*Q. Jl R. astr. Soc.* (1981) **22**, 133–145

# A Brief History of the Extraterrestrial Intelligence Concept

*Frank J.Tipler*

Center for Theoretical Physics, University of Texas at Austin, Austin, Texas 78712, USA
and
Departments of Mathematics and Physics, Tulane University, New Orleans,
Louisiana 70118, USA*

> 'Do there exist many worlds, or is there but a single world? This is one of the most noble and exalted questions in the study of Nature.'
>
> St Albertus Magnus [*c.* 1260 A.D. (8)]

> '... the way whereby one can learn the pure truth concerning the plurality of worlds is by aerial navigation [space travel].'
>
> Pierre Borell [1657 A.D. (8)]

The idea that the heavenly bodies are inhabited is very old. In fact, the debate between believers in extraterrestrial intelligent beings and proponents of the Earth as a uniquely inhabited world can be traced back to the ancient Greeks (1). As will be seen in the following history, not only does the debate re-occur periodically as the centuries pass, but many of the arguments pro and con are re-invented as a new generation of debaters take up their pens.

Throughout history, the belief in a plurality of worlds is generally associated with three other beliefs. First, and most importantly, it is associated with what Lovejoy (2) calls 'the principle of plenitude', which asserts that what can exist must exist somewhere, and that if worlds like ours exist elsewhere in the Universe, they must be inhabited by intelligent beings since no 'genuine potentiality of being can remain unfulfilled'(2). The principle of plenitude has become the principle of mediocrity in twentieth-century discussions of extraterrestrial intelligence.

A second belief closely associated with the belief in extraterrestrial intelligence is the belief in the infinity of the cosmos, that there are an actual infinity of worlds. Although this belief is sometimes regarded as a consequence of the principle of plenitude, it does not, strictly speaking, follow from it since it is conceivable that there could be only a finite number of possible worlds. Nevertheless, people who argue for extraterrestrial intelligence have in past centuries generally argued for an infinite cosmos, while doubters in ETI have tended to either deny that the Universe is infinite, or at most admit that the Universe is 'indefinite' in extent.

Finally, believers in extraterrestrial intelligence have tended to lack what might be termed 'a sense of history'. A sense of history is more than an awareness that change, or even progressive change, has occurred in the past. It is also a feel for the contingent (at least in the eyes of human observers) nature of this change, an awareness of the uniqueness of events which are unpredictable because of their apparent insignificance at the time of occurrence, but whose effects amplify with time so as to exert an enormous if not

*Permanent address.

dominant influence on future change. The rôle which the sense of history of the lack of it plays in the ETI debate will also be discussed in Appendix II.

Among the ancient Greeks and Romans, the term 'world' signified what would now be called a Ptolemaic Universe consisting of a central Earth, a single Moon and Sun, five planets and the fixed stars. A plurality of worlds meant therefore a number of self-contained Universes, each with an inhabited central Earth. Generally supporters of a plurality of worlds in this sense also argued that the Moon was of an Earthly nature, with intelligent inhabitants. The Pythagoreans, the atomists such as Democritus and Leucippus, the Stoics such as Epicurus and his follower Lucretius, Thales, Heraclitus, and Plutarch all held both views in some form, and these are the most important supporters of the many inhabited worlds concept in antiquity (**1**). The arguments in favour of a plurality of inhabited worlds – especially those of Democritus and Epicurus – were based on the principle of plenitude and the idea that the Universe is enormous. In the words of a contemporary, Metrodorus: 'It seems absurd, that in a large field only one stalk should grow, and in an infinite space only one world exist (**3**). There is no essential difference between this argument and present-day arguments for ETI based on the principle of mediocrity.

The most brilliant Greek thinkers were, however, opposed to the idea of a plurality of worlds. Plato, for instance, described those holding such a belief as possessing a sadly indefinite and ignorant mind (**4**). He did admit that the question of the habitability of the planets was open, though he himself believed the Earth was unique in this regard. The world system of Aristotle left no room for either a plurality of worlds or for inhabitants on the planets, and he argued at length against both these doctrines (**5**). The plurality of worlds would be unstable because Aristotelian physics would require the Earths of each world to come together at the centre of the Universe, and in any case each finite world would have to be separated by a void, which is also an impossibility in his physics. The planets could not be inhabited because they were of a completely different substance than those found on Earth. In short, the Universe of Aristotle was *finite*, and the Earth the only inhabited globe.

