like Stars? *Journal of Cosmology and Astroparticle Physics* **2018**:5, 20.

Litchford, Robert and Jeffrey Sheehy (2020) Prospects for Interstellar Propulsion, NASA Preprint AAS 20-068 – 200200000759-1.

Liu Cixin (2015) *The Dark Forest*. Tor.

Lockley, Andrew and Daniele Visioni (2020) Detection of pre-industrial societies on exoplanets, *International Journal of Astrobiology* **20**:1, 73-80.

Loeb, Avi (2021) *Interstellar:* *The Search for Extraterrestrial Life and Our Future in the Stars*. New York: Mariner.

----- (2022) *Extraterrestrial*: *The First Sign of Intelligent Life Beyond Earth*. New York: Mariner.

Loeb, Abraham and Sean Kirkpatrick (2023) Physical Constraints on Unidentified Aerial Phenomena (Under Review). LK1.pdf (mentealternativa.com).

Loftus, Elizabeth (2005) Planting misinformation in the human mind: A 30-year investigation of the malleability of memory, *Learning and Memory* **12**:4, 361-366.

Marshall, Stuart, *et al*. (2021) Identifying molecules as biosignatures with assembly theory and mass spectrometry, *Nature* *Communications* **12**:3033.

Matloff, Gregory (2022a) The Solar-Electric Sail: Applications to Interstellar Migration and Consequences for SETI, *Universe* **8**:5, 252.

----- (2022b) Von Neumann probes: rationale, propulsion, interstellar transfer timing, *International Journal of Astrobiology* **21**:4, 205-211.

McClain, Craig, *et* *al*. (2022) Extremophiles in Earth’s Deep Seas: A View Toward Life in Exo-Oceans, *Astrobiology* **22**:8, 1009-1028.

McMahon, Sean (2020) Do Extraordinary Claims Require Extraordinary Evidence? in *Conceptual Issues in Astrobiology*, Kelly Smith and Carlos Mariscal, eds. Oxford, 117-129.

Medina, R.M., S.C. Brewer and S.M. Kirkpatrick (2023) An environmental analysis of public UAP sightings and sky view potential, *Scientific Reports* **13**, 22213.

Melzer, David (2019) The genetics of human ageing, *Nature Reviews Genetics* **21**, 88-101.

Merino, Nancy (2019) Living at the Extremes: Extremophiles and the Limits of Life in a Planetary Context, *Frontiers in Microbiology* **10**. https://doi.org/10.3389/fmicb.2019.00780.

Michaud, Michael (2007) *Contact with Alien Civilizations: Our Hopes and Fears about Encountering Extraterrestrials*. Copernicus.

Mithen, Steven (2024) *The Language Puzzle*. Basic.

Moody, Edmund, *et al*. (2024) The nature of the last universal common ancestor and its impact on the early Earth system, *nature ecology & evolution* **8**, 1654-1666.

Murphy, Sean and Anthony Atala (2014) 3D bioprinting of tissues and organs, *Nature Biotechnology* **32**, 773-785.

Mussini, Giovanni (2023) Children of Time: the geological recency of intelligence and its implications for SETI, *British Journal for Philosophy of Science.* Published online 2023: 1-29.

Najle, Sebastián, *et* *al*. (2023) Stepwise emergence of the neuronal gene expression program in early animal evolution, *Cell* **186**:21, 4676-4693.

Nargund, G. (2009) Declining birth rate in Developed Countries: A radical policy re-think is required, *Facts, Views & Vision* **1**:3, 191-193.

National Research Council (NRC). 2007. *A Strategy for Assessing Science*, I. Feller and P.C. Stern, eds. National Academies Press.

NASA (2023a) Unidentified Anomalous Phenomena: Independent Study Team Report, uap-independent-study-team-final-report.pdf (nasa.gov).

NASA (2023b) NASA’s Planetary Defense Strategy and Action Plan. NASA Releases Agency Strategy for Planetary Defense to Safeguard Earth - NASA.

