Extraterrestrials in the Catholic Imagination

Extraterrestrials in the Catholic Imagination:

Explorations in Science, Science Fiction and Religion

Edited by

Jennifer Rosato and Alan Vincelette

Cambridge Scholars Publishing

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PREFACE

St. John's Seminary in Camarillo, California was one of forty-two seminaries selected to receive a Science for Seminaries grant from the American Association for the Advancement of Science (AAAS) during the time period of 2014-2021. This project was established by the AAAS Dialogue on Science, Ethics, and Religion (DoSER) program, in partnership with the Association of Theological Schools (ATS), to assist seminaries in integrating science into their core curricula, providing seminary students and faculty familiarity with the scientific method and achievements, and preparing future faith leaders to engage their congregants in dialogues regarding science and technology.

St. John's Seminary was particularly interested in acquiring such a grant because an increasing number of seminarians enter each year who have degrees in a scientific field (currently around 15% of the student body), as do many practicing and fallen away Catholics. Lack of proficiency in and knowledge of the sciences and technology has left fellow students, faculty, and graduates ill-prepared to converse about ethical or social implications of new discoveries or perceived conflicts involving philosophy, theology, and science.

As part of its Science for Seminaries grant initiatives, St. John's Seminary held a series of lectures and a conference on the topic of space in the Catholic imagination in the spring semester of 2020. This brought together astronomers, physicists, philosophers, theologians, and science fiction authors to discuss medieval Catholic views of the cosmos; current knowledge about the existence of exoplanets, their suitability for life and how such life might evolve; how the existence of intelligent life elsewhere in the universe would impact theology; and how Catholic science fiction authors have imagined life and religion on other worlds.

Several of these talks have been reworked and collected into this volume, and a few additional invited papers have been incorporated, as a resource for future seminarians, church leaders, and indeed for anyone interested in how Christians past and present have conceived of issues involving the cosmos and alien life forms.

Included herein are papers written by Christian astronomers, physicists, and biologists about our current state of knowledge regarding the likelihood and possible nature of life outside of our solar system; discussions by

Catholic philosophers and theologians on the medieval picture of the cosmos and its misrepresentations, as well as theological issues pertaining to the existence of intelligent life on exoplanets; and finally, presentations by Catholic science fiction authors on how science fiction has dealt with issues of religion and conceived of alien life forms, religion, and salvation.

The editors of this volume wish to thank those who contributed papers to this volume; those who contributed artwork (Daniel Vega, Chris Decaen, and Margaret Youngblood); those who gave talks not included in this collection (Kevin Brennan, Paul Ford, Timothy Pawl, Karin Öberg, and Mary Oksala); those who served as scientific advisors (Erin Smith and Mark Oksala once again) or theological advisors (Paul Louis Metzger and Robert Spitzer, S. J.) for the grant; those who assisted in bringing the conference to fruition (Luke Dysinger, Kevin Brennan once again, George Perez, Janice Daurio, Julia Scalise, John O'Brien, Anthony Lilles, Marco Durazo, Dan Schwala, and Archbishop José Gomez); and finally staff members of AAAS who assisted St. John's Seminary in these endeavors (John Slattery, Curtis Baxter, Jennifer Wiseman, and Lilah Sloane-Barrett). And finally, a warm thanks to fellow students, faculty, board members, and guests who were able to attend and contributed to one of the lectures on space in the Catholic imagination held in the spring semester of 2020.

Jennifer Rosato and Alan Vincelette

INTRODUCTION

JENNIFER ROSATO

A memorable scene from Cy Kellett's science fiction novella *Ad Limina* portrays a conversation that takes place on a space station between the first bishop of Mars and a character named Doug, who is the result of a successful experiment in which scientists induced a human brain to live within the body of an ape. Doug thinks and speaks like a human, and early in the conversation he firmly tells the bishop, "I am not an ape. . . . I am probably as human as you are." But despite this confident proclamation, it becomes clear that Doug is not used to being accepted as a human being. Hence Doug is surprised and grateful when the bishop asks him if he is a religious person: "Thank you, bishop, for referring to me as a person. Some people take a long time to see past appearances."

In fact, over the course of several pages, the reader discovers that Doug himself is not truly sure who or what he is. "Am I a child of God?" he asks the bishop, poignantly, or does his artificial origin prevent him from holding that status? Finally, Doug revisits and poses the question that his early assertion dodged: is his life is marked by the unique dignity and moral worth accorded to human beings? "But bishop," says Doug, "you are avoiding the key question—am I human? I believe I am; I am certainly sentient in a human way, does that—" When the bishop cuts him off to discuss the relationship between sentience and personhood, Doug poses his question again: "I have thought of myself as human. But since I have been thinking about God, I have felt unsure about . . . about whether I was human in a . . . religious way. Does that make sense?"[1]

As a character, Doug fills a familiar enough role in the world of science fiction. After all, it is a common technique of the genre to imagine as persons beings whose physical appearance, customs, attitudes, and history are completely foreign to our own. Whether they arise as a result of experimentation, exploration, or invasion, these beings allow authors and readers to consider real questions—about what it means to be human or a

[1] Cyril Jones-Kellett, *Ad Limina: A Novella* (March 7 Media, 2013), Kindle edition, loc. 1245–1313.

person, who we are in the context of the vast universe, how intelligent life ought to be treated, and so on—in an utterly artificial setting that nevertheless seems to foreshadow true possibilities. Doug, then, is hardly out of place in the world of science fiction. But the fact that his questions are also religious ones—questions about whether God loves him and has a plan for him; whether he was created only by the hands of scientists or also, in some other sense, by the Hand of the Creator; and ultimately whether he can be baptized—makes him a much rarer figure. Yet these questions are natural from a Catholic perspective. They are questions that arise spontaneously when believers participate imaginatively in the world created by the authors of science fiction, and they are questions that would arise with pressing force for Christians if we actually did encounter nonhuman or extraterrestrial intelligent life.