As is well-known, the Aristotelian conception dominated thought until the time of Copernicus, and though the doctrine of a plurality of worlds (in the Greek sense) was occasionally discussed, it was rejected by most scholars, both pagan and Christian, in this period (**1**). The Christian philosophers added two theological arguments against the plurality of worlds. Foremost was the idea of Christ's uniqueness (the uniqueness of the Incarnation): he appeared but *once* in the Universe, and his appearance was a consequence of an historical process peculiar to the Earth. St Augustine (**6**) therefore pointed out in the sixth century AD that if other intelligent beings similar to man existed, then they would also require a Saviour, which would contradict the uniqueness of Christ (I Peter 3: 18). Note that this argument is in part an historical argument. The uniqueness of the Incarnation is coupled with the notion of a unique historical or evolutionary process. This is the origin of the historical sense in Western thought (**7, 16, 62**). Christianity was also somewhat anthropocentric – it tended to regard the Universe as created

for man – and this was a second theological argument against the plurality of worlds.

The great medieval scholars also rejected the idea of a plurality of worlds. During the scholastic flowering in the thirteenth century, St Albertus Magnus (**8**) asserted 'Do there exist many worlds, or is there but a single world? This is one of the most noble and exalted questions in the study of Nature'. His discussions of this question were extensive (**1**), because he agreed with Augustine that a plurality of worlds would mean a plurality of Incarnations. In the end he also rejected the plurality, basing his argument on the uniqueness of Christ and Aristotelian physics. His reason for not rejecting the plurality idea out of hand was his belief in the principle of plentitude: if the power of God is infinite, why should he create merely a single finite world? By the principle of plenitude, this unlimited creative power should express itself by creating all possible worlds.

St Thomas Aquinas, who was a pupil of Albertus Magnus and is regarded as the founder of scholastic philosophy, resolved this quandary by unqualifyingly rejecting both the plurality of worlds and the principle of plenitude (**9**). He argued that if God made other worlds, they would either be similar or dissimilar to this one. If similar they would be in vain, which is not consistent with Divine Wisdom. If dissimilar, none could contain all things and therefore none would be perfect. An imperfect world could not be the work of a perfect Creator. Aquinas also rejected the idea of an infinite world (**10**). He thus denies plurality, plenitude, and infinity, the trinity of ideas which are associated throughout history. Despite the arguments of Aquinas, this trinity continued to be attractive to some medieval thinkers up to the time of Copernicus. For instance, the influential St Bonaventure contended that God could make a hundred worlds if He wished. He could suspend Aristotelian physics (i.e. the argument that two Earths would come together) and create one in a place which is beyond the fixed stars (**11**) (ETI believers have always been willing to suspend the physics of their day (**12**)). Nicholas of Cusa, whose *De docta ignorantia* (1440) was the most influential book on cosmology until the seventeenth century (**12**), was led by a belief in the principle of plenitude to accept the infinity and plurality of worlds. This work by Cusa had a considerable impact on the mystic (**13**), (**14**) Giordano Bruno, who also advocated the infinity and plurality of worlds. With Bruno the notion of a plurality of worlds takes on its modern meaning, that of inhabited planets around a central Sun, and 'inhabited' signifies 'inhabited by intelligent beings'. Hereafter I shall use the phrase 'plurality of worlds' to mean this, or to refer to inhabited planets in this solar system. Bruno is generally regarded as a martyr to science because he published one of the first defences of the Copernican System and was later burned at the stake. However, he defended Copernicus not for scientific reasons but for theological ones (**12**). Indeed, he had contempt for the close mathematical reasoning of Copernicus (**16**), (**17**), (**19**) and was only interested in using Copernicus' work to attack some of the basic tenets of the Christian religion (**12**), (**16**) such as the uniqueness of the Incarnation (his notion of time was cyclic (**16**), like that of the ancient Stoic supporters of plurality – he denied the Christian sense of history). He was executed for his mystical attack on Christianity, not for his belief in the

plurality of worlds or his defence of Copernicus (**20**). Far from being a martyr to science, Bruno actually harmed it, because the storm he raised caused the religious authorities to associate the Copernican system with anti-Christian agitation. This in fact was a major factor in the condemnation of Galileo (**20**).

