THE STELLAR UNIVERSE, AND MAN'S PLACE IN IT.

1. *Man's Place in the Universe.* By ALFRED R. WALLACE. (London, 1903.)
2. *Galileo: His Life and Work.* By J. J. FAHIE. (London, 1903.)
3. *The Stars: A Study of the Universe.* By SIMON NEWCOMB. (London, 1901.)
4. *Études sur la Structure de l'Univers.* Première Partie. Par W. STRATONOFF. (Tashkent, 1900.)
5. *Études sur la Structure de l'Univers.* Deuxième Partie. Par W. STRATONOFF. (Tashkent, 1901.)
6. *La Voie Lactée dans l'Hémisphère boréal.* Par C. EASTON. (Paris, 1893.)
7. *La Distribution de la Lumière Galactique comparée à la Distribution des Étoiles cataloguées, dans la Voie Lactée boréale.* Par C. EASTON. (Amsterdam, 1903.)
8. *Other Worlds: Their Nature, Possibilities, and Habitability in the light of the Latest Discoveries.* By GARRETT P. SERVISS. (London, 1902.)

THE question, 'Is this earth of ours the only home of intelligent life?' belongs essentially to the modern period of science. For there was no place for speculation in this direction until the invention of the telescope, three centuries ago. Before that time the universe was conceived to be small. This world was the centre of creation, its floor and its foundation, the nucleus round which the whole was built, the object for which the whole was designed. The stars were thought to be nothing but small lamps fixed in

the actual substance of a great vault, and at no transcendental distance from us. The sun, moon, and planets were larger lamps, moved in sundry directions so as to afford a variety in the warmth and illumination which they supplied. But our earth was, by its pride of place and its Creator's design, the only possible or conceivable inhabited world.

The question of the plurality of worlds, therefore, dates back to Galileo, the man whose sorrow it was, and whose undying fame, that he was the first to establish the theory of Copernicus upon a broad and unshakable basis.

He was not indeed the first man to invent the telescope, but, on the mere report that an instrument had been constructed in Holland which showed distant objects more clearly, he thought out its principle for himself, and succeeded in its construction. With one of the earliest telescopes which he thus made, he discovered four satellites revolving round Jupiter, dark and bright spots upon the sun, the phases of Venus, the irregularities of the surface of the moon, and the stellar constitution of the Milky Way. The great book of Copernicus, *De Revolutionibus Orbium Celestium*, had been printed just sixty-six years before, and not a few of the most learned men of the day had accepted it. But the telescopic discoveries brought home the actuality of the Copernican theory to men's minds as no arguments of Copernicus had been able to do. The discovery of a system of four moons revolving round Jupiter was, of course, no disproof of the Ptolemaic theory, nor proof of the Copernican, but it offered so striking an analogy to the solar system as Copernicus had conceived of it, that it did more to convince beholders than much rigid argument.

It is very difficult for us now to appreciate the full difference which these discoveries made to the way in which men regarded the heavenly bodies. They were no longer mere lights, they were great orbs; the sun in particular was seen to be much larger than our earth, which was at once reduced to a position of relative insignificance. But the change in the conception of the true nature of the stars was greater even than in the conception of the sun and planets. Certain

of the ancient astronomers, such as Aristarchus and Hipparchus, had conceived the sun to be distant from us some four or five millions of miles, and Galileo was not able to make any fundamental change in this estimate. But whereas hitherto the stars had simply been supposed to be a little farther off than Saturn, it was now absolutely necessary to admit that they were placed at distances so immense that the earth's change of place from one side of its orbit to the other, supposed at this time to be nearly ten millions of miles, made not the slightest difference to their apparent positions. The distances at which they were supposed to be placed had therefore to be increased indefinitely, whilst the revelations of the telescope had added to their numbers in no less a proportion. The universe had no longer any visible, nor indeed any conceivable, boundary.