The essays in this volume also aim to consider these sorts of questions. Instead of adopting a narrative context, however, the authors of the contributions here offer nonfictional approaches to the central theme announced in the title, *Extraterrestrials and the Cosmos in the Catholic Imagination*. How, they consider, have Catholics in the past thought about space and aliens of all sorts, not only in philosophical and theological texts but also in literature? How should Catholics today think about these topics, in light of contemporary scientific knowledge as well as our doctrinal commitments?

It is both a peculiarity and a strength of the book that it treats its central topic from a multidisciplinary approach, since it is clear even upon first reflection that such a topic will naturally lead to questions that concern not only the theologian and the philosopher, but also the natural scientist, the man or woman of letters, the historian, and others. While multi- and interdisciplinary approaches are often enough praised, publications that actually invite commentary from authors with varied areas of expertise are not as common. The breadth of this volume arose out of the decision, first, to pursue an open-ended discussion of the topic by inviting a wide variety of speakers to the series of lectures and conference held at St. John's in the spring of 2020, and the commitment to this decision was first and foremost Alan Vincelette's. Indeed, it is hard to imagine that anyone without Vincelette's unique background in both biology and philosophy, as well as his years of experience teaching at a Catholic seminary, would have had the ingenuity or the competence to conceive and organize such a series. It is thanks to the variety of speakers' perspectives, all coming at the central topic from a different angle, that we were able to conceive this volume as a means of organizing and sharing that open-ended discussion. As noted in the Preface St. John's Seminary also was the beneficiary of a Science for

Seminaries grant from the Association for the Advancement of Science that provided the funding for this speaker series and conference.

The papers in this book have been arranged into three sections, each of which roughly corresponds to a different mode of inquiry by means of which one might consider our topic. In Part One, the authors approach the topic from the standpoint of the natural sciences, inquiring into the nature of the universe and what we know about the life contained therein. Here it should be noted that there is nothing distinctively Catholic or Christian about scientific inquiry into the nature of space *per se*. Nevertheless, attention to the sciences is pertinent because Catholics will need to know something about the structure of the universe if we are to appreciate important Catholic teachings, such as the claim that our God is Creator of all things and author of all life, or to raise theological questions about how we would understand the teaching that all salvation is through Christ and His Church if it should turn out that there are other rational beings in the universe. Further, the ways that faithful Catholics today, like our predecessors before us, envision the place of the human person in the cosmos is informed by the harmonious union of knowledge acquired both through reason and by faith. In this way, the essays in the first section of the book, though they could stand alone, also prepare the way for Parts Two and Three, wherein Christian topics are considered directly.

Jeffrey Zweerink opens the volume with his essay “Is There Life Out There?” in which he addresses the question of whether it is likely that intelligent extraterrestrial forms of life exist, given what we know about our own Solar System and the conditions that might obtain on exoplanets. He explains the techniques that astronomers use to search for exoplanets and clarifies what is meant when they talk about the habitability of various planets. In the end, Zweerink argues that Earth’s capacity to host life is likely unique, but also emphasizes that many more pertinent scientific discoveries remain to be made when it comes to the question of life out there.

Next, Carol Day’s “Other Worlds and the Scientific Imagination” opens with a discussion of the scientific imagination, or the way in which the “stories” developed on the basis of scientific data shape our understanding of that data, supplementing what is most abstract or obscure in our reasoning with images that in turn direct our future research. Hence, when it comes to speculating on the possibility of life on other planets, Day reminds us to be careful to avoid “an undisciplined use of the imagination” since “nothing is so opposed to scientific objectivity as a strong desire to find a particular answer.” Day goes on to summarize current consensus as regards the origin and nature of galaxies, stars, and the Solar System, as well as the conditions under which life flourishes on Earth and whether those conditions might be found also on exoplanets. She points out that given what we know about the conditions necessary for life to arise on Earth complex life on exoplanets is likely to be rare.

In "Limitations of Life Considered: The Likelihood of Complex Multicellular Life on Earth-Like Exoplanets," Alan Vincelette appeals to what we know about the mechanisms of evolution on Earth in order to suggest that complex life on other planets might turn out to take surprisingly similar forms as life does here. In the first part of the paper, Vincelette introduces us to the phenomenon of convergent evolution, or the tendency for species of distinct evolutionary lineages to acquire similar adaptations over time when they are forced to survive in similar biological niches. Having discerned this tendency, we can see that the overall history of life is not completely random, but has rather been guided in fairly regular patterns by environmental pressures, and is likely to be guided in similar ways by similar environmental pressures on other planets. Vincelette engages in detail with the work of several recent scientists who have debated the true significance of convergent evolution and is ultimately optimistic about the possibility that the complex characteristics we think are essential to humans might also have evolved elsewhere in the universe. As a supplement to his essay, published as an appendix at the end of the book, Vincelette offers a taxonomy of 81 basic mammalian forms that have arisen as a result of convergent evolution. He proposes that such a taxonomy, based on generalized body types, would be more helpful in categorizing extraterrestrial life than other systems that prioritize the evolutionary relationships that unfolded here on Earth.

