Chapter 1
The Extraterrestrial Life Debate from Antiquity to 1900

Michael J. Crowe and Matthew F. Dowd

Abstract This chapter provides an overview of the Western historical debate regarding extraterrestrial life from antiquity to the beginning of the twentieth century. Though schools of thought in antiquity differed on whether extraterrestrial life existed, by the Middle Ages, the Aristotelian worldview of a unified, finite cosmos without extraterrestrials was most influential, though there were such dissenters as Nicholas of Cusa. That would change as the Copernican revolution progressed. Scholars such as Bruno, Kepler, Galileo, and Descartes would argue for a Copernican system of a moving Earth. Cartesian and Newtonian physics would eventually lead to a view of the universe in which the Earth was one of many planets in one of many solar systems extended in space. As this cosmological model was developing, so too were notions of extraterrestrial life. Popular and scientific writings, such as those by Fontenelle and Huygens, led to a reversal of fortunes for extraterrestrials, who by the end of the century were gaining recognition. From 1700 to 1800, many leading thinkers discussed extraterrestrial intelligent beings. In doing so, they relied heavily on arguments from analogy and such broad principles and ideas as the Copernican Principle, the Principle of Plenitude, and the Great Chain of Being. Physical evidence for the existence of extraterrestrials was minimal, and was always indirect, such as the sighting of polar caps on Mars, suggesting similarities between Earth and other places in the universe. Nonetheless, the eighteenth century saw writers from a wide variety of genres—science, philosophy, theology, literature—speculate widely on extraterrestrials. In the latter half of the century, increasing research in stellar astronomy would be carried out, heavily overlapping with an interest in extraterrestrial life. By the end of the eighteenth century, belief in intelligent beings on solar system planets was nearly universal and certainly more common than it would be by 1900, or even today. Moreover, natural theology led to most religious thinkers being comfortable with extraterrestrials, at least until 1793

M. J. Crowe (✉) · M. F. Dowd
University of Notre Dame, South Bend, IN, USA
e-mail: crowe.1@nd.edu

D. A. Vakoch (ed.), *Astrobiology, History, and Society*, Advances in Astrobiology and Biogeophysics, DOI: 10.1007/978-3-642-35983-5_1,

when Thomas Paine vigorously argued that although belief in extraterrestrial intelligence was compatible with belief in God, it was irreconcilable with belief in God becoming incarnate and redeeming Earth's sinful inhabitants. In fact, some scientific analyses, such as Newton's determination of the comparative masses and densities of planets, as well as the application of the emerging recognition of the inverse square law for light and heat radiation, might well have led scientists to question whether all planets are fully habitable. Criticism would become more prevalent throughout the nineteenth century, and especially after 1860, following such events as the "Moon Hoax" and Whewell's critique of belief in extraterrestrials. Skepticism about reliance on arguments from analogy and on such broad metaphysical principles as the Principle of Plenitude also led scientists to be cautious about claims for higher forms of life elsewhere in the universe. At the start of the twentieth century, the controversy over the canals of Mars further dampened enthusiasm for extraterrestrials. By 1915 astronomers had largely rejected belief in higher forms of life anywhere in our solar system and were skeptical about the island universe theory.

1.1 Introduction

The door that inadvertently let in the aliens was opened in 1543. It was in that year that Copernicus published his *De revolutionibus*, the treatise in which he posited a universe centered upon the Sun, about which the Earth and the other planets revolved. This counterintuitive notion of a moving Earth was initially restricted to a finite universe, though one large enough to account for the lack of observed parallax of the stars. Eventually, however, the bounds of the universe would be pushed away from the Sun, our solar system would be relegated to an unremarkable corner of this universe, and all the stars of the sky would become suns in their own right.

In this chapter, we will provide an overview of the history of the extraterrestrial life debate in the Western intellectual context prior to 1900. It is based in large part on two long and fully referenced books by Michael Crowe published in 1986 and in 2008[1] and on a course the two of us have co-taught over the last three years titled "The Extraterrestrial Life Debate: A Historical Perspective." More complete discussion of the themes and authors in this essay can be found in those books.

1.2 Before the Eighteenth Century

Prior to Copernicus, a worldview heavily informed by the work of Aristotle (384–322 B.C.) held sway in Europe. In that worldview, the Earth occupied the middle of the universe. The terrestrial region alone saw life, death, birth, decay, coming

[1] Providing full references for all the quotations by and information about the over one hundred authors discussed in the essay would be cumbersome. This has led to our decision to reference most of the quotations and some of the information to these two widely accessible books.

to be, and passing away. Above the sphere of the Moon, which surrounded the terrestrial region, no change occurred except for locomotion—movement in space. In that region, all things were eternal and unchanging, moving forever in cycles that remained inviolate. There was no place except on Earth where life of a terrestrial nature could be found. There was, literally, no place for aliens. By the end of the seventeenth century, however, extraterrestrials were understood to populate an extended universe, a universe teeming with life in much the same way as the Earth was filled with a wide variety of living creatures.

1.2.1 The Ancient and Medieval Periods

It was not always the case that aliens had no place in the universe prior to Copernicus's revolution. Two schools of thought in the ancient world came to opposite conclusions regarding life outside the confines of the Earth. The Atomists, typified by Leucippus (fl. 480 B.C.) and Democritus (d. 361 B.C.), as well as the later Epicurus (d. ca. 270 B.C.) and Lucretius (99–55 B.C.), believed in a cosmos that was infinitely large and had an infinite amount of matter that interacted in random patterns. Periodically, chance collisions could cause a world to form, leading to life, such as the world in which we live. Throughout this infinite space, similar chance events would inevitably lead to other worlds. Thus there was "life out there," but not life with which we would be likely to interact. The "world" we see, that is, the Earth below and the heavens above, did not inevitably hold life, but similar systems surely exist out in the cosmos.

The Aristotelian worldview, on the other hand, understood the physical cosmos to be fully constituted by the objects visible to us. This finite, bounded system, described above, encompassed all that is. No other world could exist, and thus no other life could exist beyond that which we find around us. This latter view became the basis for the European view of the physical cosmos in the Middle Ages. Combined with the mathematical astronomy of Ptolemy, the learned view of the physical world was of a finite cosmos, a unified system in which other inhabitable worlds simply did not fit.

Of course, scholars of the Middle Ages were creative thinkers, and so they did speculate about how our cosmos might in fact be different from this view. Thomas Aquinas (1224–1274), for example, considered in his *Summa Theologica* (part 1, question 47, article 3) the question of whether there could be more than one Aristotelian-type cosmos; he concluded in the negative (Crowe 2008, 18–20). Nicole Oresme (1325–1382) too considered this question, in his *Le livre de ciel et du monde*, speculating whether worlds might exist sequentially in time, or whether multiple worlds might be arrayed throughout space or one within another (Crowe 2008, 22–26). Although Oresme ultimately did not suggest the abandonment of an Aristotelian worldview, he did argue that

> God can and could in His omnipotence make another world besides this one or several like or unlike it. Nor will Aristotle or anyone else be able to prove completely the contrary. But, of course, there has never been nor will there be more than one corporeal world (Crowe 2008, 26).

John Buridan (ca. 1295–1358) had come to a similar conclusion—namely, that God could have made other worlds, even if logically we ought not expect them to exist—though via different arguments (Dick 1982, 29–30).

Such writings demonstrate that medieval authors were analyzing and probing the claims of Aristotle. Even though for the most part the Aristotelian worldview was retained, various aspects of it were questioned. The question of the eternity of the world, for example, was a source of wide-ranging arguments (Dales 1990). Even the motion of the Earth was discussed prior to Copernicus's revolutionary book: Nicholas of Cusa (1401–1461), for example, stated in his *Of Learned Ignorance* that the Earth moves. Moreover, he claimed that the Earth was not so distinct a region as Aristotle claimed, and that in fact the rest of the universe shared attributes of the earthly realm, including the presence of living beings (Crowe 2008, 27–34).

1.2.2 The Copernican Cosmological Shift

Despite the medieval questioning of various aspects of Aristotelian cosmology, however, the overwhelming majority of scholars would have shared the understanding that the universe was basically as Aristotle described it. Thus, in the middle of the sixteenth century, Copernicus found himself with a cosmos that was bounded with a spherical heavens with the Earth in the middle. But the system was not elegant, and longstanding problems with the calendar had yet to be solved. In an effort to address these issues, Copernicus proposed a physical system that placed the Sun in the middle of the cosmos, put the Earth revolving about it, as well as rotating about its own axis, and retained the bounded sphere of the stars.

This system thus made the Earth similar to five other planets: the Earth revolved around the Sun, as did Mercury, Venus, Mars, Jupiter, and Saturn. Setting aside the apparent problems of a terrestrial physics on a swiftly moving Earth for later scholars, Copernicus's cosmology brought about massive shifts in the understanding of the physical nature of the universe. Moving the Earth away from the center of the universe was not by itself of the greatest significance for the theory of extraterrestrial life. It was instead the breaking of the celestial sphere.[2]

As mentioned above, there was no place for aliens in Aristotle's universe. Placing the terrestrial region, the sphere of change, into motion might have opened up other places for aliens, namely, turning other planets into additional regions of change. Indeed, some early heliocentrists considered such schemes, as discussed below. But Copernicus's finite universe, with the Earth occupying a homocentric sphere somewhere between the Sun and the celestial sphere, did not persist for an extended period of time as a physical theory. Instead, the universe would burst open into a multitude of suns and accompanying planets, creating abodes for extraterrestrials throughout the now much larger universe.

---

[2] See Chap. 2 of this volume, "Early Modern ET, Reflexive Telescopics, and Their Relevance Today," by Dennis Danielson for complementary analysis of the changes brought about by the Copernican revolution.

1.2.3 Two Underlying Principles

With the walls of the celestial sphere sundered, and the basic problem that scholars didn't have the ability to directly access through observation—beyond the developing telescope technology—the vast majority of the universe, certain assumptions were made about the nature of the universe. Though not contemporarily labeled as such, we can see two important principles that operated implicitly in many scientists in the following centuries, even up to our current situation: the Copernican Principle and the Principle of Plenitude.

The Copernican Principle, also called the Principle of Mediocrity, was not one to which Copernicus himself ascribed. This principle holds that everywhere else in the universe is basically similar to Earth; alternatively, one can say that the Earth is in no way particularly special. In a weak sense, the scientific process assumes something similar: that what we observe here on Earth, and the laws of nature that we determine from them, will operate similarly elsewhere. But in the extraterrestrial life debate, this principle leads to the assumption that, because life is present here, it will exist in other places. How similar those places must be to Earth will be different for different authors and in different eras. That the other place is a planet circling a star will be enough for some. For others, as we shall see, various considerations such as the average temperature of the planet, the presence of water and an atmosphere, and a rocky surface, for example, will become more important, refining the Copernican Principle to a more stringent restriction on the expectation of life.

The Principle of Plenitude is related to, indeed, overlaps, the Copernican Principle. Frequently leading from theological assumptions, the Principle of Plenitude suggests that the universe ought to be as rich as possible. Because living things best demonstrate the richness that nature can produce, the principle implies that life will be plentiful throughout the universe. This was often based upon the claim that God values life and thus would widely populate the universe, not restrict life to the relatively miniscule environment of the Earth. The theological basis for this principle is explicit in many authors, but is not necessary for the principle, as it is also operative at times in authors who reject a divine principle underlying the physical universe; an appeal to "Nature," for example, can often substitute for a divine force responsible for life.

1.2.4 The Seventeenth Century

The Copernican system was not embraced swiftly, at least not as a physical system.[3] But a few important writers and scientists of the early seventeenth century did adopt some form of the system, particularly a moving Earth orbiting the Sun. By the end of the century, especially after the work of Descartes and Newton gave

[3] Westman (1980) identifies only ten Copernicans of the sixteenth century, at 136n6. But see Westman (1975) for ways in which the Copernican system was used as a calculational device without adherence to the physical system.

scientific validity to a heliocentric solar system and an extended universe, the cosmological change initiated by Copernicus had overwhelmingly changed our view of the universe.

An early adopter of heliocentrism was Giordano Bruno (1548–1600). Bruno was a controversial figure in his own day, and remains so today.[4] He lived a somewhat nomadic lifestyle, in part because of his propensity to anger colleagues and local officials, making a prudent withdrawal advisable. His interests were wide ranging: theology, philosophy, cosmology, magic, and mnemonics. He became a Dominican in 1566, but left the order in 1576 under a cloud of suspicion. His life ended after a trial in which he was found guilty of heresy and was burned at the stake. Controversy over his life and the reasons for his condemnation and execution remains, largely because many of the trial documents are lost.[5]

His role in the extraterrestrial life debate centers around his claims that the universe is infinite in extent and filled with life. He defends such a picture of the universe based on its being a truer reflection of the nature and grandeur of God than the bounded Aristotelian universe. A number of his writings touch on the subject. Especially significant are his *La cena de la ceneri* (*The Ash Wednesday Supper*; 1584), *De l' infinito universo e mondi* (*On the Infinite Universe and Worlds*; 1584), *De la causa*, *principio et uno* (*On Cause*, *Origin*, *and Unity*; 1584), and *De immenso et innumerabilibus* (*On the Immense and Innumerable*; 1591). Convinced of the Copernican claim that the Earth orbits the Sun, and decidedly anti-Aristotelian, Bruno posited that the universe is vastly extended in space and that it is filled with systems of stars and planets. In fact, he is the first to claim that the stars are objects like our Sun, and that they are all orbited by planets, just as in Earth's system. Moreover, consistently with the Principle of Plentitude, he argued for an animistic universe, in which life not only populates the stars and planets but in fact characterizes the celestial objects themselves (Crowe 1986, 10).

Two revolutionary astronomers of the seventeenth century, still heralded today as among the most important astronomers in history, were also Copernicans: Galileo Galilei (1564–1642) and Johannes Kepler (1571–1630). Galileo did not write a great deal about extraterrestrials, but he did have a bit to say. In his *Letter on Sunspots* of 1613, Galileo rejected as "false and damnable the view of those who would put inhabitants on Jupiter, Venus, Saturn, and the moon" (Crowe 2008, 52). He reiterates his rejection of extraterrestrials in a letter of 1616 to Giacomo Muti, in which he argues that life cannot exist on the Moon for not only does the Moon lack certain vital elements, namely, earth and water, each part of it also undergoes a cycle of fifteen days of unrelenting sunshine followed by fifteen days of darkness, which would make it impossible for life to subsist there (Crowe 2008, 52–53).

---

[4] For more on Bruno's life and thought, see Yates (1964) and Singer (1950). See also Rowland (2008), but note the critical review of Gregory (2012).

[5] For an account in English of the trial, including what materials we do and do not possess, see Finocchiaro (2002).

Kepler, on the other hand, reached the opposite conclusion. Curiously, he did not argue for an extended universe of the sort Bruno envisioned, and in fact Kepler had strong reasons for maintaining a bounded universe, as such a universe, in his view, better reflected a universe created by a Trinitarian God (Kozhamthadam 1994, 16–18, 29–34) and admitted of a clever geometric proof of heliocentrism via the Platonic solids (see Crowe 2008, 53–55). Nonetheless, Kepler was willing to populate other regions of the cosmos with life. In a 1610 response to Galileo's *Starry Messenger*, Kepler argued that the telescopic discovery of the moons of Jupiter, invisible to the unaided terrestrial eye, demonstrate that God provided those moons for the benefit of the inhabitants of Jupiter. He went on to argue that the Earth has the best place in the cosmos for observing because of its central position among the bodies orbiting the Sun. So whereas Kepler saw humanity in the most privileged position in the finite cosmos, we are not the sole place in which life resides (Crowe 2008, 59–64).

Bruno's idea of an unbounded universe remained suspect due to its association with a person tried and sentenced to death for heresy. In the hands of a leading philosopher of the seventeenth century, however, the idea became more palatable. René Descartes (1596–1650) proposed in his *Principles of Philosophy* (1644) a system in which matter is extended throughout space. Running up against one another were vortices, whirlpools of ethereal matter, with stars in their center and planets being carried along in the eddies of the moving plenum (see Fig. 1.1). Just as our planet had become one planet circling the Sun, so did our solar system become one of many such systems (Dick 1982, 106–112). Descartes himself did not, however, boldly assert whether extraterrestrials exist, stating in a letter of 1647, "although I do not at all infer … that there would be intelligent creatures in the stars or elsewhere, I also do not see that there would be any reason by which to prove that there were not" (Crowe 1986, 16). Still hedging, he made a slightly more positive statement in a letter to Frans Burman where he wrote, "An infinite number of other creatures far superior to us may exist elsewhere" (Hennessey 1999, 37).

Another cosmological system appeared near the end of the century that would eventually displace the Cartesian universe: the Newtonian system. Isaac Newton, in his *Philosophiae naturalis principia mathematica* of 1687, also known by the abbreviated title of the *Principia*, proposed a system in which "forces," rather than a plenum, were responsible for planetary systems and the movement of their constituent objects. Moreover, Netwon's system united terrestrial and celestial physics into a unified whole. The impact of the Newtonian understanding of nature can hardly be overstated, and it would become the dominant view of the physical cosmos. It too posited an extended universe with numerous star-planet systems. Though Newton did not make strong positive statements about the existence of extraterrestrials, the system could be sympathetic to them, as we shall see below.