Mr. J. J. Fahie's recent and most attractive book, *Galileo: His Life and Work*, shows that the question of the existence of other inhabited worlds was raised immediately upon Galileo's telescopic discoveries becoming known. At first the point was raised in order to disprove his discoveries. Thus, writing to Giacomo Muti from Rome on February 28, 1616, Galileo says:

A few days ago, when paying my respects to the illustrious Cardinal Muti, a discussion arose on the inequalities of the moon's surface. Signor Alessandro Capoano, in order to disprove the fact, argued that if the lunar superficies be unequal and mountainous, one may say as a consequence that, since Nature has made our earth mountainous for the benefit of plants and animals beneficial to man, so on the moon there must be other plants and other animals beneficial to other intellectual creatures. Such a consequence, he said, being most false, therefore the fact from which it is drawn must also be false, therefore lunar mountains do not exist! To this I replied: As to the inequalities of the moon's surface, we have only to look through a telescope to be convinced of their existence; as to the 'consequences,' I said, they are not only not necessary, but absolutely false and impossible, for I was in a position to prove that neither men, nor animals, nor plants, as on this earth, nor anything at all like them, can exist on the moon. . . . On the earth the sun in every twenty-four hours illuminates all parts of its

surface, each half of the moon is alternately in sunshine and darkness for fifteen continuous days of twenty-four hours. Now, if our plants and animals were exposed to ardent sunshine every month for 360 consecutive hours, and then for a similar time were plunged in cold and darkness, they could not possibly preserve themselves, much less produce and multiply. We must therefore conclude that what would be impossible on our earth under the circumstances we have *supposed* to exist, must be impossible on the moon, where these conditions *do* exist.

As regards the habitation of the planets, Galileo refused to say either yes or no, for, just as he was inexorable in putting every statement and theory to the test of observation and experiment if possible, so it was entirely foreign to his custom to theorize where there were no facts to be observed.

In Galileo's great book, *The Dialogue*, which was the cause of his persecutions, he deals in the dialogue of the First Day somewhat at length on the resemblances which exist between the earth and moon and the more distant heavenly bodies. He shows, for example, that not only does the moon shine in virtue of the sunshine falling upon her, but that the earth, Venus, Mercury, and Mars shine in the same manner. All alike have the same spherical form, all have a similar motion round the sun. 'The obvious inference seems to be, that all of these heavenly bodies are not so unlike the earth as men had always been brought to believe. Points of resemblance there certainly are, and there may be many more which the distance of the planets alone prevents us from discovering.'

In view of the sweeping character of the revolution effected three hundred years ago by Galileo, of the entire displacement which he brought about of the earth from the position which it had held in men's minds as the one central body, the one unique body in creation, it is startling at first sight to find the purpose of a serious book just written by a distinguished man of science, to be to demonstrate anew the essentially Ptolemaic proposition that the earth is an absolutely unique body, and practically, if not precisely, at

the very centre of the universe; and further, to find it urged that the entire trend of modern astronomical discovery is in this direction. But, startling as the statement may seem, we have no right on this ground to condemn it. The method of Galileo is the only correct one, to bring every physical theory to the test of observation and experiment. By these it must stand or fall.

Dr. Alfred Russel Wallace's recent book, *Man's Place in the Universe*, in which this very striking theory is set forth, was heralded by two articles in the *Fortnightly Review*; but the second article withdrew so many of the essential points of the first, and the book has taken to so great an extent a different line from either, that the *Review* articles may be considered as having been entirely superseded, and the argument as set forth in the completed volume need alone be considered. Dr. Wallace summarizes his argument under six heads. The first three of these he alleges to be 'the conclusions reached by modern astronomers'; the second three he claims to have enormous probabilities in their favour. They are:

1. That the stellar universe forms one connected whole; and, though of enormous extent, is yet finite, and its extent determinable.
2. That the solar system is situated in the plane of the Milky Way, and not far removed from the centre of that plane. The earth is therefore nearly in the centre of the stellar universe.
3. That this universe consists throughout of the same kinds of matter, and is subjected to the same physical and chemical laws.
4. That no other planet in the solar system than our earth is inhabited or habitable.
5. That the probabilities are almost as great against any other sun possessing inhabited planets.
6. That the nearly central position of our sun is probably a permanent one, and has been specially favourable, perhaps absolutely essential, to life-development on the earth.

Of these six conclusions the third is the most important, though, strictly speaking, it is not a conclusion at all, but an assumption, and an assumption not specially astronomical,

but fundamental to science in general. It is but the expression, in an imperfect and modified form, of the great Law of Causality, and rests, like it, upon purely general considerations.

