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The extraterrestrial hypothesis: an epistemological case for removing the taboo

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Abstract
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 imminently dangerous. Other hypotheses of ETC behavior, including the zoo/interdict hypothesis and the dark forest hypothesis also undercut the claim that the ETH is highly improbable, and the ETH overturns none of our well-tested scientific knowledge. It follows that evidence offered in its support need not be extraordinary. The fact that most reports of unidentified anomalous phenomena (UAP) have natural or human explanations does not count against the ETH. Inference to the best explanation offers a way to find evidence for the hypothesis and some evidence exists, some of it taking the form of reliable witness reports. The most plausible alternative explanation for some UAP declines in probability over time. A hypothesis that does not contradict well-established facts or theories, is not highly improbable for other reasons, and explains otherwise unexplained evidence is a rational hypothesis. Since the ETH meets this test, it should be evaluated alongside other possibilities when the case-specific evidence warrants it.

Keywords Extraterrestrial hypothesis · Rational agent · Dark Forest · Fermi paradox · Inference to the best explanation · Witness reliability.

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Except in connection with the demarcation problem, philosophers pay little attention to the *extraterrestrial hypothesis* (ETH), the hypothesis that an *extraterrestrial technological civilization* (ETC) is active on Earth today. Elsewhere as well, discussions of the ETH are largely "taboo" (Wendt & Duvall, 2008). Yet, the fact that some who propound this thesis engage in pseudoscience does not justify this prohibition. To advance, science must accept open competition among rational hypotheses. A hypothesis that does not contradict well-established facts or theories, is not highly improbable for other reasons, and is supported by uncontradicted evidence is, I will assume, a rational hypothesis. This article argues that the ETH is rational by this standard: Only those who violate some canon of scientific conduct in its pursuit (Boudry, 2021) can be accused of practicing pseudoscience.

The ETH suffers not so much from a failure of evidence as from a failure of theory, an anthropomorphic narrative that takes the place of a theory, and a consequent refusal to treat existing evidence fairly. To overcome these problems, this paper advances a new hypothesis of ETC behavior and discusses objections to the ETH in its light. Section 1 discusses the Fermi paradox. Section 2 discusses our lack of a theory and the narrative that stands in for one. Section 3 proposes and defends a novel *dual-goals hypothesis* (DGH) of extraterrestrial behavior. Section 4 addresses arguments against and evidence for the ETH in the light of the DGH.

1 The Fermi paradox

Our Galaxy is enormous and hosts hundreds of billions of stars. We have reasons (discussed below) to imagine that technological civilizations arose around some of these. Survivors would be older and more technologically advanced than human civilization. In the absence of 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 has always denied that any ETC is active on Earth. The apparent conflict between these observations provoked Enrico Fermi's famous question, 'Where is everybody?'

Today, the term 'Fermi paradox' denotes the following situation: We seem forced to reject either (a) the reasons we have for thinking that multiple ETCs likely exist in our galaxy or (b) astronomical observations that suggest there are no ETCs. The body of evidence supporting each prong of this paradox has only grown stronger over time (see below). Three generic resolutions to the paradox have most often been advanced (see Webb, 2015; Hanson, 1998):

A) ETCs exist and create intentional or unintentional technosignatures, but we have not observed them. Those engaged in the astronomical search for extraterrestrial intelligence (ASETI) advance this solution.
B) ETCs do not exist because (i) they never emerge (an Early Great Filter prevents it); (ii) they emerge, as we have, but then self-destruct (a Late Great Filter exists); or (iii) some natural disaster (e.g., a supernova) destroys them either early or late.

For any Great Filter or natural disaster to resolve the paradox it must apply to all or nearly all planets that might otherwise host an ETC.

C) ETCs exist but hide, either from everyone or just from us.

This section will discuss A-type and most B-type solutions. Section 3 will discuss the rest.

1.1 The ASETI solution

ASETI began with its founders' notion that an advanced ETC would establish a 'lighthouse in the sky' (Hippke, 2021, p. 1), a beacon welcoming us to the 'community of intelligence' (Cocconi & Morrison, 1959, p. 844). Yet intermittent searches since 1960 and more intensive recent searches have found no lighthouse beacon (Davies, 2010; Sheikh et al., 2021). It long seemed that inadequate sample size best explained this negative outcome. But current technologies let astronomers observe far more of the Galaxy than ever before, on millions of frequencies simultaneously. The continuing failure to find a beacon has led many to search for inadvertent technosignatures (Lingam et al., 2023). None of these searches have achieved positive results thus far, nor have multi-galaxy searches for Kardashev Type II and III civilizations (Choza et al., 2023; Garrett, 2015). This is no reason to stop searching: Seven possible Dyson sphere candidates have recently been identified (Suazo et al., 2024). But the absence of any positive evidence for an ETC to date provides our first data point: If they exist, ASETI may be unable to find them.

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 Earthlike amounts, and having similar orbital periods. They define Sun-sized stars as G Type only, though the more common K Type stars may be more likely to host life and to host it for a longer time (Lingam & Loeb, 2018). Positing two possible timeframes for abiogenesis and assuming life would evolve into a technological civilization within 5 billion years thereafter, they estimate the number of possible ETCs to be between ~2.8 and ~3.6 million.[1] This is a large enough number to justify Fermi's question, but ETCs can arise only if life originates and becomes complex. How likely is that?

Far likelier than it seemed even five years ago. Living systems are now seen as a subset of the ubiquitous set of dissipative systems (Kondepudi et al., 2020; Xavier & Kauffman, 2022; Baum et al., 2023). Life's *very* early origin on Earth (Moody

[1] If technological civilizations originate 3 billion years after life's origin, this estimate grows to between ~4.6 and ~5.4 million. Only the smallest of these four estimates will be used below.

et al., 2024) strongly suggests that it evolves readily from non-living systems when favorable conditions exist.[2] Many apparent obstacles to abiogenesis have recently 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). By showing that molecules occurring in significant numbers and requiring more than about 15 steps to form must form through some factory-like process, assembly theory supports the claim that life did not form by chance (Marshall et al., 2021).

