

FROM THE REVIEWS OF
The Planet-Girded Suns

“Engdahl has marshalled an impressive and fascinating selection of primary sources—including a roster of believers that includes Newton, Ben Franklin, Walt Whitman, and rocket pioneer Robert Goddard; and excerpts from popular hymns, poetry, and 17th century proto-science fiction. . . . Whether or not any of this justifies further efforts to make contact with other life-forms, Engdahl has shown how deep this vein of speculation runs . . . and reminded us that our ancestors entertained a view of the universe that was larger and more imaginative than the history books lead us to believe. Challenging and original.”

—*Kirkus Reviews*

“In a brisk, engrossing account Engdahl traces the theories and speculations concerning the possibility of extraterrestrial intelligent life throughout history. . . . This first nonfiction book by a noted writer of science fiction for young people is based on original research in primary sources and smoothly incorporates many quotations from scientists, philosophers, poets and theologians.”

—*ALA Booklist*

“Although written primarily for teenagers, the substantial treatment of the history of the idea of other solar systems, based largely on research in primary documents, should make it of use to scholars.” —*Isis One Hundred Second Critical Bibliography of the History of Science and Its Cultural Implications*

“*The Planet-Girded Suns* is a beautiful example of what the disciplined imagination can do. . . . It is a fine, carefully done history of the ideas about other worlds—nicely balanced in its presentation of the informational and mystical elements of the subject.”

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“Easy to read and on a timely subject approached from an original point of view, this also serves as a model to show how an idea is researched and documented.” —*School Library Journal*

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*The
Planet-Girded Suns*

*The History of Human Thought
About Extrasolar Worlds*

Updated Edition
With a New Afterword

by

Sylvia Engdahl

* Ad *
Stellae

Eugene, Oregon

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Contents

<i>Preface to the 2012 Edition</i>	7
<i>Foreword</i>	10
<i>Part I: The Vision of the Past</i>	16
<i>Chapter One</i>	17
<i>Chapter Two</i>	34
<i>Chapter Three</i>	48
<i>Chapter Four</i>	66
<i>Chapter Five</i>	84
<i>Chapter Six</i>	98
<i>Part II: The Knowledge of the Present</i>	115
<i>Chapter Seven</i>	116
<i>Chapter Eight</i>	129
<i>Part III: The Questions of the Future</i>	145
<i>Chapter Nine</i>	146
<i>Chapter Ten</i>	165
<i>Afterword: Confronting the Universe in the Twenty-First Century</i>	193
<i>Appendix: Early Poetry Mentioning Extrasolar Worlds</i>	203
<i>Notes</i>	245
<i>For Further Reading</i>	256
<i>About the Author</i>	265

. . . The clear galaxy
Shorn of its hoary lustre, wonderful,
Distinct and vivid with sharp points of light,
Blaze within blaze, an unimagi'd depth
And harmony of planet-girded suns
And moon-encircled planets, wheel in wheel,
Arch'd the wan sapphire. Nay—the hum of men,
Or other things talking in unknown tongues
And notes of busy life in distant worlds
Beat like a far wave on my anxious ear.

—*Alfred, Lord Tennyson, "Timbuctoo," 1829*

Preface to the 2012 Edition

This book was first published by Atheneum in 1974. The original text contains three parts: “The Vision of the Past,” “The Knowledge of the Present,” and “The Questions of the Future.” The first part is the longest, with six chapters as compared to two in each of the others, and is the one still of greatest significance. It covers the history of beliefs about planets of other suns, including a lot of information that’s not readily available to the general public elsewhere.

At the time I wrote the book, in 1973, much of this information was not available at all except in the actual books and magazines of past centuries. I spent many months on library research, almost all of it in primary sources, that is, the original writings of the people quoted, rather than historians’ reports of what they wrote. Because *The Planet-Girded Suns* was first published as a book for teens, which was the market in which I was then established, I wasn’t able to use nearly all of the material I gathered, and what I did use had to be presented without formal citation of sources (although I was allowed to incorporate references for exact quotations into the index). I intended to write a second, more scholarly, book for adults. But scholarly books are difficult for people without academic credentials to get published, so I never did; and since then, several fine books about the subject by scholars have appeared, so there’s no longer a great need for the one I planned.

However, those more scholarly books are not likely to be read by the general public, and certainly not by the teens for whom this one was originally issued. So since the facts about past views of extrasolar worlds aren’t widely known, I believe it has value for today’s readers. Its second and third parts, dealing with modern views, were outdated; I have updated them to remove statements that are no longer true, to add the highlights

of recent developments, and in some cases to change present tense to past. However, I have not tried to present more than a brief introduction to current knowledge. There are a great many recent books about the search for extrasolar worlds and/or extraterrestrial civilizations in which interested readers can find the details.

The book's original edition was dated by wording such as the use of "man" in the sense of "humankind," which was customary in the 1970s but would be jarring to today's readers; I have fixed that throughout. I've made a few minor additions to the historical chapters reflecting information I have come across since its first publication, and have added endnotes and a selection of more recent books for further reading. In addition, I have included an appendix containing longer portions of the poems that introduce the chapters, as well as other poems about extrasolar worlds written in the seventeenth through early twentieth centuries.

It is significant, I think, that people of past centuries did believe that such worlds exist, without any scientific evidence whatsoever. It shows that human beings have an instinctive sense of kinship with the wider universe and a desire to see the realms that lie beyond this one small planet—and perhaps, eventually, to go there. Our ancestors conceived of such voyages only in a spiritual sense, as occurring after death. But we who have taken our first small steps into space are aware that our descendants may set foot on the worlds of other suns, and those of us who have faith in such a future believe it to be the destiny toward which humankind has been moving throughout history—a step essential to the long-term survival of humankind. Had this been known to the writers of earlier times who spoke of those worlds with longing, they would wonder at the public apathy toward space travel that prevails just when we stand on the threshold of fulfilling their dream.