The essays in Part Two of the volume explore how Catholics, both recently and over the centuries, have imagined the possibility of extraterrestrial life and its significance in light of Christian faith. These shorter selections introduce us to aspects of the Catholic intellectual and literary tradition that touch on these topics. In fact, the authors of the six chapters in this section have all contributed to that tradition themselves by writing successful works of science fiction.

Robert Chase's essay, "From the Antipodes to Infinity" opens the section by documenting and then refuting the popular assumption that Christian faith would crumble if extraterrestrials were to be discovered. In fact, Chase argues, a brief survey of key figures from St. Augustine to Pope Francis reveals that Catholics are generally quite at ease with the possibility of extraterrestrials. Chase closes by contrasting the ways in which three works of Catholic science fiction—Mary Doria Russell's *The Sparrow*, Michael Flynn's *Eifelheim*, and Chase's own *The Game of Fox and Lion*—

envision what human interaction with other intelligent beings would look like.

Michael Flynn's "Sciopods, Blemyae, and the Green Children of Woolpit: 'Aliens' in the Catholic Imagination, Premodern Era," fills in some of the gaps left by Chase's survey and introduces us to various strange but rational beings described in texts by premodern Catholics such as John Mandeville and Ralph of Coggeshall. What are we to make of these stories of 'alien' beings, such as the sciopods who hop on one large foot, or the race of beings who have the bodies of men and the heads of dogs, or the two green-skinned children who crawled out of a pit in a village in Suffolk one day speaking a foreign language? Flynn himself adopts St. Augustine's position on the matter: we're not bound to believe everything we hear, but if these beings do exist, and if they have intellect and will, then "they would be just like any other species of man."

While both the possibility of extraterrestrial life and our modern understanding of the universe's vast size are sometimes taken to be significant challenges to the Christian account of creation, original sin, and salvation, anyone who actually examines these ostensible arguments against Christianity will discover that they are neither new nor convincing—at least, such is the position that John C. Wright defends in "What Has Outer Space to Do with Christ?" In fact, these challenges aren't arguments at all, but rather ways of telling a story about who man is, traceable more clearly to the science fiction of authors such as Arthur Clarke and Carl Sagan than to actual science fact. Wright suggests that what is needed in response is better storytelling: epics "set against the backdrop of all the width of starry space" wherein the basic doctrinal commitments of a Christian worldview form a framework within which the science fiction author's creative imagination weaves truthful fiction.

Next, Cy Kellett reflects on two classic examples of Catholic science fiction in his "Science Fiction and Religion": Walter Miller's *A Canticle for Leibowitz* and Walker Percy's *The Thanatos Syndrome*. As he sees it, both of these books, as well as his own *Ad Limina*, represent the "insanity" of modern Western society, which over the past several centuries abandoned first Christ and then reality itself. Kellett's brief narrative of decline situates the novels, each of which reminds us in its own way that advanced technology does not save us from moral failure, and encourages us to reflect anew on what it means to be human.

The fact that Catholic science fiction authors generally critique contemporary society shouldn't mean their stories are merely didactic exercises or thinly veiled metaphors for current sociopolitical concerns. Tim Powers reminds us of this at the start of his "Catholic Questions in Science

Fiction and Fantasy." Good stories must be convincing simply as stories first, and the supernatural elements in science fiction and fantasy need to grip as frighteningly, imaginatively plausible if they are to achieve their purpose. Powers proposes that, while science fiction and fantasy are just fiction, the supernatural is real, and Christian readers may be better prepared to envision the true supernatural elements of the Gospels having imaginatively taken the mere fictions as seriously as possible. After all, we Catholics hold that such supernatural realities as transubstantiation, the Resurrection, demons, and man's immortal soul are no mere metaphors.

The final chapter of Part Two comprises a dialogue between Flynn, Powers, and Wright, and is derived from the actual discussion these authors shared during the Q&A session at the close of the conference in May 2020. In the selections recorded here, the authors reflect on why science fiction today is typically inhospitable to religion; on how their own science fiction work incorporates real-world facts; and on the way that science fiction and fantasy stories function convincingly both as stories and as ways of reflecting on philosophical and theological truths.

The third and final part of this volume includes three essays in which Catholic philosophers consider questions raised by the possibility of extraterrestrial life and our contemporary scientific understanding of the cosmos. The first paper assesses the implications of the Copernican revolution for philosophical and theological anthropology, while the second and third reflect on how Christians should think about the possible ways in which intelligent extraterrestrial life could fit into God's plan of salvation.

In "Human Significance for the Medieval Mind," Alan Vincelette aims to refute the popular myth "that medieval cosmology placed humans on a pedestal which the Copernican theory pulled out from under them." Here Vincelette documents the ways in which patristic, medieval, and Renaissance Christians conceived man's place in the cosmos. While individual thinkers vary in their degree of optimism regarding human dignity, they all situate man in a middle place between angels and the lower animals, seeing in him a being created in the image of God whose earthly existence is nevertheless a foul and painful experience filled with poverty, disease, suffering, and ultimately death. Neither, Vincelette goes on to argue, does the commitment to geocentrism signify that premoderns thought of the Earth as the most important or noblest place in the universe; to the contrary, he documents instances in which premodern thinkers went out of their way to correct the false implication that the Earth's geographical centrality might challenge the superior dignity and significance of the heavens. In the last section of the paper, Vincelette offers his account of how the relative size and position of men in the universe came to be seen, over the course of the modern period, both as evidence of humans' cosmic insignificance and, contrary to the historical record, as a challenge to the premodern conception of human worth.