Nicholson, Arwen, *et al.* (2018) Gaian bottlenecks and planetary habitability maintained by evolving model biospheres, *Monthly Notices of the Royal Astronomical Society* **477**, 727-740.

Office of the Director of National Intelligence (ODNI) (2021) *Preliminary Assessment of Unidentified Aerial Phenomena*. Prelimary-Assessment-UAP-20210625.pdf (dni.gov).

ODNI (2023) *FY 2023 Consolidated Report on Unidentified Anomalous Phenomena*. <https://www.aaro.mil/Portals/136/PDFs/UNCLASSIFIED-FY23_Consolidated_Annual_Report_on_UAP-Oct_25_2023_1236.pdf?ver=FDHBtn1AmOwRRjiCO6hBQQ%3D%3D>,

Omand, Dennis (2015) *Securing the State*. Oxford.

Omohundro, Stephen (2008) The Basic AI Drives, in *Artificial General Intelligence 2008. Proceedings of the First AGI Conference*, ed. Pei Wang, Ben Goertzel and Stan Franklin. IOS, 483-492.

O’Neil, C., Julian Lowman and Jonathon Wasiliev (2020) The effect of galactic chemical evolution on terrestrial exoplanet composition and tectonics, *Icarus* **352**, 114025.

Osmanov, Z.N. (2023) Are we visible to advanced alien civilizations, *Acta Astronautica* **216**, 1-3.

Pacey, Arnold and Francesca Bray (2021) *Technology in World Civilization, Rev. Ed*. MIT.

Panskepp, Jules and Garet Lahvis (2011) Rodent empathy and affective neuroscience, *Neuroscience and Biobehavioral Reviews* **35**:9, 1864-1875.

Papastavrou, Nikolaos, *et* *al*. (2024) RNA-catalyzed evolution of catalytic RNA, *PNAS* 121:11, e2321592121.

Pearce, David (2020) Humans and Intelligent Machines: Co-Evolution, Fusion or Replacement? in Steven Gouvela, ed. *The Age of Artificial Intelligence: An Exploration*. Vernon.

Phelan, Matthew (2019, December 19) Navy Flier Who Filmed the ‘Tic Tac’ Video Speaks: ‘It Wasn’t Behaving by the Normal Laws of Physics,’ *New York Magazine*.

Piccinini, Gualtiero (2009) First-person data, publicity and self-measurement, *Philosophers’ Imprint* **9**, 1-16.

Prothero, Donald and Timothy Callahan (2017) *UFOs, Chemtrails, and Aliens*. Indiana U.

Pulletikurti, Sunil, *et* *al*. (2024) Experimentally modeling the emergence of prebiotically plausible phospholipid vesicles, *Chem* **10**:6, P1839-1867.

Purvis, Graham, *et* *al*. (2024) Generation of long-chain fatty acids by hydrogen driven bicarbonate reduction in ancient alkaline hydrothermal vents, *Communications Earth and Environment* **5**:30.

Qian, Chao and Hongsheng Chen (2021) A perspective on the next generation of invisibility cloaks, *Applied Physics Letters* **118**, 180501.

Raybeck, Douglas (2014) Predator-Prey Models and Contact Considerations, in Vakoch, ed., *supra*, 48-62.

Read, Duane (2012) *Winning at Deposition*. Westway.

Rich, Alexander and Todd Gureckis (2019) Lessons for artificial intelligence from the study of natural stupidity, *Nature Machine Intelligence* **1**, 174-180.

Riedman, Leigh Ann, *et al*. (2023) Early eukaryotic microfossils of the late Palaeoproterozoic Limbunya Group, *Papers in Paleontology* **9**:6, e1538.

Righter, Kevin (2007) Not so rare Earth? New developments in understanding the origin of the Earth and Moon, *Geochemistry* **67**:3, 179-200.