And yet, today's apparent apathy may be rooted in something much deeper than is commonly supposed. While updating this book for republication, I was struck by a parallel between our time and an earlier era that I had not seen before, which puts my worries about our lagging progress in space into a different light. I have therefore written a fairly long Afterword dealing with our society's current outlook on the universe and the

reasons why the first moon landing led not to the further exploration that was then expected, but to decades of marking time in near-Earth space. I hope that space advocates will find it meaningful, whether or not the historical sections of the book are of interest to them.

—*Sylvia Engdahl, May 2012*

Foreword

. . . Amid the radiant orbs
That more than deck, that animate the sky,
The life-infusing suns of other worlds. . . .
The enlighten'd few . . . they in their powers exult,
That wondrous force of thought, which mounting spurns
This dusky spot, and measures all the sky.

—James Thompson, *The Seasons*, 1746

Surprising though the current interest of scientists in the possibility of life in other solar systems is to some, a still greater surprise to most people of today is the fact that belief in inhabited extrasolar worlds is not new. The idea was not, as is commonly believed, invented by science fiction writers. On the contrary, it was accepted by the majority of educated people from the late seventeenth century until the early twentieth century. Scientists, philosophers, clergymen and poets wrote a great deal about it. When in the 1850s the head of a well-known college wrote a book suggesting that there might *not* be other inhabited worlds, he published it anonymously because he felt it might damage his reputation—and indeed, most of the book's many reviews were disapproving. A prominent university's magazine declared that plurality of worlds was a subject on which "until now it was supposed that there was scarcely room for a second opinion."¹

This fact does not appear in history books. Until recently the information was to be found mainly in the books and magazines of past centuries. Famous authors of those eras sometimes mentioned their belief in other worlds, but they spoke of it briefly and casually, thinking it too commonplace an idea to merit much discussion. Most of the writers who went into detail about it are no longer famous. Their books, many of which were bestsellers

in their time, have been nearly forgotten. They remain in the collections of large libraries, rarely called for, in some cases with bindings so old and brittle that they fall apart in one's hands when one first opens them to read.

Such books are not science fiction. Though a few imaginative stories about voyages through space were written as early as the seventeenth century, they were presented as dreams, satire on human society, or fantasy; they did not suggest that space travel would ever become a reality. Not until the late nineteenth century was there any fiction set in the future. The widespread literal belief in extrasolar worlds, on the other hand, was discussed in nonfiction—"popular science" works and also religious ones, reflecting their authors' conviction that God would not have created the stars merely for people on this one small planet to look at. All contain speculation about the inhabitants of other planets that was intended to be taken seriously. Readers did not laugh at speculation of that kind, for none of it—even the portions concerning life on the moon—was contrary to the science of its time. Later scientists, who knew more, looked upon it with scorn. Several generations, the generations that came of age during the years between the twentieth century's two world wars, got the impression that science had always laughed at talk of "space people" and that it always would; not until the 1960s did respected authorities begun to speculate again.

The speculations in old books, and in most modern scientific ones, have nothing to do with UFOs. The question of whether there are inhabited worlds elsewhere in the universe is separate from the question of whether or not any of those worlds' inhabitants have ever visited our world. Nonfiction of past centuries about extrasolar planets does not mention such a possibility. The idea did not occur to anyone until about the time of World War II. Since then, many people—some of whom are scientists—have investigated records of strange objects seen in the past, and have suggested that these might have involved alien visitors. But science considers the existence of other civilizations far more probable than the notion of their representatives' having come here. And during the former period when almost all educated people were utterly convinced that superior civilizations exist, actual contact between

the ones of different solar systems was not even imagined.

At the time this book was written, searching for the old writings about extrasolar worlds was a little like a treasure hunt: one could not predict just where they would be found, and one had to look in many places without finding anything. Libraries had reference tools that helped, but these tools were only a beginning; often they provided merely clues leading on to other clues. Occasionally they led to a dead end, such as a work of which the only existing copy was in an inaccessible museum. (Thanks to the progress of technology since the 1970s, some of the books then only in exceptionally large university libraries are now available on the Internet as scanned ebooks.) Yet an astonishing number of relevant volumes were available, even before scholars had published the accounts of past writings that now exist. One could go to a library shelf, take down a magazine well over a hundred years old, and turn to an article that thousands of people must have read when it was new—and that never, perhaps, has been looked on by anyone now alive. The wording of such articles may seem quaint, and their authors may have been ignorant of facts that are now known, but the idea expressed is often closer to what scientists are saying today than to what they said when one's grandparents were young.

There are many current science books about extraterrestrial life. This, however, is not a science book. It is the history of an idea. Not all men and women with important ideas are scientists; science studies only that which can be systematically observed. Long before the invention of the telescope made it possible to observe distant parts of the universe—long before the belief in other worlds became popular—there were men who thought about what might lie beyond Earth. Some had followers, but others were ridiculed or persecuted and at least one was put to death for his theories. Since that time more facts about the universe have been learned; present views of far-off solar systems have scientific foundation. Still, the question of what inhabitants of those solar systems are actually like cannot yet be studied scientifically. When scientists give opinions on it, they are speaking not as authorities but simply as members of the human race, just as their predecessors did. They are expressing not proven truths, but thoughts. This book is the story of humankind's thoughts about the worlds

of other suns: past thoughts, remarkably similar present thoughts, and thoughts that will be investigated in the future.