That law is frequently misunderstood by the general reader, and sometimes misrepresented even by scientific men. The following statement of it, due to Professor T. N. Thiele, the distinguished director of the Copenhagen Observatory, in his recent work on *The Theory of Observations*, sets it forth briefly and clearly:

> We start with the assumption that *everything that exists and everything that happens, exists or happens as a necessary consequence of a previous state of things.* If a state of things is repeated in every detail, it must lead to exactly the same consequences. Any difference between the results of causes that are in part the same must be explainable by some difference in the other part of the causes.
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> This assumption, which may be called the law of causality, cannot be proved, but must be believed, in the same way as we believe the fundamental assumptions of religion, with which it is closely and intimately connected. The law of causality forces itself upon our belief. It may be denied in theory, but not in practice. Any person who denies it, will, if he is watchful enough, catch himself constantly asking himself, if no one else, why *this* has happened, and not *that*. But in that very question he bears witness to the law of causality. If we are consistently to deny the law of causality, we must repudiate all observation, and particularly all prediction based on past experience, as useless and misleading.

Just precisely as we are obliged to assume the law of causality, and as, consciously or unconsciously, we inevitably do assume it, because without it it would be impossible to gain any scientific knowledge, so, when we seek to extend scientific research to extra-terrestrial fields, we are bound to assume the existence there of the same kinds of matter as those with which we are acquainted here, and the action of the same physical and chemical laws. In no other way than by making the assumption could we arrive at any conclusion as to the meaning of what we can see or infer. This assumption is no deduction from the revelations which the

spectroscope has made; rather it preceded and underlay them. And though 'celestial chemistry' has given us the evidence of the existence in sun and stars of hydrogen, calcium, iron, and other elements most familiar to us here, and so may justly be claimed as confirming this deduction, it has none the less given us also the evidence of the existence there of some, possibly many, elements, which we have not yet recognized upon the earth, and which may have no existence here. So too, though our observations of double stars are consistent with the idea that the same law of gravitation which prevails within the solar system is effective with them, Professor S. C. Chandler has not failed to point out that they afford as yet no demonstration that that is the case. So far as our observations go, they are not incompatible with the operation of a law of quite a different character. Preserving, therefore, an open mind for possible modifications of our knowledge, we are undoubtedly right in assuming in the meantime the law of gravitation to be effective throughout the entire universe.

The subject of the first of Dr. Wallace's conclusions is one of immense difficulty, and of equal attractiveness. His own treatment of it is confessedly based upon some studies originally published by Professor Simon Newcomb, the late superintendent of the American Nautical Almanac Office, and more recently completed and issued by him in book form under the title of *The Stars: A Study of the Universe.* Unfortunately, Dr. Wallace took up the subject first, inspired simply by Professor Newcomb's magazine articles, and fell into a serious error, against which Professor Newcomb was careful to guard his readers in his completed volume.

'The problem of the structure and duration of the universe is,' writes Professor Newcomb, 'the most far-reaching with which the mind has to deal.'

Its solution may be regarded as the ultimate object of stellar astronomy, the possibility of reaching which has occupied the minds of thinkers since the beginning of civilization. Before our time the problem could be considered only from the imaginative or the

speculative point of view. Although we can to-day attack it to a limited extent by scientific methods, it must be admitted that we have scarcely taken more than the first step toward the actual solution. We can do little more than state the questions involved, and show what light, if any, science is able to throw upon the possible answers.

Professor Newcomb divides the inquiry into three heads. First, as to the extent of the universe of stars: whether the latter are scattered through infinite space or confined within a limited area, however vast. Secondly, granted the universe to be finite, what is the arrangement of stars in space, and, especially, does the Milky Way form part of one and the same definite structure as the remaining stars? Thirdly, what is the duration of the universe in time? The first and third of these questions are rather metaphysical than physical in character, but there are certain facts which may be adduced with respect to the first.