Once it arises, life is likely to persist.[3] It tends to preserve and enlarge its domain (Bourrat, 2023; Doolittle, 2020; Arthur & Nicholson, 2023), and to adapt to a vast range of environments (Danovaro et al., 2010; Merino, 2019; McClain et al., 2022). We do not know the outer limits of habitability, but we have no positive reason to think the planets Cai and colleagues describe would lie outside them. Earthlike size and liquid water are likely to create plate tectonics on a rocky planet (Foley, 2018); these planets meet the first criterion and would likely meet the second (Young et al., 2023).[4] Other aspects of the limiting Rare Earth Hypothesis (Ward & Brownlee, 2003) have dwindling evidentiary support (Kasting, 2010; Schulze-Makuch & Bains, 2017; O'Neil et al., 2020; Balbi et al., 2020; Schulze-Makuch et al., 2020).

The growth of biological complexity seems possible on many paths (see Freeland, 2022; Bartlett & Wong, 2020). As to the origin of eukaryotic cells, endosymbiosis is a widely occurring and diverse phenomenon (Wernegreen, 2012), and oxygenating bacteria became mitochondria not long after the Great Oxygenation Event (Lane, 2022; Imachi et al., 2020). Shortly after their origin, eukaryotes 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 & 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 and high intelligence evolved 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.

Little evidence now supports the belief that life must take multiple 'hard steps' to proceed from its origin to technological civilization (Graham et al., 2024).

2 As to the contrary view that the anthropic principle explains life's early origin on Earth, see Whitmire (2022).

3 As to the suggestion by Chopra and Lineweaver (2016) that it is likely to die out, see Nicholson, et al. (2018).

4 Non-Earthlike planets and non-Sunlike stars may also support complex life (Battistuzzi et al., 2023; Heller & Armstrong, 2014; Schulze-Makuchen et al., 2020).

Language, art, technology, and symbolic thought are not unique to Homo sapiens (Dediu & Levinson, 2018; Hoffman et al., 2018; Leder et al., 2021; Çep et al., 2021); they began deep in our hominin past (Mithen, 2024; Ferentinos et al., 2024). Interactions among cultures rather than unique cultural traits seem essential to the birth of technological civilization (Pacey & Bray, 2021). Diverse cultures would likely evolve on any Earth-sized planet; trade and warfare would bring them into contact.

Altogether, we have no evidence for the sort of quasi-universal obstacle that would constitute an Early Great Filter (see Webb, 2015).

1.3 Natural disaster or late great filter

Natural disasters would probably come too soon or too late to reduce the number of ETCs by a meaningful amount. 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, potential disasters could likely be overcome or avoided (see NASA, 2023b). If natural disasters were the only threats to their existence, technological civilizations could persist for a billion years or more (Grinspoon, 2003; Graham et al., 2024), even longer if they could escape their dying star (see below).[5] Wilkinson (1987) argues that most human civilizations never collapsed; they were instead engulfed by a polycultural 'Central Civilization.' That civilization originated ~ 3500 years ago at the junction of Africa and Asia and today encompasses nearly all of humanity.

A frequently offered explanation for the Great Silence is that advanced technological civilizations typically self-destruct. The suggested means of destruction include thermonuclear war, bioengineered pandemic, environmental catastrophe, nanotechnology (gray goo), and artificial general intelligence (AGI) (Bostrom & 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., 2022; Tonn & McGregor, 2018). The likelihood of self-destruction declines if an ETC becomes multi-planetary, even within a single system. The exception may be uncontrolled AGI, an artificial 'superintelligence' that can perform all the skills of biological intelligence better than the most capable biologics (Bostrom, 2014; Garrett, 2024). However, any AGI would be a *rational agent* (defined below). If it drove biological intelligence to extinction, it would become its successor. Extinction by AGI would not resolve the Fermi paradox.

[5] Even supernovae may be less widely fatal than has been assumed (Christoudias et al., 2024).

Self-annihilation by any means would seem to 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 their survival were at stake. We cannot know all the internal challenges a more advanced civilization may face, but the ones we know about do not seem capable of destroying all or even most ETCs. The apparent absence of ETCs seems to require an explanation other than those considered above.

2 Need for a theory

Progress in any field of science requires more than data. Yet, ASETI has long lacked a non-anthropocentric theory of ETC behavior (Bohlman & 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 no persuasive replacement has emerged. We are still looking for a civilization much like our own.

The high probability of planetary variation suggests that this approach is flawed. Astrobiologist Nathalie Cabrol (2016, 665) 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' (*id.*, 667). On Cabrol's principle, aliens may possess divergent biochemistries (Bartlett & Wong, 2020), be post-biological systems (Dick, 2008), or be something else. Any ETC would be the 'strangest stranger' we have ever encountered (Döbler & Raab, 2021). To imagine how they might 'communicate their presence,' we need a theory of ETC behavior that does not depend on attributes some may possess but others may not.

The lack of a theory hampers the Earthside search for extraterrestrial intelligence (ESETI) even more than it hampers ASETI. Here a widely accepted narrative stands in the place of a testable hypothesis. The following comments from respected sources enunciate this *Spaceship Narrative*. '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 light years 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). A White House liaison to NASA says: '[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. That doesn't seem realistic' (Wilde, 2024). The common threads are that aliens would 'pilot' their 'ships' through space; that their ships would therefore need to be of substantial size and mass, requiring vast quantities of energy for propulsion; and that trips across light years of space would consume too much time to be worthwhile. Since our 'cosmic visitors' would come because of us they would not come until they learned of our existence; once here, they would not 'hang out … and hide badly.' To overcome these preconceptions and explain the negative evidence of ASETI's failure, this section grounds a new hypothesis of ETC behavior in first principles.