Thoughts about the unknown concern not only science, but religion. For many centuries all speculation about astronomy was inseparable from religion, since the mysteries of the heavens could be explained only in religious terms. Today, when more scientific data can be obtained, there seems to be a firm line between the two. In the past, however, people who drew a line between religion and other affairs placed the subject of other worlds on the “religious” side of that line, while it now usually falls on the “scientific” side. Unlike their predecessors, modern scientists who believe that the universe was created by God do not spend their time debating about whether the various features of it could have resulted from what they think God must have done; they accept their observations as evidence of what God did do. In other words, they study what exists and form their theories from its nature—not God’s, which they do not expect to explain scientifically.

To people of past eras such reasoning would have seemed backwards. They felt that they knew a great deal about God, and they realized how little knowledge they had of the universe. At first they did not guess that it was possible to obtain more. Gradually, as science did acquire more knowledge, certain ideas about God had to be discarded; and although some lost faith in all religion when that happened, others came to feel that less had been known of God than had been supposed. They developed new ideas about religion as well as about astronomy, sometimes disagreeing strongly with the established churches. But until the twentieth century, few if any people separated their personal religious beliefs from their thoughts about what the universe is like. Even those who paid little attention to religion in everyday life considered cosmology—the nature of the cosmos—too unknowable to be viewed as a purely scientific matter.

That astronomical discoveries came into conflict with the religious view current at the time of Copernicus and Galileo is a familiar fact of history. It is often said that learning that the earth moves around the sun lessened people’s feeling of central importance. Historians, however, point out that the relation between the earth and the sun was not the real issue. More upset-

ting was the discovery that there are other suns, and therefore, perhaps, other earths—innumerable earths, all of equal importance in the universe. Yet though this was a blow to human pride, before long the public began to look upon the existence of countless worlds as proof of God's power and glory. Not everyone agreed with that idea, but by the nineteenth century most religious leaders favored the view that God had probably created inhabitants for many worlds besides this one. When no scientific evidence is available, faith of some kind is the only basis for believing in the unseen.

Near the end of the nineteenth century another crisis occurred, one that has not been discussed often. People had been saying for two hundred years that a world would not be created for no purpose, and the only purpose anyone could think of was habitation. Travel from one world to another was not thought possible. So when scientists concluded that the moon and nearby planets are not inhabited, it was natural to start wondering whether the universe is really purposeful. The most common argument for extrasolar life seemed less convincing than before. Furthermore, around the turn of the twentieth century a new theory was adopted about the origin of planets. Astronomers began to think that solar systems came into existence accidentally. Such accidents were considered rare; even among people who still viewed cosmology in a religious way, there were many who abandoned their faith in worlds of other suns.

Today, the opposite situation prevails. Since the mid-twentieth century scientists have believed it is highly unlikely that ours is the only inhabited planet in the cosmos, for solar systems have been considered common—a theory recently confirmed by the discovery of many planets orbiting other stars. The likelihood of sentient species elsewhere is accepted by men and women of differing faiths, and also by those with no religious faith. It is frequently assumed that discovery of extraterrestrial life would be upsetting to religion. This is not true; there has been little if any conflict since the early seventeenth century and most if not all the religious thinkers who have considered the issue believe that existence of other inhabited worlds is compatible with their faith. (Interestingly, a poll has shown that many people think members of *other* religions would be disturbed, though not their own.) Yet the former Soviet Union's philosophy of dialectical

materialism supports the same idea. In 1958 a Soviet astronomer wrote, "The thesis of the existence of life outside the earth is shared in our epoch . . . in equal measure both by the materialists and by the idealists."² There are few issues of such importance on which people with conflicting philosophies can so readily agree.

If life does exist in other solar systems, our view of it is surely important. This book tells the story of humankind's view.

Part I

The Vision of the Past

Yet is this mighty system, which contains
So many worlds, such vast ethereal plains,
But one of thousands, which compose the whole,
Perhaps as glorious, and of worlds as full. . . .

All these illustrious worlds, and many more,
Which by the tube astronomers explore:
And millions which the glass can ne'er descry,
Lost in the wilds of vast immensity;
Are suns, are centres, whose superior sway
Planets of various magnitudes obey. . . .

Witness, ye stars, which beautify the skies,
How much do your vast globes, in height and size,
In beauty and magnificence, outgo
Our ball of Earth, that hangs in clouds below!
Between yourselves, too, is distinction found,
Of different bulk, with different glory crown'd;
The people, which in your bright regions dwell,
Must this world's low inhabitants excel;
And since to various planets they agree,
They from each other must distinguished be,
And own perfections different in degree.

—*Richard Blackmore, The Creation, 1712*

Chapter One

. . . Other Suns, perhaps,
With their attendant Moons, thou wilt descry. . . .
But whether thus these things, or whether not,
Whether the Sun predominant in Heaven
Rise on the Earth, or Earth rise on the Sun. . . .
Solicit not thy thoughts with matters hid. . . .
Dream not of other Worlds, what creatures there
Live, in what state, condition, or degree.

—*John Milton, Paradise Lost, 1667*

Over four centuries ago, on February 17th of the year 1600, a man was publicly burned alive in a plaza of Rome called the Campo dei Fiori. Such executions were not uncommon at that time. Burning at the stake was the usual punishment for the crime of unrepented heresy, not only in Rome but elsewhere; the laws of many countries specified that men and women could be put to death for refusing to believe what the government-endorsed church told them they should believe. This man was not an ordinary heretic, however. He had done more than deny details of the established religion with which he did not agree; he had developed a new view of Earth's place among the stars. His name was Giordano Bruno, and he had written books about an infinite universe containing innumerable worlds. He was the first person to say that there are planets circling distant suns.