Kepler and Galileo, the two major figures in the early part of the Copernican Revolution, were actually *opposed* to the idea of a plurality of inhabited worlds as put forward by Bruno. In his *Third Letter on Sunspots*, Galileo denounced 'as false and damnable the view of those who would put inhabitants on Jupiter, Venus, Saturn, and the Moon, meaning by "inhabitants" animals like ours, and men in particular'. He claimed he could prove that other planets were without inhabitants of any kind (**21**), (**22**). Kepler, on the other hand, believed in the existence of living creatures on the planets, but he felt that they were definitely inferior to humans (**22**). As to the question of inhabited planets around other stars, he regarded this as at best unsolved: 'No moons have yet been seen revolving around [the stars]. Hence this will remain an open question until this phenomenon too is detected' (**23**). Kepler also argued against an infinite number of inhabited worlds in a manner similar to Aquinas: if there were infinitely many planets there would be vain duplications: there would be 'as many Galileos observing new stars in new worlds as there are worlds' (**25**). (The idea that an infinite Universe implies an infinite number of identical people has recently (1978) been advanced by Ellis and Brundrit (**26**).)

In spite of the opposition of Kepler and Galileo, the plurality of worlds concept was given a very strong boost by the Copernican Revolution. This occurred in several ways. First of all, the telescope disclosed mountains on the moon and satellites around Jupiter. These observations suggested that the planets were similar to the Earth in gross structure. Second, the Earth was demoted from the status of being an enormous body in the centre of the Universe to just one of six planets. To minds conditioned by the discovery of America in the previous century to see unknown lands on this planet inhabited, it took but a small application of the principle of plenitude to envision the planets – regarded as distant lands – as inhabited also. Further, the telescope had revealed innumerable stars, which were regarded as Suns like our own. Teleological concepts such as the principle of plenitude were strong in the thinking of the day, and it was felt that the planets and stars must have been created for some purpose. Since the Copernican Revolution had discredited the idea that these objects were created for our benefit – the telescope disclosed innumerable invisible stars, for example, and these could hardly have been created to light the night sky – it was argued that they must have been created to be the abodes of other intelligent beings, just as the Earth had been created for human beings.

The question of the plurality of worlds was often discussed in the seventeenth and eighteenth centuries, but rarely in scientific treatises. Rather, it was subject matter of widely-read books which were intended as popularizations of the new science. Probably the most influential of these was *Conversations on the Plurality of Worlds*, first published in 1686 by Bernard de

Fontenelle, a novelist who later became secretary of the French Academy of Sciences. This work was a seventeenth century best-seller. It went through numerous editions in French and was translated at least three times into English (**27**). The book was written in the form of a series of conversations between Fontenelle and a lady, the Marchioness, who was ignorant of the new astronomy but intelligent and anxious to learn. The arguments presented by Fontenelle in favour of a plurality of worlds were the teleological, the plenitude and the analogy (the Earth and planets are the same in the large, hence they should be the same in having inhabitants) arguments outlined in the preceding paragraph. Around the time Fontenelle was writing his *Conversations*, speculations on the possibility of interplanetary travel were widely discussed (**28**) (e.g. by Pierre Borel (**8**), (**29**)) and he embraced such ideas as his own:

> '. . . The art of flying is yet in its infancy, it may hereafter be brought to perfection; and the time may come when mankind may fly to the Moon.
>
> I will not consent to this, said she [the Marchioness], that mankind will ever carry the art of flying to such perfection, but that they will immediately break their necks. Very well, answered I [Fontenelle], if you will insist upon it, that mankind will always be such bad flyers, they may fly better in the Moon; the inhabitants of that Planet may be better formed for this trade than us; for it is very immaterial, whether we go there, or they come here, and we shall then be like the Americans, who could not form to themselves the idea of sailing so far on the sea, tho' at the other end of the world, they had long understood the art of Navigation.' (**30**).

The Marchioness of 1686 immediately realized from this what many twentieth century scientists have not realized, and which I have pointed out at length in an earlier paper (**24**), namely that if such intelligent beings on other planets existed and possessed interplanetary travel technology, they would have already arrived here on Earth:

> 'The people of the Moon would therefore have come to us before now, replied the Marchioness, almost in anger.' (**30**).

There is but one reply to the Marchioness' objection if one still wishes to defend the plurality of worlds doctrine: one must argue that such beings would have had insufficient time since the creation of the Universe to develop the necessary flight technology and fly to the Earth. Fontenelle indeed makes such an answer:

> 'The Europeans did not arrive in America till nearly at the end of six thousand years, replied I, breaking out into a laugh; this time was necessary for them to carry their Navigation to such perfection, so as to cross the Ocean. The people of the Moon know already, perhaps, how to make little flights in the Air; and at this time may be exercising themselves; when they shall be more able, and more experienced, we may see them; and God knows what will be our surprise.' (**31**).