3 Characteristics and goals

Any ETC regardless of its nature would likely have the following characteristics and goals:

- It would be an *agent*, a physical system that can perceive and shape its environment and act to achieve a specific goal. This claim does not imply the absence of divisions (or even politics) within it (see Lindsey, 2022). It only implies that it would behave as a unified agent in its external activities. Absent this assumption we would encounter too many degrees of speculative freedom to frame a meaningful theory.
- *Cognition*, defined as the 'acquisition, organization, and usage of knowledge inherent in every living organism' (Dȍbler & Raab, 2021, 701), is an essential activity of life (Dall et al., 2005; Bartlett & Wong, 2020; Kessler & Mueller, 2024). *Higher-order cognition* is cognition that operates effectively in a wide range of situations and environments, both physical and social. A *rational agent* is an agent whose behavior is at least in part shaped by higher-order cognition. An ETC would be a rational agent.
- An ETC would have explicit or implicit *ultimate* goals, ends to which it assigns intrinsic value. We can know nothing of these. Whatever its ultimate goals, any rational agent would also have *instrumental* goals: ends pursued because they aid in achieving their ultimate goals. Two of these would be self-preservation and the acquisition of resources. These goals are convergent among rational agents because they are essential to achieving any goals, including unselfish ones (Benson-Tilsen & Soares, 2016; Omohundro, 2008; Bostrom, 2014).
- The median potentially habitable planet in our Galaxy is ~2 billion years older than Earth (Ćirković, 2017), and our technological civilization has only recently arisen. We can therefore assume that any ETC we encounter would be substantially older than ours (Kipping et al., 2020). Its science and technology would be much advanced.
- An ETC's technological capability would reflect both the advanced state of its scientific knowledge and the contingencies of its history. The latter may be as great a source of variation as the former: 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 than the number of possible simple ones. These factors make imagining specific ETC capabilities impossible. But we can suggest constraints it would likely have overcome by identifying some we seem likely to overcome in the medium to longer term. These include:

Aging and Death. Individuals (assuming they exist) would have extremely extended lifespans compared to ours. Biologists have already identified many genes associated with human aging (Melzer, 2019); gene therapies have extended the lives of mice, worms, and fruit flies, in one case to ten times their natural span (Davis, 2018, p. 8). People living today are rationally planning for exceptionally long lifespans (Kurzweil, 2024). A super-long-lived being might be an artificial intelligence (*id.*) or inhabit a designer body (Pearce, 2020); in either case, a very long lifespan (by our standards) would be in prospect. Individuals who could live for millennia would have lower implicit discount rates (see Huffman et al., 2019) and be much more attuned to far-future threats and opportunities than individuals with shorter lifespans. Longer lifespans also correlate with lower fertility rates (Nagund, 2009; Giaimo & Traulsen, 2019). An advanced ETC composed of such individuals would likely be a stable, far-sighted system (Bainbridge, 2018), as would an ETC that *was* such an individual.

Home Star. Plausible means of interstellar propulsion exist or are on the horizon, even with no new science (Litchford & Sheehy, 2020; Loeb, 2022). Near light speed travel may be possible (Fuchs et al., 2024). By one means or another (Armstrong & Sandberg, 2013; Romanovskaya, 2022; Matloff, 2022a), an advanced ETC could relocate some fraction of its population to another stellar system if that were required to avoid extinction. That would let it become old indeed (see Smart, 2012).

Native Cognitive Power. On Earth, AI is likely to become superintelligent within two or three decades, perhaps sooner (Kurzweil, 2024). From that point forward, its cognitive power will grow exponentially (Bostrom, 2014). Bio-engineered brains may also advance in capability (Pearce, 2020). By one means or another, any ETC we encounter would have considerably greater cognitive power than we do now. This would likely enable it, *inter alia*, to successfully model the behaviors of less advanced societies (see Turchin, 2018).

Observation and Observability. To observe the galaxy, 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 2011; Borgue & Hein, 2021; Matloff, 2022b; Ellery, 2022). These could be controlled by AGI or by biological entities grown at the destination (Hein & Baxter, 2018; Murphy & Atala, 2014). Nanotechnology and lightweight materials would make them low in mass (Loeb, 2022), reducing both the energy cost of propulsion and observability. While possessing the capacity to observe others, ETC could effectively cloak, substantially reducing the ability of others to observe its home planet and its probes (Kipping & Teachey, 2016; Qian & Chen, 2021).

Any ETC we encounter would have other capabilities as well. It may possess nearly limitless energy from fusion and perhaps antimatter (Schmidt et al., 2000). Effectively faster-than-light 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).

3.1 From goals to objectives

For an ETC that overcomes the abovementioned constraints, the dual goals of self-preservation and resource acquisition would imply two objectives: avoiding or eliminating existential risks and acquiring information. The latter would be essential to the former.

3.1.1 Existential risk and the dark forest hypothesis

Any advanced ETC would seek to avoid or eliminate risks to its existence. Assigning each possible human life the same value, Bostrom and Ćirković (2008, 18–19) write, '[T]he expected value of reducing existential risk by a mere *one-millionth of 1% point* [is] at least a hundred times the value of a million human lives.' This calculation only accounts for the number of humans living on Earth over the next billion years. To an ETC that could survive the destruction of its home star, an existential risk could have greater disvalue.

Existential risks can be internal or external, natural or non-natural. Section 1 discussed natural risks and non-natural internal risks. External, non-natural risks perceived to be existential often draw a decisive response. In 2001, U.S. 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 (2015, 484) imagines how the perception of a non-natural, 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. Even breathing is done with care. 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, a fairy or demigod — there's only one thing he can do: open fire and eliminate them.

Liu's 'dark forest' hypothesis, that every civilization poses an existential risk to every other and is likely to recognize this fact, is grounded on three propositions.

First, a ‘chain of suspicion’ would arise between extraterrestrial civilizations due to distance and biological/technical/societal differences. Second, a ‘technological explosion’ could quickly make a ‘mostly harmless’ place like Earth suddenly dangerous. Third, in the interstellar context, attacking first could confer a decisive strategic 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 & Lahvis, 2011) and becomes more difficult as organisms grow more distantly related (Michaud, 2007). Unrelated societies that evolve on different planets will differ in fundamental ways. Tit-for-tat, a strategy that can lead to cooperation among competitors, breaks down when actors cannot understand the responses of their adversaries. Then ‘a single mistake about the intentions of the adversary can lead to retaliation and start an endless string of counterstrikes’ (Dothan, 2021, 1075). In human history, fear has often led to the extermination of whole peoples, including inherently peaceful ones (Blackhawk et al., 2023). An inherently peaceful ETC that became aware of this possibility would rationally fear discovery and possible extermination (Brin, 2018). An advanced ETC would understand these realities and their implications.

In support of his technological explosion claim, Liu (2015, 483) notes that human technology arose over three hundred years.