That view was not Bruno's only heresy, to be sure. Many other accusations, some true and some false, had been made against him, although none concerned actions that would be considered crimes today. There are historians who feel that he was executed solely on account of his religious beliefs. Others, however, are convinced that his ideas about the universe were central to the case. These ideas were thought dangerous; it may

well be that they were the reason he was kept almost eight years in the dungeons of the Inquisition in the hope that he could be made to recant. Normally, heretics who would not recant were executed much more quickly than that. It is recorded that when sentence was finally passed upon him Bruno said to his judges, "Perhaps you who pronounce my sentence are in greater fear than I who receive it." Quite possibly that was true.

Why should an astronomical theory have aroused fear in the people of Bruno's time? Why should the church have been so deeply concerned about it? Today it would be classed not as a religious matter, but as a scientific one. Bruno himself tried to keep it separate from church controversies; during his trial he insisted that he had taught only philosophy (as all science was called in his era) and that his beliefs were not opposed to Christianity. Indeed, his vision of an infinite universe was founded on his faith in an infinite God. He had led a tempestuous life, traveling from city to city throughout Europe and more often than not, leaving hurriedly after incurring the wrath of dignitaries whom he had criticized. Yet though he could not seem to stay out of trouble, his deepest wish was merely to reveal truth as he saw it to those who would listen. Most people would not.

To understand why they would not, it is necessary to understand the picture of the universe they already held. According to that picture no worlds existed except Earth; the moon and visible planets were thought to be bodies unlike worlds. This was taught not only by both the Catholic and Protestant churches, but by all the universities. It was the official theory of science as well as of religion. Bruno's defiance of it brought him into sharp conflict with the acknowledged authorities in every branch of learning.

Giordano Bruno is sometimes considered simply a martyr for freedom of thought and speech. But his idea of innumerable worlds was important to him apart from freedom to express it. The idea has since become important to many people. Though Bruno's true role in its acceptance cannot be positively determined, it is known that he was the earliest writer to present its modern form. To future generations this may rank among mankind's most significant advances.

It was not a wholly new idea even in his day. The concepts of infinite space and numerous worlds originated centuries be-

fore with the ancient Greeks. Democritus, who lived in the fifth century B.C., taught them; and one of his followers, Metrodorus of Chios, said that for there to be only one world in the infinite would be as strange as for only a single ear of corn to grow in a large plain. However, by far the most influential Greek philosophers were Plato and Aristotle, both of whom were strongly opposed to those concepts. Though such theories were kept alive through various Muslim, Jewish and Christian writings, the belief that there was only one world prevailed.

Bruno had read many of the old writings. Among his favorite books was *On the Nature of Things*, by the Roman poet Lucretius. "You must admit that in other parts of space there are other earths and various races of men and kinds of wild beasts," this book said. "You must admit that earth and sun, moon, sea and all things else that are, are not single of their kind, but rather in number past numbering."³

Lucretius had lived in the first century B.C., sixteen hundred years before Bruno. During those sixteen centuries the opinion that the earth and sun were not "single of their kind" was rejected by almost everyone. Saint Augustine and Saint Thomas Aquinas, two of the greatest theologians, were firmly against the idea; and most people accepted what they said. Nevertheless, there were exceptions. Some churchmen declared that the power of God was unlimited and that it was therefore wrong to say that God could not create a plurality of worlds. In the year 1277 the Bishop of Paris officially condemned the proposition that God was unable to do so. These men, however, did not teach that other worlds actually existed. According to the theories of physics then believed, there could not be more than one earth because all the rest would fall to the center of the universe, where our earth was presumed to be. The advocates of plurality merely maintained that *if* God made others, each one would stay where it was placed.

One of the men who argued that there might be other worlds was the Jewish philosopher Crescas. In 1410 he wrote, "Everything said in negation of the possibility of many worlds is 'vanity and a striving after wind.'" But he did not go so far as to say he really believed in them. "Inasmuch as the existence of many worlds is a possibility true and unimpeachable," he continued, "yet we are unable by means of mere speculation to ascertain

the true nature of what is outside this world, our sages, peace be on them, have seen fit to warn against searching and inquiring into 'what is above and what is below, what is before and what is behind.'"⁴

A Christian philosopher who felt much the same way was Cardinal Nicholas Cusanus, who, in the year 1440, wrote a book called *Of Learned Ignorance*. Unlike many of his time, Cusanus believed that not everything could be determined by reason, and that it was wise to be aware of one's ignorance. In this book he speculated not only about other worlds, but about their inhabitants. "Rather than think so many stars and parts of the heavens are uninhabited," he wrote, "and that this earth of ours alone is peopled . . . we will suppose that in every region there are inhabitants, differing in nature by rank and all owing their origin to God."⁵ He went on to say that there was no way to compare such beings with the natives of this earth. The animals here know little of other species, so "of the inhabitants . . . of worlds other than our own we can know still less, having no standards by which to appraise them."

Cusanus associated infinity of the universe with the infinity of God, as Bruno did; and in fact Bruno was deeply impressed by the Cardinal's book. "This honest Cusan hath known and understood much," he said in one of his own books. "He is indeed one of the most remarkably talented men who hath lived in our world."⁶ But Cusanus lived more than a hundred years before Bruno. He did not think of the universe in a physical, astronomical sense; he was more concerned with the idea that God is incomprehensible.

Though for centuries learned men discussed other worlds, they never viewed such discussion as having an actual connection with humankind's place in the scheme of things. It was too abstract and theoretical to be taken seriously. Moreover, very few people had heard about it, for most could not read their own languages, let alone Latin, which was the language all European scholars used. Printed books were a relatively new invention even in Bruno's time.