In Dr. Wallace's first magazine article he urged that, if the stars were infinite in number, then, by the laws of optics, the entire sky should shine as brightly as the sun at noon. The argument was based upon a misreading of Professor Newcomb, and some astronomers pointed out that we had evidence of the existence of dark stars as well as of bright, and that precisely the same line of argument applied to the dark stars would lead to a very different conclusion. The answer as it stood was sufficient for its purpose, for a line of argument cannot be valid which leads to two opposite and mutually exclusive conclusions. But it was further pointed out that it was invalid because it assumed two conditions, neither of which prevailed. It assumed that there was no systematic loss of light in space from any cause whatsoever, such as the imperfect transmission of light by the ether, the absorption of light by cosmical dust, by dark stars and nebulae, and the like. It assumed also that there was no definite structure throughout the sidereal system, but that every region of space of some great but finite extent is, on the average, occupied by at least one star. It is quite conceivable, just as the earth and its moon forms

a little system within the solar system, similar in character to the systems formed by the other planets and their satellites, and these all are separated from each other by spaces that are very great compared with the actual dimensions of each, and as again the solar system is separated from the nearest star by a space which is very great compared with the size of the solar system, that so the sun itself may be a unit in a vast stellar system which may be separated by a space relatively great from other stellar systems of the same order. The possibility of such an arrangement leaves us unable to deal even inferentially with the question as to whether the stars are scattered through infinite space. We can simply deal with the stars which we see, and we may set aside the question of infinity in any sense as wholly outside our resources. Our concern, then, is only with what is directly within our ken, and that, from the nature of the case, is finite; and if we use the term 'universe' in reference to it, it is neither to affirm nor to deny that there may be many similar universes, or even that it may be conceived of as but an item in the structure of some yet more majestic whole.

The problem is therefore reduced to the second of Professor Newcomb's questions: 'What is the arrangement of the stars in space?' And here the attention centres itself at once upon that mysterious form, that unchanging bow in the heavens in monochrome, which we term 'the Milky Way.'

The Milky Way is essentially a naked-eye object. If we turn a telescope upon it, we at once 'lose the wood for the trees.' The more powerful our instrument, the greater the number of glittering points which it reveals to us, the smaller must necessarily be the area of the part of the heavens under our scrutiny, and the cloud-like forms which are so apparent to the naked eye are entirely lost. This being the case, it seems strange, and it certainly is regrettable, that so few astronomers have devoted themselves to the naked-eye study of the Milky Way. The description given by Ptolemy in A.D. 138 still remains one of the best in our possession.

Mr. Easton, one of the highest of our living authorities, declares that it is certainly not inferior to the description by Sir John Herschel. In our own day, however, three men have done excellent work in this direction—Dr. Boeddicker, at Lord Rosse's observatory in Ireland; Mr. Backhouse, at his own observatory in Sunderland; and Mr. Easton, at Rotterdam. The Milky Way, as they have delineated it—that is to say, as it is seen by the naked eye—is an impression due to immense numbers of small stars, so crowded together that the eye is powerless to separate them, and so small that the eye could not perceive them were the individual stars isolated. It is not due in any appreciable degree to the presence of nebulosity. Nebulae are indeed included within it, but one of the brightest of these, the great nebula (called, from its shape, 'The America'), appears to have no effect at all upon the naked-eye drawings. The Galaxy is essentially an accumulation of minute stars.

What is its relation to the other members of the celestial host? Is it a structure apart by itself, or do they and it form portions of the same building?

The answer, suggested in a number of different ways, is distinct. However the heavens have reached their present form, the great majority of the objects which we behold must belong to one and the same structure. The first man to show this was Herbert Spencer. In 1858 he wrote an article in the *Westminster Review*, in which he pointed out that the nebulae were especially clustered in the region of the heavens farthest from the Galactic band. Such an arrangement, he truly said, could not be accidental; the Galaxy and the nebulae must be related phenomena. The thought was carried further by R. A. Proctor, in collaboration with whom the late Mr. Sidney Waters prepared some beautiful charts for the Royal Astronomical Society in 1873, showing the distribution of the nebulae, star-clusters, and lucid stars (that is, stars visible to the naked eye) with reference to the Galaxy. These charts are most striking; the star-clusters crowding along the whole course of the

Galaxy, the nebulae avoiding it as markedly.[1] More recently, the distinguished Italian astronomer, Schiaparelli, has carried out a series of charts showing the distribution of the lucid stars, and he again has been followed by Stratonoff, the director of the Russian Observatory at Tashkent, Turkestan, who has extended the same treatment to the stars down to magnitude 9½, to the bright and faint nebulae, and to the two principal types of stellar spectra. The distribution of nebulae and clusters, first pointed out by Spencer and emphasized by Proctor and Waters, is rendered yet more striking in these charts of Stratonoff.