> On the scale of the universe, that’s not development. It’s an explosion! … And it might be that my knowledge of your existence and the information I received from our communication was the perfect spark to set off [another] 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 of an ‘explosion’ because it would accelerate a society’s capacity for technological development. ‘[O]nce the “knee of the curve” is achieved and the exponential growth explodes, the linear models break down’ (Kurzweil, 2005, p. 97). Imagine an ETC 100 light years from Earth. If their first notice of our existence came in the form of signals we emit today, they would learn we have a history of violence, are searching for other civilizations, have weaponized space, and are developing artificial intelligence. On receiving these signals, they might well imagine that we were already a threat.

As to the first mover advantage, Alexander Suvorov called surprise ‘the soul of war’ (Gradev, 2015), and asymmetrical knowledge makes surprise possible (Hillier, 1997). In the interstellar context, knowledge can be extremely asymmetrical. A defender may not even know the attacker exists until the attack occurs. Even then, its origin may be unknown, making counterattack impossible. In the interstellar context, it is Nash equilibrium for a player to strike without warning (Yasser, 2020). According to this scenario, 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; it may or may not entail extinction. This strategy would appeal most strongly to an

ETC that believed itself to be among the first technological civilizations to arise in its domain of possible action. For civilizations that arise later, the likelihood of taking more advanced civilizations by surprise could be reduced and the chance that an active strategy would reveal its location to a more advanced civilization could be greater. Instead of acting, they might try to conceal themselves from the world at large.

Some writers (e.g., Hall, 2007; Jiang et al., 2022) think potential gains from trade and cooperation would lead ETCs to develop mutual interests with other spacefaring civilizations. We have little reason to believe this. For us 'resources' connotes tangible products or materials, items often acquired through trade and joint enterprise. But an advanced ETC could produce any physical item from simpler constituents, given only sufficient information (Wang et al., 2023; Murphy & Atala, 2014). Since the cost of obtaining tangible products or materials from other stars would exceed the cost of home production, interstellar trade would be uneconomical (Lampton, 2013; Hickman, 2018). Extraplanetary information is likely to have considerable economic value (see Section 3.1.2), but it could be acquired without cooperation. See Section 3.2. Thus, even setting the risks of contact aside, interstellar cooperation is likely to bring little commercial advantage.

A technological society would likely possess an internal ethical system, but we have no reason to think it would extend to extraplanetary societies. An ETC might be an AGI, descend from a predator species (Raybeck, 2014), or exhibit in-group altruism and out-group hostility (Choi & 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).

3.1.2 Information acquisition

Information alerts agents to opportunities and risks while enabling useful action; its acquisition, processing, and dissemination are universally essential. 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). For Sun Tzu (2022, 60), the goal of spying was 'knowledge of the enemy.' An intelligence professional explains, '[I]nformation 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 & Yariv, 2004). Covert information-gathering for strategic ends has been ubiquitous in human history. Its principles are grounded in game theory (*id.*), so any rational agent would adhere to them.

Even if it intended to terminate a civilization (for reasons explained above), an ETC would spy before trying to do so. Without close observation, an ETC might be surprised by what Donald Rumsfeld called 'unknown unknowns.' These could include both technological surprises and unexpected reactions (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 and improvement of knowledge and intelligence is 'the central driving force of cultural evolution.'. Societies of any sort are unlikely to attain and maintain a state of advancement unless they value knowledge (practical competence as well as true beliefs) and pursue its acquisition. Knowledge often confers instrumental benefits, but curiosity, a 'demand for information that has no instrumental benefit' also has survival value. Indeed, it seems 'indispensable' to any complex system that needs to survive in a real-world environment (Cervera et al., 2020, p. 48).

A desire for and enjoyment of novel *experiences* for their own sake also seems universal, even among modestly intelligent creatures (Jaegle et al., 2019). Indeed, whatever boundary may exist between experience and knowledge is thin (Wood-Gush & Vestergaard, 1991). We can therefore assume that an advanced ETC would seek both new knowledge and novel experiences that could be virtually replicated (Fogg, 1987; Lampton, 2013; Jaegle et al., 2019) from sources it could safely and efficiently access. Both count as non-strategic information.

An advanced ETC would focus on acquiring biological, cultural, and technical information. Simpler systems like stars have shorter causal pathways toward their creation than complex systems like biospheres or civilizations (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 richer in information content. Even the chemistry of life may differ from planet to planet (Bartlett & 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 likely exhibit processes and structures that another civilization, even a more advanced one, would find new and valuable.

Novel ideas would be especially valued. On Earth, Indigenous societies often possess techniques, ideas, and information unknown to societies with higher technologies because they inhabit different environments (Jessen et al., 2022; Johnson et al., 2023). This would be more likely in the more highly differentiated interstellar context.[6] Knowledge aside, the art and music of a target civilization could 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,

6 George de Mestral invented Velcro after burdock seeds clung to his woolen socks and coat. The idea for a similar product might never arise on a planet without hooked seeds.

the gathering of non-strategic information would not be a one-and-done event. By virtue of its complexity, any target planet would be a producing 'spring' of knowledge and novel experience. So long as ETC retained a secure capacity to terminate the society quickly, it could delay termination until safety required it.

3.2 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 ineffective for this purpose (see Billingham & Benford, 2011). Even an advanced ETC could not easily assess the threat potentials of distant planets hidden by occluding stars or astrophysical dust; nor could it easily resolve sporadic or ambiguous indications of civilization (Lingam et al., 2023). Pre-technological indications like urban fires, seasonal agriculture, and air pollution (Lockley & Visioni, 2020; Osmanov 2023; Kopparapu et al., 2021) could be transient or hard to disambiguate. A civilization may promulgate radio signals only briefly (Brin, 2018) before concealing itself. An exoplanetary civilization could easily become dangerous before a nearby ETC learned of its existence if the latter engaged only in long-range observation. Even if signals from such a planet were sent, received, and decoded (see Rescher, 1985; Janković, 2014), the receiver could learn no more than the sender chose to disclose. Crucially, 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 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. Various means of probe propulsion have been considered (Litchford & Sheehy, 2020; Matloff, 2022b), as have plans for probe distribution (e.g., Loeb & Kirkpatrick, 2023). Trajectories could be optimized to maximize gravity boosts (Carbone et al., 2023) because constraints on accelerations imposed by the fragility of biological organisms would not apply to probes. Travel speeds could be non-relativistic (with lower energy cost) because biological lifespans would not be at issue. Through a program utilizing probes ETC could investigate potentially worrisome developments, gain valuable information, and defuse potential threats.