Numerous authors of the seventeenth century worried at the problem of extraterrestrials. Tackling the issue from the Cartesian point of view were authors such as Henry Regius (1598–1679), Jacques Rohault (1620–1675), Henry More (1614–1687), and Pierre Borel (ca. 1620–1671), among others, some arguing for extraterrestrials, some against (Crowe 1986, 16–18; Dick 1982, 112–120). Pierre

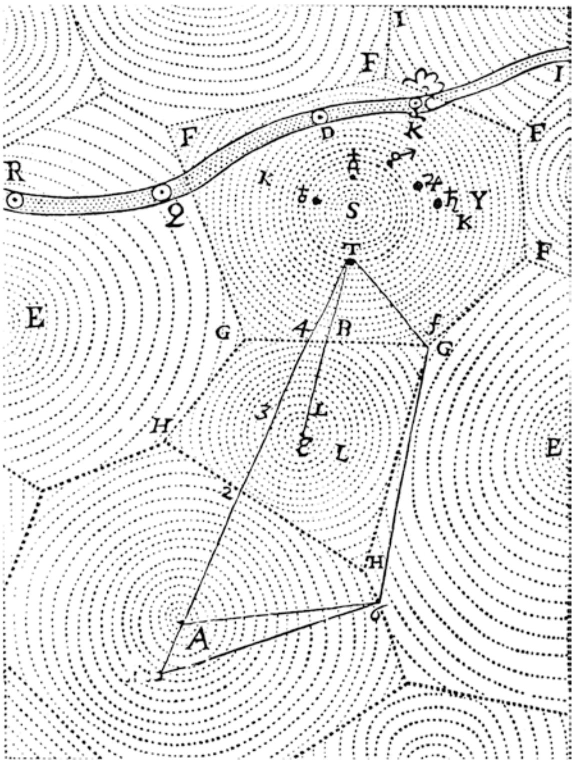

Fig. 1.1 A diagram of the Cartesian vortices from Descartes' *Le Monde* (1664)

Gassendi (1592–1655) and Otto von Guericke (1602–1686) applied the Principle of Plentitude to the question of extraterrestrials existing on other planets in our solar system as well around other stars (Crowe 1986, 17–18; Hennessey 1999, 38–39). Throughout the latter half of the century, then, extraterrestrials were gaining intellectual traction.

1.2.5 Reaching a Wider Audience

Undoubtedly one of the most engaging and influential authors to bring the question of extraterrestrial life into the limelight was Bernard le Bovier de Fontenelle (1657–1757). Fontenelle wrote deliberately for a wide, popular audience—including women—when he composed his *Entretiens sur la pluralité des mondes* (*Conversations on the Plurality of Worlds*), published in 1686. The book was quickly translated from its original French into a number of languages, including Danish, Dutch, English, German, Greek, Italian, Polish, Russian, Spanish, and Swedish. The book presents a dialogue between a philosopher and a curious marquise, in which the philosopher presents Copernican and Cartesian ideas to this intellectually able woman.

While doing so, Fontenelle also incorporates a great deal of discussion about extraterrestrials. Not only does he assert their existence, he also discusses the characteristics they must have, which differ based on their environment. The inhabitants of Mercury, for example, "are so full of Fire, that they are absolutely mad." Moreover, they are used to a much greater intensity of light and heat than any inhabitant of Earth. But, the philosopher assures the marquise, they would be perfectly at home in their own environment, even one that we would find unbearable, because "Nature never gives life to any Creature, but where that Creature may live; then thro' Custom, and ignorance of a better Life, those people may live happily" (Crowe 2008, 79–80).

Fontenelle was cognizant of the appeal of the work and its musing on extraterrestrials. In an addition made to the book in 1687, he added the following summary of important arguments of the work:

> [1] the similarities of the planets to the earth which is inhabited; [2] the impossibility of imagining any other use for which they were made; [3] the fecundity and magnificence of nature; [4] the consideration she seems to show for the needs of their inhabitants as having given moons to planets distant from the sun, and more moons to those more remote; and [5] that which is very important—all that which can be said on one side and nothing in the other (Crowe 2008, 73).

Note that we can see both the Copernican Principle and the Principle of Plentitude at work here. The Earth and our solar system are taken as typical representatives of what the rest of the universe must be like, and, due to the fecundity of nature, we can expect other places to be filled with life with characteristics appropriate to the circumstances in which they find themselves.

Another author of the late seventeenth century also had a great influence on the extraterrestrial life debate, this time a highly esteemed scientist: Christiaan Huygens (1629–1695). Published posthumously in 1698, his *Cosmotheoros*, or, as the English version has it, *The Celestial Worlds Discover'd*: *or*, *Conjectures Concerning the Inhabitants*, *Plants and Productions of the Worlds in the Planets*, was an extended treatise sprinkled with pieces of scientific information, which provide a springboard for conjectures about the inhabitants of other planets. He too makes use of the Copernican Principle. In some cases, he seems to be defending the principle. For example, in discussing whether Jupiter has water, he asserts that such a claim "is made not improbable by the late Observations" that the darker areas of the planet change, implying the presence of clouds on the planet. He thus has tried to demonstrate that the assumption of water's presence is reasonable. But for the most part, Huygens simply assumes the principle is true, making a number of assertions that seem unwarranted. In the case of water on Jupiter, for example, he discusses how, due to the planet's distance from the Sun, the water on Jupiter must in some way be different from that on Earth such that it can maintain its liquid form in colder temperatures (Crowe 2008, 91–92). He makes similar arguments about animals, in this case arguing that just as on Earth we find different animals in different regions of the planet, so too will we find different animals on different planets. Eventually, Huygens comes to the conclusion that the planets house rational creatures in some degree similar to us, both in the senses by which they learn about the world and the sciences they must have developed.

1.2.6 Extraterrestrials and Religion at the End of the Seventeenth Century

Throughout the medieval and early modern periods, natural philosophy, what we most closely identify with science, was linked with considerations of God's relationship to the physical world. Up to this point, however, we have not concentrated our discussion on the religious implications and arguments surrounding the idea of extraterrestrial life. But it had played a role in the debate, as the brief mentions above regarding Bruno and Kepler, for example, make plain. Also significant is that, again using those two authors as examples, religious arguments could be used for different purposes. Bruno posited that God's nature suggests an extensive universe filled with life, whereas Kepler envisioned a harmonious, bounded universe reflective of God's order. As extraterrestrials became a more common assertion, the religious implications of their existence also had to be considered.

An early example of the way extraterrestrials could be used in the religious context is revealed in the writings of Richard Bentley (1662–1742). Bentley was commissioned in 1692 to deliver a series of sermons under funding from Robert Boyle given for the purpose of "proving the Christian religion" (Crowe 2008, 115). A devotee of Isaac Newton, Bentley incorporated the Newtonian system into these sermons, which meant he had to address the ways in which this system, far different from the traditional Aristotelian universe, was compatible with and indeed supportive of the Christian religion.

In the eighth sermon of the series, Bentley discussed the issue of extraterrestrial life. Repeating a claim similar to Kepler's, Bentley argues that recent telescopic discoveries of celestial objects invisible to the unaided human eye demonstrate that portions of the universe are not made for the benefit of humans. Because God does not act in vain, those objects must have been made for the purpose of other beings.

> It remains therefore, that all Bodies were formed for the sake of Intelligent Minds: and as the Earth was principally designed for the Being and Service and Contemplation of Men; why may not all other Planets be created for the like Uses, each for their own Inhabitants which have Life and Understanding? (Crowe 2008, 117–118).

Moreover, recognizing that different planets might have very different environments, Bentley asserts that God would create those extraterrestrials so that they were of a nature proper to their own situation, not unlike the claim Fontenelle had made.

By the end of the seventeenth century, then, the size and nature of the universe had changed drastically from what it had been: from a bounded, geocentric universe in which life was restricted to the terrestrial region to a vastly extended universe of multiple solar systems that, despite a lack of observational evidence, were assumed to teem with planets and life, similar to ours in some ways but perhaps significantly different in the details. Extraterrestrials populated the new universe, and intellectuals of the following centuries would expend a great deal of effort to say more about them.

1.3 The Extraterrestrial Life Debate in the Eighteenth Century

Let us begin with a broad and important claim: Nearly half the leading intellectuals of the eighteenth century (sometimes labeled the Enlightenment) discussed extraterrestrial life issues in their writings. Our basis for this claim is an examination done about a decade ago of eight anthologies of Enlightenment thought, taking the list of authors included in each as an indication of the editor's judgment as to who were the leading Enlightenment thinkers. This study (Crowe 2008, xvii–xviii) found that at least 41% of the authors included by each of the eight editors met this criterion; moreover, in five of the eight cases, the percentage exceeds 53%. This test seems adequate to justify the claim that not only many, but, in fact, close to a majority of Enlightenment intellectuals actively engaged in a debate that many persons currently assume first arose in their own lifetimes. It is noteworthy that the percentages found in this study are all lower bounds, which can only increase as future research finds extraterrestrials in the pages of other authors in these anthologies. Moreover, it is significant that relatively few scientists and no astronomers appear in these anthologies; had at least the latter been included, the percentages would have risen significantly.

The materials that follow not only demonstrate how successfully extraterrestrials have propagated, but also their extraordinary adaptability. Hundreds of authors have found ways to adapt them to their thought and writings. So pliable is the doctrine of a plurality of worlds, or pluralism, that almost any author can create extraterrestrials suited to his or her system. Fiction writers beset by such limitations as characters with a single head or civilizations with only two sexes, or frustrated by the small scale of merely terrestrial catastrophes, have long since learned that extraterrestrials can rescue their writings from such restrictions. Writers from almost every era, and nearly all the authors discussed in this survey, have succeeded in creating extraterrestrials suited to their needs.

1.3.1 The Period from 1700 to 1750

During the first half of the eighteenth century, numerous authors discussed the question of a plurality of worlds, most embracing the positive side. Space limitations prohibit mentioning all, so we will focus on illustrative cases. Among these, one who especially effectively illustrates the tendencies of the time is Rev. William Derham (1657–1735), who was a key figure in linking pluralism with Newtonian science and with natural theology, as well as dissociating it from the astronomy of the previous century. While serving in 1714 as chaplain to the future King George II, Derham published his *Astro-Theology*, *or A Demonstration of the Being and Attributes of God from a Survey of the Heavens*, a volume that by 1777 had attained fourteen English and six German editions. As the title suggests, its goal was to illustrate the power and goodness of God through astronomy, which fits very well with pluralism. Simultaneously, it championed the Newtonian system. Pluralism permeates the book, adding to its attractiveness and religious appeal. Derham's indebtedness to Huygens's *Cosmotheoros* did not preclude his arguing against the Dutchman's waterless and lifeless Moon. A particularly important feature of the book is that it delineates three world systems, these being the "Ptolemaick," which he rejects, the "Copernican," which he accepts, but only as a precursor to his "New Systeme." This third system includes the Copernican, but goes beyond it by the supposition that "there are many other Systemes of *Suns* and *Planets*, besides that in which we have our residence; namely, that every Fixt Star is a sun and encompassed with a Systeme of Planets, both Primary and Secondary as well as ours" (Crowe 2008, 121) (see Fig. 1.2). One of his arguments for this system is that it "is far the most magnificent of any; and worthy of an infinite CREATOR" (Crowe 2008, 123). That Derham should be seen more as symbol than as the source of the increasing acceptance of pluralism in early eighteenth century is shown by mention of Thomas Burnet (1635–1715), John Ray (1628–1705), and Nehemiah Grew (1641–1712), all of whom in the three decades before Derham's *Astro-Theology* had endorsed pluralism in physicotheological treatises.

Various universities taught the doctrine of a plurality of worlds, for example, Oxford. At that esteemed establishment, students learned of pluralism from David Gregory (1661–1708), the Salvilian professor of astronomy, as well as from his eventual successor in that chair, John Keill (1671–1721). Whereas Gregory was

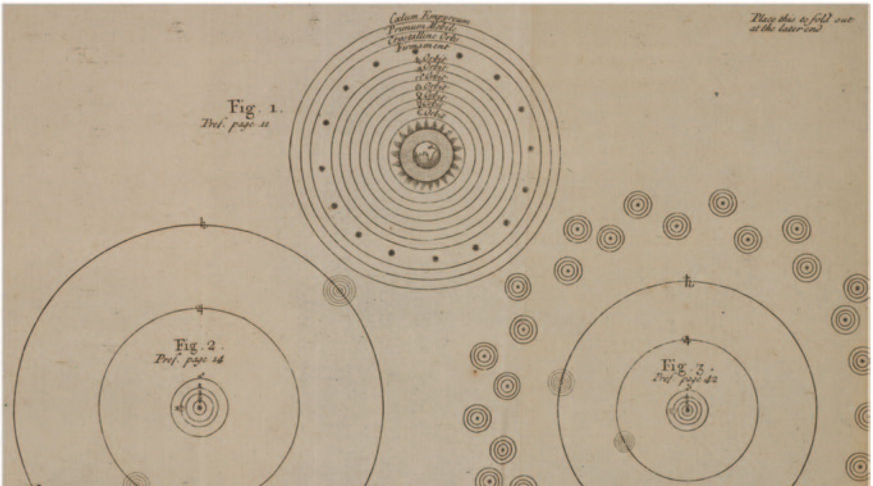

Fig. 1.2 Derham's diagram of his third system. Reproduced from the original held by the Department of Special Collections of the University Libraries of Notre Dame

noncommittal in his *Astronomiae physicae et geometricae elementa* (1702), Keill was outspoken, claiming in his *Introductio ad veram astronomiam* (1718) that it is "no ways probable" that God would create stars without placing planets around them "to be nourished, animated, and refreshed with the Heat and Light of these Suns" (Crowe 1986, 30–31). Oxford's Savilian professor of geometry at this time was Edmond Halley (1656–1742), who in 1720 became Astronomer Royal. Not only did Halley endorse pluralism, he argued from his statement that all planets "are with Reason suppos'd habitable" to the possibility that habitable globes exist beneath the Earth's surface. He had proposed subterranean globes to explain apparent shifts in the Earth's magnetic poles, but was delighted to add concerning their habitation: "Thus I have shew'd a possibility of a much more ample Creation, than has hitherto been imagin'd" (Crowe 1986, 31).

At Cambridge University William Whiston (1667–1752), who in 1702 succeeded Newton as Lucasian professor of mathematics, repeatedly advocated pluralism. As early as his *New Theory of the Earth* (1696), Whiston urged that other planets and planetary systems have inhabitants subject to moral trials. Two decades later in his *Astronomical Principles of Religion* Whiston extended his pluralism by proposing denizens dwelling in the interiors of the sun, planets, and comets; moreover, he posited "Not wholly Incorporeal, but Invisible Beings" living in planetary atmospheres (Crowe 1986, 31). In the intervening years, Whiston advanced the Newtonian system by publishing his Cambridge astronomical lectures wherein he identified stars as suns, but in 1710 he lost the Lucasian chair because of charges of religious heterodoxy, in particular, of Arianism. Nonetheless, he continued to lecture on astronomy at various locations and to spread the pluralist doctrine.

One such location was Button's coffeehouse in London, where Whiston's lectures in 1715 introduced Alexander Pope (1688–1744) to the new pluralist universe (Crowe 1986, 31). Two decades were to pass before Pope presented pluralism in his *Essay on Man*, but from the time of its publication, wherever or in whatever language that poem was read, Pope's message that the "proper study of mankind" must include consideration of extraterrestrials was brought before the public. Pope's poem sets out this point in the following lines, which had such appeal to Thomas Wright and Immanuel Kant that they quoted them when in the 1750s they published their theories of the universe:

> He, who thro' vast immensity can pierce,
> See worlds on worlds compose one universe,
> Observe how system into system runs,
> What other planets circle other suns,
> What vary'd Being peoples ev'ry star,
> May tell why Heav'n has made us as we are
> (Crowe 1986, 31).

Of all eighteenth-century English poems using scientific materials, only one rivaled and possibly surpassed Pope's *Essay on Man* in popularity. This was *Night Thoughts*, published between 1742 and 1745 by the already sixtyish rector of Welwyn, Edward Young (1683–1765). Translated into French, German, Italian, Magyar, Portuguese, Spanish, and Swedish, it was, according to one of Young's biographers, "for more than a hundred years … more frequently reprinted than probably any other book of the eighteenth century" (Crowe 1986, 84). Young divided *Night Thoughts* into nine "Nights," in the last of which he makes a final attempt to reform the libertine Lorenzo by means of "A Moral Survey of the Nocturnal Heavens." Whereas other physicotheological poets were finding in flora and fauna the finest field for proving the Deity, Young above all seeks Him in the celestial:

> Devotion! Daughter of Astronomy!
> An undevout astronomer is mad.
> True; all things speak a God; but in the small
> Men trace out Him; in great, He seizes man…
> (Crowe 2008, 200).

Young's universe was thoroughly pluralistic, being constructed, if not from Derham, at least on Derham's "New Systeme":

> One sun by day, by night ten thousand shine,
> And light us deep into the Deity…
> (Crowe 2008, 200).

This pluralistic universe raises a host of questions, scientific and religious, concerning the extraterrestrials encountered late in "Night Ninth":

> What 'er your nature, this is past dispute,
> Far other life you live, far other tongue
> You talk, far other thought, perhaps, you think,
> Than man. How various are the works of God?
> But say, what thought? Is Reason here Inthroned,
> And absolute? Or Sense in arms against her?
> Have you two lights? Or need you no reveal'd?….
> And had your Eden an abstemious Eve?….
> Or if your mother fell, are you redeemed?….
> Is this your final residence? If not,
> Change you your scene, translated? or by death?
> And if by death; what death? Know you disease?
> (Crowe 2008, 200–201).

A final excellent illustration of the debate about extraterrestrials in the first half of the eighteenth century involves Russia. Intent to drag mother Russia into the modern world, Peter the Great (1672–1725) encouraged translation of various European books into Russian. The need for this is evident in the fact that before 1717 no published exposition in Russian of the Copernican system existed. This situation was remedied not by one of the classic volumes of Copernicus, Galileo, Kepler, or Newton, but rather by Peter having Jacob Bruce prepare a translation of Huygens's *Cosmotheoros*. After Bruce completed his translation in the mid-1710s, Peter the Great ordered Mikhail Avramov to publish it. Avramov upon reading the treatise found it a work of "Satanic perfidy" (Crowe 1986, 158). Decades later he described his dilemma in a letter to the more traditional Empress Elizabeth: "concealing his godless, frenzied, and atheistic heart, Bruce praised the book by the delirious author—Kristofer Huiens, … pretending that it was very clever and wholesome for the educating of all the people, … and with such habitual and godless flattery deceived the sovereign." Avramov was not however duped; as he explained: “I examined this book which was contrary to God in all ways, and with my heart quaking and my soul overawed, I fell before the mother of God with the sobbing of bitter tears, frightened to publish and frightened not to publish” (Crowe 1986, 158). The daring decision he made was to subvert the Tsar’s order by printing only thirty copies of the book and making efforts to conceal these. Such was the entry of pluralism into Russia, a country that for some decades was the most active in radio searches for extraterrestrials.