Six thousand years is indeed the approximate time the human race needed to develop from savagery to interplanetary travel. In Fontenelle's day it was also the age of the Universe (**7**). Nevertheless, the insufficient time scale argument was no more acceptable then than similar arguments are today. The Marchioness' opinion of the time-scale argument was:

> 'You are insupportable, said she, to push things so far with such weak reasoning.' (**31**).

Fontenelle's book on the plurality of worlds was soon followed by two other very influential popular books supporting that belief. In 1698 the great Dutch scientist Christiaan Huygens, who discovered Saturn's rings and was instrumental in the formulation of the conservation of momentum law, published in Latin a defence of plurality entitled *The Celestial Worlds Discover'd* (32). Widespread interest in plurality is indicated by the fact that an English translation appeared in the same year as the Latin version, and a French edition soon after. Huygens' book was followed in 1715 by William Derham's *Astro-Theology, or a Demonstration of the Being and Attributes of God from a Survey of the Heavens* (33). Derham was a clergyman, the religious tutor of the Prince of Wales, and his book appeared under royal patronage (34). Both of these books presented the Copernican system to the lay reader, and both argued for a plurality of inhabited worlds. The arguments in both books for a plurality were the usual ones mentioned above. Observations were cited to justify the rough similarity of the Earth and the planets, and then the principle of plenitude was invoked to justify the existence of inhabitants. As Derham put it:

> 'Having thus represented the state of the Universe, according to the New [Copernican] System of it, the usual Question is, what is the use of so many Planets as we see about the Sun, and so many as are imagined to be about the Fixt Stars? To which the answer is, that they are *Worlds*, or places of habitation, which is concluded from their being habitable, and well provided for Habitation.' (35).

(Note the lack of a sense of historical change in Derham's phrasing.) The existence of inhabited planets around each of the fixed stars was, as usual, justified by Derham on the basis of the principle of plenitude and anti-anthropocentric teleology:

> 'And if the Fixt Stars are so many Suns, certainly they minister to some grand uses in the Universe, far above what hath usually been attributed unto them. And what more probable uses, than to perform the office of so many suns? that is, to enlighten and warm as many Systems of Planets; after the manner as our Sun doth the Erraticks encompassing it. And that this is the Use and Office of the Fixt star is probable,
>
> 1. Because this is a far more probable and suitable use for so many Suns, so many glorious Bodies, than to say they were made only to enlighten and influence our lesser, and I may say inferior, Globe;
>
> 2. From the Parity, and constant Uniformity observable in all God's works, we have great reason to conclude that every Fixt Star hath a systeme of Planets, as well as the Sun.
>
> 3. This account of the Universe is far more magnificent, worthy of, and becoming the infinite CREATOR, than any other of the narrower schemes' (36).

Note the striking similarity between the wording of Derham's point 2, and Sagan's formulation of the principle of mediocrity (11). A similar formulation is also to be found in Huygens' *Celestrial Worlds* (37), which Derham cites in defense of point 2.

In spite of the fact that the key arguments for a plurality of inhabited worlds were philosophical and theological rather than empirical – as Galileo pointed out (38), there were no 'sure observations' on the question of inhabitants, and the astronomer cannot affirm a thing to exist merely because it is logically possible – the belief in plurality was nearly unanimous in the

world scientific community by the end of the eighteenth century (I have been unable to discover any counter-examples). This is probably due to the hold the principle of plenitude had on men's minds, coupled with the fact that *all* popular works in astronomy at the time argued at length in favour of plurality, and the scientific treatises mentioned pluarlity not at all, or only in passing. If there is no opposition to a view, it will become generally accepted whatever the evidence for it (witness the contemporary situation of ETI in the popular press).

By the beginning of the nineteenth century, the belief in a plurality of worlds was regarded as so obviously true, that plurality was used as an argument *against* the Incarnation, and hence against Christianity (the reverse of the situation from St Augustine to Aquinas). As the American revolutionary Thomas Paine put it in his *Age of Reason* (1794):

> 'From whence then could arise the solitary and strange conceit, that the Almighty, who had millions of worlds equally dependent on his protection, should quit the care of all the rest, and 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 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' (**39**).

According to Thomas Chalmers, one of the most famous Scottish theologians of the early nineteenth century, this argument was a major source of intellectual doubts about Christianity in this period (**40**), and he wrote an entire book, *Discourses on the Christian Revelation Viewed in Connection with the Modern Astronomy*, to refute it. This book was generally quoted in discussions on ETI during the following 40 years. What is remarkable is that in it Chalmers never once questions the existence of ETI. He can only argue that *Homo sapiens* may be the only intelligent species in the Universe that fell from grace, an idea developed in the twentieth century by C.S.Lewis in his well-known science fiction trilogy.