Romanovskaya, Irina (2022) Migrating extraterrestrial civilizations and interstellar colonization: implications for SETI and SETA, *International Journal of Astrobiology* **21**:3, 163-187.

Roth, Gerhard (2015) Convergent evolution of complex brains and high intelligence, *Philosophical Transactions B* **370**, 20150049.

Rudnyk, Adrian (2021) *The Assessment*: *The Arrival of Extraterrestrials*. Adrian Rudnyk.

Russell, Stuart and Peter Norvig (2022) *Artificial Intelligence: A Modern Approach*. Pearson India.

Schmidt, G.R., *et* *al*. (2000) Antimatter Requirements and Energy Costs for Near-termPropulsion Requirements, *Journal of Propulsion and Power* **16**:5.

Schacter, Daniel (1996) *Searching for Memory: The brain, the mind and the past*. New York: Basic.

----- (2001) *The Seven Sins of Memory*. Houghton Mifflin.

----- (2021) The Seven Sins of Memory: An Update, *Memory* **30**: 1, 37-41.

Schulze-Makuch, Dirk and William Bains (2017) *The Cosmic Zoo*. Spring

Schulze-Makuch, Dirk, René Heller and Edward Guinan (2020) In Search for a Planet Better than Earth: Top Contenders for a Superhabitable World, *Astrobiology* **20**:12, 1394-1404.

Schupbach, Jonah (2023) On the Logical Structure of Best Explanations, *Philosophy of Science* 90, 1150-1160.

Scientific Coalition of UAP Studies (SCU) (2019) *2004 USS Nimitz Navy Strike Group Incident Report*, 2004 USS Nimitz Navy Strike Group Incident Report (explorescu.org).

Seligman, Lara (2023, November 8) Pentagon boss to step down next month, *Politico*.

Sharma, Abhishek, *et* *al*. (2023) Assembly theory explains and quantifies selection and evolution, *Nature* **622**, 321-328.

Sheikh, Sofia, *et* *al.* (2021) Analysis of the Breakthrough Listen signal of interest blc1, *Nature Astronomy* **5**:3, 1153-1162.

Shermer, Michael (2011) *The Believing Brain*. Times.

Shkurko, Vladimirovich (2024) The Social Science Perspective on the Fermi Paradox, *International Journal of Astrobiology* **23**, e13.

Shostak, Seth (2022, Dec. 15) Could the Government *Really* Cover Up UFOs? *Wall Street Journal.*

Smart, John (2012) The Transcension Hypothesis, *Acta Astronautica* 78, 55-68.

Solan, Eilon and Leeat Yariv (2004) Games with Espionage, *Games and Economic Behavior* **44**:1, 172-199.

Stephenson, D.G. (1982) Models of Interstellar Exploration, *Quarterly Journal of the Royal Astronomical Society* **23**, 256-251.

Susskind, Ron (2006) The Untold Story of al-Qaeda’s Plot to Attack the Subways (June 26) *Time*.

Tipler, Frank (1980) Extraterrestrial Intelligent Beings Do Not Exist, *Quarterly Journal of the* *Royal Astronomical Society* **21**, 267-281.

Tonn, Bruce and Donald MacGregor (2018) A Singular Chain of Events, *Futures* **41**:10, 706-714.

Torres, Phil (2018) Space colonization and suffering risks: Reassessing the ‘maxipok rule,’ *Futures* **100**, 74-85.

Turchin, Peter (2018) *Historical Dynamics: Why States Rise and* *Fall*. Princeton.

Tversky, Amos and Daniel Kahneman (1974) Judgment under Uncertainty: Heuristics and Biases, *Science* **185**:4157, 1124-1131.

Vargemezis, G.N., *et al.* (2024) Contribution of VLF electromagnetic survey to the investigation of Hessdalen lights, *Journal of Applied Geophysics* **226**, 105398.

Wandel, Amri (2022) The Fermi Paradox Revisited: Technosignatures and the Contact Era, *The Astrophysical Journal* **941**:2, 184.