By 1750, pluralism had been championed by an array of authors, including some of the most prominent figures of the age. Presented with exceptional appeal by Fontenelle, given legitimacy in scientific circles by Huygens and Newton, reconciled to religion by Bentley and Derham, set to poetry by Pope and Young, integrated into philosophical systems by Berkeley and Leibniz, taught in textbooks by Wolff and in taverns by Whiston, the idea of a plurality of worlds was winning international acceptance. This transformation was revolutionary. Nevertheless, from the perspective of the present its foundation was frail, resting as it did on analogical arguments of dubious force, on metaphysical principles such as the Principle of Plenitude and Copernican Principle, and on a scattering of astronomical observations. However that may be, the era of the extraterrestrial had begun and would continue even unto the present.

1.3.2 The Sidereal Revolution of the 1750–1800 Period

The single most important eighteenth-century development in astronomy took place in the 1750–1800 period and centered on four authors. This revolutionary development was nothing less than the founding of stellar astronomy. Moreover, it will be suggested that these four authors—Thomas Wright, Immanuel Kant, Johann Lambert, and William Herschel—were not only heavily committed to extraterrestrial life ideas, but also that in a number of ways these ideas were significantly involved in their contributions to stellar astronomy.

The sidereal revolution, second in significance for astronomy only to the Copernican Revolution, opened astronomy to the regions beyond our solar system and culminated in the 1920s. During its founding period it encompassed three conclusions: (1) that the Milky Way is an optical effect arising from the scattering of millions of stars over a roughly planar area, (2) that these stars form a giant disk-shaped structure many light years in diameter, and (3) that many of the thousands of nebulous patches seen in the heavens are galaxies comparable in magnitude to our own Milky Way galaxy.

The chief publication of Thomas Wright (1711–1786), an Englishman with no university training, is his *An Original Theory or New Hypothesis of the Universe* (1750), a volume rich in both illustrations from Wright’s hand and speculations from his active imagination. Both reflect his desire not only to work out the physical structure of the universe but also to integrate it with the spiritual. In the course of his book, Wright attains the first of the three fundamental notions of sidereal astronomy, but—despite decades during which he was credited with the second—he failed to attain the disk structure, although he does propose three wrong models, the last of which he formulated late in his life. This consists in the idea that the Milky Way's appearance is due to the overflow of a ring of volcanoes inside the starry vault. Regarding the idea that the nebulae are island universes, some attribute it to him, whereas others dispute this (Crowe 1986, 45–47). A careful reading of Wright's volume, which is filled with mention of extraterrestrials, suggests this his enthusiasm for them played a major role in this romp through the sidereal realm. Among dozens of quotations he takes from such authors as Bruno, Fontenelle, Newton, Huygens, Derham, and Pope supporting the plurality of worlds, Wright describes this idea as having "ever been the concurrent Notion of the Learned of all Nations" (Crowe 1986, 43). His pious purposes appear when his calculation that possibly 170,000,000 inhabited globes exist within "our finite view" spurs him (along with the Copernican Principle) to reflect: "In this great Celestial creation, the Catastrophy of a World, such as ours, or even the total Dissolution of a System of Worlds, may possibly be no more to the great Author of Nature, than the most common Accident in Life with us" (Crowe 2008, 135). This deistic remark in a book containing no mention of Christ stimulates Wright to comment: "This Idea has something so cheerful [!] in it, that I own I can never look upon the Stars without wondering why the whole World does not become Astronomers" (Crowe 2008, 136).

Immanuel Kant (1724–1824), although standing in maturity barely five feet two and never weighing more than a hundred pounds, is now recognized as a giant of thought who boldly explored the depths of the human mind and the heights of the heavens. Trained at Königsberg in Leibnizian and Wolffian thought, exposed simultaneously to Newtonianism, so devoted to Lucretius's *De rerum natura* that he memorized long passages, the young Kant was well prepared to publish in 1755 his *Allgemeine Naturgeschichte und Theorie des Himmels*, the first book to set out all three claims constitutive of sidereal astronomy. Nevertheless, the situation is more complex in that Kant had read a review in a German journal of Wright's 1750 volume and was led by the review to credit Wright with the disk theory of the Milky Way, which as mentioned above Wright had never attained. The review did not, however, mention Wright's speculation that nebulae may be other universes, a conceptual leap Kant himself attained. And not least, Kant lays out in his volume an early version of the nebular hypothesis, which was part of his concern for working out cosmic evolution.

Kant's book is in three parts, the above developments being set out in the first two along with some ideas of extraterrestrial life. For example, in part two, he turns to the Principle of Plenitude:

> Now, it would be senseless to set Godhead in motion with an infinitely small part of his creative ability and to imagine his infinite force, the wealth of a true inexhaustibility of nature and worlds to be inactive and locked up in an eternal absence of exercise. Is it not much more proper, or to say better, is it not necessary to represent the very essence of creation as it ought to be, to be a witness of that power which can be measured by no yardstick? For this reason the field of the manifestation of divine attributes is just as infinite as these themselves are (Crowe 2008, 139).

In the third part, centered on the solar system, Kant makes clear the extent of his commitment to extraterrestrials. He effectively sets out its fundamental purpose and methodology by describing part three as “an essay on a comparison, based on the analogies of nature, between the inhabitants of the various planets” (Crowe 2008, 140). Relying on various assumptions, including the Great Chain of Being, and the idea that one can infer the nature of a planet’s inhabitants from the type of matter dominant on the planet, Kant asserts that the planetarians “*become more excellent and perfect in proportion to the distance of their habitats from the sun*” (Crowe 2008, 145). Kant’s Mercurians and Venusians are consequently dullards, whereas his earthlings occupy “exactly the middle rung … on the ladder of beings” and his Jovians and Saturnians are greatly superior beings. As he states: “From one side we saw thinking creatures among whom a man from Greenland or a Hottentot would be a Newton, and on the other side some others who would admire him as [if he were] an ape” (Crowe 2008, 148).

As a treatise on extraterrestrials, Kant’s book is rather remarkable: almost never before and rarely since did an author advocate such widespread life in both the solar and sidereal systems. The book reveals that the philosopher, later so famous for his critiques of speculative systems, wrote not without having experienced their siren call. That Kant later realized that he had allowed his imagination to roam too far in the 1750s is indicated by the fact that when in 1791 J. F. Gensichen prepared an edition of Kant’s book to accompany the German translation of three astronomical papers by William Herschel, he noted that Kant had forbidden him to include any materials beyond his fifth chapter because of their excessively hypothetical character.

The third pioneer of sidereal astronomy was Johann Heinrich Lambert (1728–1777), whom Kant in 1765 described as “the greatest genius in Germany” (Crowe 1986, 56). He was a brilliant mathematician, physicist, and philosopher, who was the first person to discern the structure of the Milky Way. Although Lambert did not publish the disk theory until 1761 when he brought out his *Cosmologische Briefe uber die Einrichtung des Weltbaues*, he had attained that idea in 1749. As Lambert recounted to Kant in 1765, his *Cosmological Letters* had its origin one evening in 1749 when “from my window I looked at the starry sky, especially the Milky Way. I wrote down on a quarto sheet the idea that occurred to me then, that the Milky Way could be viewed as an ecliptic of the fixed stars, and it was that note I had before me when I wrote the *Letters* in 1760” (Crowe 1986, 56). It is a complex question whether Lambert attained the notion of nebulae as other universes, but it is indisputable that this book was as richly stocked with extraterrestrials as those of Wright and Kant. Lambert in 1765 stated to Frederick the Great that the public considers his *Letters* as a second volume “to the one on plurality of worlds by Fontenelle” and an Italian physics professor, Rev. Giuseppe Toaldo, praised it as the most beautiful of pluralist books (Crowe 1986, 56).

If one compares the books of Kant and Lambert, one finds that only the former was concerned with cosmogony, whereas Lambert unlike Kant was above all interested in comets and their inhabitants. A knowledgeable Newtonian, Lambert was aware that comets move either in elliptical orbits or in nonrecurring parabolic or hyperbolic paths. Lambert incorporates the latter paths into his system by proposing that such comets pass from one system to another and are populated by astronomically interested extraterrestrials blessed with an atmosphere that by expanding at certain times preserves livable conditions on these comets. Lambert's passion for populating the millions of comets in his system as well as his overall pluralism derived from the teleological approach everywhere evident in his volume. He also relies heavily on the Principle of Plenitude and a version of the Copernican Principle. Nonetheless, unlike Kant, Lambert favored a finite universe.

William Herschel at one point described a version of Lambert's book as "full of the most fantastic imaginations" (Crowe 1986, 57). Nonetheless, far more frequently than Kant, Lambert labels particular claims as speculative and attempts to specify the degree of credibility each deserved. His book (in some cases in a condensed form) had by 1801 been translated into French, Russian, and English. One suspects that the interest in Lambert's book may have derived more from its ideas about extraterrestrials than from its pioneering views in stellar astronomy. Ironically these three pioneers of stellar astronomy may have had no more concern about stars than their contemporaries; it was rather inhabited planetary systems that interested them and that they sought to arrange into systems. The Milky Way for them was not primarily a giant array of glowing globes, but rather a visible collection of sources of heat and light serving the myriads of beings living on the admittedly unobservable planets of the stellar systems. Kant's dull Mercurians and super Saturnians and Lambert's cometary astronomers moving from one solar system to another are now seen as bizarre companions to the more durable doctrines developed in their books. Nevertheless, eighteenth-century readers may have had the opposite view.

Among the four pioneers of sidereal astronomy, Sir William Herschel (1738–1822) ranks first in importance; indeed, he is arguably the most influential astronomer of modern times. When his career is looked at broadly enough to include his role in the extraterrestrial life debate, he emerges not primarily as a tireless telescopic technician and model empiricist seeking to learn what his extraordinary telescopes would teach him. Rather it appears (1) that Herschel was at various times a speculatively inclined celestial naturalist, quixotically caught up in a quest for evidence of extraterrestrials; (2) that many of his efforts make most sense when seen as attempts to transform pluralism from being a delight of poets, a doctrine of metaphysicians, and a dogma of physicotheologians into a demonstration of astronomers; and (3) that pluralism was a core component in Herschel's research program and as such influenced a number of his astronomical endeavors, especially but not exclusively in his formative years.

Born in Hanover, Herschel lacked a university education but, after immigrating to England in the 1750s, established himself as a musician, composer, and music teacher, working in various locations, especially in Bath, where he settled with his sister Caroline, who also contributed to astronomy. Until well into his forties, Herschel worked as a professional musician. One of the key factors that led Herschel to turn from music to astronomy occurred in 1773, when he purchased and began reading *Astronomy Explained upon Sir Isaac Newton's Principles* by James Ferguson (1710–1776), a popular itinerant science writer, whose book scholars believe significantly influenced Herschel. Ferguson's book teaches some elementary astronomy and shows much enthusiasm for a plurality of worlds.

Ferguson's universe includes "Thousands of thousands of Suns … attended by ten thousand times ten thousand Worlds … peopled with myriads of intelligent beings, formed for endless progression in perfection and felicity" (Crowe 1986, 60). Ferguson focuses chiefly on the solar system, concerning which he notes that the outer planets are provided with extra moons, and in the case of Saturn with a ring, to illuminate the nights of their inhabitants. He stresses that "by the assistance of telescopes we observe the Moon to be full of high mountains, large valleys, and deep cavities. These similarities leave us no room to doubt but that all the Planets and Moons in the System are designed as commodious habitations for creatures endowed with capacities of knowing and adoring their beneficent Creator" (Crowe 2008, 173). Influenced by such readings, Herschel began to construct telescopes and to observe the heavens. The abilities he showed in this undertaking were recognized in 1781 when he became world famous for discovering the planet Uranus.

Striking evidence in Herschel's unpublished manuscripts shows that Herschel may well have thought at that time that he had made an even more important discovery five years earlier. Among the earliest of Herschel's lunar observations is that dated 28 May 1776, when with a newly acquired telescope, he reports that while observing the Moon,

> I was struck with the appearance of something I had never observed before, which I ascribed to the power and distinctness of my Instrument, but which perhaps may be an optical fallacy—I believed to perceive something which I immediately took to be *growing substances*. I will not call them Trees as from their size they can hardly come under that denomination, or if I do, it must be understood in that extended signification so as to take in any size how great soever…. My attention was chiefly directed to Mare humorum, and this I now believe to be a forest, this word being also taken in its proper extended signification as consisting of such large *growing substances*. (Crowe 2008, 177–178).

Herschel's ambivalence about these observations led him in late 1778 to compose a new analysis, which shows that by then Herschel believed he had evidence not only of forests but also of lunar towns. Suspecting that lunar craters may be the towns of the lunarians, he remarks:

> Now if we could discover any new erection it is evident an exact list of those Towns that are already built will be necessary. But this is no easy undertaking to make out, and will require the observation of many a careful Astronomer and the most capital Instruments that can be had. However this is what I will begin (Crowe 1986, 65).

Herschel continued his search for evidence of lunar life at least until 1783, finding "roads," a "city" and much else, but never secured observations that he deemed conclusive enough for publication. It is clear from his writings that he believed all the planets are inhabited; for example, he refers periodically to the inhabitants of such planets as Mars and Uranus, and eventually published two papers (treated later) advocating life on the Sun.

With this as background, we can turn to Herschel's very important contributions to sidereal astronomy. One of Herschel's most important achievements was his observation of nebular patches, then called nebulae. When Herschel began observing them regularly around 1782, just over a hundred were known, these having been listed by Charles Messier, who was one of the few astronomers of that period interested in them. In fact, Messier's chief interest was comets. What led to Messier's interest in nebulae was that they resemble comets in appearance, which led Messier to make a catalogue of nebulae so that astronomers would not mistake them for comets. Herschel, typically using giant reflecting telescopes that he himself had constructed, managed over the course of his career to discover nearly 2,500 more nebulae. What seems to have led him to this effort was that by 1784 he had formulated the disk theory of the Milky Way and proceeded from this to claim that the nebulae are other universes comparable to the Milky Way. It is within this context that one should view the exclamation of the poetess Fanny Burney who in 1786 visited Herschel: "he has discovered fifteen hundred universes! How many more he may find who can conjecture?" (Crowe 1986, 67). It is true that by 1791 Herschel had backed away somewhat from the island universe theory because he had concluded that some nebulae consist of a "shining fluid" rather than being a cluster of a vast number of stars. Such studies by Herschel served to launch stellar astronomy, which many decades later came to be the most important area of astronomy. As in the case of other founders of sidereal astronomy, it appears that the claim that inhabited planets orbit stars spurred interest in the stellar regions. In Herschel's case, it seems very possible that in building some of his telescopes, he was initially motivated more by hope of detecting evidence of extraterrestrials than by an interest in observing nebulae, in which objects his contemporaries took little interest.

In the eighteenth century, publications in stellar astronomy represented perhaps five percent of the astronomical literature. It should not be assumed that other leading astronomers were not continuing to advance astronomy in other areas. Nor should it be assumed that they were not concerned about extraterrestrials. Johann Elert Bode (1747–1826), director of the Berlin Observatory and editor of one of the leading astronomical journals of the period published so widely on extraterrestrials that his position has been labeled "un panpopulationnisme cosmique" (Crowe 1986, 73). Active especially on the observational level, for example, searching for lunarians was Johannes Schröter (discussed later). One indication of his passion for sighting terrestrial features elsewhere in the solar system is his report of sighting mountains on the rings of Saturn (Crowe 1986, 72). The leading mathematical astronomer of the period, Pierre Simon Laplace (1747–1827), also came out forcefully for pluralism as did his French contemporary Jérôme Lalande (1732–1827).

1.3.3 At the End of the Eighteenth Century

During the period from 1600 to 1800, pluralism, viewed in relation to the scientific community, passed through a remarkable transformation. Many seventeenth-century scientists—Galileo, Descartes, Newton (in his published writings)—had viewed it as a speculation at the limits of legitimate science. During the eighteenth century, however, an international array of astronomers, including Wright, Lambert, Herschel, Bode, Schröter, Laplace, and Lalande, embraced extraterrestrials; in fact, for some pluralism formed an integral part of their research program.

Moreover, while scientific journals published pluralist papers, astronomical texts and university courses regularly treated this topic. In short, pluralism made extraordinary progress with practitioners of the most ancient science.

If, however, we examine eighteenth-century pluralism from the perspective of the present, it is clear that its conjectural component was large. Broad analogy more than detailed astronomy, physicotheology more than physics, and teleology more than telescopes had been used to erect a vast edifice on what nineteenth-century scientists gradually found to be a frail foundation. Although by the eighteenth century, the medieval cosmos with its crystalline spheres, angelic planetary movers, and associated metaphysical and mythical elements had been discredited, it should not be forgotten that the cosmos championed by many Enlightenment figures was not free of comparable associations. Carl Becker did not discuss pluralism when in his *Heavenly City of the Eighteenth-Century Philosophers* he maintained that the Enlightenment "*philosophes* demolished the Heavenly City of St. Augustine only to rebuild it with more up-to-date materials" (Crowe 1986, 161), but he might have found in such authors as Wright, Kant, Lambert, and Herschel evidence to support a parallel claim for the heavens of Enlightenment astronomy. Crystalline spheres had disappeared, but Halley's inhabited subterranean spheres and Herschel's cool solar nucleus became available. Disputes about hierarchies of angels may have been abandoned, but a number of authors debated whether the superbeings of the solar system live on the outer planets, inner planets, or on the Sun itself. Moreover, although some authors analyzed the question of other worlds in largely scientific terms, the majority, explicitly or implicitly, invoked religious or metaphysical considerations.