The final two chapters of this book take up the topic of how we should understand the potential or actual existence of intelligent extraterrestrials in the context of the Christian account of salvation history. In "Christianity and Intelligent Extraterrestrials," Marie George asks first whether Christianity is incompatible with the possibility that intelligent extraterrestrial life exists. Answering no, George goes on to consider whether Christianity renders the existence of extraterrestrials likely or unlikely. Central to George's deliberation are key passages of Scripture which, she argues, teach that Christ's incarnation on Earth is the central event of cosmic history and suggest Christ took on human flesh precisely because he wanted to share the lineage of those who would be saved by His sacrifice. George concludes that theological considerations do seem to render the existence of either fallen or unfallen extraterrestrial existence implausible, but they do not definitively rule it out, nor would the real existence of these creatures undermine the Christian understanding of the special place humans hold in the cosmos.

The final essay of Part Three is Janice Daurio's "Are Extraterrestrials Saved?" In this piece, Daurio asks what significance the Christian story would have for intelligent extraterrestrial beings, assuming they exist. Daurio argues forcefully that if such extraterrestrials are persons, then they are just as capable of receiving salvation through Christ's death on Calvary as human persons are. The question of whether such extraterrestrials are in fact persons, claims Daurio, cannot be decided until we actually encounter such beings. If upon encounter there should be ambiguity about the fact, however, Daurio suggests that we should treat extraterrestrials as persons until proven otherwise, lest we end up repeating moral abominations of the past in which various individuals and groups of humans were treated as non-persons.

In closing, I would simply like to draw attention to the artwork included in the volume and placed at the beginning of each section. The pieces by Chris Decaen, Daniel Vega, and Margaret Youngblood, both contemplative and whimsical in tone, are a fitting addition to a volume that invites the reader to consider how the Catholic imagination envisions outer space and extraterrestrial life. It remains to be seen whether there are ever Donut Sundays at a station church in orbit or whether Carmel ever includes winged aliens, but the evangelical spirit that foresees Christ's truth extending beyond our present understanding and to the farthest reaches of the universe can inspire us even now.

find life necessarily, we do possess the tools to discuss how many planets there are, what kinds of stars they orbit, and whether they might be habitable. Based on current research, a potentially habitable planet will be rocky like Earth and it will orbit its star at an appropriate distance.

Before exploring what exists beyond our Solar System, it's worth looking at the Solar System itself because it provides a frame of reference for what we might find beyond the Sun. As shown in Figure 1-1, eight planets orbit the Sun: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. The first four are rocky planets that orbit relatively close to the Sun, whereas the last four, comprised dominantly of ice and gas, are much larger and orbit farther from the Sun. An abundance of smaller bodies—called Kuiper Belt objects and appearing as dots in the figure—resides beyond the orbit of Neptune out to the Oort cloud, which is the boundary of our Solar System.

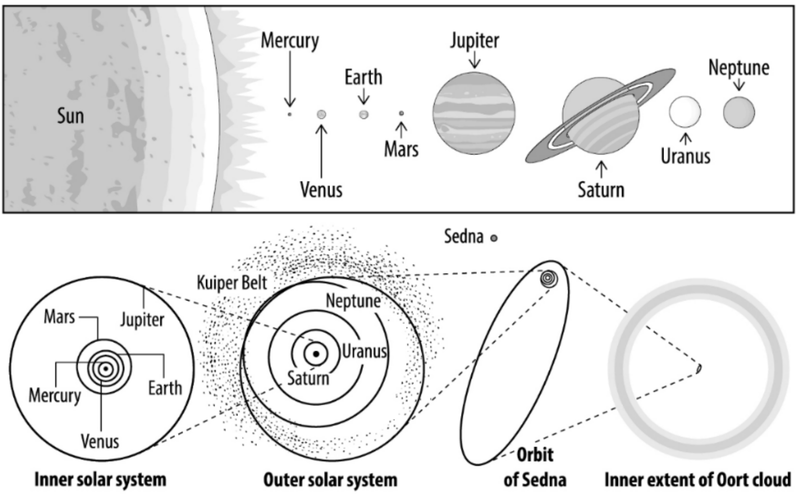

Figure 1-1: Basic structure of the Solar System. All eight planets reside in nearly circular orbits. The planetoid Sedna has an elongated orbit. Credit: Reasons to Believe.

I highlight this solar system structure because astronomers had long thought that planetary systems discovered around other stars would look largely like the Solar System. This similarity, called the Copernican principle, embodies the belief that our Solar System is ordinary in its location, structure, composition, and the life—found only on Earth so far—that resides here.

How Do Scientists Find Exoplanets?

The most important scientific advance in the search for life elsewhere in the universe is the relatively recent capacity to detect planets around other stars. Until the early 1990s, astronomers knew only of the eight planets orbiting the Sun although they expected that planets existed around most stars. In the time since the first confirmed discovery in 1992, astronomers have discovered thousands of exoplanets—planets orbiting a star other than the Sun. Astronomers use several techniques to detect exoplanets, and each method has advantages and limitations. Four are worthy of mention.