Given a speed of 0.01 c, an expansion front of observation probes could cover the ~50,000 light years from the galactic center to the edge in $\sim 5 \times 10^6$ years. A more sedate 0.001 c would increase this time by an order of magnitude and seems feasible with future human technology (Matloff, 2022b; Litchford & Sheehy, 2020). Warp drives may achieve near-light speeds without time or mass dilation (Fuchs et al., 2024), and effectively faster-than-light travel (e.g., through wormholes) could render all calculations moot. For a technological society with a realistic possibility of persisting for more than a billion years, even the longest of these estimates does not seem excessively long. The most valuable benefit, observing and securing its immediate neighborhood, would be obtained long before the expansion ended. Additional benefits would accrue at no additional cost over a very extended time.

Observation probes could produce and launch planetary probes to investigate interesting or suspicious developments. Once on target, these probes could generate other instrumentalities, controlled by an AGI or a locally grown biological. A planetary probe and its progeny would conceal their presence for several reasons. The target civilization might try to interfere with their activities if it became aware of them. It could demand information in exchange for that which ETC acquired, or it could use what it learns from ETC's presence to advance its own science and technology. Knowledge of ETC's presence could distort the target's independent cultural path, making the information obtained less unique and therefore less valuable (see Section 3.3). Strategically as well, disclosure could be dangerous. Given foreknowledge, a target might prove hard to terminate. If it learned of ETC's planetary origin it might broadcast that information, drawing the attention of a more potent foe (Liu, 2015).

Complete concealment may at times be inconsistent with the mission. As one example, testing a target's defenses may require attracting attention rather than avoiding it. Deception could then supplement concealment. Concealment prevents an opponent from perceiving an asset; deception confuses the opponent's elite about one's nature and aims. '[E]mpirical evidence confirms assumptions drawn from cognitive psychology that deception seldom fails when it exploits a target's preconceptions' (Heuer, 1981, p. 294). This would include the preconception that no ETC is active on Earth.

3.3 Comparison to other solutions

'Sociological' solutions to the Fermi paradox accept the past or present existence of ETCs but argue that their behavior prevents us from observing them. The dark forest hypothesis and Fogg's (1987) interdict hypothesis are two such solutions; each takes one DGH objective as ETC's motive.

Unlike most sociological solutions, the dark forest hypothesis does not need to describe the behavior of all or nearly all ETCs. If just one civilization in a galaxy (or whatever region constitutes its domain) adopts a strategy of silent hunting, the others in that domain 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 could be brief. Humans have had radio for only a century and superintelligent AGI, perhaps the most threatening technology, may appear on Earth in a decade. We would be very unlikely to hear any signals a civilization might emit over such a brief period. Nor would we receive signals from a 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.

A Kardashev Type II or Type III civilization would be visible even to predators outside its galaxy, making it more vulnerable. So the dark forest hypothesis predicts that we will observe none. So would colonization: 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 easily result (Torres, 2018, p. 74). Colonization of Earth and its environs should therefore not be expected, despite ETC's age and the project's feasibility. In these respects, the dark forest hypothesis fits the evidence.

However, it has a salient weakness: It ignores the ease with which an advanced ETC that had only self-preservation as its goal could find and destroy exoplanetary civilizations *before* they became 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.[7] Yet, though the planets in our Galaxy from which Berserkers might come are billions of years older than Earth and we have never hidden, we still exist. This suggests that no ancient ETC has followed the dark forest strategy to its logical conclusion. By contrast, the DGH holds that an ETC with a presence on a planet would keep extracting information until the danger the target civilization poses begins to exceed the value of the information obtained. The information-gathering and cognitive capabilities of whatever agent ETC has on or near the target planet would let that agent, that planetary probe in our hypothetical, determine this point of unacceptable risk and execute at that time. Humanity is not, at this moment, a danger to any extraterrestrial civilization, so the DGH comports with our continued existence.

The interdict hypothesis modifies Ball's (1973) zoo hypothesis, which held that one or more ETCs were keeping Earth as a wilderness preserve to allow mankind to evolve on our own. Fogg (1987, 381) said ETC would 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' (quoting Stephenson, 1982). On Cabrol's principle, Earth's information would be unique. 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 have less value. See Crawford and Schulze-Makuch (2024). Thus, the zoo/interdict hypothesis makes the same predictions about ETC's *current* activities on Earth as the DGH, but objections to it exist. Would all ETCs 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,

[7] Espionage would likely precede Berserker destruction, but this scenario differs from the DGH in giving us no reason to think it is occurring now.

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 whether 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.

Other sociological narratives exist (Webb, 2015). Each could reduce the number of ETCs, but none seem capable of explaining their complete absence. By contrast, the DGH offers a unified account that suggests and explains the two most plausible solutions of the Fermi paradox in ASETI: the destruction 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 it was grounded on the Rare Earth Hypothesis, it would not do this; its premises would be numerous and complex. The DGH is not the only hypothesis that predicts the likely presence of ETC on Earth (see Fogg, 1987; note 7, *supra*), but it has three virtues: It is grounded on instrumental goals that rational agents share, it makes the testable prediction that ASETI is unlikely to discover evidence of an ETC, and it leaves no loose ends that must be tied up by further assumptions. Beyond all this, it suggests that we should not ground rejection of the ETH on assumptions about ETC behavior when we can be sure we have not imagined all the possible forms that behavior might take.

4 Evidentiary status of the ETH

Generically, the ETH says an ETC is somehow active on Earth today, a claim too broad to be useful. We will therefore limit it to the hypothesis that one or more reports of *unidentified anomalous phenomena* (UAP) reflect 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 standard objections to the scientific investigation of UAP, including the claims that UAP characteristics are impossible and that we would know by now if there were something to UAP reports. The discussion in this section 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). In the judicial context, evidence is anything that 'has any tendency to make a fact more or less probable than it would be without the evidence.'[8] The words 'tends' and 'tendency' acknowledge that, almost invariably, no single piece of evidence can be dispositive. The search is always for the most probable pattern or story that 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

8 U.S. Federal Rules of Evidence, Rule 401(a).

identify an unknown object as an alien craft because no one can say what an alien craft should look like. Circumstantial evidence is the alternative; assessing it often requires an inference to the best explanation (IBE). This section will discuss some objections to the ETH, IBE, and an incident suggestive of extraterrestrial activities.