The charts of Stratonoff dealing with the stars bring a different feature to light. He groups the stars visible to the naked eye in a single chart, and then devotes a separate chart to every half magnitude—that is to say, the stars from magnitude 6 to magnitude 6½ are shown in one chart, from magnitude 6½ to 7 in another; and so on, down to magnitude 9½. The lucid stars cluster towards the Milky Way, but the zone which they most affect is inclined at a very considerable angle to its axis. As we pass to the fainter stars, there is, on the whole, a constantly increasing tendency to conform to Galactic distribution, and the faintest stars shown in Stratonoff's charts most closely correspond to the naked-eye Milky Way. Mr. Easton, by counting the stars in certain restricted areas, has been able to extend this examination from magnitude 9½ to magnitude 14, and he finds that the greater portion of the light of the Milky Way seen by the naked eye is due to stars between the 9th and 12th magnitudes. Just as the Milky Way, therefore, does not owe its form to any considerable extent to the brighter stars, so again it does not to stars of an indefinite degree of faintness, or to stars at an indefinitely great distance.

When we come to the teachings of the spectroscope, the relation of the Milky Way to the rest of the heavens be-

[1] This avoidance of the Galaxy by the 'white nebulae' is denied by Professor Max Wolf, who states that his photographs do not show it. It is undoubtedly strongly marked in charts of the nebulae discovered visually.

comes still further accentuated. The great majority of the stars show spectra which may be broadly classified under two heads: Stars like Sirius and Vega, mostly shining with a somewhat bluish light, and with spectra of great simplicity, in which the lines of hydrogen form the principal feature; and stars like our sun, Arcturus and Capella, somewhat more yellow in tinge, with more complex spectra, in which the lines of many metals are conspicuous. Now, when these two types are separated, as done by Stratonoff, we see clearly that the Sirian stars tend to approximate in their distribution to the neighbourhood of the Galaxy, whilst the solar stars appear to be quite independent of it. But when we come to a small class of faint stars, known from their discoverers as Wolf-Rayet stars, showing some peculiar bright lines, then, with one most significant reservation to be mentioned hereafter, the whole of them are grouped close to the central Galactic circle—its equator, as it is usually termed. Further, when we classify nebulae in the same manner, separating between the nebulae giving bright lines—that is to say, composed of glowing gas—and those giving continuous spectra, the 'white nebulae,' we find that the former are essentially Galactic, the latter essentially extra-Galactic, with the same significant exception as before.

The natural and legitimate inference from these converging indications is, that the Milky Way is not a formation apart from the other objects in the heavens, but that it is essentially a portion of the same structure—a member, if we may so express it, of the same organism, of the same growth. Without being able to decide as to whether all the stars which we see belong to the same community, and reserving the case of the exception already alluded to, we may say that, broadly, the whole of the members of the heavenly host belong to one and the same system. The first of the conclusions, therefore, which Dr. Wallace has laid down as having been reached by modern astronomers, namely, 'that the stellar universe forms one connected whole, and though of enormous extent is yet finite,' is fully warranted. We pass now to consider his second: 'That the

solar system is situated in the plane of the Milky Way, and not far from the centre of that plane. The earth is therefore nearly in the centre of the stellar universe.'

In his first magazine article Dr. Wallace laid great stress on this proposition ; indeed his whole argument then rested on the idea that the sun was precisely in the medial plane of the Milky Way, and at its centre—so precisely at the centre that no other star could enter into competition with it in this respect.

In a rough sense, in a sense quite sufficient for many purposes, it is correct to say that we are in the medial plane of the Galaxy and in its centre. But this is only just in the way that a man living within the four-mile radius from Charing Cross would be justified in speaking of himself as living in the centre of London. A hearer who inferred from this expression that London was a truly circular town, and that the speaker lived in its precise geometrical focus, would be much in error.