Radial Velocity: An orbiting exoplanet exerts a gravitational pull on its host star, causing the star to move toward and away from Earth. By mapping the star's motion, astronomers can determine the minimum mass and the orbital characteristics of the exoplanet. Until recently, this was the most prolific exoplanet-finding technique available to researchers. However, this technique provides no other information, and the current technology cannot find Earth-sized planets on Earth-like orbits when looking at Sun-like stars.

Transit: This technique looks for dips in the amount of detected starlight resulting from a planet passing in front of the star. Transits allow astronomers to determine the orbital characteristics, planet size, and mass (when combined with radial velocity). Occasionally, light from the planet itself can be measured during the transits. Using this technique, the Kepler mission discovered over 2,500 exoplanets. Even with current technology, this technique has the potential to discover a planet similar to Earth. While more information comes from transits, they occur less frequently. Also, this process works only for exoplanetary systems with the correct alignment with Earth.

Gravitational Lensing: Occasionally, a star and an associated planet will pass in front of a background star. For specific alignments, the star and planet gravitationally lens (enhance the view of) the background star, causing a brief but dramatic increase in detected light. While gravitational lensing searches have detected only a dozen or so planets thus far, it is the only technique capable of finding Earth-mass planets around stars with masses similar to the Sun.

Direct Detection: This method seeks to directly detect the light coming from an exoplanet. To see the exoplanet's light, an instrument must block the host star's light because the latter is a million to a billion times brighter. One limitation of the method is that current technology allows astronomers to detect only Jupiter-class planets orbiting relatively far (more than 10 times the Earth-Sun distance) from their host stars. However, one distinct advantage is that the light from the planet carries ample information about the planet size, temperature, orbit, and atmosphere. Several ground-based and space telescopes seek to directly image an Earth-like planet with an Earth-like orbit around a Sun-like star.

Figure 1-2 shows the sensitivity (shaded areas) of the different techniques as a function of mass and orbital period. As seen by the location of the Solar System planets, the techniques are not generally capable of detecting exoplanets like Earth; i.e., those with the capacity to support life (only Jupiter shows up). But that does not mean that astronomers cannot extract some interesting information related to the search for life.

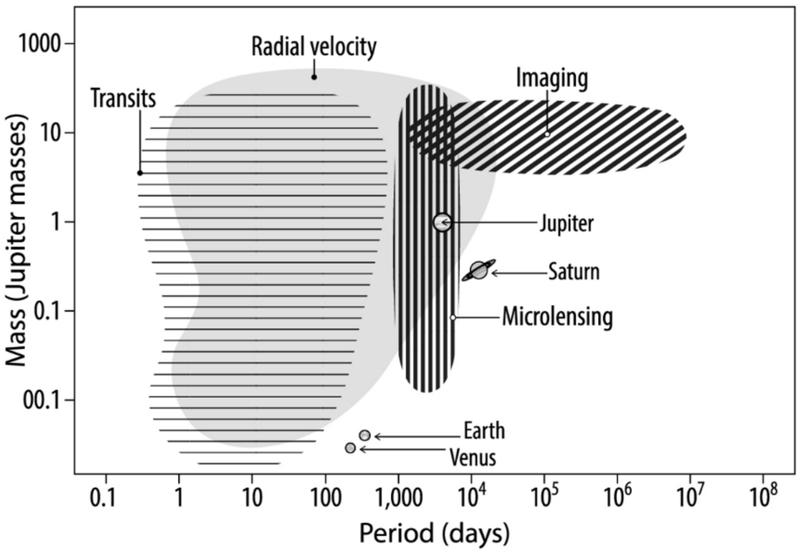

Figure 1-2: The different techniques find exoplanets of different sizes and orbits. Solar System planets are shown for reference. Notice that with the current technology, astronomers would have great difficulty detecting most of the exoplanets in a system resembling the Solar System. Credit: Reasons to Believe.

For example, the data (for all detection methods) shows that exoplanets with smaller masses are exponentially more abundant than more massive exoplanets. Furthermore, the number of confirmed exoplanet discoveries has grown exponentially over the past three decades to well over 4,000.[3] Using these facts, and accounting for the details of each detection method, astronomers have calculated that the Milky Way galaxy contains ~160 billion exoplanets with masses like Neptune or larger. When shrinking the mass to something Earth-like, the number of exoplanets grows to more than 400 billion!

Planet Migration and Harsh Environments

Given the incredible number of Earth-sized exoplanets, will the detection of life be inevitable? Probably not. The discoveries highlight a strong word of caution about the hopes of finding life beyond Earth. Remember, the Solar System consists of four rocky planets closer to the Sun and four more-distant gaseous planets—all of which orbit the Sun on nearly circular paths.

However, the first large group of exoplanets discovered looked nothing like this. Of the first 200 detections, more than half were "hot Jupiters"—gaseous, not rocky, exoplanets the size of Jupiter but with orbits much smaller than Earth's! This discovery caused some consternation because our understanding of planet formation precludes objects of this size forming so close to a star. Eventually, astronomers recognized that most, if not all, planetary systems undergo a period of migration where the planets drift inward or outward from their place of birth. A planet the size of Jupiter migrating from its birthplace (at least 5 times the radius of Earth's orbit for a Sun-like star) to an orbit less than the size of Earth's would completely disrupt the process of planet formation. It would likely preclude the formation of any rocky planets capable of hosting life.