Shortly before that time, there was a period when intellectual freedom flourished. In the sixteenth century, however, many changes came, among which the rapid spread of ideas through printing was only one. Abstract theories about the universe were

not the only topic of debate. People began to question other religious issues too, and that, in some countries, led to the formation of Protestant churches—which in turn led to religious wars and to suppression of heretical opinions by whatever church happened to be in power in a particular area. In the face of this, most thoughtful men feared that further upheaval would occur if the accepted cosmology were laid open to doubt. Besides, they were satisfied with the astronomical system that had been devised almost two thousand years before.

That system is now known as Aristotelian, or Ptolemaic, cosmology, since it was described in the writings of the Greek philosopher Aristotle and was modified by an astronomer named Ptolemy. It can also be called geocentric cosmology because it placed Earth in the center of the universe. Aristotelian cosmology had deep meaning for people. It was not merely a primitive way to explain the appearance of the sky. Its development was a magnificent mathematical achievement, and in addition it involved basic ideas about the sources of human knowledge and the relationship between the earth and God.

In the first place, Aristotelian cosmology was assumed to be correct simply because Aristotle was considered an absolute authority on most aspects of philosophy, including scientific theory. Men of the sixteenth century did not seek knowledge in the same way as those of later ages. They did not expect to discover new things; instead, they tried to acquire and elaborate upon the secrets of the ancients. This was not as unreasonable as it sounds. The ancients, especially the Greeks, had known many things that had been forgotten during Europe's Dark Ages. Most writings of the Greek philosophers had been preserved only in Muslim countries, and when in the twelfth and thirteenth centuries manuscripts were translated from Arabic into Latin and brought to Western Europe, scholars were greatly excited. Aristotle's work in particular seem to them far better than anything they or their successors could ever develop. At first there was a problem because Aristotle had lived before the time of Christ and had therefore made statements unlike some of those in the Bible; but in time Aristotelianism was reconciled with Christianity, and in many cases became a part of Christian doctrine.

During the Dark Ages, almost everyone believed that the

earth was flat. The ancient Greeks had known better, however, and when Aristotelian cosmology was adopted the spherical shape of the earth was accepted by educated people with little difficulty. It did not conflict with the basic existing religious concepts; heaven and hell remained in much the same positions they had occupied before. If anything they were less vague; hell was pictured in the center of the earth instead of simply “below,” and the location of heaven, too, could be envisioned more specifically. In Aristotelian cosmology, the earth was surrounded by layers of transparent, revolving spheres: one for the moon, one for the sun, one for each of the “wandering” bodies—the planets—and an outer one for the “fixed” stars, which were thought to be actually fixed and unchanging. Outside the stars’ sphere was heaven.

It is important to realize that the spheres associated with this system were more than mathematical abstractions; they were believed to be made of a solid invisible material. Nothing was known of the physical laws that keep planets in orbit, and it therefore seemed self-evident that if the celestial bodies were not firmly attached to something, they would not stay up. Certainly they would not make exact, predictable movements year after year, as they had been meticulously observed to do. Aristotle and the others who had pondered the question of planetary motion were intelligent, ingenious men who had given complex reasons for every detail of their theory. Like brilliant men in every era, they had often worked from false premises; but their logic had been sound.

One of the false premises from which both the ancient Greek philosophers and their Christian successors reasoned was that while things on Earth are imperfect, things in celestial regions are perfect. This assumption referred not merely to heaven in a spiritual sense, but to the physical realms of the heavenly bodies. Thus all such bodies had to revolve in precise circles because the circle was considered the only perfect form; and since no single circular motion could account for the movements of the planets among the stars, planets were supposed to move in many additional circles, called epicycles, within their spheres. The mathematics required to construct such a scheme was extremely complicated. Hundreds of years elapsed while more and more elaborations were added to the geometrical diagram. And that

diagram did explain—or *almost* explain—the seemingly erratic progress of Mercury, Venus, Mars, Jupiter and Saturn, which were viewed not as worlds but as small luminous orbs.

Moreover, the idea of celestial perfection went much deeper than the assumption that planets moved only in circles. To the people of the time it was demonstrated beyond all doubt by the sphere of the “fixed” stars. There were no telescopes, and the stars appeared to be constant, unchanging, immutable in a way that no earthly permanence could match. That which was found on earth might pass away. The stars, embedded in the flawless crystal of the outermost sphere, were eternal. So perfection must surely increase as distance from Earth increased; was not hell the center and heaven outside the most distant sphere of all? The permanence of the stars as compared to the wandering planets seemed visible proof of this principle: a principle reflected in the belief that things celestial were of a different *substance* from things terrestrial. They were not composed of the same elements. They could not be, since earthly elements were obviously lacking in perfection.

This was the picture that Giordano Bruno dared to challenge. Certain aspects of it had been challenged earlier; Copernicus, who died five years before Bruno was born, had declared that the sun was in the center of the universe, that the earth revolved around it, and that the movement of heavenly bodies across the sky was caused by rotation of the earth rather than rotation of the crystal spheres. But although Copernicus took a tremendous step forward, he did not alter the basic features of Aristotelian cosmology. He neither eliminated the spheres nor modified the supposition that all celestial motion was circular; he simply found a way to diagram that motion with fewer circles. For him, the “fixed” stars were still fixed. The universe was still bounded by the star-studded outermost sphere. The term “Copernican theory of the universe,” which is often used to describe the new cosmology, is not an accurate name, for the Copernican theory accepted by science concerned only the arrangement of this solar system. The theory of the *universe* that brought about far-reaching changes in human thought in the seventeenth century, and that has been retained in its general form ever since, was first suggested by Bruno.