4.1 Preliminary objections

The following objections challenge the plausibility of the ETH or give reasons to treat it as suspect.

Extraordinary claims require extraordinary evidence This assertion, call it *Sagan's dictum*, accords with Hume's dictum that we should proportion our belief to the strength of the evidence. It says 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,' deserve this assignment because they conflict with the nature of reality as we understand it. As earlier sections have tried to show, the ETH does not do that; it only suggests that a known possibility might be actual. In practical terms, Sagan's dictum has meant that any ETC-related hypothesis must be the explanation of last resort. This would be unproblematic if it meant we should not waste time pursuing unknown causes until possible known causes have been exhausted. But it has too often meant that extraterrestrial explanations can never be pursued because highly improbable conventional explanations can be stretched to fit the situation.

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.' To require extraordinary evidence for claims that do not meet this standard but only *seem* extraordinary would be to commit an epistemic mistake. Reports of UAP capabilities *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 certainly cannot predict all the technologies that may be consistent with those we have (NRC, 2007; Watters et al., 2023, App. A). So Hume's argument has no purchase here. Setting its perceived 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 knowledge' (Prothero & Callahan, 2017, p. 11) than other possible discoveries, it would overturn none. Indeed, it was our growing knowledge of the universe that led Fermi to ask his famous question. Our sense of the prior improbability of the ETH depends largely on our assumptions about ETC behavior. The Spaceship Narrative makes ETC's presence here seem highly improbable, but that narrative itself is improbable and is not the only one on offer. Other narratives are consistent with an ETC presence.

Without contesting these points, an anonymous reviewer writes, 'the discovery of extraterrestrial life, any life … would be an extraordinary discovery. It would need to be backed up by solid evidence….' This standard should indeed be met before science pronounces judgment on this question. But (i) 'solid' evidence is not 'extraordinary' evidence, and (ii) the question at issue is not what science should say about the truth of the ETH but only whether it should be accepted as a rational hypothesis. The ETH meets the other requirements mentioned above: It does not contradict well-supported scientific facts or theories, and on the hypotheses discussed in Section 3.3 it is not highly improbable. If it is also supported by *some* reliable evidence, it should be regarded as a rational hypothesis. As to that, see Sections 4.2 and 4.3.

Most UAP reports have been explained Investigators have provided more-or-less plausible natural or human explanations for perhaps 95% of UAP reports. In the remaining cases, no 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 & Callahan, 2017, v). But whatever its value in other fields of science,[9] this approach is unwarranted here.

First, the discovery of natural or human explanations for most UAP reports does not imply that the ETH is false. To know a contingent proposition is false, we must know positive facts that together entail its falsity (Cheyne & Pigden, 2007). The ETH asserts that one or more UAP events reflect ETC activity on Earth. We would need an alternative explanation for *every* reported UAP to know this to be false, but that we do not have (Hastings, 2017; ODNI 2021, 2023; Sturrock, 2000; Coumbe, 2023; Knuth et al., 2019).

Shermer's argument can be better framed as a probabilistic appeal to induction:

Premise 1: Most UAP reports have been found to have natural or human explanations.
Premise 2: We have no reason to believe that unexplained reports are systematically different.
Conclusion: All UAP reports probably have natural or human explanations.

This is a valid argument but premise 2 fails. Imagine that balls are drawn randomly from a bin. Nearly all, say 95%, of drawn balls, are seen to be white; the rest are obscured from view. Perhaps they are drawn as a cloud passes by. If the clouds and the drawing were independent events, an observer could reasonably come to 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. No similar assumption can be made in the case of UAP. A report from the U.S. Government's All-Domain Anomaly Resolution Office (AARO)[10] explains that 'the use of "UAP" to refer to *all* potential possibilities provides a false sense of commonality, such as their origins, identity, purpose, type, and threat they may pose. The only commonality that they all share, at

[9] Compare Kuhn (1970, 52), 'Discovery commences with the awareness of anomaly….'

[10] This office within the U.S. Department of Defense is charged with investigating certain classes of UAP.

least initially, is that they are each unidentified' (2024, 12). With UAP observations we are not drawing balls from a bin; we are 'drawing' a heterogeneous collection of events having no common nature or cause from multiple locations. We identify most eventually; others we cannot. Our identification of some tells us nothing about the rest because *nothing* connects these events except our initial inability to identify them. Even the proportion of 'explained' to 'unexplained' events tells us nothing, for the number of extraterrestrial events may well be smaller than the number of those that remain unexplained.

This limitation on the power of induction applies to any collection of events that are not related in ways that make meaningful generalization possible. See Goodman (1983, 3–30). It is especially salient when we know in advance that most reported events will *not* be of the type we are seeking. Humans tend to find patterns and attribute them to intelligent agents (Shermer, 2011). Novel aerospace technologies create easily misperceived phenomena, and media reports stimulate more reporting (AARO, 2024). People see more 'phenomena' when they have more opportunity to see them (Medina et al., 2023). Once the 'flying saucer' or 'UFO' idea entered public discourse, many reports could be expected to fit that rubric. The predictable fact that most have been explained tells us nothing about possible ETC activity.

If they are so advanced, why do we observe them? An anonymous reviewer writes, 'It seems a bit absurd to find such sophisticated alien spies accidentally revealing themselves in phenomena that are typically cited as UAPs, such as the tic tac footage. If anything, one would expect not to find any evidence from such spies….' The simplest response is that everyone makes mistakes, accidents happen, and some disclosures may be intentional. See Section 3.2. All these things occur frequently in espionage (Sun Tzu, 2022; 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 & Kahneman, 1974). Artificial intelligence makes similar mistakes, apparently for the same reason (Rich & Gureckis, 2019). Any decision-making system may need heuristics of one kind or another to meet requirements of compactness, speed, and cost. Both answers are more compelling if (as suggested here) relatively few genuine observations of ETC have occurred.

Witnesses are unreliable For any UAP report, three types of supporting evidence may exist: witness statements, sensor data (including photographs and video recordings), and physical evidence. A few scientists say that only physical evidence, a tangible substance that can be analyzed a potentially indefinite number of times, 'can be of any use' in such investigations (Prothero & Callahan, 2017, p. 10). Most would accept sensor readings, at least when two or more adequate and well-calibrated sensors yield the same result (Coumbe, 2023). But witness reports are said to be unreliable evidence. In response, one might ask: Why then are witnesses essential to the judicial process? Why are recorded witness reports (e.g., letters) a primary source for historians? The answer must be this: Those charged with finding the truth in these fields are more likely to do so if they consider this evidence than if they ignore it.