Some exoplanet finds point to an even more disruptive form of migration. In the Solar System, the Sun rotates and all the planets revolve in the same direction. In most instances, this trend extends to the planetary rotations and even to the motion of planetary moons. However, some Jupiter-sized exoplanets orbit in a *different* direction than the host star. The migration required to produce this disparity occurs over a timescale (tens of millions of years) much longer than the period in which rocky planets can

[3] See exoplanet.eu/, exoplanets.nasa.gov/exoplanet-catalog/, and in addition exoplanetarchive.ipac.caltech.edu/ for some catalogs that allow you to see all the detected exoplanets and their properties.

form. Also, the strong gravitational influences of such migration ensure that no rocky exoplanets exist in these environments.

One particular exoplanet highlights the diversity of environments found so far. The exoplanet known as HIP 13044b formed in another galaxy more than 6 billion years ago.[4] Its host star, HIP 13044, exhausted its nuclear fuel and died. (Or, in technical terms, the star ascended the horizontal giant branch.) The Sun will experience a similar death in 5–6 billion years, which will cause it to expand in size beyond Earth's current orbit! HIP 13044b survived this death (so far) and the process in which the Milky Way galaxy ingested its host dwarf galaxy. Based on this discovery, astronomers think our Solar System's outer planets may face a similar danger when our Sun dies. Astronomers truly make some amazing discoveries!

Are Any Known Exoplanets Habitable?

With little effort, astronomers can easily dismiss most of the discovered exoplanets as potential life sites because they orbit their host star outside the "habitable zone." The habitable zone is the region around a star where a hypothetical planet would receive enough stellar radiation to keep all water from freezing, but not so much radiation that all the water would evaporate. A long-standing supply of liquid water is seen as a key feature of the habitable zone. However, keep in mind that some disagreement exists among astronomers as to the proper way to define the habitable zone. Additionally, just because an exoplanet orbits in the habitable zone doesn't mean that the exoplanet could host life. The atmosphere and size of the planet dramatically affect habitability.

Looking at Earth's Neighbors for Clues

Many definitions of the habitable zone, when applied to the Solar System, would include Mars and Venus. The proximity of these two planets to Earth permits a closer investigation, which reveals that neither currently holds much promise for hosting life. Venus has a mass about 20% smaller than Earth's and orbits 30% closer to the Sun. That might not look like much of a difference, but the surface temperature of Venus exceeds 750°F. A piece of paper on Venus would spontaneously burst into flames—if the planet's atmosphere contained any oxygen. Even though smaller in mass, Venus experiences an atmospheric pressure almost 100 times greater than Earth's. The recent excitement surrounding the discovery of phosphine gas on

[4] See exoplanet.eu/catalog/hip_13044_b/ for more details on this exoplanet.

Venus—a gas produced uniquely by life on Earth—does not change the inherent hostility of Venus to originating and hosting life. If scientists eventually discover life on Venus or anywhere else in the Solar System, such evidence strongly demonstrates the robustness of Earth's life as it moves around the Solar System.

Mars is a barren, frozen wasteland. With a mass one-tenth that of Earth's, the red planet's atmospheric pressure is one *fiftieth* that of the top of Mount Everest. Mars's small mass also makes it unable to hold on to its water as it seeks to escape into space. However, the data shows that Mars *did* have abundant water in the past. NASA's *Spirit* rover found formations of 90% (or more) pure silica just below the surface. The best (and maybe only) process for producing such formations are streams with dissolved silicates feeding a body of standing water where the silica can precipitate to the bottom. Also, NASA's *Phoenix* lander found water-ice cubes as it dug a few inches into the Martian surface.

Planetary models and observational data both indicate that Earth, Mars, and Venus all started with an abundance of water. Today, Earth exhibits an extraordinary water cycle that sustains a thriving array of abundant and diverse life. Neither Mars nor Venus shows any hint of stable liquid water, much less a water cycle.

As mentioned earlier, astronomers now know that the planet formation process includes a period where planets migrate from their birthplace. The Solar System is no exception. Theoretical and observational evidence show that the migration era revealed an unusual process that greatly enhanced Earth's capacity to host complex life. Figure 1-3 shows three panels representing the time just before migration, a snapshot during migration, and the effects of migration. Only the orbits of the four gaseous planets are shown. The best planet formation models indicate that the orbits of Jupiter and Saturn begin moving toward the Sun (much like the process of forming the hot Jupiters mentioned earlier). However, the motion halts and reverses direction. As Jupiter moves back near its starting point, the orbits of the remaining three gas giants destabilize briefly and move even farther from the Sun. The net effect of this migration produces three interesting results.

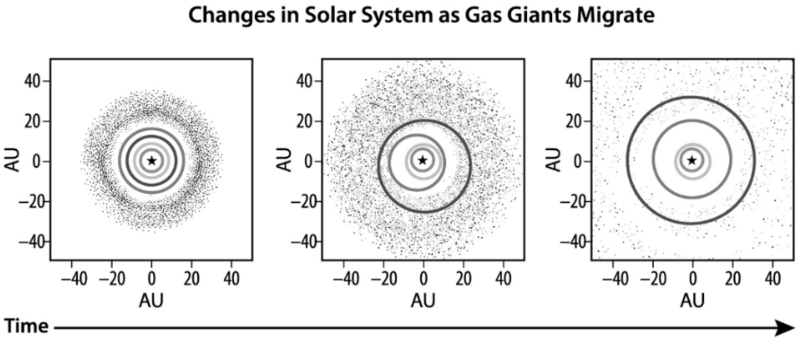

Figure 1-3: Effects of planetary migration in the Solar System. The four circles represent the migrations of Jupiter, Saturn, Uranus, and Neptune. Credit: Reasons to Believe.