The contribution of Bruno is not well known in English-speaking countries. In Russia he is generally recognized as the first man to seriously believe in the plurality of habitable worlds beyond our solar system. But although he has been hailed by many Western scholars, especially Europeans, as a great and daring thinker and champion of intellectual freedom, his name is far less familiar to American readers than those of Copernicus and Galileo. Popular histories of astronomy often do not even mention him.

There are a number of reasons for this. In the first place, Bruno was not an astronomer. He was a philosopher. To be sure, all scientists were called philosophers in his day, since what is now "science" was then known as "natural philosophy." But Bruno was a philosopher even by the modern definition. He did not watch the stars systematically; he simply thought about them. His theories were based not on observation, but on what he had read and what he was able to imagine.

Because Bruno's idea of innumerable worlds was not favored by scientists during the first half of the twentieth century, its significance has been noted only by the few historians with special interest. Usually even they have not viewed him as a major contributor to astronomy. His cosmological theories were inseparably tied to his conception of God both in the sight of church authorities and in his own mind; and many people have disagreed with that conception. It has been claimed that he was an atheist—although actually he was not—and this is another reason why his writings are not widely known. Still another is that some of them have never been translated into English.

However, one does not have to agree with Bruno's religion to appreciate the importance of his contribution to man's view of other solar systems. His belief in many worlds is no longer opposed by the Catholic Church. His vision of a universe infinite in size was adopted by all scientists for over two centuries, and although since the early 1900s most of those outside the Soviet Union have believed space to be finite, no one now contests the fact that it contains an inconceivably large number of suns.

That was the revolutionary concept Bruno originated. Others before him had suggested that there might be an infinite number of stars. But Bruno taught that stars are suns—or, more significantly in the implications both for his own fate and

for the history of human thought, that the sun is only a star.

It does not sound revolutionary today, when everyone is used to the idea; but to people who believed that they lived at the center of the universe, it was an appalling thought. It was much worse than what Copernicus had asserted. As far as religion was concerned, it did not really make much difference whether the sun moved around the earth or vice versa. In either case, the universe—the abode of humankind—was safely enclosed, a finite creation of God intended solely for human benefit. Men had argued before that God was surely capable of creating more than one world. That, however, was not the same as saying that he really had made more than one. Although philosophers like Nicholas Cusanus had spoken of the universe being infinite and had realized infinity could have no center, they still envisioned the earth and the sun as special. They thought of the stars as something quite different; most even pictured “other worlds” as being outside the sphere of fixed stars, enclosed within separate sets of spheres. To declare that the sun was a star like other stars, and that the others were surrounded by earths, was far more upsetting.

That the theory of Copernicus was once opposed by religious leaders is well known today to students of history. But that theory aroused relatively little excitement when it was first introduced. The teaching of it was not prohibited by church authorities until after Bruno’s execution—more than seventy years after the death of Copernicus himself. Many historians believe that it did not begin to seem dangerous until Bruno associated it with the idea of countless habitable globes.

Giordano Bruno’s book *On the infinite Universe and Worlds* was published in 1584, while he was living in London as the secretary of the French ambassador to England. At the court of Queen Elizabeth I there was much more freedom of opinion than in Europe, for the Queen was tolerant of all religions and enforced England’s religious laws only against people suspected of being involved in political plots. Foreign refugees were welcome there.

Bruno had long been a refugee. In his mid-teens he had become a monk; that was the only way for a boy of poor family to get a college level education, and he probably did not realize he would come to disagree so strongly with what he was taught.

Monks of his time were not permitted to leave their orders, or to disagree with their superiors, so Bruno had to flee his native Italy after it was discovered that he had been reading forbidden books. He lived as a wandering teacher in France, Switzerland and Germany, but he was not on much better terms with Protestant authorities than with Catholic ones. In Geneva they arrested him for publishing an attack on a professor in whose lectures he had detected twenty errors. After similar trouble in Paris the king of France, who liked Bruno, recommended him to the ambassador in England. It was a safer place, although even there he made enemies.

In England as elsewhere, Bruno encountered a great many learned professors who were pompous and intolerant. He himself was not at all tolerant of those he thought stupid, nor had he any gift for tact; rashly, he ridiculed them in public. He was especially disdainful of the revered Aristotle and of anyone who accepted Aristotle's authority. Oxford University was at that time a stronghold of Aristotelianism. The students, who were as devoted to Aristotle as the professors, reacted indignantly to any criticism of him; they took an oath to "drink from the fountain" of that master's teachings, and were fined five shillings for each deviation from them. Understandably, Bruno did not find the faculty and student body of Oxford congenial. His visit there came to its inevitable abrupt end following a public debate with the head of one of the colleges, after which he wrote in one of his books about the way "that pig comported himself." It is easy to see why neither he nor his ideas won many friends in academic circles.

At court it was different; in the house of the French ambassador for whom he worked, Bruno had a chance to meet men who were interested in science, literature and new philosophies. He may have known Sir Walter Raleigh, Edmund Spenser, and—some have suggested—Shakespeare, although it is doubtful that Shakespeare was in London while Bruno was there. Much later, at his trial, Bruno testified that he had met the Queen herself, and it is thought that some of his books were financed by Sir Philip Sidney, one of her chief courtiers.

Bruno's books were somewhat livelier reading for these men than most philosophy. Many were written in Italian, a fashionable language, instead of in Latin; and they contained a good

deal of scandal. Moreover, they took the form of conversations between characters with different viewpoints. Dialogue was a traditional type of philosophic writing; Plato, in ancient Greece, had used it to record the ideas of Socrates. But in Bruno's dialogues, the characters often resorted to name-calling. Perhaps this was a good thing. *On the infinite Universe and Worlds* was a serious book and its lengthy arguments about the universe were quite difficult to digest. Was it simply imprudence that made Bruno intersperse passages in which the speakers insulted each other, using terms like "baboons," "donkeys" and worse—or did he want people to keep reading?