So in truth the Milky Way is no such simple structure as Dr. Wallace supposes. An admirable description of its actual form, from the best observations available to us, is given in Mr. Easton's recent monograph, *La Distribution de la Lumière Galactique.* To begin with, the chart which accompanies it shows at once how far from a simple great circle it is, since the line of maximum brightness forms an undulating curve, which finds itself now on one side and now on the other of the great circle which has been assumed as the Galactic equator. Indeed, in one portion of the sky that equator coincides very nearly with the centre of a barren region, the Great Rift, and the Galaxy itself flows on at a considerable distance right and left. Its irregularity of form is great, and this renders any inquiry as to the relative distances of different portions very difficult. But in some extreme cases the evidence is strong. Thus two great regions are marked out as of especial Galactic brilliancy, the one stretching from Monoceros to Capella, the other in the region from Cygnus to Cassiopeia. The former, however, is particularly bare of the brightest stars, and its light is

entirely Galactic; the latter is rich in stars of every rank of magnitude. This is a difference which is explained best by the assumption that the Monoceros region is much more remote than the Cygnus region. Similarly, there is reason to suppose that in the divided portion of the Milky Way, alluded to above, the more southern branch is the more distant. Mr. Easton sums up our present knowledge of the true form of this great structure thus:

La région galactique près de Gamma Cygni forme le noyau d'une énorme agglomération stellaire, centre de courants ou couches composées d'étoiles et amas d'étoiles. Le plus important de ces courants se rapproche le plus du Soleil dans Cepheus, pour se recourber à travers Cassiopeia, en s'éloignant de plus en plus du Soleil, et former ensuite la branche principale de la Voie lactée dans Aquila, Scutum, etc., qui se rattache, en traversant tout l'hémisphère austral, aux condensations stellaires de Monoceros et d'Auriga, entourant ainsi la région de l'espace où se trouve le Soleil.

With an object so irregular, and of which some portions are much more remote from us than others, it becomes impossible for us to speak of our being in its centre except in the loosest manner. But both Stratonoff and Easton have shown that when we are dealing with the distribution of stars, brighter than those which make up the Galaxy, they are situated in zones that are inclined to the Galactic zone, at considerable angles — angles which vary from zone to zone, and deviate most widely from the Galactic equator in the case of the brightest stars. Concerning the latter—the lucid stars, that is to say—Stratonoff further points out that they do not form a great circle; so that, though the sun lies roughly in the central plane of the Milky Way, it does not hold that relation to the nearer zone composed of the lucid stars.

There is one other characteristic of the Milky Way of great importance—the existence in it of 'holes' and 'rifts.' There is but one possible explanation of these, namely, that they indicate regions in the heavens of real sparseness, and their relation to regions of exceptional richness leads us inevitably to the conclusion, upon which Proctor frequently insisted, that the rich regions have been formed at the

expense of the poorer. The Milky Way, then, is as unlike a simple, regular ring as it is possible to conceive. It consists essentially of a number of formations which may fitly be described as actual streams of faint stars—streams which tend to flow together to make yet richer agglomerations, and which by their interlacing are united to form a single structure. This structure, though of dimensions which entirely transcend our power to appreciate, is clearly finite, inasmuch as we are practically able to penetrate deeper into space than its outer boundary, for the stars which principally make up its light are by no means the faintest which the telescope reveals to us. The distance of its inner boundary is still a matter of conjecture. Many attempts have been made to form a rough estimate of it. How uncertain these are may be seen from the fact that they vary from a distance which would be crossed by light in 300 years, i.e. about 1,800 millions of millions of miles, to one about thirty times as great. The lower value seems to me the more probable.

There are two other agglomerations, which, though not in the Milky Way, are of it. These are the two strange objects in the southern sky, known as the Magellanic Clouds. The greater Cloud in particular is distinguished as including within itself objects of all those classes which are most strictly characteristic of the Galaxy. Here are found the Wolf-Rayet stars with gaseous spectra, otherwise absolutely confined to the Milky Way. Here, too, are found both star-clusters and irresolvable nebulae, elsewhere generally antithetical to each other. Here then, if anywhere, we may recognize the presence of Galactic systems other than our own; yet in all probability they are not independent systems, but satellite Galaxies; by-products, possibly, in the evolution of our own.

Dr. Wallace's fourth conclusion—'That no other planet in the solar system than our earth is inhabited or habitable'—leads us to an altogether different class of facts and arguments from those which we have been just considering; and, as we have a right to expect from the pen of one of the most eminent of living biologists, the chapters in Dr. Wallace's book, in which he leads up to this conclusion, are

much the most interesting and convincing. The same subject has been recently treated more from the astronomical point of view, in a charming little book, *Other Worlds*, by one of the most graceful of writers on popular astronomy, Mr. Garrett P. Serviss.