In the case of science, so also in regard to religion: serious difficulties lay just beneath the surface. The very success of the natural theological enterprise, whether practiced by Christians or deists, tended to emphasize "Nature's God" while downplaying the idea of an incarnated redeemer. Structures of insects or solar systems may evidence God's existence, but they are mute as to a messiah. Furthermore, pluralist physicotheology set off in even starker relief the radical nature of the Christians' claim. Why would the God of all worlds select an insignificant planet for his most remarkable actions? In short, whereas by the 1790s pluralism had reached a rapprochement with theism, tensions with Christianity had not as yet been fully faced. This is at least the conclusion suggested by the sensation that resulted when in the 1790s Thomas Paine launched a vigorous attack on Christianity on a pluralist basis.

In 1793, the rapprochement worked out between extraterrestrials and many religious writers began to shatter as thousands of people read a book written by Thomas Paine (1737–1809). Entitling his book *The Age of Reason*, Paine argued that astronomical science had made it impossible for any thinking person to accept the central Christian notions of a divine incarnation and redeemer. In his book, Paine recounts that James Ferguson, a popular and pious lecturer on astronomy, had convinced him that a good and generous God must have populated the Moon and planets. When Paine confronted Christianity with this astronomical claim, he became a deist, that is, a person accepting a remote, impersonal God, but denying such central Christian doctrines as Christ's incarnation and redemption. In his book Paine argues that although the existence of intelligent life only on the Earth is not a specific Christian doctrine, it is nonetheless "so worked up therewith from … the story of Eve and the apple, and the counterpart of that story—the death of the Son of God, that to believe otherwise … renders the Christian system of faith at once little and ridiculous" (Crowe 2008, 224). Paine presses the same point in even stronger language by asking:

> From whence … could arise the … strange conceit that the Almighty … should … come to die in our world because, they say, one man and one woman had eaten an apple! And, on the other hand, are we to suppose that every world in the boundless creation had an Eve, an apple, a serpent, and a redeemer? In this case, the person who is irreverently called the Son of God, and sometimes God himself, would have nothing else to do than to travel from world to world, in an endless succession of death, with scarcely a momentary interval of life (Crowe 2008, 229).

Paine's conclusion was stark: either reject belief in extraterrestrial life—a doctrine that he claimed had been established by astronomy—or reject Christianity.

Paine's *Age of Reason* attracted an immense readership both in Britain, where 60,000 copies of it were printed, and in America, where a single Philadelphia bookshop sold over 15,000 copies. It also generated more than fifty published responses, some explicitly opposing Paine's extraterrestrial life attack on Christianity.

1.4 The Extraterrestrial Life Debate in the First Half of the Nineteenth Century

1.4.1 Some Considerations from Science

As of 1800, the level of belief in extraterrestrial intelligences was higher than it had ever been before or than it would ever be again. Educated Europeans and Americans believed that wherever celestial objects might be, there also must be extraterrestrial subjects. It is true that not a shred of satisfactory direct empirical evidence confirmed this conviction, but powerful principles—chiefly the Copernican Principle and Principle of Plenitude—supported this belief. So also, it was thought, did such observations as lunar mountains and whitish Martian polar caps. Not only itinerant lectures but also prestigious university professors and eloquent preachers shared this exciting news with their audiences. It is true that Paine's *Age of Reason* (1793) caused some ripples, but chiefly it set Christian religious writers to searching for ways to reconcile this exciting message with traditional Christian belief in an incarnated redeemer.

On one level at least, the widespread confidence shown by early nineteenth-century intellectuals in the existence of extraterrestrials is surprising. In particular, by the early 1800s various scientific results were available, some of which scientists had attained more than a century earlier, that presented, one would think, serious difficulties for those wishing to populate the planets. For example, already in the late seventeen century, Newton in his *Principia* had used his law of universal gravitation to determine the relative masses and densities of the Sun, Earth, Jupiter, and Saturn and also the relative force of gravitation on the surface of each of these objects. (His calculation depended on the fact that each of these bodies has a body in orbit around it.) His results revealed immense diversity among these objects. For example, he found that it would take 169,282 Earth masses to match the Sun's mass. Similarly, it would take 3,021 Saturns or 1,067 Jupiters to match the Sun's mass. This suggested, one would think, the problematic character of claims that these giant bodies are analogous to the Earth and hence probably also inhabited. Even more striking was Newton's calculation that if one assigns a density of 100 to the Sun, the density of Jupiter is 94.5, Saturn 67, and Earth a whopping 400. Even more problematic is that if an earthling weighs 435 units, a Saturnian would weigh 529, a Jupiterian 943, and a solarian 10,000 units. This indicated that were a human transported to the Sun, the human's weight would increase by a factor of 235.[6]

If one turns from gravitational considerations to optical and thermal ones, the situation becomes more complex historically, but no less striking. Consider first of all light, especially the fundamental photometric result that the amount of light radiating from a point source decreases according to the inverse square law. Thus if a piece of paper is placed one unit from a point source of light radiating in all directions, then moving the paper twice as far away leads to its receiving only one fourth as much light per unit area at that distance. At ten units distance, the amount of light drops to 1/100 of the original intensity. The inverse square law for light propagation was well known at least from 1720 when Pierre Bouguer published experiments demonstrating its correctness with Johann Lambert in 1760 adding further evidence (Mach n.d., 13–17). This makes it easily possible to determine that Saturn, being about 9.5 times farther from the Sun than the Earth, must receive about 90 times less light per unit surface area than our Earth. This would seem to present a problem for proponents of Jupiterians; instead Christian Wolff writing in 1735 saw it as an opportunity. Setting the distance of Jupiter as 26/5 times farther from the Sun than the Earth and using the inverse square law and calculating what pupil diameter would be necessary in the eye of a Jupiterian to see as much as we do and assuming that pupil diameter would enable him to calculate the height of a typical Jupiterian, Wolff calculated that Jupiterians must be extremely tall (Crowe 1986, 30). Some were impressed by this calculation, but Voltaire viewed it as so absurd that he satirized it in his famous *Micromégas* (1752) (Crowe 1986, 120–121).

Regarding the amount of heat each planet receives from the Sun, the situation was still more complicated, partly because the nature of heat was still under discussion in 1800, around which time William Herschel discovered infrared rays. It does seem correct to say that by the middle of the nineteenth century scientists were fully aware that the amount of heat from our Sun reaching any planet would, like the amount of light, drop off at a rate governed by the inverse square law.

Severe as these problems may seem to us, proponents of inhabited planets rarely took them seriously, or at most (say in the case of light) viewed them as an explanation of why God had provided Saturn with a ring.[7] One example of an

---

6 For Newton's text and a full explanation, see Crowe (2006, 194–99).

7 James Ferguson and Emanuel Swedenborg and a number of scientists made this claim. See Crowe (2008, 172, 218).

author who used these considerations against extraterrestrials was Thomas Young, who, commenting in 1807 on William Herschel's arguments for life on the Sun, suggested that the Sun's great mass would make human-sized solarians weigh over two tons (Crowe 1986, 168).

In the 1830s, arguably the most prominent astronomer on our planet was John Herschel (1792–1871). In 1833, he published his *Treatise on Astronomy*, which was the most respected presentation of astronomy available in English. Regarding the heat/light problem discussed above, he states: "The intensity of solar radiation is nearly seven times greater on Mercury than on the earth, and on Uranus 330 times less; the proportion between these two extremes being that of upwards of 2000 to one" (J. Herschel 1833, 277–288). Regarding the gravity issue, he declared that "the intensity of gravity, or its efficacy in … repressing animal activity on Jupiter is nearly three times that on Earth, on Mars not more than one third, and on the four smaller planets probably not more than one twentieth; giving a scale of which the extremes are in the proportion of sixty to one" (Herschel 1833, 273). Regarding the density issue, he states that the density of Saturn is about one eighth of the Earth's, "so that it must consist of materials not much heavier than cork." All this does not lead him to back away from extraterrestrials but to remark on "what immense diversity must we not admit in the conditions of that great problem, the maintenance of animal and intellectual existence and happiness, which seems … to form an unceasing and worthy object of the exercise of the Benevolence and Wisdom which presides over all" (Herschel 1833, 273). As we shall see, twenty years later, one of Herschel's contemporaries analyzed these factors in quite a different way.

1.4.2 Some Prominent Philosophers

A telling illustration of the overconfidence many had in the existence of extraterrestrials comes from consideration of two prominent philosophers known for their empiricist orientation, who nevertheless wrote about extraterrestrials in a very speculative manner—without apparently realizing it. The philosophers were Sir John Herschel and Auguste Comte.

In 1833, Herschel, as noted previously, published his *Treatise on Astronomy*. At that time, British intellectuals held Herschel in high esteem not only as a scientist but also as an expert on scientific method, the subject of his *Preliminary Discourse on the Study of Natural Philosophy* (1830). In its opening paragraph, he urges the prospective scientist to "strengthen himself … for the unprejudiced admission of any conclusion which shall appear to be supported by careful observation and logical argument, even should it prove of a nature adverse to notions he may have previously formed for himself … without examination, on the credit of others. Such an effort is, in fact, a commencement of that intellectual discipline which forms one of the most important ends of all science" (Crowe 2008, 238). In his second paragraph, he stresses that this restraint is especially necessary in astronomy, because "Almost all its conclusions stand in open and striking contradiction with those of superficial and vulgar observation, and with what appears to every one, until he has understood and weighed the proofs to the contrary, the most positive evidence of his senses" (Crowe 2008, 239). Shortly thereafter, he offers the following example: "The planets, which appear only as stars somewhat brighter than the rest, are to (the astronomer) spacious, elaborate, and habitable worlds; several of them vastly greater and far more curiously furnished than the earth he inhabits … and the stars themselves properly so called … are to him suns of various and transcendent glory—effulgent centres of life and light to myriads of unseen worlds" (Crowe 2008, 239). The actual situation was very different: Herschel's claims regarding planets being "spacious, elaborate, and habitable worlds" and stars being "effulgent centres of life and light to myriads of unseen worlds" was hardly empirical information revealed by telescopes nor were these beliefs "adverse to (popular) notions." In fact, such were among the popular notions of the day.

The case of Auguste Comte (1798–1857), famous as the founder of positivism, is comparable. In the second volume of his *Cours de philosophie positive* (1830–1842), Comte sets out a systematic analysis on empiricist grounds of the methodology of astronomy, the only science that Comte believed had as yet transcended the theological and metaphysical stages of development (Comte 1968, 2, 1). Despite its advanced state, Comte prescribes further purification for astronomy. For example, he warns astronomers against excessive speculation concerning the heavenly bodies: "we will never by any means be able to study their chemical composition or their mineralogical structure" (Crowe 2008, 312). The imprudence of this pronouncement, coming but a few decades before the development of spectroscopy, has often been noted. So has Comte's lack of insight in rejecting sidereal astronomy. What has not been noted is that Comte's strictures are not extended to the most highly speculative area of astronomy, the question of extraterrestrials. Yet one finds in the same discussion Comte's assertion that "If, what is highly probable, the planets provided with an atmosphere, as Mercury, Venus, Jupiter, etc. are in fact inhabited, we can regard those inhabitants as being in some fashion our fellow citizens, since from what is a sort of common fatherland, there ought of necessity result a certain community of thought and even of interests, whereas the inhabitants of other solar systems will be complete strangers" (Crowe 2008, 316).

Comte carries his critique of astronomy even farther in his *Systeme de politique positive*, the first volume of which appeared in 1851, five years after the discovery of the planet Neptune. In that volume Comte criticizes astronomers for their interest in remote regions of the solar system, lamenting the "mad infatuation … which some years ago possessed, not only the public, but even the whole group of Western astronomers, on the subject of the alleged discovery (of Neptune), which, even if real, would not be of interest to anyone except the inhabitants of Uranus" (Crowe 2008, 317). One cannot but be struck by the inconsistency of Comte in banishing the stars and Neptune from astronomy, while embracing, without supporting arguments, the existence of Uranians. The explanation of the latter anomaly may lie in his use of pluralism in criticizing theology. Comte excoriates in this context those who see astronomy as allied with religion, "as if the famous verse 'The Heavens declare the glory of God' had preserved its meaning. It is, however, certain that all true science is in radical and necessary opposition to all theology." Moreover, he adds that for those familiar with the true philosophy of astronomy, "the heavens declare no other glory than that of Hipparchus, of Kepler, of Newton, and of all those who have cooperated in the establishment of laws" (Crowe 2008, 317). In particular, what has shown the unacceptability of theology is the realization that the Earth, rather than being the center of the universe, is only a secondary body circling the Sun "of which the inhabitants have entirely as much reason to claim a monopoly of the solar system, which is itself almost imperceptible in the universe" (Crowe 2008, 318). If it is correct that Comte's enthusiasm for extraterrestrials arose from a belief that their existence invalidated any theology in which humanity has a primacy, then it appears legitimate to suggest that Comte's own astronomy may not have transcended even the anti-theological stage.

Repeatedly in the history of the extraterrestrial life debate one encounters arguments based on analogies. It is interesting that various philosophers addressed this issue, sometimes directly in regard to extraterrestrial life issues. The first of these was Étienne de Condillac in his *La logique* (1780), who distinguished between different sorts of analogy, for example, those of resemblance and those where cause and effect are involved (Crowe 1986, 137). John Stuart Mill (1807–1873) in his famous *System of Logic* (1843) provided a much fuller discussion, centered on the question of life on the Moon and planets. In the course of his extended discussion, two of the most important points Mill makes are these: (1) Regarding the planets, he remarks "when we consider how immeasurably multitudinous are those of their properties which we are entirely ignorant of, compared with the few which we know, we can attach but trifling weight to any considerations of resemblances in which known elements bear so inconsiderable a proportion to the unknown" (Crowe 1986, 231), and (2) regarding analogies in general, he cautions that their chief value lies "in suggesting experiments or observations that may lead to positive conclusions" (Crowe 1986, 231). In more modern parlance, Mill's suggestion is that analogies are primarily involved in the logic of discovery rather than the logic of verification. A very perceptive remark came in 1885 from Charles Sanders Peirce (1839–1914), who remarked "There is no greater nor more frequent mistake in practical logic than to suppose that things that resemble one another strongly in some respects are any more likely for that to be alike in others," adding that "any two things resemble one another just as strongly as any two others, if recondite resemblances be admitted" (Crowe 1986, 552).

1.4.3 Religious Issues

During the first half of the nineteenth century, religious issues arose repeatedly in the extraterrestrial life debate. It should not, however, be assumed that the nature of the debate took the form of religious writers resisting belief in extraterrestrials.

The situation was far more complicated. By 1800, numerous authors had concluded that belief in God was not only reconcilable with the existence of extraterrestrials, but that belief in an omnipotent and omnibeneficent God implies life elsewhere. The Principle of Plenitude had not diminished in popularity or power. Authors of books on natural theology regularly featured extraterrestrials. On the other hand, in the period after Paine's *Age of Reason* (1793), tensions were felt in regard to Christianity with its notions of a divine incarnation and redemption. To put it differently, tensions arose in some cases between natural theology and revealed theology.

1.4.3.1 Three Authors in the Paine Tradition

Early in his education, the famous romantic poet Percy Bysshe Shelley (1792–1822) became convinced of the existence of extraterrestrials; in fact, one Shelley scholar has argued that it was astronomy that led Shelley to forsake Christianity (Evans 1954, 69). This fits with one of Shelley's early poems, *Queen Mab* (privately printed 1813), where he employed extraterrestrials against central Christian claims. At one point in his poem, he refers to "Innumerable systems," adding that the plurality of worlds makes it

> impossible to believe that the Spirit that pervades this infinite machine begat a son upon the body of a Jewish woman; or is angered at the consequences of that necessity, which is a synonym of itself. All this miserable tale of the Devil, and Eve, and an Intercessor, with the childish mummeries of the God of the Jews, is irreconcilable with the knowledge of the stars. The works of His fingers have born witness against Him (Crowe 2008, 234).

Shelley greatly expanded this argument in a satirical essay, "On the Devil, and Devils," which he wrote later in his short life but which was sufficiently shocking that it was withheld from publication for many years (Crowe 2008, 235–239).

Examination of the early diaries of John Adams (1735–1826), second president of the United States, indicate that already by 1756 he had forsaken traditional Christianity. As he explained in his diary:

> Astronomers tell us … that not only all the Planets and Satellites in our Solar System, but all the unnumbered Worlds that revolve round the fixt Starrs are inhabited…. If this is the Case all Mankind are no more in comparison of the whole rational Creation of God, than a point to the Orbit of Saturn. Perhaps all these different Ranks of Rational Beings have in a greater or less Degree, committed moral Wickedness. If so, I ask a Calvinist [Christian], whether he will subscribe to this Alternitive [*sic*], "either God almighty must assume the respective shapes of all these different Species, and suffer the Penalties of their Crimes, in their Stead, or else all these Being[s] must be consigned to everlasting Perdition?" (Crowe 2008, 207–208).

A letter Adams wrote on 22 January 1825 suggests that Adams retained this position throughout his life. Writing to his friend and successor as U.S. president, Thomas Jefferson, who was then seeking to hire faculty for the University of Virginia, Adams warned Jefferson against hiring European professors: "They all believe that great Principle which has produced this boundless universe, Newton's universe and Herschell's [*sic*] universe, came down to this little ball, to be spit upon by the Jews. And until this awful blasphemy is got rid of, there never will be any liberal science in the world" (Crowe 2008, 208).

The third religious figure in the Paine tradition is the famous American Transcendentalist Ralph Waldo Emerson (1803–1882). One of the best-known events in American literary and religious history occurred in September 1832, when Emerson resigned his pulpit because he could no longer reconcile his religious views with administering the Lord's Supper. A plausible case can be made that what triggered this event was linked to the idea of a plurality of worlds. On 27 May 1832 Emerson delivered a sermon titled "Astronomy," the theme of which appears in a rhetorical question in his diary for 23 May 1832, where he asked, given modern astronomy, "Who can be a Calvinist or who an Atheist[?]" (Crowe 2008, 318). In other words, astronomy in effect supports belief in God but refutes belief in the Incarnation and Redemption. To some extent, Emerson summarizes his position by announcing:

> And finally, what is the effect upon the doctrine of the New Testament which these contemplations produce? It is not contradiction but correction. It is not denial but purification. It proves the sublime doctrine of One God, whose offspring we all are and whose care we all are. On the other hand, it throws into the shade all temporary, all indifferent, all local provisions. Here is neither tithe nor priest nor Jerusalem nor Mount Gerizim. Here is no mystic sacrifice, no atoning blood (Crowe 2008, 322).