However that may be, he expressed opinions about his opponents that were as honest as his comments on their theories—a tactic hardly likely to win them over. Of Aristotelians, for example, he wrote, "Make then your forecasts . . . with which you seek to discern the fantastic nine moving spheres; in these you finally imprison your own minds, so that you appear to me but as parrots in a cage, while I watch you dancing up and down, turning and hopping within those circles."⁷

This was no doubt a plain statement of fact. Bruno's perception of other people's views was less keen than his intuitive grasp of facts about cosmology, and he failed to see that to the Aristotelians, their system of circles really seemed associated with God's perfection. To him such a system diminished God. Further on in the same paragraph he declared, "We recognize . . . a spectacle worthy of the excellence of Him who transcendeth understanding, comprehension or grasp. Thus is the excellence of God magnified and the greatness of his kingdom made manifest; he is glorified not in one, but in countless suns; not in a single earth, a single world, but in a thousand thousand, I say in an infinity of worlds."⁸

Today, the ideas in *On the Infinite Universe and Worlds* have become so commonplace that it is hard to realize how advanced they were for the time in which they were written. The scholar who translated Bruno's words from the Italian used Elizabethan English, which helps to remind readers that Bruno was a contemporary of Shakespeare. Nevertheless, it is easy to forget that people of Shakespeare's era were shocked by them.

"I believe and understand that beyond this imagined edge of the heaven there is always a further ethereal region with

worlds, stars, earths, suns . . . though owing to the extreme distance they are not perceptible to us,” Bruno asserted through the speech of one of his characters. And another character replied, “You would deny that they are as it were embedded in a single cupola, a ridiculous notion which children might conceive, imagining perhaps that if they were not attached to the celestial surface by a good glue, or nailed with stoutest nails, they would fall on us like hail . . . You consider that those innumerable other earths and vast bodies hold their positions and their proper distances in ethereal space just as doth our earth.”⁹

These were startling concepts, so startling that Bruno himself, who sensed they must be true, did not fully understand them. Because he knew nothing of the physical laws that were to be discovered later, he believed—as did many ancient and medieval thinkers—that worlds were in some way animated. Nothing within his experience could move by itself unless it was alive. That was not a stupid mistake; he was groping for facts beyond his reach, as any daring speculator must do, and the fundamental picture he formed was valid.

The thing that made this picture different from all previous ones was that it was based on other *solar systems* instead of merely “other worlds” in a general sense. Its details occupied many pages of dialogue, of which the following is only a short sample:

Elpino: The proper motions of the bodies known as fixed stars . . . are more diverse and more numerous than the celestial bodies themselves . . . It is but their great distance from us which preventeth us from detecting the variations. . . .

Philotheo: That is so.

Elpino: There are then innumerable suns, and an infinite number of earths revolve around those suns, just as the seven we can observe revolve around this sun which is close to us.

Philotheo: So it is.

Elpino: Why then do we not see the other bright bodies which are earths circling around the bright bodies which are suns? . . .

Philotheo: The reason is that we discern only the largest suns, immense bodies. But we do not discern the earths because, being much smaller, they are invisible to us. Similarly it is not impossible that other earths revolve around our sun and are invisible to us on account either of greater distance or of smaller size. . . .¹⁰

Bruno wrote this twenty-five years before the first telescope was turned on a heavenly body, and almost two hundred years before the first planet not visible to the naked eye was discovered in our solar system. Until 2004 no planet in another solar system had been directly seen by a telescope, for exactly the reason he gave.

Elpino: Therefore you consider that if the stars beyond Saturn are really motionless as they appear, then they are those innumerable suns or fires more or less visible to us around which travel their own neighboring earths which are not discernible by us.

Philotheo: Yes, we should have to argue thus, since all earths merit the same amount of heat, and all suns merit the same amount.

Elpino: Then you believe that all those are suns?

Philotheo: Not so, for I do not know whether all or whether the majority are without motion, or whether some circle around others, since none hath observed them. . . . But however that may be, the universe being infinite, there must ultimately be other suns. . . . Around these bodies there may revolve earths both larger and smaller than our own.

Elpino: How shall I know the difference? How, I say, shall I distinguish fiery bodies from earths?

Philotheo: Because fiery bodies are fixed and earths are in motion; because fiery bodies scintillate and earths do not; of which indications, the second is more easily perceptible than the first.

Elpino: They say that the appearance of scintillation is caused by the great distance from us.

Philotheo: If that were so, the sun would not scintillate more than all the others; and the small stars which are more remote would scintillate more than the larger which are nearer to us.

Elpino: Do you believe that fiery worlds are inhabited even as are watery bodies?

Philotheo: Neither more nor less.

Elpino: But what animals could live in fire?

Philotheo: You must not regard these worlds as compounded of identical parts, for then they would be not worlds but empty masses, vain and sterile. Therefore it is convenient and natural to assume that their parts are diverse just as our own and other earths comprise diverse parts, though some celestial bodies have the appearance of illuminated water as others of shining flames.

Elpino: You believe then that the prime matter of the sun differeth not in consistency and solidarity from that of the earth? For I know that you do not doubt that a single prime matter is the basis of all things.¹¹

Bruno made other mistakes there, of course. Suns do move, and they are so unlike planets that modern scientists do not think life can exist on them. But Bruno's reasoning, based on what little information he possessed, was sound. He perceived that "fire" was not a single element, as was thought at the time, but that many elements must exist in the stars—the same elements that exist on Earth rather than uniquely "celestial" ones.