The conditions of habitability were never more happily stated than by a great writer, who himself took no interest in astronomy, and indeed regarded the science with aversion. Ruskin, in his *Modern Painters*, writes:

When the earth had to be prepared for the habitation of man, a veil as it were of intermediate being was spread between him and its darkness; in which were joined, in a subdued measure, the stability and the insensibility of the earth, and the passion and the perishing of mankind.

But the heavens also had to be prepared for his habitation. Between their burning light—their deep vacuity—and man, as between the earth's gloom of iron substance and man, a veil had to be spread of intermediate being,—which should appease the unendurable glory to the level of human feebleness, and sign the changeless motion of the heavens with a semblance of human vicissitude. Between the earth and man arose the leaf. Between the heaven and man came the cloud. His life being partly as the falling leaf, and partly as the flying vapour.

How close to the poetic description the scientific comes, may be judged by a quotation from Mr. Serviss:

On the earth we find animated existence confined to the surface of the crust of the globe, to the lower and denser strata of the atmosphere, and to the film of water that constitutes the ocean. It does not exist in the heart of the rocks forming the body of the planet, nor in the void of space surrounding it outside the atmosphere. As the earth condensed from the original nebula, and cooled and solidified, a certain quantity of matter remained at its surface in the form of free gases and unstable compounds, and, within the narrow precincts where these things were, lying like a thin shell between the huge inert globe of permanently combined elements below, and the equally unchanging realm of the ether above, life, a phenomenon depending upon ceaseless changes, combinations, and recombinations of chemical elements in unstable and temporary union, made its appearance, and there only we find it at the present time.

The application of the principles thus laid down, both by the brilliant writer and the man of science, excludes all the members of the solar system, except the earth and the two neighbouring planets, Mars and Venus, from the category of possible homes of life. For these two Mr. Serviss is inclined to plead, especially for Venus, a planet so nearly like our own in its chief conditions. Dr. Wallace rejects both. For Venus the case turns entirely upon whether we accept or reject Schiaparelli's statement that she always turns the same face to the sun. If this be so, there can be no doubt that life is impossible there. But if not—and the growing opinion of observers is that the atmosphere of Venus is too constantly cloud-laden for us ever to catch a glimpse of her actual surface, and therefore to determine her rotation period—there seems no reason why we should pronounce her necessarily uninhabitable. In that case, however, her actual surface being invisible, the decision, one way or another, would be a mere guess.

Of Mars we know much more; and on that account, no doubt, we are frequently told that, of all the members of the solar system, it most resembles our own earth. But in reality the differences between the two bodies are numerous and important. Mars receives much less of the sun's light and heat; its surface gravity is smaller, causing an altogether different arrangement of the atmosphere, which is evidently very tenuous and almost free from cloud. The question as to whether it has any water on its surface has been disputed, but the probabilities seem to be that it has some, but only in a far smaller proportion than on the earth. Mr. Percival Lowell, the well-known American astronomer, has indeed argued that certain straight lines which have been discerned upon its surface, and to which the name of 'canals' has been given, are actually artificially constructed waterways, and therefore afford a direct evidence of the presence on the planet of intelligent life. But the 'canals' have more recently been shown to be of the nature of an optical illusion, and, with their disproof as objective realities, the serious difficulties which always existed in the way of believing Mars habitable regain their full force.

On the whole, therefore, there can be no serious objection to Dr. Wallace's fourth conclusion, 'That no other planet in the solar system than our earth is inhabited.' When we pass to his fifth—'That the probabilities are almost as great against any other sun possessing inhabited planets'—we enter a region where we have no assured facts really bearing upon the question at issue.

Dr. Wallace attempts to establish this point by seeking to differentiate our sun from the many millions of other suns. This he does in three ways. First, by position; he rejects all stars in or near the Milky Way. Next, by type of spectrum; he excludes all stars not showing the solar type. Third, our sun being a solitary star, he decides that life could not arise on the planets of binary or multiple systems.

There is some slight plausibility about the first point. The complicated structure of the Milky Way, presenting as it does rich streams which have apparently been formed by the drainage of neighbouring space, gives the impression that it is in a state of flux; that it has developed from a different arrangement, the form of which we cannot infer, and is in the process of change into further and diverse forms, which we are unable to forecast. It is conceivable that this flux may be proceeding too rapidly to allow the development of intelligent life within the Galactic regions.