1.4.3.2 Some Authors in the Christian Tradition

Numerous Christian authors in the period after Paine responded to his polemics. Three of the most successful were Timothy Dwight, Thomas Chalmers, and Thomas Dick.

Timothy Dwight (1752–1817) served as president of Yale University from 1795 until his death. One of Dwight's goals as Yale president was to combat deism, to which end he prepared a series of 173 sermons, which he repeated every four years lest any undergraduate miss his message. In these sermons, Dwight not only urged students to good actions but also marshaled extraterrestrials on behalf of his evangelical urgings. For example, in his fifth sermon, Dwight states that God called into existence "the countless multitude of Worlds [which] he stored, and adorned, with a rich and unceasing variety of beauty and magnificence, and with the most suitable means of virtue and happiness" (Crowe 1986, 175). In his next sermon, Dwight calls Yale students to repentance by asking them: "How different will be the appearance, which pride, ambition, and avarice, sloth, lust, and intemperance, will wear in the sight of God, in the sight of the assembled universe" (Crowe 1986, 176). Lunarians were also employed. Dwight informed those hearing his seventh sermon that although many astronomical investigations had shown that the Moon lacks an atmosphere, nonetheless "it is most rationally concluded, that intelligent beings in great multitudes inhabit her lucid regions, being probably far better and happier than ourselves" (Crowe 1986, 176).

Late in the series of sermons Dwight turns to problems raised by Paine's polemics, resolving them by the suggestion that a rebellion from God occurred only among angels and among terrestrials. In particular, "The first [rebellion] was perpetrated by the highest [i.e., the angelic], the second by the lowest [i.e., human] order of intelligent creatures. These two are with high probability the only instances, in which the Ruler of all things was disobeyed by his rational subjects" (Crowe 1986, 177). Thus Dwight was combating Paine's objection by declaring that humanity is the only race in the universe that fell into sin and required redemption. This bold response to Paine made for powerful preaching; in fact, Dwight's sermons were so effective that in a number of years as many as a third of Yale's graduates entered the ministry.

Ideas of extraterrestrial life played an even larger role in the evangelical movement in Scotland, where Thomas Chalmers (1780–1847) was not only the leading evangelical but also the most prominent Scottish religious figure of his day. Chalmers's rise to fame began with a series of sermons he delivered in Glasgow in 1815. In these sermons, Chalmers mixed evangelical piety with extraterrestrial themes similar to those of Dwight, thereby delighting hundreds who waited hours to experience his eloquence. His sermons, when published as *Astronomical Discourses on the Christian Revelation*, went through dozens of editions in both Britain and America.

Even more energetic about employing extraterrestrials in the service of religion was another Scotsman, Thomas Dick (1774–1857). From his observatory near Dundee, Dick deluged America with books blending ideas of extraterrestrial life with various religious themes. He edified readers of his first book, *The Christian Philosopher* (1823), by stating that the wisdom of God is shown by our Sun being placed at just such a distance as best to benefit us. Dick hastens, however, to add that the Sun's position does not prevent other planets from being happily inhabited by beings appropriately formed for their varying distances from the Sun. We learn from this book that rational beings dwell not only on all the planets but also on the Moon and Sun. For example, Dick states that God placed within the immense body of the Sun "a number of worlds … and peopled them with intelligent beings" (Crowe 1986, 196). Turning to the Moon, he predicts that "direct proofs" of the Moon's habitability will be forthcoming, supplementing this by appendices in which he discusses whether the observations of the German astronomers Schröter and Gruithuisen provide such proofs. Dick, moreover, boldly claims that the existence of extraterrestrial life "is more than once asserted in Scripture" (Crowe 1986, 197).

Dick presents similar ideas in his *Philosophy of Religion* (1826) and his *Philosophy of a Future State* (1828). In the former book, he asserts that "the grand principles of morality … are not to be viewed as confined merely to the inhabitants of our globe, but extend to all intelligent beings … throughout the vast universe [in which] *there is but one religion*" (Crowe 1986, 197). In the latter book, he calculates that 2,400,000,000 inhabited worlds exist in the visible creation. In his *Celestial Scenery* (1836), he provides a table of the population of each planet, including even the ring, and the edge of the ring, of Saturn! It has been reproduced here in Fig. 1.3.

SUMMARY VIEW OF THE SOLAR SYSTEM. 401

	Square Miles.	Population.	Solid Contents.
Mercury	32,000,000	8,960,000,000	17,157,324,800
Venus.............	191,134,944	53,500,000,000	248,475,427,200
Mars	55,417,824	15,500,000,000	38,792,000,000
Vesta	229,000	64,000,000	10,035,000
Juno	6,380,000	1,786,000,000	1,515,250,000
Ceres	8,285,580	2,319,962,400	2,242,630,320
Pallas............	14,000,000	4,000,000,000	4,900,000,000
Jupiter	24,884,000,000	6,967,520,000,000	368,283,200,000,000
Saturn	19,600,000,000	5,488,000,000,000	261,326,800,000,000
Outer ring of Saturn.	9,058,803,600		
Inner ring..........	19,791,561,636	8,141,963,826,080	1,442,518,261,800
Edges of the rings ..	228,077,000		
Uranus	3,848,460,000	1,077,568,800,000	22,437,804,620,000
The Moon..........	15,000,000	4,200,000,000	5,455,000,000
Satellites of Jupiter .	95,000,000	26,673,000,000	45,693,970,126
Satellites of Saturn..	197,920,800	55,417,824,000	98,960,400,000
Satellites of Uranus .	169,646,400	47,500 992,000	84,823,200,000
Amount.......	78,195,916,784	21,894,974,404,480	654,038,348,119,246

Fig. 1.3 Thomas Dick's population figures for the solar system from *Celestial Scenery* (1836)

1.4.3.3 Two New Religions Involving Extraterrestrials

Consideration of Dwight, Chalmers, and Dick suggests how deeply ideas of extraterrestrial life had entered into religious thought in the nineteenth century. The same point can be made even more forcefully by noting two very prominent religious figures who not only founded major religious denominations but also provided these new religions with scriptures incorporating extraterrestrials. These persons were Ellen G. White (1827–1915), the prophetess of the Seventh-day Adventist Church, and Joseph Smith (1805–1844), founder of the Church of Jesus Christ of Latter-day Saints (or Mormon Church).

Ellen G. White during the 1840s became involved with the Millerite movement, which had predicted that Christ's second coming was imminent. By November 1846, she had begun to experience visions involving extraterrestrial beings. Regarding Saturn, she reported: "The inhabitants are a tall, majestic people…. Sin has never entered here" (Crowe 2008, 329). Further visions came in 1849, such visions convincing her associates that she possessed special gifts. By the early 1860s, she and her associates founded a new denomination, which they designated the Seventh-day Adventist Church. For it, White provided a theology incorporating extraterrestrials, including the doctrines that sin occurred only on earth and that correspondingly Christ came only to our planet. As she wrote in one of her books, *The Story of Patriarches and Prophets*, "It was the marvel of all the universe that Christ should humble himself to save fallen man. That he who has passed from star to star, from world to world, superintending all … [took] upon himself human nature, was a mystery which the sinless intelligences of other worlds desired to understand" (Crowe 2008, 331). This theology not only provided a way around Paine's dilemma, it also presented a remarkable cosmic conception that seems to have enhanced the attractiveness of this new religion. Ellen White's denomination has continued to grow and in fact to spread throughout the world, with current membership, according to the church's website, over seventeen million.

The second case of a new religion embracing extraterrestrials is no less remarkable. Joseph Smith provided his Latter-day Saints not only with the *Book of Mormon* but also with a number of other scriptures including *Doctrine and Covenants* and *The Pearl of Great Price*. In both these texts, Smith advocates the idea that the universe contains a vast number of inhabited worlds. In the later work, God is presented as revealing that "I can stretch forth mine hands and hold all the creations which I have made; and … among all the workmanship of mine hands there has not been so great wickedness as among thy brethren" (Crowe 2008, 326). Two other pluralist notions advocated by Smith are that some inhabited worlds have already passed away and that new inhabited worlds will arise. The great emphasis Mormons place on this doctrine may have played a significant role in the spread of the Mormon community, which, according to the church's website, now numbers over fourteen million members.

1.4.4 The Sun and Moon as Special Cases

In discussions of the habitability of celestial bodies, the Sun and Moon are not only special cases, but also provide illuminating instances of the intensity of interest in believing in extraterrestrials. It takes a robust commitment to extraterrestrials to conclude that they inhabit our Sun, which seems overly warm, or the Moon, which seems inhospitable for life because stars rapidly disappear behind the Moon indicating the absence of a lunar atmosphere.

1.4.4.1 The Sun

William Herschel certainly possessed a sufficiently robust commitment to extraterrestrials to populate our Sun—and thereby the millions of stars in the universe. An incident reported in the 1787 issue of the *Gentleman's Magazine* helps put Herschel's publications in this regard in perspective. A certain Dr. Elliot was brought to trial in London for having set fire to a lady's cloak by firing pistols near it. Insanity was the plea made for Elliot, in support of which a Dr. Simmons recounted examples of Elliot's bizarre behavior, especially his having submitted a paper to the Royal Society arguing for the Sun's habitability (Manning 1993).

This incident leads us to wonder what may have been the reaction among readers of the Royal Society's *Philosophical Transactions* when in 1795 and 1801 they encountered papers in which Herschel theorized that the Sun consists of a cool, solid, dark, spherical interior above which floats an opaque layer of clouds. In 1795, Herschel suggested that separate rays carry heat and light and that heat rays generate a rise in temperature only when in contact with special material (W. Herschel 1912, 1:470–84). In 1801, Herschel expanded the theory by proposing two exterior layers, the upper consisting of the glowing matter, the lower being a reflecting shield keeping the inner surface cool. As Herschel states: "The sun … appears to be nothing else than a very eminent, large, and lucid planet, evidently the first, or in strictness of speaking, the only primary one of our system …. Its similarities to the other globes of the solar system … leads us to suppose that it is most probably … inhabited … by beings whose organs are adapted to the peculiar circumstances of that vast globe" (W. Herschel 1912, 2:479). Herschel argues for his solarians by suggesting that terrestrial life flourishes in a variety of situations and by arguing that terrestrials who deny life to the Sun have no more logic on their side than inhabitants of a planetary satellite who deny life to the primary around which they revolve. Such arguments seem to support E. S. Holden's statement that Herschel's views on solar and lunar life "rest more on a metaphysical than a scientific basis" (Crowe 1986, 67).

Holden's conclusion needs, however, to be qualified in one important way, which helps explain why the premier astronomer of that period favored such a strange theory. Although as early as 1780 Herschel had considered a form of this solar model (W. Herschel 1912, 1:xcvi), he had between then and 1795 accumulated astronomical evidences that, when viewed in terms of his strong belief in the plurality of worlds doctrine, substantially increased the attractiveness of this model. In particular, during this period Herschel's stellar researches had led him to observe what he describes in his 1795 solar paper as "very compressed clusters of stars." He goes on to argue that stars in such clusters will be too tightly packed to accommodate inhabited planets. This did not lead Herschel to abandon the region as a home for extraterrestrials; rather it led him to conclude that the stars themselves must be "very capital, lucid, primary planets" so structured as to allow habitation (W. Herschel 1912, 1:483). Thus Herschel had found a way to save these stars from being "mere useless brilliant points" (W. Herschel 1912, 1:484). That Herschel's solar theory was no passing fancy in his thought is shown by his having elaborated it further in his 1801 paper in which he refers to the Sun as "a most magnificent habitable globe" (W. Herschel 1912, 2:147) and by his 1814 description of stars as "so many opaque, habitable, planetary globes" (W. Herschel 1912, 2:529). However bizarre Herschel's solar theory may seem, there is good evidence that it persisted as the preferred theory of the Sun until the 1850s (Meadows 1970, 6; Crowe 2011, 172–173).

Among advocates of solarians in the first half of the nineteenth century, some knew almost nothing of astronomy and mathematics. Such a charge cannot, however, be brought against Carl Friedrich Gauss (1777–1855), recognized as possibly the most brilliant mathematician of all time. Moreover, Gauss by profession was professor of astronomy at the University of Göttingen and director of its observatory. We know Gauss's views regarding extraterrestrials partly from his writings, but also from other sources, for example, records kept by his Göttingen colleague Rudolf Wagner (1805–1864), of conversations with the great mathematician. Wagner's records show that Gauss had adopted the doctrine that after death our souls take on new material forms on other cosmic bodies, including even the Sun. That Gauss held such an extreme idea is also evidenced in the biography of Gauss written immediately after his death by Wolfgang Sartorius von Waltershausen. This intimate friend revealed that Gauss

> held order and conscious life on the Sun and planets to be very probable and occasionally called attention to the action of gravity on the surface of heavenly bodies as bearing preeminently on this question. Considering the universal nature of matter, there could exist on the sun with its 28-fold greater gravity only very tiny creatures … whereas our bodies would be crushed (Crowe 1986, 208).

1.4.4.2 The Moon

The special significance of our Moon for the debate derives from its nearness. No celestial body provided more promising hunting grounds for extraterrestrials than the Moon, as numerous nineteenth-century astronomers realized. In 1802, Johannes Schröter (1745–1816) published the second and final volume of his *Selenotopographische Fragmente*, the most ambitious telescopic investigation of the Moon that had ever been undertaken. In the first volume, Schröter had stated that he was "*fully convinced that every celestial body may be so arranged physically by the Creator as to be filled with living creatures … praising the power and goodness of God*" (Crowe 1986, 70–72). He backed up this claim for the Moon by numerous observations he made with telescopes that in size rivaled even those of William Herschel. More of the same followed in his second volume, fifteen sections of which he devoted to his observations relevant to selenites, as he called the lunar inhabitants (Crowe 1986, 70–73).

Although some of Schröter's contemporaries sought to cast doubts on his extravagant claims, others sought to surpass him. The most striking case is the German astronomer Franz von Paula Gruithuisen (1774–1852), who during his lifetime published 177 astronomical papers and edited three astronomically oriented journals. He would perhaps rank as his most important paper his 1824 "Discovery of Many Distinct Traces of Lunar Inhabitants, Especially of One of Their Colossal Buildings." On the one hand, this long paper, in which he reports observing cities, forts, a temple, and animal trails on the Moon may have helped his career, in that two years later he became the professor of astronomy at Munich University. In the longer run, however, this paper discredited him and made him an object of ridicule, Gauss, for example, complaining of Gruithuisen's "mad chatter" (Crowe 1986, 204).[8]

The British public learned about the remarkable results attained by Gruithuisen partly from an essay that Thomas Dick published on lunar observation and lunar life in which, although he expressed skepticism about Gruithuisen's 1824 claims and wrongly attributed them to another German astronomer (whose name he misspelled), nonetheless held out great hopes for the detection of evidence of lunar

[8] For further information on Gruithuisen and on the intense debate on lunar life, see Crowe (1986, 202–8), and Sheehan and Dobbins (2001, 49–118).

life, which he amplified in later publications. For example, Dick discusses observations made by William Herschel of bright points on the Moon. Dick comments:

> Certain luminous spots, which have been occasionally seen on the dark side of the moon, seem to demonstrate that fire exists in this planet. Dr. Herschel and several other astronomers suppose, that they are volcanoes in a state of eruption. It would be a more pleasing idea, and perhaps as nearly corresponding to fact, to suppose, that these phenomena are owing to some occasional splendid illuminations, produced by the lunar inhabitants, during their long nights (Crowe 2008, 262–263).

Although more could be said about ideas of and searches for life on the Moon during this period, let us conclude by recounting an extraordinary event that occurred in 1835, which illustrates the degree to which the public had come to believe in extraterrestrial life. In that year, Richard Locke (1800–1871), a writer with the New York *Sun* newspaper, created a sensation by publishing a series of articles reporting that intelligent beings had been telescopically detected on the Moon (for a depiction of those beings, see Fig. 1.4). The noteworthy feature of this event is that nearly everyone believed Locke's report, even though substantial evidence had already been gathered to show that the Moon lacks an atmosphere. Locke's articles won him a place in the history of journalism as the author of what is now called "The Great Moon Hoax." Our claim is that a careful analysis of this incident shows that this was *not* a hoax. Locke had a much more serious intent: he was writing satire, a satire that nearly all his contemporaries missed. The reason is that for decades they had believed excessive claims for extraterrestrials, including selenites and solarians, made by astronomers, philosophers, professors, religious

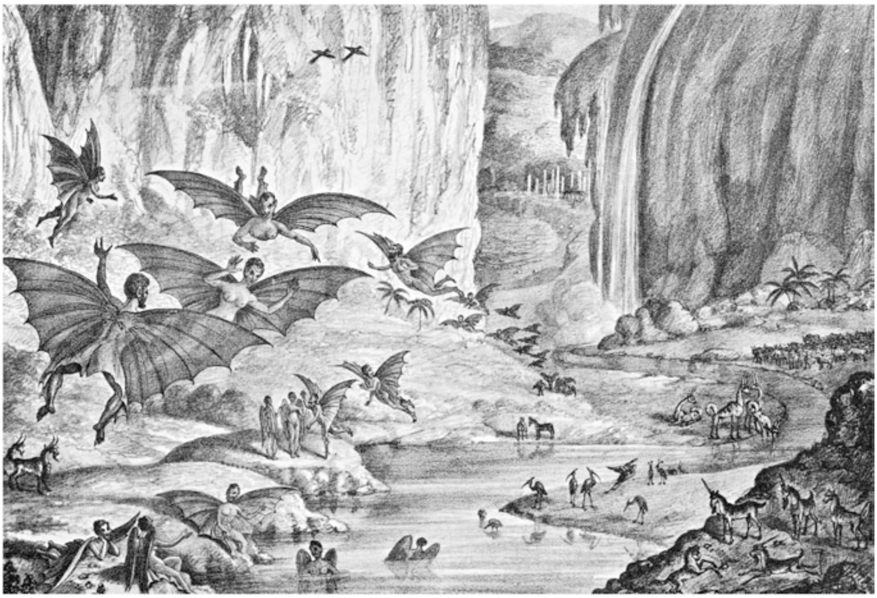

Fig. 1.4 An 1835 lithograph picturing the lunarians

writers, and the public press. When in 1852 William Griggs edited a new edition of Locke's Moon writings, he stressed Locke's satiric intent:

> we have the assurance of the author, in a letter published some years since, in the *New World*, that it was written expressly to satirize the unwarranted and extravagant anticipations upon this subject, that had been first excited by a prurient coterie of German astronomers, and then aggravated almost to the point of lunacy itself … by the religio-scientific rhapsodies of Dr. Dick (Crowe 2008, 294).