Speaking of Nicholas Cusanus, Bruno had Philotheo say: "As to the apprehension of truth . . . he is a swimmer in the tempestuous waves cast now upward, now downward, for he did not see the light continuously, openly and clearly, and he swam not in calm and quiet, but with interruptions and at certain intervals; the reason being that he did not discard all those false principles imbibed with the usual doctrine from which he had parted."¹² That description could as well apply to Bruno himself, and to all men who have ever striven toward truth unknown in their time.

Truth was of tremendous importance to Bruno; he said a good deal in other books about how highly he valued it. In the introduction to *On the infinite Universe and Worlds* he wrote: "Assuredly I do not feign; and if I err, I do so unwittingly; nor do I in speech or in writing contend merely for victory, for I hold worldly repute and hollow success without truth to be hateful to God, most vile and dishonourable."¹³ He did not always perceive the truth. As a sixteenth-century man, he too believed that knowledge was to be sought in the past: in the work of Greeks still more remote than Aristotle, in that of medieval writers of all creeds, and even in the occult secrets of ancient Egypt. What was new and powerful in his thought was the way he combined the ideas he met there, and the implications he saw in their relationship to the theory of Copernicus. Some historians of science believe that Bruno was too much of a mystic and a dreamer to be counted among the founders of modern cosmology; but the fact remains that he was the first to say that if there was one sun around which planets revolved, there must also be others. Today it seems strange that he had to die for his far sight.

Yet in a way it is not so strange. The world-view Bruno threatened was cherished by his society, a society that had seen the "new" star of 1572 (a supernova) as a sign of impending doom. To that society's representatives all thought of change in the heavens was repugnant. "Where then is that beautiful order, that lovely scale of nature rising from the denser and grosser body which is our earth . . . to divine which is the celestial body?" demanded one of the speakers in *On the infinite Universe and Worlds*. And he was answered, "You would like to know where is this order? In the realm of dreams, fantasies, chimeras, delusions."¹⁴

It must be remembered that the question represented the viewpoint of all established authority, scientific as well as religious. For Bruno to answer it by calling the old cosmology a delusion was the same as to say that all the men in positions of respect were crazy. Worse, he was attacking something that people desperately *wanted* to believe in, an orderly system that in their minds was solace for the confusion of life in the world they knew. "In this way, you would put the world upside down," the protestor asserted. In reply he was asked, "Wouldst thou consider him to do ill who would upset a world which was upside

down?"¹⁵ Bruno surely knew that he would indeed be considered to have done ill.

A book like his had a potentially more explosive effect than any political tract. Though printed in England, it bore a false imprint of Venice. Bruno later said that he had been told that this would increase its sales, since Italian literature was popular among educated Englishmen. Scholars feel that the real reason was that the publishers were afraid to put their own name on it.

He wrote other books on cosmology and religion that were equally objectionable to people. He also wrote some on magic, which were less objectionable; magic was quite respectable if not of the diabolic sort. Bruno was often thought to be a magician, and there are some modern historians who believe that he envisioned himself as a mage, or benevolent wizard. Be that as it may, he sincerely thought he could teach "magical" arts of memory improvement: an occupation that proved fatal to him in the end. Six years after leaving England to resume his wanderings, he accepted the invitation of an Italian nobleman who wanted to learn such arts. When Bruno arrived in Italy and proved unable to impart occult powers, this nobleman—who had hoped to acquire more than a better memory—betrayed him to the Inquisition.

It is not known why Bruno decided to go back to Italy. He must have realized that his peril would be great there. However, in the records that have survived of his life and imprisonment, there are indications that he really believed the church authorities would accept his ideas if they could only be made to listen. He considered himself a Catholic despite his disagreement with many of the official Catholic teachings, and at his trial it seems he was attempting to convert his judges to his own way of thinking. At one point, when it appeared likely that he would be condemned for minor heresies, he agreed to abjure "all errors" he had ever made; but neither then nor later did he specifically retract any of his beliefs about the infinite universe and worlds. He was sent to the dungeons of Rome; and finally, after nearly eight years, to the stake. An early biographer wrote, "The report was current among the newsmongers of the day that Bruno said he died a martyr and willingly."

It is easy now to see that Bruno chose to die in defense of his ideas, which might have been forgotten if he had repudiated

them. It is harder to see that those who sentenced him were also defending an idea, one they truly believed must be upheld for the good of all concerned. No one can be sure what went on in the minds of Bruno's judges during the years he was imprisoned, but it seems likely that for the first time they gave serious consideration to the concept of extrasolar planets; and the records, though incomplete, do show that he was told to give up his "vanities concerning diverse worlds." Such speculations, combined with the theory of Copernicus, could shatter the barrier that divided the world from heaven. They could destroy the whole view of celestial regions on which religion then seemed to depend. The church authorities who recognized this could see ahead, though not far enough to realize that the enduring things in Christianity had nothing to do with Aristotelian cosmology. No doubt they were less worried over Bruno's ideas about God, which were unlikely to gain popular support in any case, than over those that threatened people's faith in a well-structured universe centered upon God's concern for humankind.

Execution by fire was at that time an established legal procedure, formally carried out by the civil authorities. The judges of the Inquisition were mistaken in thinking its cruelty justified, but they were not dishonest; and their methods were in keeping with the customs of the age in which they lived: a fact illustrative of the progress that has been made since the sixteenth century.

Today in the Campo dei Fiori there is a statue of Giordano Bruno, erected in the year 1889 and dedicated before a crowd of thirty thousand people who gathered to honor his memory. Most of these people thought of him in connection with freedom of religion alone. Science had earned the credit for proving that stars were suns, and the belief that those suns must have planets—probably inhabited planets—had become so widespread that few recalled who originated it. For Bruno died in 1600, at the dawn of the seventeenth century; and by the time that century was over almost all educated people believed exactly what he had said about the existence of other worlds.