The first person to take a critical *scientific* look at the empirical, as opposed to the philosophical or theological, evidence for extraterrestrial intelligence, was William Whewell, Master of Trinity College, Cambridge. Whewell pointed out that Chalmers' concessions were unnecessary, because all available evidence indicated that conditions on other planets of this solar system were so unlike those on Earth as to render them uninhabitable by any form of life known to us. Furthermore, there was no evidence to show the existence of planets around the fixed stars analogous to the planets on our solar system. Whewell concluded that:

> 'The belief that other planets, as well as our own, are the seats of habitation of living things, has been entertained, in general, not in consequence of physical reasons, but in spite of physical reasons; and because there were conceived to be other reasons, of another kind, theological or philosophical, for such a belief' (**41**).

Whewell also attempted to refute some of these extra-scientific reasons for a belief in a plurality of worlds. In particular, he argued *against* plenitude by emphasizing the *historical* change which the Earth had undergone. By the

geological evidence, humanity was very recent; for most of its history the Earth was *uninhabited* by intelligent beings, and so Derham's argument for habitability loses its force. Whewell also doubted the infinity of the Universe. However, the belief in ETI was by now too ingrained in popular culture for such arguments to make much headway. The publication of Whewell's book was greeted with a cry of outrage, almost as great as that which greeted Darwin's *Origin of the Species* 5 years later. A great number of books and reviews appeared on the ETI question, most critical of Whewell's thesis (**42, 63**).

As is well-known, there was a huge increase of interest in ETI in the latter part of the nineteenth century due to the claim that canals made by intelligent beings had been observed on Mars. These observations, popularized by the American astronomer Percival Lowell, were soon discounted by most professional astronomers (**43**), but they retained a hold on the lay imagination for a century. Lowell's books about life on Mars provoked Alfred R.Wallace, with Darwin the discoverer of the theory of evolution by natural selection, into analysing the likelihood of the evolution of an intelligent species elsewhere in the Universe. He concluded that it was essentially zero, and thus we are alone in the Universe. His arguments are worth repeating in detail, because although published in 1905 they are exactly the same as those given by modern evolutionists such as Dobzhansky (**64**), Simpson (**65**), and Mayr (**66**). Thus the biological arguments against the evolution of intelligence have not changed in 75 years. The great evolutionists have always been united against ETI. The biologists who have supported ETI have generally been biologists with the viewpoint of a physicist, and lacking the historical sense of the evolutionist. Such men often err in questions about evolutionary biology; in particular they err about questions concerning the probability of the evolution of a species with specified properties, as the recent recombinant DNA debate shows (**44**).

Wallace's original arguments (**45**) against ETI were, like Whewell's, primarily physical not biological. The evolutionary arguments against ETI appeared as an appendix to a later edition of his book, *Man's Place in Nature*:

> 'Those among my critics who have expressed adverse opinions, usually agree that my proofs of the absence of human life in the other planets of our system are very cogent if not quite conclusive, but declare that they cannot accept my view that the unknown planets that may exist around other suns are also without intelligent inhabitants. They give no reasons for this view other than the enormous number of suns that appear to be as favourably situated as our own, and the probability that many of them have planets as suitable as our earth for the development of human life. Several of them consider it absurd, or almost ludicrous, to suppose that man, or some being equally well organized and intelligent, has not been developed many times over in many of the worlds which they assume must exist. But not one of those who thus argue give any indication of having carefully weighed the evidence as to the number of very complex and antecedently improbably conditions which are absolutely essential for the development of the higher forms of organic life. . .' (**46**).

Wallace first pointed out that

> '. . . if it is true that each species has arisen from one parental species, and one only [Wallace had earlier given evidence for this], then the whole line of descent

> from any living species (and therefore from man) back to the earliest form of life has been fixed and immutable; so that if any *one* of the thousand or millions of successive species in the line of descent had become extinct before it had been modified into the next species in the line of descent (or, which is the same thing, if it had been differently modified from what actually occurred), then that particular species which constitutes the last link in that particular line of descent – and this also applies to man – would never have come into existence.
>
> The ultimate development of man has, therefore, roughly speaking, depended on something like a million distinct modifications, each of a special type and dependent on some precedent changes in the organic and inorganic environments, or on both. The chances against such an enormously long series of definite modifications having occurred twice over, even in the same planet by in different isolated portions of it . . . are almost infinite, when we know how easily the balance of nature can be disturbed . . .' (47).