Griggs added in regard to Dick that

> it would be difficult to name a writer who, with sincere piety, much information … and the best intentions, has done greater injury, at once, to the cause of rational religion and inductive science, by the fanatical, fanciful, and illegitimate manner in which he has attempted to force each into the service of the other (Crowe 2008, 294).

Professor James Secord has located Locke's letter, which fully supports Griggs's claim (Crowe 2008, 294–296) We would, perhaps, dispute somewhat Griggs's claim about the difficulty of locating authors who rival Dick in the degree to which their enthusiasm overwhelmed their discretion. In fact, a few of the authors analyzed in this section may be proposed as competitors. We would also suggest—admittedly it would be difficult to prove—that Locke's 1835 satire had a sobering effect on the extraterrestrial life debate.[9]

1.5 The Extraterrestrial Life Debate in the Second Half of the Nineteenth Century

As of 1850, the belief that extraterrestrial intelligent beings populate the planets and moons not only of our solar system but of other systems as well, remained widespread, at least in Europe, the United States, and other areas where there was a high level of learning. Soon after 1850, scientists found themselves entering the debate equipped not only with telescopes of greatly increased size, but also with powerful spectroscopic methods, which methods were central in astronomy coming to include astrophysics and astrochemistry. Moreover, scientists in the quest for extraterrestrial life had already gained the fundamental insights of geology and were soon to have access to the theory of evolution by means of natural selection. The tensions that pluralism had presented for religion had by 1850 somewhat subsided; in fact, it was widely assumed that belief in extraterrestrial life was not only compatible but also supportive of religion. Bright as prospects might seem for major advances in establishing the legitimacy of belief in extraterrestrial intelligent life, we shall see that by about 1910, various authors had gradually succeeded in driving intelligent extraterrestrials certainly from the solar system and possibly even from the universe.

[9] For recent analyses of the "Moon Hoax" see Sheehan and Dobbins (2001, Chap. 7), and Goodman (2008).

A major campaign in the battle against the extraterrestrials began in 1853, led by a warrior who earlier had eloquently endorsed extraterrestrials (Crowe 2008, 300–307) and who in 1853 came forth, not under his own name, but cloaked in anonymity. His campaign, it was later learned, was launched not only from Cambridge University, not only from its most prominent college, Trinity College (which had been the college of John Wilkins, Isaac Newton, and Richard Bentley), but also from the heart of Trinity, the Master's Lodge, where dwelt Rev. William Whewell. As one might suspect, most terrestrial religious figures and prominent scientists rallied around the extraterrestrials in opposing this attack. They won this *battle*, but gradually lost the *war*.

By the late 1870s, extraterrestrials had been expelled from nearly every planet of the solar system except Earth and Mars. Beginning in 1877, a major counteroffensive began on behalf of the Martians, coming from Milan, Italy, and Flagstaff, Arizona. Even this effort on behalf of the extraterrestrials had by 1915 failed. And after the Martians had been driven from our system, the extraterrestrials of our solar system managed only a few small and fruitless forays. The remaining sections of this survey are on one level an account of this crusade against the extraterrestrials of our solar system.

1.5.1 William Whewell

In 1850, British scholars recognized Rev. William Whewell (1794–1866) as one of the wonders of his age. He had made significant contributions not only to a number of sciences, but also to the history and philosophy of science. He wrote on ethics, economics, architecture, tidal theory, and a diversity of other areas too numerous to mention. He was well known for a treatise he published in 1833 on science and religion titled *Astronomy and General Physics Considered with Reference to Natural Theology*, in which he befriended extraterrestrials. Yet in 1853, he attacked them in his *Of the Plurality of Worlds*: *An Essay*. Various authors have offered explanations of this reversal (including Crowe 1986, Chap. 6), but a discussion of these would take us too far afield. Probably the least popular but most prophetic claim in Whewell's book was that that all other planets of our solar system lack intelligent life. In fact, he was the first person to glimpse the solar system of the twenty-first century, a system lacking higher forms of life except on Earth. Taking up astronomical data long available but largely neglected, Whewell argued that solar radiation, given the inverse square law of solar light propagation, must make the inner planets excessively hot and the outer planets excessively cold (Crowe 2008, 345). Moreover, he took Newton's determination that the density of Jupiter is about four times lower than the density of our Earth, to indicate that Jupiter may well be a planet without a solid surface (Crowe 2008, 345–349). Similarly, he used observations of the Magellanic Clouds made by John Herschel to suggest that the nebular patches that some claimed were other universes comparable to our Milky Way could not be composed of vast numbers of stars, which created serious difficulties for the island universe theory (Crowe 2008, 344). The breadth of Whewell's analysis is suggested by the fact that he used the best available information on the age of the Earth to critique those who maintained that God's efforts would have been wasted had the vast universe not contained plentiful intelligent life. Against this, he maintained that the best scientific determinations of the age of the Earth were such as to reveal that throughout most of the vast age of our Earth, no intelligent beings were present. In other words, he argued that though the Earth may occupy an extraordinarily small area of space, we cannot infer from this that intelligent life must be widespread unless we are also willing to accept the idea that God's efforts were wasted because through vast periods of the past, the Earth lacked intelligent beings (Crowe 2008, 343–344).

Whewell's position in the debate has at times been dismissed because religious passages appear periodically in his writings on a plurality of worlds. Such dismissal in a number of ways seriously distorts his position. Because so many of his contemporaries had employed the Principle of (Divine) Plenitude in support of extraterrestrials and because pluralists writing in the tradition of natural theology had so frequently argued that if other celestial bodies were not inhabited, it would entail that God's efforts would have been wasted had the planets been bereft of life, in short, because so many authors had based their claims for extraterrestrials on religious ideas, Whewell could not but discuss theological issues. What is crucial to understand is that Whewell typically argued that theology and religion shed no light on issues regarding extraterrestrial life. In fact, it would be possible to argue that Whewell played a key role in *opposing* and *freeing* the extraterrestrial life debate from religiously based arguments, which were so prominent in the eighteenth and nineteenth century. Thus it would be nearer the truth to say that Whewell led the way in opposing the practice of basing of claims about extraterrestrials on religious ideas. Moreover, a careful reading of Whewell's writings will show that he was quite scrupulous about basing his anti-pluralist claims on scientific information, as illustrated in the prior paragraph. In fact, we have a direct statement from Whewell that shows that such was both his position and practice. In his *Dialogue on a Plurality of Worlds*, Whewell responded to various critics of his book. In replying to Critic Y, who according to Whewell had chastised him for building "the philosophy of your Essay on a religious basis [and taking] for granted the truths of Revealed Religion, and reason[ing] from them," Whewell stressed that "I do not reason in the way which you ascribe to me. I obtain my views of the physical universe from the acknowledged genuine sources: observation and calculation" (Whewell 2001, 54).

In the preface to his book, Whewell had suggested "It will be a curious, but not a very wonderful event, if it should now be deemed as blameable to doubt the existence of inhabitants of the Planets and Stars as, three centuries ago, it was held heretical to teach that doctrine" (Crowe 2008, 335). And this prediction was confirmed. Numerous authors who had come to believe in extraterrestrials on the basis of natural theology, especially the principle of God's plenitude, were deeply distressed, perhaps none more than the well-known Scottish scientist David Brewster (1781–1868), who responded with his *More Worlds than One*: *The Creed of the Philosopher and the Hope of the Christian* (1854), wherein he asserts that our Sun is "a domain so extensive, so blessed with eternal light, it is difficult to claim that it is not occupied by the highest order of intelligences" (Crowe 2008, 356). The debate, which in some ways set the stage of the Darwin debate later in the 1850s (Brooke 1977), ended up generating at least twenty other books and over fifty journal publications, some scientific, some religious, and most a blend of the two. Over two-thirds of these publications opposed Whewell (Crowe 1986, Chap. 7).

1.5.2 Richard Anthony Proctor and Camille Flammarion

The most interesting and influential response to Whewell's claims came (gradually) from Richard Anthony Proctor (1837–1888), a British astronomer and prolific expositor of that science. Proctor's first major success as an author came in 1870, by which time the development of spectroscopy was transforming astronomy into astrophysics and astrochemistry. In that year, Proctor published his *Other Worlds than Ours*, an immensely popular discussion of extraterrestrial life ideas, one theme of which was an analysis of the Whewell-Brewster debate. Although siding in many cases and ultimately with Brewster, Proctor jettisoned Jupiterians, precisely for the reasons that Whewell had indicated. Also, because William Huggins's spectroscopic work in the 1860s had shown that earlier observational claims that Orion consists of a vast number of stars, indicating that it may be an island universe, could not possibly be correct because Orion gives a bright line spectrum, Proctor showed hesitation at the island universe theory, an important component of the pluralist position. Whewell's analysis of Herschel's observations of the Magellanic Clouds also influenced him.

By 1875, Proctor had moved further in what he called a "Whewellite" direction. A key essay in this alteration was Proctor's "A New Theory of Life in Other Worlds" (1875). In this essay, he withdraws intelligent extraterrestrials not only from most planets of our solar system but also of other systems. Writing in this Darwinian period Proctor suggests that planets are evolving, that "Each planet, according to its dimensions, has a certain length of planetary life, the youth and age of which include the following eras:—a sunlike state; a state like that of Jupiter or Saturn, when much heat but little light is evolved; a condition like that of our earth; and lastly, the stage through which our moon is passing, which may be regarded as planetary decrepitude" (Crowe 2008, 402). Within this perspective, he admits that not only most planets, but also most solar systems are bereft of intelligent life. Then he adds:

> Have we then been led to the Whewellite theory that our earth is the sole abode of life? Far from it. For not only have we adopted a method of reasoning which teaches us to regard every planet in existence, every moon, every sun, every orb in fact in space, as having its period as the abode of life, but the very argument from probability which leads us to regard any given sun as not the centre of a scheme in which at this moment there is life, forces upon us the conclusion that among the millions on millions, nay, the millions of millions of suns which people space, millions have orbs circling round them which are at this present time the abode of living creatures (Crowe 2008, 403–404).

One wonders whether Whewell, dead nearly a decade by then, would have been pleased or rather would have commented: "Pluralism dies hard!"

Prolific and popular as Proctor was, he was outdone by his French counterpart, Camille Flammarion (1842–1925), who like Proctor established his reputation by publishing a very popular plurality of worlds volume (*La Pluralité des mondes habités*, 1862), which in later editions expanded to nearly ten times its original size. Rarely has the pluralist position had a more prolific and enthusiastic advocate, an advocacy that lasted even to the last year of Flammarion's long life. One of the most forceful features of the volume is Flammarion's stress on the prodigality of nature. He also wrote about ideas of extraterrestrials in such a way as to link them with transmigrational, agnostic, and existentialist ideas. His advocacy of the Martians at the turn of the century, carried out in two huge volumes, was legendary. Nevertheless, because he sided with Schiaparelli and Lowell rather than Maunder and Antoniadi, he ended up on the losing side.

1.5.3 The Sun and Moon

Solarians are gone. Their departure was far more than an event of local significance. When our Sun lost its inhabitants, so did every star in the universe. This raises a question: When and by whom were the solarians slaughtered? Their departure was not caused by a direct attack. It is true, as we have seen, that Newton raised serious problems for them as did Thomas Young in the first decade of the nineteenth century and also François Plisson in an 1847 volume skeptical of extraterrestrials (Crowe 1986, 168, 248–249). But what above all drove the solarians from the Sun was the progress of astrophysics. As more and more was learned about the Sun and stars, for example, their mechanisms and temperatures, it became not just difficult but nearly impossible to assume solarians. The modifier "nearly" has been added because in 1861, no less an authority than John Herschel publicly suggested that certain immense structures on the surface of the Sun that James Nasmyth reported observing might be "*organisms* of some peculiar and amazing kind" (Crowe 1986, 221). Although in the early decades of the nineteenth century, many saw solar life as plausible, by the last decades of the nineteenth century, such seemed impossible. For example, when in 1870 Richard Proctor published his *Other Worlds Than Ours*, he labeled life on the Sun "too *bizarre* [for] consideration" (Proctor 1870, 20). Some castles crumble as a result of rapid and direct attack; others fall vacant and over decades become uninhabitable. The latter fate befell the Sun and stars.

Selenites proved to be of hardier stock. In fact, they were sirens who drew various astronomers to them. It is true that from the 1860s on, the spectroscope made it far more difficult to argue for a lunar atmosphere. But it is also true that some selenographers, as those who map our Moon are called, had turned against the selenites. Writing in 1876, the lunar specialist Edmund Neison lamented the low level of interest in selenography, attributing it to the high quality lunar mapping done in the 1830s by Wilhelm Beer and J. H. Mäedler, suggesting that this was because Beer and Mäedler and their work had "finally solved … the great questions" in regard to the Moon; in particular, they had "demonstrated that the moon was to all intents an airless, waterless, lifeless, unchangeable desert" (Crowe 1986, 387). Selenography, however, was given new life after 1866 when Julius Schmidt (1825–1874), a respected Greek observer, reported that the lunar crater Linné had disappeared! According to Neison, this was seen as so exciting that "Nearly every astronomer was led to study the moon, and for months all the principal telescopes of Europe were turned upon our satellite. Moreover, many of our present amateurs were then for the first time led to purchase telescopes, and take up the study of astronomy" (Crowe 1986, 387). Of course what caused such excitement was the prospect of finding evidence of selenites. Reports of the disappearance of or changes in other lunar features followed, for example, in the Alpetagius, Plato, Messier, and Hyginus N regions. It has now been concluded the Schmidt's Linné observations were almost certainly spurious, but the important point is that, as Neison noted, many were drawn to astronomical observation on this basis. Moreover, selenites had a significant role in the erection of the Lick Observatory in 1888 with the largest refracting telescope that had ever been erected. Such at least was reported by the director of the observatory, Edward S. Holden, who revealed what led Lick, an uneducated millionaire, to donate $700,000 for the observatory. Lick originally planned to build, according to Holden, "a marble pyramid larger than CHEOPS on the shores of San Francisco Bay," but was dissuaded from this by the fear that it would be destroyed in a bombardment. Lick then hit upon the idea of an observatory; as Holden recorded, "The instruments were to be so large that new and striking discoveries were to follow inevitably, and, if possible, living beings on the surface of the moon were to be described, as a beginning" (Crowe 1986, 389–390).

Persons hoping for selenites found encouragement not only from observers but also from mathematical astronomers of distinguished reputation, such as Peter Andreas Hansen, who in 1856 published a paper arguing that a previously unaccounted for motion of the Moon might be explained were the Moon egg-shaped, the narrow end pointing to the Earth. In particular, he estimated that the Moon's center of figure is located about thirty-three miles nearer us than its center of mass. Hansen added that because of this, "one can no longer conclude that the [remote] hemisphere may not be endowed with an atmosphere, and that it has no vegetation and living beings" (Crowe 1986, 390). Various pluralists, including John Herschel, immediately jumped on this possibility to save the selenites. Their efforts ceased after 1868, when Simon Newcomb found a better way of explaining those motions of the Moon that had led to Hansen's calculation (Crowe 1986, 391).

1.5.4 Messages and Meteorites

In the latter half of the nineteenth century, there was widespread awareness of two ways in which the confirmation of life elsewhere could come suddenly: the reception of a message from an extraterrestrial source or the finding on Earth of some object from space that contains life from another planet. This section will survey these possibilities.

In 1866, Victor Meunier (1814–1903) suggested that lunarians may be trying to communicate with us. Encouraged by this, another Frenchman, Charles

Cros (1846–1888), in 1869 wrote an essay suggesting the use of parabolic mirrors to signal Mars or Venus, which essay was published in 1871 in *Cosmos*, a journal edited by Meunier. Cros also proposed that flashes reported by such astronomers as Messier and Schröter on Venus and Mars might be signals. In 1891, Flammarion announced that a woman had offered the Académie des sciences a prize of 100,000 francs to be awarded to the first person who communicates with the Martians. Flammarion encouraged the competition by assuring the public that Mars was the ideal object for the competition because "its intelligent races … are far superior to us" (Crowe 1986, 395). The offering of this prize sparked much controversy, which extended to England, where in 1892 Francis Galton proposed a method employing mirrors. Some labeled such discussions silliness, but others took them seriously, noting that flashes had at times been seen on the surface of Mars. In 1896, Galton published a now famous paper proposing a method of communicating with the Martians through the use of dots and dashes. In 1892, J. Norman Lockyer, prominent astrophysicist and founder of a leading scientific journal, *Nature*, actively joined the discussion. Later in 1896, Konstantin Tsiolkovskii (1857–1935), eventually famous as a rocket pioneer in Russia, followed up on Galton's proposals. As the century ended, A. Mercier and Flammarion kept these issues alive among the French.

In the early years of the nineteenth century, scientists attained an understanding that gave them hope that evidence of extraterrestrial life might literally fall from the skies at any time. The recognition that they had attained was that meteorites, rather than being ejecta from terrestrial volcanoes, actually came from outer space. This led them to examine meteorites in detail, especially determining whether they contain evidence of extraterrestrial life, possibly in fossilized form.