First, the orbits of Neptune and Uranus (the outer two circles) switch places. Although interesting, this probably has no impact on Earth's habitability. Second, the orbits of the four gas giants become more widely separated. This increased separation will tend to minimize various orbital resonances that destabilize the smaller bodies (like rocky planets, asteroids, etc.) in the inner Solar System. Third, the migration causes a period known as the late heavy bombardment (LHB) that thins the dense cloud of debris remaining from the Solar System formation by a factor of ~1,000. Because the amount of debris (asteroid and comet material) decreases by such a large factor, the rate of meteor impacts on Earth also drops by a similar factor.

To understand the significance of this reduction, consider the impact 66 million years ago that caused the dinosaurs (and much other life) to go extinct. Scientists estimate that similar impacts happen every 50–100 million years. Without the LHB, which happened about 4 billion years ago, these extinction-causing impacts would happen every 50–100 *thousand* years. For reference, that is the timescale for humanity's residency on Earth. One would seriously question if a planet experiencing extinction-level impacts every 50–100 thousand years could host the complex life seen so abundantly throughout Earth.

Earth's Unlikely Life-Friendly Transitions

When looking at all the data, Earth alone appears amazingly designed for life. At least several powerful processes have affected the planet, and especially its habitability. Astronomically, the Sun's luminosity (brightness) started 30–40% smaller than today and has steadily grown to its current value. Geologically, Earth started covered in water but today continents make up 30% of its surface. Free oxygen comprises 21% of the atmosphere today but was virtually nonexistent for the first ~2 billion years of Earth's history. Biologically, the transitions required to go from relatively simple, single-celled organisms to complex animals (like humans) radically transformed Earth's environment.

Any one of these processes had the potential to demolish Earth's capacity to host life. Yet, over the 4.5 billion years in which they occurred, the average global temperature remained solidly within a 20ºC window that enabled a thriving biosphere. The scientific data increasingly demonstrates that Earth repeatedly came dangerously close to becoming uninhabitable from the same processes that made Venus and Mars hostile to life. Such a finding leads me to expect that our search for habitable exoplanets will yield a wealth of planets that appear habitable at first, but upon further study will be uninhabitable for a variety of reasons.

What if We Find Life beyond Earth?

This essay presents a case that Earth is likely unique in its capacity to host human life. Often this case involves arguing for evidence of design that points to the Christian God. Usually those arguments entail some probabilities. Without some caution, this line of argumentation can lead one to conclude that the discovery of extraterrestrial life—a highly improbable event that, in this case, turns out to be true—would argue against Christianity. But this is incorrect.

Well before science had the capacity to explore life beyond Earth, Christians had wrestled with the idea. The main issue relates to the grand redemption story described in Scripture, which can be summarized as follows. God created the universe and the first humans, Adam and Eve, placing them in the garden fashioned on Earth. The first couple rebelled against God's command, subjecting themselves and their posterity to a life of futility. The second person of the Godhead took on human form and became a man, Jesus Christ. After living a sinless life, Jesus atoned for humanity's sin by dying on the cross and resurrecting from the grave on the third day. He now sits on the throne until returning to judge the world and usher in the new creation.

Would the discovery of life (sentient life like humanity) out there undermine any of the story? In short, Christian scholarship says no. In fact, Christian thinkers have proposed at least five options (in no particular order) that provide a broader context for the redemption story.

1. Jesus's work here brings redemption for all sentient extraterrestrial life. One could imagine that the Scripture revealed on other planets with intelligent life says that Christ existed on Earth rather than specifically visiting their exoplanet.
2. Jesus incarnates on each planet. This idea recognizes that while humans are made in God's image, we don't fully reflect his image. If Jesus could take on a human nature without changing, maybe he took on a Klingon (or any alien) nature also.
3. God has another means of redemption for other sentient life. We don't know what this alternative means might be, but we only know of Christ's redemption because God revealed it to us.
4. No redemption is possible for other life out there. This seems to be the fate of the angelic realm.
5. No redemption is necessary for other life out there. Perhaps there exists intelligent life that never rebelled.

Considering any of these possibilities may bring some level of apprehension. The main point is not to debate which one might be correct. Rather, it is simply to demonstrate that Christianity is a robust worldview (although so much more) that can easily accommodate an incredible discovery like extraterrestrial live in the universe!

Exciting Times Lie Ahead

With the discovery of the first exoplanet in 1992, science definitively marked its place in the quest to find life in the universe. As the search continues, we've learned at least two things. One, Earth-sized planets abound in the Milky Way galaxy. We know of thousands and have the potential to explore millions of times more than that! Two, at the same time, the remarkable features of Earth point to a Creator or Designer who fashioned this planet for a purpose. The fact that these two scientific finds exist in some degree of tension highlights how fascinating the search for extraterrestrial life will be.

Is there life out there? It is a great scientific question *and* a great theological question. It may be decades before science provides more data for an answer, but I can guarantee that the journey will be exhilarating.