Thus the existence of *Homo sapiens* on another planet was ruled out. Wallace then generalized this argument from human beings to the class of intelligent beings:

> 'Of course, it may be said that a creature with a mind and spiritual nature equal to that of man might have been developed in a very different form. . . . I briefly state why it seems quite inadmissible. In the first place, man differs from all other animals in the range and speciality of his mental nature even more than in his physical structure. It is generally admitted that his mental development has been rendered possible by a combination of three factors: the erect posture and free hand, the specialized vocal organization . . . and the exceptional development of the brain. . . .
>
> No other animal types make the slightest approach to any of these high faculties or show any indication of the possibility of their development. . . . The mere assertion, therefore, that a being possessing man's intellectual and moral nature combined with a very different animal form, might have been developed, is wholly valueless. We have no evidence for it, while the fact that no other animal than man *has* developed his special faculties even to a lower degree, is strong evidence against it . . . the evolutionary improbabilities now urged cannot be considered to be less than perhaps a hundred millions to one . . .' (48).

Wallace's arguments were ignored in future ETI debates; the modern evolutionists have independently rediscovered them (which argues for their correctness).

As Wallace mentioned in the above passage, the strongest argument for the existence of ETI *somewhere* in the Universe hinged on there being an enormous number of planets. This assumption was generally accepted throughout the nineteenth century, for it seemed a consequence of the nebular hypothesis for the formation of the solar system, which was itself generally accepted. However, this theory was rejected in the period 1900–1945 in favour of the 'stellar collision theory' (12), which made it appear that our solar system was a very rare phenomenon, if not unique. Consequently, most discussions of ETI in this period tended to reject the idea of ETI. This was certainly the case in the two most widely read popular books on astronomy in the period, *The Universe Around Us* (49) (1929), by Sir James Jeans, and in *The Nature of the Physical World* (50) (1928), by Sir Arthur Eddington. The latter in fact asserted: '. . . I feel inclined to claim that *at the present time* [Eddington's emphasis] our race is supreme . . .' (50). Nevertheless, the principle of plenitude still exerted a strong hold on Eddington's mind, for he

prefaced the above remark with: 'I do not think that the whole of the Creation has been staked on the one planet where we live; and in the long run we cannot deem ourselves the only race that has been gifted with the mystery of consciousness'. Non-scientists put more trust in plenitude than in scientific theories of planetary formation. E.W.Barnes, the Bishop of Birmingham, asserted: 'My own feeling that the cosmos was created as a basis for the higher forms of consciousness leads me to speculate that our theory of the formation of the solar system is incorrect' (51). It is interesting that at the time Jeans and Eddington were writing, astronomers believed the Universe to be topologically a three-sphere, and hence *finite* in size (52), (53). The infinite Universe came back into vogue soon thereafter, however, and the noted British cosmologist E.A.Milne developed the concept in the context of non-Einsteinian relativity. Milne believed in ETI, and he offered a novel suggestion for resolving the traditional Christian paradox between the uniqueness of Christ and the plurality of worlds. He pointed out that radio communication between inhabited planets is possible, and

> '... in that case there would be no difficulty in the uniqueness of the historical event of the Incarnation. For knowledge of it would be capable of being transmitted by signals to other planets and the re-enactment of the tragedy of the crucifixion in other planets would be unnecessary' (54).

Most modern theologians who mention the ETI question don't seem to worry about the uniqueness question that bothered St Augustine, Aquinas, Chalmers, and Milne. They accept the plurality of worlds; their arguments are the principle of plenitude and anti-anthropocentric teleology similar to that of Derham (51), (55), (56), (57), (58). In contrast to the early Christian thinkers, they deny the uniqueness of Earth's history and feel history is cyclical in the sense that it is repeated on many planets. Their view was influenced by the ahistorical steady state cosmology (see below). Suggestions that we could use radio waves to communicate with ETI goes back to the invention of radio in the nineteenth century (59), but most of these involved just the other planets of this solar system. F.Galton, the nineteenth century British statistician who first investigated the inheritance of human intelligence, even worked out a code for communicating with these beings, a code which is quite similar to those made by modern SETI proponents (67). The earliest proposal for interstellar communication via radio that I'm aware of was made (60) by Bishop Barnes in 1931 in an article in *Nature*.