Scientists often have greater access to non-witness evidence than courts or historians, but this is not always true. Only first-person reporting can provide 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. No sensor data or physical evidence supported these observations; they were plain 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, like acts of espionage, 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, they are 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. In the case of rogue ocean waves, ignoring them was a serious Type 2 error. Scientists refused to credit multiple reports of these waves until one struck Norway's Draupner E drilling platform in 1995 (Kharif et al., 2008). Before that they sank many ships. Like rogue waves and robberies, UAP are unpredictable phenomena, almost always observed by non-scientist witnesses. Accurately assessing them without considering witness reports would be impossible, for even instrument readings and physical evidence concerning a UAP will likely be gathered by non-scientists. If witnesses were intrinsically unreliable this would be highly problematic; however, they are not.

That notion derived in part from the exoneration of multiple defendants convicted by eyewitness testimony (Loftus, 2005; Brewin et al., 2020; Brewin, 2020), but recent research paints a more nuanced picture. Reports of previously perceived events are regarded as reliable when their accuracy is proportional to the witness's confidence in them, when a memory expressed with high confidence is likely to be true. The factors affecting witness reliability are classified as either 'estimator' or 'system' variables. *Estimator variables* relate to the witness 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 the fairness of a lineup, the phrasing of questions, and conflating information provided after the event (Albright & Garrett, 2022, p. 528).

Witnesses generally understand the estimator variables that affect their capacity to observe. Thus, their initial confidence in their reported observations is usually a reliable measure of accuracy. Later, system variables may alter their confidence and even what they report. But recent 'laboratory 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). The question is always how close to 'pristine' the circumstances surrounding a report might be.

System variables pose problems mainly because most witnesses are unaware of them. Wrongful convictions often occur when system variables cause a witness' confidence and specificity at trial to exceed that which they expressed at the initial lineup or interview (Wixted & Wells, 2017; Wixted et al., 2018; Brewin et al., 2020; Brewin, 2020). But if a witness makes an early, confident assessment of an event under non-biasing conditions, it should be given evidentiary weight: '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, p. 308). False identifications and similar problems usually arise because specific, well-researched factors induce inaccuracy (Schacter, 2001, 2021). Rather than disregarding witness reports, investigators should scrutinize them for these biasing factors.

This requires probing the details of each incident, including the viewing conditions and the witness' special qualifications. A witness might, for example, be trained to operate a certain piece of equipment (a radar or video system) and to accurately report the events it depicts. Their account of those events would likely be more accurate than their account of fast-moving 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 airborne object at close range in broad 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, p. 9). Military personnel face consequences for making a false report and are unlikely to report to a 'UFO investigator' who asks misleading questions. Civilian observers lack these safeguards and advantages.

Finally, the conclusion one draws from a witness report should depend on the pattern it fits within, not the report standing alone. Together with other evidence, witness reports changed scientific orthodoxy in 1803 when Biot combined them with a chemical analysis of meteorites to demonstrate the latter's astronomical origin (Gounelle, 2006). They did it again in 1995, when a single reported event at a well-instrumented platform led scientists to reconsider previously ignored accounts from sailor witnesses (Kharif et al., 2008). Each case ought to be evaluated on its total merits, not ignored because of a generalized concern about witness evidence.

4.2 Inference to the best explanation

In UAP investigations it is easy to see how evidence can make the ETH a *less* likely explanation: It only needs to support a plausible natural or human one. The harder question is how reliable information about an event could tend to make the ETH a *more* likely explanation. A NASA task force report (2023a, 17) alludes to the problem: 'Convincing evidence of verified anomalous accelerations and velocity would point towards potentially novel explanations for UAP.' *Not* toward the ETH, but toward unspecified unknowns. Writing from a different perspective, Loeb (2021, 14) criticizes assertions that certain events do not indicate alien activity because such assertions beg 'the unanswered question, "What would such an indication be?"' These statements illustrate the *problem of direct evidence*: How can we say that X is or is not a Y if we have no idea what a Y might be like?

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

Premise 1: H, if true, would explain E.
Premise 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 or natural explanations into evidence for the ETH. To accomplish this transformation 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 data (minimal 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. A skeptic might assign the ETH a zero prior but, for reasons explained above, there is no rational basis for doing that. When little is known about a topic, analysts often use an uninformative prior, letting the evidence drive the conclusion (Kass & Wasserman, 1996). This avoids subjectivity but adds nothing to our knowledge and can be misleading (van Dongen, 2006). Many statistical methods treat rare but potentially catastrophic 'black swan' events as outliers, effectively assigning them a zero probability; the extraterrestrial taboo does this for the ETH, which could, if true, describe a catastrophe for humanity. Chichilnisky (2009) explains why this approach is improper and suggests a corrective. Yet, the corrective, while welcome, does not identify the factors that determine the ETH's probability.

The prior probability of the ETH seems to depend on three component probabilities: the probability that a non-trivial number of ETCs exist in our Galaxy, either because they arose here or because they entered from elsewhere (Armstrong & Sandberg, 2013); the probability that at least one of these has adopted a proactive strategy resembling the one described in Section 3.2; and the probability that the expansion wave has reached Earth. The second and third component probabilities appear to be high, so the prior probability of the ETH seems to turn on the probability that some non-trivial number of ETCs exist, or at least existed at a stage in their development when they could launch a proactive exploratory program. Once launched, that program would not necessarily require their continued existence.

2) 'How thorough was the search for alternative explanations?' This question asks about the NEW hypothesis: In addition to any suspected causes, might some *unsuspected* natural or human cause be responsible for the reported obser-

vation? Here observations in space and on Earth need to be distinguished. 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 the domain of outer space, many unknown possibilities remain; we regularly discover new ones. However, in other 'domains …. [t]he space of unconceived alternatives may be pretty small.' Earth's atmosphere is a well-studied domain.[11] When novel natural phenomena are discovered in the atmosphere they are almost always discovered in rare and localized conditions (e.g., Vargemezis et al. 2024). Most UAP reports do not involve conditions of that sort.