In the 1830s, interest in this approach grew especially intense, partly because on 12 November 1833, the most brilliant meteor shower in recorded history drew widespread interest. In 1834, J. J. Berzelius (1799–1848), the leading analytical chemist of the period, performed a chemical analysis of a carbonaceous chondrite that had fallen in the Alais region of France, concluding that he could not tell whether it contained carboniferous materials of extraterrestrial origin (Crowe 1986, 401–402).

By 1871 the consensus among scientists was that some meteorites contain organic materials, but that there was no direct, clear-cut evidence that any meteorites contain remains of an extraterrestrial life forms. In that year's British Association for the Advancement of Science meeting, William Thomson (1824–1907), later Lord Kelvin, brought his presidential address to a sensational conclusion by simultaneously discussing spontaneous generation, evolutionary theory, meteorites, and the plurality of worlds. Raising the question of the origin of terrestrial life, Thomson states that both "philosophical uniformitarianism" and Pasteur's experiments rule out spontaneous generation (Crowe 1986, 402). Given this, Thomson asks: "How, then, did life originate on earth?" The answer offered is that

> because we all confidently believe that there are at present, and have been from time immemorial, many worlds of life besides our own, we must regard it as probable in the highest degree that there are countless seed-bearing meteoric stones moving about through space…. The hypothesis that life originated on this earth through moss-grown fragments from the ruins of another world may seem wild and visionary; all I maintain is that it is not unscientific (Crowe 1986, 403).

Thomson was not the first to have proposed a meteoric origin of terrestrial life, but he was the most prestigious. The reaction to Thomson's theory was mixed, even after 1875 when the premier German physicist of the period, Hermann von Helmholtz (1821–1894), revealed that he had arrived at the same hypothesis slightly before Thomson and had presented it in a public lecture in spring 1871 at Cologne and Heidelberg. Contained in the lecture is his statement:

> Who can say whether the comets and meteors … may not scatter germs of life wherever a new world has reached the stage in which it is a suitable dwelling place for organic beings? We might, perhaps, consider such life to be allied to ours, at least in germ, however different the form it might assume in adapting itself to its new dwelling place (Crowe 1986, 405).

Despite this support, many scientists were hesitant to accept this theory, possibly because though rich in explanatory power, it was poor in falsifiability.

1.5.5 The Rise and Fall of the Island Universe Theory

At the beginning of the nineteenth century, the theory that the thousands of nebular patches observed by William Herschel are in fact universes comparable to our own Milky Way system had a measure of support, which was important for advocates of extraterrestrials because it was assumed that these universes would, like ours, be well stocked with life. Crucial to this claim was the question whether with improved telescopes the nebular patches could be resolved into individual stars, which would support the claim that they are distant universes rather than nearby patches of glowing gas. Many were resolved into individual stars, but giant Orion resisted such resolution until the mid-1840s when Lord Rosse in Ireland and William Cranch Bond at Harvard reported their successful resolution.

The theory, however, was beset by the difficulty that whereas the nebular patches, if other milky ways, should be seen as randomly distributed over the heavens, they tended to cluster toward the poles of our galaxy. Another problem had been pointed out by Whewell, who noted that in the Magellanic Clouds nebulae were seen as in many areas comparable in size to nearby stars, indicating that they could not be vast, very remote milky ways. A further difficulty arose when in the 1860s William Huggins found that the spectroscope indicated that the Orion nebula produced a bright-line spectrum, indicative of glowing gas, whereas if it were an island universe, it should generate a dark line spectrum indicative of stars, in other words, that the resolutions reported by Bond and Rosse were spurious. Richard Proctor also pressed the distribution problem, which led to the situation that by 1900 the island universe theory had been discredited. Agnes Clerke accurately expressed the consensus of astronomers when in the 1880s she wrote:

> There is no maintaining nebulae to be simply remote worlds of stars in the face of an agglomeration like the Nebecula Major [the Large Magellanic Cloud], containing in its (certainly capacious) bosom *both* stars and nebulae. Add the evidence of the spectroscope to the effect that a large proportion of these perplexing objects are gaseous, with the facts of their distribution telling of an intimate relation between the mode of their scattering and the lie of the Milky Way, and it becomes impossible to resist the conclusion that both nebular and stellar systems are parts of a single scheme (Clerke 1887, 456–457).

The island universe theory would be successfully resurrected decades later, but until then the positive side in the extraterrestrial life debate was deprived of one of its chief supports.

1.5.6 Extraterrestrials and Evolutionary Theory

Ideas of extraterrestrial life were associated in various ways with the growing significance in the last half of the nineteenth century of evolutionary ideas. Of course, evolutionary theory was linked even earlier (think of Kant and William Herschel) with astronomy and cosmogony. As John Brooke has stressed, William Whewell's *Essay* of 1853 raised many of the same issues as were debated after the publication of Darwin's *Origin of Species* in 1858 (Brooke 1977). Darwin himself never directly entered the extraterrestrial life debate, but it is possible that the idea of a plurality of worlds may have helped him to his theory. In particular, in the 1844 essay he drafted (but did not then publish) to formulate and explain his theory of natural selection, he commented "It is derogatory that the Creator of countless Universes should have made by individual acts of His will the myriads of creeping parasites and worms, which since the earliest dawn of life have swarmed over the land" (Crowe 2008, 372). It is also clear that the naturalistic approach associated with evolutionary theory influenced debates about extraterrestrials, in both a pro-pluralist and at other times in an anti-pluralist direction. It is especially striking that the co-discoverer of the theory of evolution by natural selection, Alfred Russel Wallace (1823–1913), emerged near the end of the nineteenth century as not only a critic of pluralism but also to publish in 1904 an appendix to his *Man's Place in the Universe* (1903), an appendix that lays out for the first time the type of argument based on evolutionary theory against extraterrestrials (Crowe 2008, 427–437) that has been taken up by many evolutionary theorists in the last thirty years, for example, by Ernst Mayr, Simon Conway Morris, William Burger, and Jared Diamond.

1.5.7 The Controversy over the Canals of Mars

As of 1877, Mars, which seen from Earth is so small that a teacup a half mile distant will cover it, was in the dramatic position of appearing to be the last, best hope for life elsewhere in our planetary system. In the period from 1877 to about 1910, developments occurred that led to dozens of books, hundreds of telescopes, thousands of articles, and millions of people being focused on whether intelligent beings, possibly desperately struggling to survive, conceivably seeking to signal us, roam its surface. Various earlier astronomers had attempted to draw a map of Mars, including its polar caps, and had determined its period of rotation. Then in 1877, Giovanni Schiaparelli (1835–1910) at Brera Observatory in Milan reports sighting numerous "canali" on Mars. Other astronomers at first had difficulty confirming his observations, but gradually over the next decades many succeeded in sighting them. During the next Mars opposition in 1879, Schiaparelli reported sighting a doubling of some canals, or what he called a gemination. By 1890, a significant portion of the astronomical community accepted the canal observations, but with little agreement as to their cause, one of the theories of the canals being that Martians, because they were very short on water, constructed them as irrigation devices.

In 1893, Percival Lowell (1855–1916), a wealthy Harvard-educated businessman and orientalist, returned from Japan to enter the canal controversy. He founded, funded, directed, and served as chief astronomer and publicist for the Lowell Observatory, which he erected in Flagstaff, Arizona, and equipped with a 24-inch refractor. Lowell announced his intention to launch an "investigation into the conditions of life in other worlds" and prophesized that "there is strong reason to believe that we are on the eve of pretty definite discovery in the matter" (Crowe 1986, 508). For a chronology of this and other major developments in the canal controversy, see Table 1.1.

In 1894, W. W. Campbell at Lick Observatory attempted to reconfirm earlier spectroscopic reports by William Huggins and other astronomers of water vapor in Mars's atmosphere. Campbell "fails," but concludes that if the Martian atmosphere contains water vapor, its quantity must be below what could be detected by available instrumentation. In the same year, E. W. Maunder (1851–1928) of Greenwich Observatory published a paper questioning the canal observations. Having noted that adjacent sunspots at times appear as a continuous line, he suggests that the canals may be optical illusions arising from the tendency of the eye to integrate fine detail below the limits of vision. Maunder asserted regarding Mars: "We cannot assume that what we are able to discern is really the ultimate structure of the body we are examining" (Crowe 1986, 500).

Certainly by 1896, the canal controversy had spread through the educated world, with many advocates for and against the Martians. For example, in that year Campbell reviewed Lowell's *Mars* for the journal *Science*, accusing Lowell of taking "the popular side of the most popular scientific question afloat" (Crowe 2008, 484). He argued that Lowell has neither adequate observations nor mastery of the Mars literature. On the other hand, Agnes Clerke in the *Edinburgh Review* described the canals "as among the least questionable, though perhaps the very strangest of planetary phenomena" (Crowe 1986, 513). In the same year, a Greek astronomer living in Paris, Eugène Antoniadi (1870–1944), became director of the British Astronomical Society's Mars section and for the next two decades edits its reports. Although at first an advocate of the canals, by the late 1890s he becomes skeptical, moved especially by the arguments made by E. W. Maunder. One indication of the intensity of interest in Mars at the end of the nineteenth century is the publication in 1899 of H. G. Wells's *War of the Worlds*, one of the most popular works of science fiction of all time.

In the first decade of the twentieth century, various developments occured that culminate in the astronomical community concluding that the canal claims are untrustworthy, even though there was agreement that under certain conditions some observers could see thin lines on Mars. Among these developments were tests in which subjects in classrooms were instructed to draw what they saw in a test diagram, which showed spots but no thin lines. The result was that the test

Table 1.1 Highlights of observational evidence for Martian canals

Observer	Date	Observatory	Instrument	Method	Result/remarks
Schiaparelli	1877	Brera (Milan)	8 in.	Visual	First observation of system of *canali*
Green	1877	Madeira	13-in. reflector	Visual	Shaded area boundaries; no canals
Hall/Harkness	1877	U.S. Naval	26 in.	Visual	Moons of Mars found but no canals
Schiaparelli	1879/1880	Brera (Italy)	8 in.	Visual	First report of double canals
Maunder	1882	Greenwich	28 in.	Visual	Some canals
Perrotin/ Thollon	1886 1888	Nice (France)	15 in. 30 in.	Visual	Many canals; first confirmation of double canals
Holden/ Keeler et al.	1888	Lick	36 in.	Visual	Some canals but no doubles
Pickering/ Douglass	1892	Harvard Arequippa (Peru)	13 in.	Visual	Canals and "lakes" at canal junctions
Barnard	1892	Lick	36 in.	Visual	Some canals but not fine lines
Lowell/Pickering/ Douglass	1894 1895	Lowell	12 in. 18 in.	Visual	Canals artificial
Antoniadi	1894/1896	Juvisy (France)	9.6 in.	Visual	42 canals; 1 double doubling is illusion
Cerulli	1896	Teramo (Italy)	15.5 in.	Visual	Illusion—optical origin
Lampland	1905	Lowell	24 in.	Photographic	Canals photographed
Todd/E. Slipher	1907	Chile	18 in.	Photographic	Canals photographed
Antoniadi	1909	Meudon	33 in.	Visual	Canals resolved
Hale	1909	Mount Wilson	60-in. reflector	Visual	Much detail, no canals
Trumpler	1924	Lick	36 in.	Visual/photographic	Strips of vegetation

Sources of data M. J. Crowe, *The Extraterrestrial Life Debate* (Cambridge, 1986); W. G. Hoyt, *Lowell and Mars* (Tuscon Ariz., 1976), and primary sources. Instruments are refractors unless specified otherwise
Source Dick (1998), 28 (Table 2.1); used with permission. (Observational highlights of Martian canals, 1877–1924)

subjects frequently drew lines. One of Lowell's staff, C. O. Lampland, reported attaining photographs showing dozens of canals, but the images prepared by Lampland, although impressive, were only three-eighths of an inch in diameter and proved unconvincing. In addition, although new spectroscopic observations

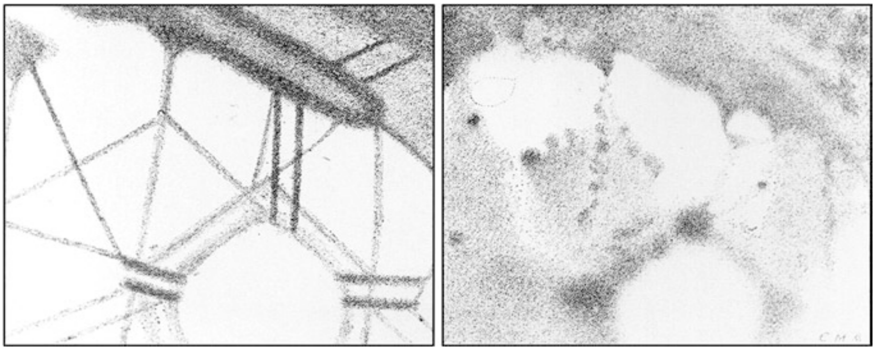

Fig. 1.5 Drawings of one region of Mars by Schiaparelli (*left*) and Antoniadi (*right*)

made at Lowell Observatory by Vesto Slipher supported the existence of water vapor in the Martian atmosphere, W. W. Campbell's new observations again gave a negative result. Maunder and Antoniadi published numerous papers arguing the illusion theory of the canals, winning over astronomers as influential as Simon Newcomb. A key development occurred when it became clear that Campbell's spectroscopic results fit very well with the claims of the illusion theorists. Another key development consisted of a drawing of a specific region of Mars made by Antoniadi using the high quality telescope at Meudon Observatory, which drawing appears alongside a drawing of the same area by Schiaparelli (see Fig. 1.5). Whereas Schiaparelli's drawing showed numerous canals, Antoniadi's showed diffuse detail, but no canals.

In short, by about 1912 Maunder and Antoniadi, in conjunction with contributions from W. W. Campbell, Vincenzo Cerulli, Simon Newcomb, and others, had built a case against the claims of Schiaparelli, Lowell, Flammarion, and their allies, a case that convinced the astronomical community that the canal sightings are illusory, which left Mars bereft of evidence for higher forms of life. As the Spanish astronomer J. Comas Sola put it in 1910: "The marvelous legend of the canals of Mars has disappeared with this opposition" (Crowe 2008, 509).

1.5.8 The Extraterrestrial Life Debate at the End of the Nineteenth Century

This survey of the last half of the nineteenth century cannot do justice to the large number of intellectuals who became involved with ideas of extraterrestrials. Literary and philosophical figures from America as prominent as Whitman, Twain, and Peirce, from Britain as important as Tennyson, Hardy, and Newman, from Germany as well known as Engels and Strauss, from France as prestigious as Balzac and Hugo, and from Russia the great novelist Dostoevsky entered the debate.

On the substantive level, we suggest that the most significant change that occurred during the nineteenth century (completed by 1910 or so) was the exit of the extraterrestrials from our solar system. On the methodological level this led to an attenuated Copernican Principle and a weakened Principle of Plenitude. Moreover, it probably called into question the belief that the discovery of extraterrestrial intelligent life was only a few years distant. Influenced by the increased naturalism that went with the successes of evolutionary theories in biological and physical sciences, including geology, religious and metaphysical claims became less evident in the debate. On the other hand, immense improvements in the instrumentation of astronomy, including spectroscopy and photography, as well as major advances in physical science, including an understanding of energy, of atomism including both chemical and physical aspects, and of stellar regions, as well as a far deeper understanding of biological forms all gave indications that the debate about extraterrestrials might be coming closer to resolution.

1.6 Overview of Part I

In this chapter, we have provided a historical overview of the extraterrestrial life debate from antiquity through the start of the twentieth century. In broad outline, we have seen waxing and waning of belief in extraterrestrial life. Two schools of thought in antiquity, Aristotelian and Atomistic, reached differing conclusions about its existence. By the Middle Ages, the Aristotelian view, which denied its existence, was predominant in intellectual circles, though this view was occasionally challenged. The Copernican revolution, however, eventually led to a view of the universe as expansive, in which the Earth was merely one planet among many, and the Sun the center of merely one solar system. By the end of the seventeenth century, belief in extraterrestrials was winning many converts, laying the groundwork for a vast corpus from various fields of inquiry—scientific, philosophical, theological, literary—discussing extraterrestrials over the next two centuries. At the same time, and with the benefit of hindsight, we can see that much of this discussion was highly speculative, and included a great number of religious and metaphysical assumptions. In the middle of the nineteenth century, William Whewell wrote a powerful critique of the assumed position, arguing that many factors mitigate against the existence of extraterrestrial intelligent beings. A newfound skepticism about at least the commonality of extraterrestrials, and certainly about their existence in our own solar system, developed in the latter half of the century, with Richard Proctor playing a major role and eventually culminating in the controversy over the canals of Mars. As we entered the twentieth century, then, our confidence in the existence of extraterrestrials had ebbed from its heights a century before.

The remainder of the first part of the present volume consists of five chapters that examine various individuals and concepts at greater length than has been done in this overview chapter. In addition, Michael Crowe, one of the co-authors of this chapter, has added a short addendum to this chapter that contains two brief historical analyses that supplement his previous (and extensive) work on the historical extraterrestrial life debate.

The following chapters, as well as the present chapter, demonstrate that many of the issues still facing us today have precedents in earlier years of the debate. The questions that arise now, even if our scientific information has expanded, are not always greatly different from those that our intellectual predecessors confronted. The dearth of precise information about other solar systems or about other terrestrial planets, for example, leads us to reason about those places, and on their suitability for life, on the basis of analogy. The implications of extraterrestrial life, too, have been the subject of much analysis, and will continue later in this volume.