CHAPTER TWO

OTHER WORLDS AND THE SCIENTIFIC IMAGINATION[1]

CAROL A. DAY

Before I begin to talk about the search for planets orbiting other stars and the prospects for finding habitable planets beyond the Earth, I'd like to say a little about the role of imagination in natural science. This may seem out of place, but I thought it would be appropriate to connect my lecture to the general topic of this course, "Space and the Catholic Imagination." You will have noticed that the title of my lecture refers to the scientific, not the Catholic imagination, and you may wonder what I mean by the scientific imagination. All I mean by that phrase is the imagination as it functions in scientific thought and investigation. The scientific imagination is not Catholic, nor does it belong to any sect, philosophy or ideology, although it may be influenced by any of these. The well-functioning scientific imagination is, however, proper to a mind ordered according to right reason and so belongs in a way to the Church, as do all good things. In that sense only can we call it Catholic.

Science is not just a collection of data, equations and models. If it were only that, no one but scientists would be much interested in it. Science also includes what I think we should call stories, not meaning any disrespect by the term. We want to know things; that is part of being human. When we read an article in a popular scientific journal or a book for the general public, we are being told a story, by which I mean a summary account either of what is generally thought about the subject in question or about some new discovery or hypothesis. By no means do I mean to imply that a story in my sense is something "made-up" or that it has no relation to reality. Rather, it is an attempt to put into words in a more or less simplified manner what a scientist or group of scientists are thinking about the subject. A good story

[1] The following is based on a lecture delivered at St. John's Seminary in Camarillo, CA on March 4, 2020.

will have some details and also a certain amount of reasoning or argument, more or less as the reader is expected to have a stronger or weaker background in the subject. To see what I mean by a scientific story by way of contrast, one might read about a subject, for example black holes, first in *Sky & Telescope* or *Scientific American* and then in the *Astrophysical Journal*.

It would be wrong to think that stories, in my sense, have no importance for professional scientists. Leaving aside the obvious point that a professional in one field may have an amateur's interest in another quite different branch of science, even in one's own field of expertise stories are useful and may sometimes even be necessary.[2] Whatever is very abstract or conceptually obscure in our explanations must be supplemented by the imagination, especially for the sake of the uninitiated. We cannot tell the story of quantum mechanics, for example, to the general public by giving them the Schrödinger equation or telling them about Hilbert spaces. We might ask them instead to imagine something of no determinate size or location that is in flux such that if you look at it one way it looks like a particle and in another way it looks like a wave, or we might even tell them a story about a cat in a box. Even the scientist cannot think in terms of the story, as distinct from the technicalities of the theory and its calculations, without forming some kind of image.

Scientific knowledge seems to be characterized above all by careful observation and strict reasoning. Our ideas about some things in the natural world, however, cannot be deduced by logical reasoning from prior scientific knowledge or induced from experience. This is especially true of unrepeatable or as far as we know unrepeated things. These things need to be approached both from the standpoint of science and of philosophy. Both deductive and inductive reasoning may be involved in coming up with the story, but they do not give us sufficient detail to be fully satisfying, nor are they without their puzzles and paradoxes. Whatever gaps are left in our reasoning must be filled in by the imagination. The larger the scope, the greater the gaps are likely to be.

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[2] This seems to have been the view of Werner Heisenberg, who wrote: "The physicist may be satisfied when he has the mathematical scheme and knows how to use it for the interpretation of the experiments. But he has to speak about his results also to nonphysicists who will not be satisfied unless some explanation is given in plain language, understandable to anybody. Even for the physicist the description in plain language will be a criterion of the degree of understanding that has been reached" (*Physics and Philosophy: The Revolution in Modern Science* [London: George Allen & Unwin LTD, 1958], 145–46). Plain non-technical language is a distinguishing mark of a scientific story.

So, here are a few things I think we should keep in mind. First, thinking and imagining go hand in hand in human thought, both scientific and otherwise. We can see a two-fold movement between them, from reasoning to imagining and from imagining to reasoning. Scientific observation and experiment, like other forms of experience, provide raw material for our imagination. This is obvious. Perhaps less obvious, but just as true, is that the imagination guides what kinds of questions scientists ask and where and how they look for answers. Here is an example of what I have in mind. Albert Michelson decided to measure the speed of light with respect to the electromagnetic ether, the elastic substance that was supposed to be the medium for light waves. Since the ether could not be directly observed, it had to be imagined. Michelson invented an experimental set-up to detect the motion of light relative to this imagined medium. What his experiment helped to show was that there is no such ether. Bare logic cannot produce a sophisticated experimental apparatus; this calls for creativity.[3] We see in this example that the very thing being sought in this experiment was a product of the imagination and the way of seeking it involved the creative imagination of the experimenter.

The second thing to keep in mind is that the scientific imagination is, or at least should be, different from the imagination of the novelist or other creative artist. The scientist must often posit things that are not directly seen, such as the ether that most physicists of Michelson's day believed in. But the scientist does not have the freedom of the artist, since his imagination must be governed by prior knowledge and reasonable hypotheses about the physical world and must be subject to experimental test as well as to logical examination. The scientific imagination gives rise to models that are meant to explain some aspect of reality. Atoms, for example, were imagined by John Dalton as invisible and indestructible bits of matter capable of hooking on to one another to make chemical compounds. These imagined atoms were able to explain some things known to the chemist, such as the law of definite proportions. Later, when the chemical atoms were known to be composed and not simple, they were imagined as tiny solar systems with electrons orbiting a nucleus made up of protons and electrons. Later still, the electrons themselves could be imagined in more than one way, as standing waves or as clouds of probability. My point is that, as we learn more, our way of imagining the constituents of the world must change, but without changing their character as images.

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[3] For example, after some failed trials Michelson realized that the way to protect the apparatus from vibration caused by traffic outside the lab was to float it in a pool of mercury.