But when we come to the question of type of spectrum, no real reason can be alleged why life should be impossible in a system of the Sirian type; for, though stars of this class are generally supposed to be in an earlier stage of development than our sun, thousands of them must in absolute time be of as great age. Moreover, since Dr. Wallace follows the doctrine held by Sir Norman Lockyer and others (a doctrine which I do not myself hold) that the sole cause of difference of spectrum type is the stage of development of the star, he should allow that all stars like our sun in spectrum should have been in a stable condition for a sufficiently long time, for at least one attendant planet in each case to have become the home of life. And, as we know nothing whatsoever of the internal economy of binary sys-

tems, Dr. Wallace is speaking entirely without book when he decides that life-bearing planets cannot be present in such.

His last conclusion—'That the nearly central position of our sun is probably a permanent one'—is against all the evidence we possess. The evidence for the actuality of the sun's motion in space at the fairly rapid pace of about 12½ miles a second, is derived from two entirely independent methods, and cannot be easily set aside. Whether it is orbital or in a straight line, we have at present no direct means for deciding. If in a straight line, the motion is swift enough to have carried us right across the enormous void enclosed by the Galaxy in a fraction of the time demanded by geologists for organic life upon this earth.

Dr. Wallace's process of thought would seem to have actually been in precisely the opposite direction to that in which he seeks to lead his readers. He would seem to have been troubled, as many another pious mind has been, by the discrepancy between the relative insignificance of this little world amidst the unfathomable glories of creation, and the fact that it has been chosen of God to be the scene of the stupendous and adorable mystery of the Incarnation of His Only Begotten Son. And, desiring as it were to make it a worthier resting-place for Him (who yet disdained not to be born in a stable), he has tried to invest it with a certain material pre-eminence over all the countless other spheres of space. Under the influence of this desire, he has read in to not a few astronomical facts the very inference which he would derive from them. And so, in the prosecution of what we may term a neo-Ptolemaic theory, he has taken up an attitude not unlike some of those against whom Galileo contended. In the celebrated Third Day of the *Dialogue* the Ptolemaist, Simplicio, speaks, and the Copernican, Salviati, answers him:

SIMPLICIO—'All this is very well, and it is not to be denied that the heavens may surpass in extent the capacity of our imaginations, nor that God might have created them a thousand times larger than they are. But we ought not to admit anything to be created in vain, or useless in the universe. Now we see this

beautiful arrangement of the planets, disposed round the earth at distances proportioned to the effects that they are to produce on us for our benefit. To what purpose, then, should such a vast vacancy be afterwards interposed between the orbit of Saturn and the starry spheres, containing not a single star, and altogether useless and unprofitable? to what end? and for what use and advantage?'

SALVIATI—'Methinks we arrogate too much to ourselves, Simplicio, when we assume that the care of us alone is the adequate and sufficient work and limit, beyond which the divine wisdom and power do nothing and dispose of nothing. I feel confident that nothing is omitted by God's providence which concerns the government of human affairs; but that there may not be other things in the universe dependent on His supreme power, I cannot, with what power of reasoning I possess, bring myself to believe.'

I do not know whether it is straining too far that beautiful and familiar parable of our Lord, told in the first verses of the fifteenth chapter of St. Luke, to apply it to the present question; but there is no hint given there that the sheep for which the shepherd went so far was in aught distinguished or pre-eminent amongst the flock; still less that it was the only one. There were ninety and nine that he did not seek. In one thing, and in one only, was that sheep different from all the rest. It was lost.

Astronomy, then, is powerless—at any rate at present—to reply one way or the other to the question, 'Is this earth of ours the only home of intelligent life?' But if it were otherwise, or if with increase of knowledge it should become otherwise, and we could say assuredly that this earth was but one, and the smallest, most insignificant, of tens of thousands of worlds teeming with life and intelligence, what then? Is it not God's way and will to choose the weak things, and things which are despised, and was not it written of old by the prophet Micah:

> But thou, Beth-lehem Ephrathah, which art little to be among the thousands of Judah, out of thee shall One come forth unto Me that is to be ruler in Israel; whose goings forth are from of old, from everlasting.

E. WALTER MAUNDER.