Wang, Shanshan, *et al*. (2023) A Review of 3D Printing Technology in Pharmaceutics, *Pharmaceutics* **15**:2, 416.

Ward, Peter and Donald Brownlee (2003) *Rare Earth*. Copernicus.

Watters, Wesley, *et al*. (2023) The Scientific Investigation of Unidentified Aerial Phenomena (UAP) Using Multimodal Ground-Based Observatories, *Journal of Astronomical Instrumentation* **12**:1.

Webb, Stephen (2015) *If the Universe Is Teeming with Aliens, Where Is Everybody?* 2nd ed. Springer.

Wendt, Alexander and Raymond Duvall (2008) Sovereignty and the UFO, *Political Theory* **36**:4, 607-633.

Wernegreen, Jennifer (2012) Endosymbiosis, *Current Biology* **22**:14, R555-R561.

Whitmire, Daniel (2022) Abiogenesis: The Carter Argument Reconsidered, *International Journal of Astrobiology* **22**:2, 94-99.

Wilde, Gabrielle (2024) Clinical professor says solar system ‘full of life,’ *GB News*, [Clinical professor says solar system ‘full of life’ in staggering alien verdict (msn.com)](https://www.msn.com/en-us/news/technology/clinical-professor-says-solar-system-full-of-life-in-staggering-alien-verdict/ar-BB1mZFq2?ocid=msedgdhp&pc=U531&cvid=96f1b28fca1f4666a1c177d0bd3a6a83&ei=34).

Wiley, Keith (2011) The Fermi Paradox, Self-Replicating Probes, and the Interstellar Bandwidth, arXiv:1111.6131v1 [physics.pop-ph].

Wilkinson, David (1987) Central Civilization, *Comparative Civilizations Review* 17, Article 4.

Wimmer, Jessica, *et al*. (2021) Energy at Origins: Favorable Thermodynamics of Biosynthetic Reactions in the Last Universal Common Ancestor (LUCA), *Frontiers in Microbiology* **12**. <https://doi.org/10.3389/fmicb.2021.793664>.

Winterbotham, Frederick (1974) *The Ultra Secret*. New York: Harper & Row.

Wiseman, Charles (1988) *Strategic Information Systems*. Richard Irwin.

Wixted, John and Gary Wells (2017) The Relationship Between Eyewitness Confidence and Identification Accuracy: A New Synthesis, *Psychological Science in the Public Interest*, **18**:10, 10-11.

Wixted, John, *et al*. (2018) Rethinking the reliability of eyewitness testimony, *Perspectives on Psychological Science* **13**:3, 324-335.

Wood-Gush, D.G.M. and K. Vestergaard (1991) The seeking of novelty and its relation to play, *Animal Behaviour* **42**:4, 599-606.

Xavier, Joana and Stuart Kauffman (2022) Small-molecule autocatalytic networks are universal metabolic fossils, *Philosophical Transactions A* **380**:2227.

Xia, Lili, *et* *al*. (2022) Global food insecurity and famine … due to climate disruption from nuclear war soot injection, *naturefood* **3**, 586-597.

Yasser, Shehab (2020) Aliens, the Fermi Paradox, and the Dark Forest Theory, *Towards Data Science,* Aliens, The Fermi Paradox, And The Dark Forest Theory: A Game Theoretic View | by Shehab Yasser | Towards Data Science.

Young, Edward, Anat Shahar and Hilke Schlicting (2023) Earth shaped by primordial H2 atmospheres, *Nature* **616**, 306-311.

1. Espionage would likely precede Berserker destruction, but the dark forest hypothesis does not suggest it would be occurring now. [↑](#footnote-ref-2)
2. Compare Kuhn (1970, 52), ‘Discovery commences with the awareness of anomaly….’ [↑](#footnote-ref-3)
3. By contrast, only ~26% of the ocean’s floor has been mapped; far less has been explored. [↑](#footnote-ref-4)