The first of the five further chapters on the historical debate is by Dennis Danielson. To lead off that chapter, he discusses how the division of the world into sublunary and superlunary realms, the typical Aristotelian view of the cosmos, was dissolved in the sixteenth and seventeenth centuries, focusing especially on the contributions of Thomas Digges (1546–1595). Galileo's telescopic observations further reinforced the analogy between the Earth and other environs of the universe, leading some authors to consider the existence of extraterrestrials on other planets in our solar system. Danielson then draws our attention to imaginative fictions from the mid-seventeenth century that involve the idea of travelling away from the bounds of the Earth to the Moon, and even beyond. Finally, he concludes the chapter with discussion of seventeenth-century examples of "reflexive telescopics," or the notion of considering the Earth from a point of view outside of the Earth itself, as an extraterrestrial would see it. The implications of Earth's similarity to other bodies of the universe were thus grasped and sparked imaginations immediately after the Copernican cosmological shift changed our view of Earth's place in the cosmos. In addition, Danielson's exposition nicely illustrates how analysis of literary works can reveal changes in thought that are less accessible in other sources.

Woodruff T. Sullivan, III, discusses some of the principles—metaphysical, religious, methodological—that supported astrobiological considerations in the eighteenth and nineteenth centuries, focusing especially on William Herschel. Sullivan notes that these principles, and not least the use of analogy, are problematic, this being evidenced by the fact that astronomers believed that the Sun and stars are themselves inhabited. One can also note Herschel's tendency to see planets, moons, stars, and the Earth as having important similarities and hence analogous. Sullivan, following John Stuart Mill's analysis, notes that the principle of analogy can be fruitful not as a method of proof, but as a guide to discovery and formulation of new theories. Sullivan's contribution is especially interesting because Sullivan himself has long been active in contemporary astrobiology, including radio astronomy, but also writes as an author fully sensitive to and practiced in historical research. He also very appropriately stresses the importance of what he labels "the $N = 1$ Problem," that is, the fact many astrobiological inferences are limited by the fact that in searching for other earths we have only Earth as our sample.

The focus of the chapter by Joseph T. Ross is the philosophy of the prominent German philosopher Georg Friedrich Wilhelm Hegel (1770–1831), especially Hegel's views on the trustworthiness of analogical arguments and on the credibility of claims for extraterrestrial life. Ross begins by presenting information on how philosophers from the ancient Greeks to the early nineteenth century (and especially Immanuel Kant) viewed analogical reasoning. Hegel himself, Ross shows, tended to be skeptical of analogical arguments. Moreover, Ross shows that Hegel, far more than most of his contemporaries, expressed reservations about claims for extraterrestrial life. He was especially skeptical of claims for life on the Sun and on moons, believing that only planets are in any significant degree analogous to the Earth. A striking aspect of this essay emerges if Hegel is compared with various astronomers, for example, William Herschel, who tended to view stars, moons, planets, comets, and Earth as five fundamentally similar entities, whereas Hegel viewed them as significantly different. In this, Hegel was closer to the astronomy of the twentieth century than his scientific contemporaries. In important ways, this chapter contrasts with a number of others, not only in regard to Hegel's reservations about analogical inferences but also in regard to the degree of primacy that Hegel assigns the Earth.

Stéphane Tirard examines evolutionary ideas, including the origins of life, from the nineteenth century, and how those ideas were applied to discussions of life on other worlds. Both Charles Darwin (1809–1882) and Herbert Spencer (1820–1903) proposed materialistic theories for the origins of life, thereby suggesting that life could arise elsewhere in analogous fashion; an alternate theory of the nineteenth century, panspermia, pushed away the question of the origins of life, but in fact insisted that life must exist elsewhere in the universe. Tirard then discusses two writers of the late nineteenth and early twentieth century, Camille Flammarion and Edmond Perrier (1844–1921). Both considered the question of how life would evolve on other planets, offering evolutionary paths for life elsewhere based on analogy with the progression of evolution on Earth, though modified to fit the environment of other planets. Interestingly, Perrier restricted extraterrestrial life in our solar system to Venus and Mars, the worlds most like our own Earth.

Florence Raulin Cerceau's chapter focuses on the issue of finding a proper definition of "habitability," a concern that has intensified with the discovery of numerous exoplanets. Her essay opens with a brief survey of ideas regarding extraterrestrial life in the period before 1700, in which she stresses the importance of Copernicanism and also notes that Christiaan Huygens in his *Cosmotheoros* anthropomorphized his extraterrestrials. She then turns to the latter half of the nineteenth century, focusing on the ideas of Richard Proctor, Jules Janssen, and Camille Flammarion. She presents Proctor as taking more seriously than his predecessors the need to discuss habitability in terms of specific features of a planet or moon. She stresses the importance of the new spectroscopic techniques for studying planetary habitability by noting Jules Janssen's emphasis on spectroscopy, including his report of his detection of water vapor in the Martian atmosphere. Concerning Camille Flammarion, she stresses his readiness to argue that extraterrestrials could be dissimilar to humans. Finally, she turns to the efforts around 1950 of Hubertus Strughold, a physiologist, to stress the need to think of planetary life in terms of such biological categories as ecology.

1.7 An Addendum by Michael J. Crowe: Updating My *Extraterrestrial Life Debate* (1986)

I have added this addendum in order to supplement this survey by two historical analyses that I developed after the publication of my *Extraterrestrial Life Debate, 1750–1915*: *The Idea of a Plurality of World from Kant to Lowell*, and I have also included some broad remarks on research and teaching on the history of the extraterrestrial life debate (hereafter the ETD).

1.7.1 Blaise Pascal, Copernicanism, and Parallax

A number of authors have noted that we lack solid evidence that the brilliant scientist and religious author Blaise Pascal (1623–1662) was a Copernican. One of these authors, Arthur Lovejoy, reported finding in Pascal "the curious combination of a refusal to accept the Copernican hypothesis with the unequivocal assertion of the Brunonian" (Crowe 1986, 14). It is true that Pascal nowhere in his published writings directly affirmed the Copernican position. What Lovejoy was no doubt thinking of in making his claim about Pascal is various statements from Pascal's *Pensées*, such as:

> The whole visible world is only an imperceptible atom in the ample bosom of nature … . … let man consider what he is in comparison with all existence; let him regard himself as lost in this remote corner of nature; and from the little cell in which he finds himself lodged, I mean the universe, let him estimate at their true value the earth, kingdoms, cities, and himself. What is a man in the Infinite? (Pascal 1938, pensée #72).

In my 1986 volume, I accepted Lovejoy's first claim but argued against his second (Crowe 1986, 14–16). I shall not repeat those arguments. Rather what I now shall claim is that Pascal was indeed a Copernican. Because a central theme of the *Pensées* is the infinitization of the universe, because no author before 1660 had written more effectively about the vastness of the universe, and because this vastness is a feature that results directly from the heliocentric and not from the geocentric system, it seems certain that Pascal was Copernican. I suspect that Pascal writing on religious matters in his *Pensées* and adopting positions that upset many of his orthodox contemporaries did not wish directly to assert his Copernican convictions, but his genius and the geometry of his universe are definitely Copernican.

1.7.2 Immanuel Kant and "The Starry Skies Above Me"

Inscribed on the tombstone of Immanuel Kant (1724–1804) is arguably the most famous line from his many writings: "the starry heavens above me and the moral law within me." This is from his *Critique of Practical Reason*, where he wrote:

> Two things fill the mind with ever new and increasing admiration and awe, the oftener and more steadily they are reflected on: the starry heavens above me and the moral law within me…. The former … broadens the connection in which I stand into an unbounded magnitude of worlds beyond worlds and systems of systems…. The former view of a countless multitude of worlds annihilates, as it were, my importance as an animal creature, which must give back to the planet (a mere speck in the universe) the matter from which it came (Kant 1949, 258–259).

This leads to two questions, one of which I sought to answer in my 1986 volume, and other of which I shall address now. The first question is: What was Kant's conception of the "starry heavens," and the other is: was he correct in his view? In my 1986 volume, where I analyzed about eight of Kant's writings discussing extraterrestrials, I attempted to show that Kant was not only referring to the three thousand or so stars visible on a clear night, but that he was thinking of those stars as typically encircled by inhabited planets, as worlds filled with life, indeed intelligent life. He was not envisioning stars as merely big and blazing balls of fire. This is what filled his "mind with ever new and increasing admiration and awe" and so deeply moved his heart (Crowe 1986, 47–55). It seems unnecessary to repeat all the evidence for this conclusion in the present paper. Rather I shall now turn to the second question, which I believe can now be definitively answered. That question is whether the numerous stars that Kant saw and we see on a dark night are typically seats of life. Twentieth-century studies of the nature, lifetimes, and locations of stars make it possible to answer this question.

Two factors are above all important in determining whether a star is visible to us: (1) its distance and (2) the luminosity of the star—how much light it produces. The importance of distance is evident from the fact that given two stars A and B with equal luminosity, if star A is twice as far from us, it will appear one quarter as bright. The overall rule is brightness is inversely proportional to distance squared. The luminosity of a star is an even more important factor in determining whether we can see it. We now know that stars differ very greatly in luminosity. One star may be millions of times more luminous than another. This fact is understated in the classification of stars as dwarfs and giants or even supergiants. The net effect of this is that an examination of the three thousand or so stars visible to us shows that the great majority of them are giant or supergiant stars.

A passage from Joel Achenbach's book *Captured by Aliens* supports this overall point about giant stars:

> Most of the stars we see with the naked eye are extremely hot, bright supergiants that are several times the size of the Sun and, more important, much younger. The supergiants reach their demise after only a matter of some millions of years, not billions. That's too short a period, probably, for the evolution of intelligent life. Everything we know about life on Earth tells us that it requires a tremendous span of time to evolve into anything like

> a thinking organism. We don't know for sure, but life probably needs billions of years, not millions, to reach the level of worms and plankton, never mind intelligence. The next time you look at a star filled night sky and wonder who might be out there, slap yourself upside the head and remember that *those* stars for the most part, are not friendly to life. Those are just the showy stars, the flamboyant stars, the most extravagant examples of nuclear physics (Achenbach 1999, 281).

We now need to examine what characteristics determine whether a star—assuming that it has both a habitable zone and a planet moving in that zone—will exist for a sufficiently long period that higher forms of life will develop. Our benchmark for estimating how long in takes for higher forms of life to develop is what has happened in our solar system, where we now know that it has taken near 4.5 billion years to form and develop conditions adequate for us. It turns out that although no simple linear relationship applies, we can say that for the most part, the lifetime of a star varies inversely with its mass. This entails that the supergiants and giants do not have lifetimes long enough for higher forms of life to develop on planets in their habitable zones. Thus it is clear that among the stars visible to Kant on a clear night nearly all must be barren of higher forms of life.

It should be stressed that this analysis applies only to the relatively small number of stars visible to humans. It leaves out of consideration stars of mass significantly lower than that of our Sun because they lack naked eye visibility. Such stars do face some problems, for example, their planets (if they have such) tend to become tidally locked (as is our Moon) so that they always keep the same side to their suns. Some recent work indicates that such stars may turn out to be reasonably good candidates for habitability.

1.7.3 On Investigating the History of the Extraterrestrial Life Debate

Persons interested in extending their knowledge of the ETD may wish to know that my long historical treatment (Crowe 1986) now has a companion in the form of a source book (Crowe 2008), which was specifically designed for classroom use; in fact, Dr. Dowd and myself have for a number of years used it as a text for the first half of a University of Notre Dame course called The Extraterrestrial Life Debate: A Historical Perspective. Professor Peter Ramberg of Truman State University has also made extensive use of the source book. This 2008 volume incorporates a useful bibliography of publications on the ETD.

Scholars wishing to take up any topics treated in my two volume may wish to know that my main research files (running about thirty linear feet) developed while writing these volumes and teaching in this area were donated in 2011 to the Adler Planetarium and Astronomical Museum in Chicago, where they have been carefully referenced and cataloged and will shortly become available to researchers.

References

Achenbach, Joel. 1999. *Captured by Aliens: The Search for Life and Truth in a Very Large Universe*. New York: Simon and Schuster.

Brooke, John H. 1977. "Natural Theology and the Plurality of Worlds: Observations on the Brewster-Whewell Debate." *Annals of Science* 34: 221–286.

Clerke, Agnes. 1887. *Popular History of Astronomy in the Nineteenth Century*, 2nd ed. Edinburgh: A. and C. Black.

Comte, Auguste. 1968. *Cours de philosophie positive*, vol. 2 of *Oeuvres de Auguste Comte*. Paris: Éditions Anthropos.

Crowe, Michael J. 1986. *The Extraterrestrial Life Debate 1750–1900: The Idea of a Plurality of Worlds from Kant to Lowell*. Cambridge: Cambridge Univ. Press. Repr. 1999, as *The Extraterrestrial Life Debate 1750–1900*. Mineola, NY: Dover.

Crowe, Michael J. 2006. *Mechanics from Aristotle to Einstein*. Santa Fe: Green Lion.

Crowe, Michael J., ed. 2008. *The Extraterrestrial Life Debate, Antiquity to 1900: A Source Book*. Notre Dame: University of Notre Dame Press.

Crowe, Michael J. 2011. "The Surprising History of Claims for Life on the Sun." *Journal of Astronomical History and Heritage* 14:169–179.

Dales, Richard C. 1990. *Medieval Discussions of the Eternity of the World*. New York: E. J. Brill.

Dick, Steven J. 1982. *Plurality of Worlds: The Origins of the Extraterrestrial Life Debate from Democritus to Kant*. Cambridge: Cambridge University Press.

Dick, Steven J. 1998. *Life on Other Worlds: The Twentieth-Century Extraterrestrial Life Debate*. Cambridge: Cambridge University Press.

Evans, Ifor. 1954. *Literature and Science*. London: Allen and Unwin.

Finocchiaro, Maurice A. 2002. "Philosophy versus Religion and Science versus Religion: The Trials of Bruno and Galileo." In *Giordano Bruno: Philosopher of the Renaissance*, ed. Hilary Gatti, 51–96. Aldershot: Ashgate.

Goodman, Matthew. 2008. *The Sun and the Moon: The Remarkable True Account of Hoaxers, Showmen, Dueling Journalists, and Lunar Man-Bats in Nineteenth-Century New York*. New York: Basic Books.

Gregory, Brad S. 2012. "Giordano Bruno Superstar." Review of Rowland. 2008. *Books and Culture* 18, no. 2 (March/April):19–21. Also available through booksandculture.com.

Hennessey, Roger. 1999. *Worlds without End: The Historic Search for Extraterrestrial Life*. Charleston: Tempus Publishing.

Herschel, John. 1833. *Treatise on Astronomy*. London: Longman.

Herschel, William. 1912. *The Scientific Papers of Sir William Herschel*. London: Royal Society and Royal Astronomical Society.

Kant, Immanuel. 1949. *Critique of Practical Reason and Other Writings in Moral Philosophy*. Translated by Lewis White Beck. Chicago: University of Chicago Press.

Kozhamthadam, Job. 1994. *The Discovery of Kepler's Laws: The Interaction of Science, Philosophy, and Religion*. Notre Dame: University of Notre Dame Press.

Mach, Ernst. n.d. *The Principles of Physical Optics: An Historical and Philosophical Treatment*. New York: Dover.

Manning, R.J. 1993. "John Elliot and the Inhabited Sun." *Annals of Science* 50: 349–364.

Meadows, A.J. 1970. *The Early Solar Physics*. Oxford:Pergamon Press.

Pascal, Blaise. 1938. *Thoughts*. Translated by W.F. Trotter. Harvard Classics edition. New York: P. F. Collier and Son.

Rowland, Ingrid D. 2008. *Giordano Bruno: Philosopher/Heretic*. New York: Farrar, Straus and Giroux.

Sheehan, William, and Thomas Dobbins. 2001. *Epic Moon: A History of Lunar Exploration in the Age of the Telescope*. Richmond: Willmann-Bell.

Singer, Dorothea. 1950. *Giordano Bruno: His Life and Thought, with Annotated Translation of His Work "On the Infinite Universe and Worlds."* New York: Henry Schuman.

Westman, Robert. 1980. "The Astronomer's Role in the Sixteenth Century: A Preliminary Study." *History of Science* 18: 105–147.

Whewell, William. 2001. "A Dialogue on the Plurality of Worlds." In *Of the Plurality of Worlds, Facsimile*, ed. Michael Ruse. Chicago: University of Chicago Press.

Yates, Frances. 1964. *Giordano Bruno and the Hermetic Tradition*. London: Routledge and Kegan Paul.

Further Readings:

Basalla, George. 2005. *Civilized Life in the Universe: Scientists on Intelligent Extraterrestrials*. New York: Oxford Univ. Press.

Boss, Valentin. 1972. *Newton and Russia: the Early Influences, 1698–1796*. Cambridge: Harvard Univ. Press.

Crowe, Michael J. 1997. "Extraterrestrial Intelligence." In *History of Astronomy: An Encyclopedia*, ed. John Lankford, 207–209. New York: Garland.

Danielson, Dennis. ed. 2000. *The Book of the Cosmos: Imagining the Universe from Heraclitus to Hawking*. Cambridge: Perseus Publishing.

Goldsmith, Donald. ed. 1980. *The Quest for Extraterrestrial Life: A Book of Readings*. Mill Valley CA: University Science Books.

Guthke, Karl S. 1990. *The Last Frontier: Imagining Other Worlds from the Copernican Revolution to Modern Science Fiction*. Translated by Helen Atkins. Ithaca: Cornell University Press.

Jaki, Stanley. 1978. *Planets and Planetarians*. Edinburgh: Scottish Academic Press.

Lovejoy, Arthur. 1960. *The Great Chain of Being*. New York: Harper and Row.

Ross, Joseph. 1991. "Kant's and Hegel's Assessment of Analogical Arguments for Extraterrestrial Life." M.A. thesis, University of Notre Dame.

Tipler, Frank. 1981. "A Brief History of the Extraterrestrial Intelligence Concept." *Quarterly Journal of the Royal Astronomical Society* 22: 133–145.

Westman, Robert. 1975. "The Melanchthon Circle, Rheticus, and the Wittenberg Interpretation of the Copernican Theory." *Isis* 66: 165–193.

Whewell, William. 1859. *Of the Plurality of Worlds: An Essay*, 5th ed. London: John W. Parker and Son.