As to novel, human-created phenomena, a frequently proffered alternative hypothesis deserves special mention. Observers have frequently reported the testing or deployment of advanced and secret military techologies as UAP (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 said, "If we don't prove it's aliens, then what we're finding is evidence of other people doing stuff in our backyard. And that's not good' (Seligman, 2023). However this explanation has an inherent limitation. Disclosure – in the limited sense that the capabilities and provenance of an advanced technology become public even if its internal workings do not – eventually occurs and does so for multiple reasons. Technologies are invented simultaneously in multiple countries and settings (Lemley, 2012); they are shared, sold, and used in war. Theft of military secrets and intellectual property is widespread (Andrew, 2019; Glitz & Meyersson, 2020). Technical advances require 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 only disclosed in 1974, ~30 years later (Winterbotham, 1974).

Consider an event, E, that occurs in year 1. Equation 1 describes the situation *if* it could have been explained at that time *only* as the product of either extraterrestrial activity (H_a) or secret human technology (H_s).

$$\Pr(H_s \mid E)_1 + \Pr(H_a \mid E)_1 = 1. \tag{1}$$

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 $\Pr(H_s|E)_1$ would change by a subsequent year, c, if the probability of disclosure would increase to 1 by a later year, y, at a linear rate.

[11] By contrast, only ~26% of the ocean's floor was even mapped as of June 2024. *Seabed 2030 announces latest progress on World Hydrography Day — Seabed 2030*. Far less than that has been explored in detail.

$$\Pr(H_s \mid E)_c = \Pr(H_s \mid E)_1(1 - c/y) \tag{2}$$

Let y = 30 and c = 20. For this example, we can arbitrarily set $\Pr(H_s|E)_1$ at 0.99. Taking the simplest possible approach, the probability of an extraterrestrial explanation, $\Pr(H_a|E)_c$, would be 0.67 twenty years after the event. As time passes and $\Pr(H_s|E)$ decreases, its probability would increase. Secret human technology is a decreasingly plausible explanation for unexplained events that occurred decades in the past.

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. Here a multi-hypothesis set would, *ceteris paribus*, become increasingly improbable as the number of unrelated hypotheses needed to cover all the observations in an event increased.

4.3 The Nimitz event

A meaningful discussion of the evidence for the ETH would require more than a section at the end of an article. It will, however, be useful to describe one incident. 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.[12] *Princeton* was equipped with an advanced SPY-1 radar system but also coordinated radar data from *Nimitz* and an EC-2 Hawkeye early warning aircraft. According to *Princeton*'s 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 sea level in just 0.78 s then stopping. Physicist Daniel Coumbe (2019, 8) writes, 'Such a maneuver would require a staggering acceleration, far beyond what humans could withstand.' See Knuth et al. (2019) for the relevant calculations. On November 14, *Princeton* and the Hawkeye dispatched fliers to investigate one of these objects.

[12] For a detailed account see SCU (2019), which draws on recorded interviews with participants and government documents (available at the same site). See also the testimony of CDR David Fravor (House, 2023); a *60 min* interview with Fravor and LT Alex Dietrich (Navy pilots recall "unsettling" 2004 UAP sighting – 60 min - CBS News); and an interview with LCDR Chad Underwood (Phelan, 2019).

The sea was calm, the sky was blue, and visibility was unlimited. Yet, at the targeted location, two Navy F/A-18F aircraft (each with 2 crew) observed an ~50-meter circular patch of turbulent white water.[13] Not far above it, they observed a 40–50 foot long, wingless, white, smooth, '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 on radar precisely at the fliers' combat air patrol (CAP) point, about 60 miles from the initial encounter.[14] 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. The flyer who recorded the video, LCDR Chad Underwood, describes the object's behavior on his video screen this way (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, which is not possible. … The video shows a source of heat, but the normal signatures of an exhaust plume were not there. There was no sign of propulsion. You could not see the thing that the ATFLIR pod should pick up 100% of the time: the source of heat and exhaust that a normal object flying would give you.
>
> Most participants were debriefed immediately after this event (see SCU, 2019). Witness accounts have remained consistent throughout.

Several possible sources of NOISE have been suggested. Herrington (2023) suggests that radar systems malfunctioned or else misidentified the Taurid meteor shower; however, the system was checked and rebooted, and radar is very unlikely to mistake astronomical bodies for aircraft (Hunter, 2017). Herrington also suggests a submerging submarine might have created the observed turbulence. But submarines do not create broad 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). In addition, the flyers have stated that, when some novel technology

[13] A Marine flyer had viewed the turbulent water moments earlier.

[14] This CAP point was an operational secret (see Knuth et al., 2019).

is involved in an incident of this sort, they are debriefed about it (SCU, 2019; Phelan, 2019). That did not occur in this case. Some say the ATFLIR video might depict a distant aircraft (Graff, 2023, p. 414), but an aircraft would exhibit distinct sources of heat and would not exhibit the erratic movements that Underwood describes. These hypotheses become more improbable when one considers that all or nearly all would be needed to explain the observations in this event.

None of the radar data and only a portion of the video from this event have been made public (Phelan, 2019). So, apart from the video portion, we cannot give the sensor evidence the weight it would have if we could examine the recorded data directly. Yet, neither can we disregard the reports we have about it, for they are mutually consistent and bear all the hallmarks of reliability. In addition, four Navy and one Marine flyer provide eyewitness evidence. All five saw the circular patch of white water, and the four Navy flyers saw the Tic Tac object. Of that object, one reports that 'There was no gradual acceleration or spooling up period, it just shot out of sight immediately. I have never seen anything like it before or since. No human could have withstood that kind of acceleration' (LCDR Jim Slaight at SCU 2019, 11).

The U.S. Department of Defense continues to regard this incident as unresolved.[15] Since it became public, three U.S. Government offices have issued reports on the UAP question (see NASA, 2023a; ODNI, 2021 and 2021; and AARO, 2024). None address this specific event or offer evidence about it, but AARO seems to refer to this event among others when it reports '[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' (2024, 2). The evidence discussed above therefore stands as unrebutted.

This is one of several incidents for which the ETH seems to be the best explanation; see Coumbe (2023, 17–38) for another. Some unrebutted evidence therefore supports the ETH. Since it also meets the other requirements outlined above, it is a rational hypothesis that should be openly discussed.

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[15] See *UAP Case Resolution Reports (aaro.mil).*

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I am the sole author of this work.