The modern discussion of the ETI question really begins with the publication in *Nature* of the radio contact proposal by Cocconi & Morrison in 1959, which was given wide publicity in a large number of popular books. (It is during this time that the question of other intelligent beings in the cosmos ceases to be called 'the plurality of worlds question', as it was referred to for hundreds of years, and becomes the 'ETI question'.) There were a number of *scientific* developments in the preceding 20 years which supported the ETI hypothesis. First, the nebular hypothesis for the formation of the solar system came back in to vogue after the end of the Second World War, and this hypothesis suggests that planets are common. Second, the experiments of Stanley Miller suggested that life would spontaneously appear on many of these planets. This to a limited extent was experimental evidence for the

principle of plenitude. Third, the development of radio astronomy technology made it possible to *experiment* on the ETI question rather than merely talk about it – and the beginning of the space age in 1957 encouraged such experiments. Fourth, the steady-state theory, which is an infinite-Universe cosmology that has no history in the large, was the dominant cosmology during the early 1950s. The first three scientific developments were used to justify the existence of ETI, while the fourth tended to reinforce the philosophical and theological reasons for believing in ETI. And I contend that, as has been the case for 2000 years, these philosophical and theological beliefs are the main motivations for the belief in ETI.

## ACKNOWLEDGMENTS

This research has been supported by the National Science Foundation under grants numbers MCS-76-21525, PHY-77-15191 and PHY-78-26592. I should like to thank J.Brooke, S.L.Jaki, and J.A.Wheeler for helpful comments on an earlier version of this paper.

## REFERENCES

(1) McColley, G., 1936. *Annals of Science*, 1, 385.
(2) Lovejoy, A.O., 1936. *The Great Chain of Being*. Harvard University Press, Cambridge (USA). In chapter 4 of this book there is an extensive discussion of the relation between the principle of plenitude and the concept of extraterrestrial intelligence in the seventeenth and eighteenth centuries.
(3) Quoted in Ref. (1), p. 390.
(4) Plato, *Timaeus*, 31, 55.
(5) Aristotle, *De Caelo*, I, 5–9.
(6) St Augustine, *The City of God*, book 12, chapter 11.
(7) Haber, F., 1959. *The Age of the World*, p. 14. John Hopkins University Press, Baltimore.
(8) St Albertus Magnus, *De Caelo et Mundo*, Lib. I, Tract III, Cap. I; quoted in McColley, G., 1936. *Annals of Science*, 1, 385. Pierre Borell, 1658. *New Treatise Proving a Multiplicity of Worlds*. London; quoted in Sullivan, W., 1966. *We Are Not Alone*, p. 34. Signet, New York.
(9) Thomas Aquinas, *Commentarius in Libros Aristotelis*, Book 1, chapters 9–21.
(10) Thomas Aquinas, *Summa Theologica*, question 47, article 3.
(11) Bonaventure, *Commentaria in Quatuor Libros Sententiarum Magistri Petri Lombardi*, book 1, discourse 44, article 1, question 4.
(12) Jaki, S.L., 1979. *Planets and Planetarians*, p. 13. Wiley, New York. This book contains an excellent history of the ETI concept.
(13) Koyré, A., 1968. *From the Closed World to the Infinite Universe*, pp. 6, 14. Johns Hopkins University Press, Baltimore.
(14) Kuhn, T.S., 1959. *The Copernican Revolution*, p. 235. Vintage, New York.
(15) Ref. (12), p. 14.
(16) Jaki, S.L., 1974. *Science and Creation*, pp. 262–265. Scottish Academic Press, Edinburgh.
(17) Lerner, L.S. & Gosselin, E.A., 1973. *Scientific American*, 228, 4.
(18) Yates, F.A., 1964. *Giordano Bruno and the Hermetic Tradition*. University of Chicago Press, Chicago.
(19) Michel, P.-H., 1962. *La Cosmologie de Giordano Bruno*, pp. 3, 32–36. Hermann, Paris.
(20) Santillana, G. de, 1959. *The Crime of Galileo*, p. 23. University of Chicago Press, Chicago. It should be mentioned, however, that a belief in the plurality of worlds *was* one of the eight heretical positions on which Bruno was charged. (I am grateful to

Dr John Brooke for pointing this out to me.) Nevertheless, scholars today generally agree that neither this belief nor a belief in the Copernican system was the reason for Bruno's execution.
(21) Drake, S., 1957. *Discoveries and Opinions of Galileo*, p. 137. Doubleday, Garden City, New York.
(22) Ref. (12), p. 23.
(23) Rosen, E., *Kepler's Conversation with Galileo's Sideral Messenger*, p. 39. Johnson Reprints, New York.
(24) Tipler, F.J., 1980. *Q. Jl R. astr. Soc.*, **21**, 267.
(25) Ref. (23), p. 44.
(26) Ellis, G. F. R. & Brundrit, G.B., 1979. *Q. Jl R. astr. Soc.*, **20**, 37.
(27) Ref. (2), p. 130.
(28) Nicolson, M.H., 1948. *Voyages to the Moon*. Macmillan, New York.
(29) Borel, P., 1657. *Discours nouveau prouvant la pluralité des mondes*. Geneva.
(30) Fontenelle, B. de, 1760. *Conversations of the Plurality of Worlds*, translated by 'A Gentleman of the Inner Temple', p. 112. Withy, London.
(31) Ref. (30), p. 113.
(32) Huygens, C., 1698. *The Celestrial Worlds Discover'd*, English translation by T.Chitde. White Hart, London. This first English edition has been facsimile reproduced by Cass, London, 1968.
(33) Derham, W., 1715. *Astro-Theology*, 1st edn. W.Innys, London.
(34) Ref. (2), p. 133.
(35) Ref. (33), p. xlix.
(36) Ref. (33), pp. 35–36.
(37) Ref. (32), p. 18.
(38) Galileo, G., 1962. *Dialogue concerning the Two Chief World Systems*, Day I, 114, tr. S.Drake. University of California Press, Berkeley.
(39) Paine, T., 1885. *The Age of Reason*, Part I, p. 47. Belford, New York.
(40) Chalmers, T., 1817. *Discourses on the Christian Revelation Viewed in Connection with the Modern Astronomy*, 4th edn, p. 5. John Smith, Glasgow.
(41) Whewell, W., 1853. *Of the Plurality of Worlds*, p. 208. Parker, London.
(42) Brooke, J.H., 1977. *Annals of Science*, **34**, 221. This is a very informative article on the history of the ETI debate begun by Whewell.
(43) Hoyt, W.G., 1976. *Lowell and Mars*. University of Arizona Press, Tucson.
(44) Davies, B.D., 1977. *American Scientist*, **65**, 547.
(45) Wallace, A.R., 1903. *Fortnightly Review*, **73**, (NS), 395; **74**, 380.
(46) Wallace, A.R., 1905. *Man's Place in Nature*, 5th edn, p. 326. Chapman and Hall, London.
(47) Ref. (46), pp. 331–332.
(48) Ref. (46), pp. 333–334.
(49) Jeans, J., 1929. *The Universe Around Us*, p. 33. Cambridge University Press, Cambridge.
(50) Eddington, A.S., 1928. *The Nature of the Physical World*, p. 178. Cambridge University Press, Cambridge.
(51) Barnes, E.W., 1933. *Scientific Theory and Religion*, p. 402. Cambridge University Press, Cambridge.
(52) Ref. (50), p. 167.
(53) Tipler, F.J., Clarke, C.J.S. & Ellis, G.F.R., 1980. In: *General Relativity and Gravitation*, Vol. 2, p. 97, ed. A.Held. Plenum Press, New York.
(54) Milne, E.A., 1952. *Modern Cosmology and the Christian Idea of God*, p. 154. Clarendon Press, Oxford.
(55) Inge, W.R., 1934. *God and the Astronomers*, p. 248. Longmans, London.
(56) Mascall, E.L., 1957. *Christian Theology and Natural Science*, pp. 36–45. Longmans, London.
(57) Tillich, P., 1957. *Systematic Theology*, Vol. 2, pp. 95–96. Nisbet, London.
(58) Macquarrie, 1960. *The Scope of Demythologizing – Bultmann and his Critis*, pp. 60–61, 179. SCM Press, London.

(59) Sullivan, W., 1966. *We Are Not Alone*. Signet Books, New York.
(60) Barnes, E.W., 1931. *Nature, Lond.*, **128**, 722.
(61) Tipler, F.J., 1981. *Q. Jl R. astr. Soc.*, **22**, No. 3, to be published.
(62) Butterfield, H., 1957. *The Origins of Modern Science*, p. 225. Macmillan, New York.
(63) Carl Friedrich Gauss, the great nineteenth century mathematician, was another critic of Whewell, although he never published his opposition to Whewell's opinions. Gauss's support of plurality was apparently based on the principle of plenitude. See Dunnington, G.W., 1955. *Carl Friedrich Gauss: Titan of Science*, p. 303. Exposition Press, New York.
(64) Dobzhansky, T., Ayala, F.J., Stebbins, G.L. & Valentine, J.W., 1977. *Evolution*, Freeman, San Francisco.
(65) Simpson, G.G., 1964. *This View of Life*, Chapters 12 and 13, Harcourt, New York.
(66) Mayr, E., 1978. *Scientific American*, **239**, 46 (September).
(67) Galton, F., 1896. *Fortnightly Review*, **66**, 657.