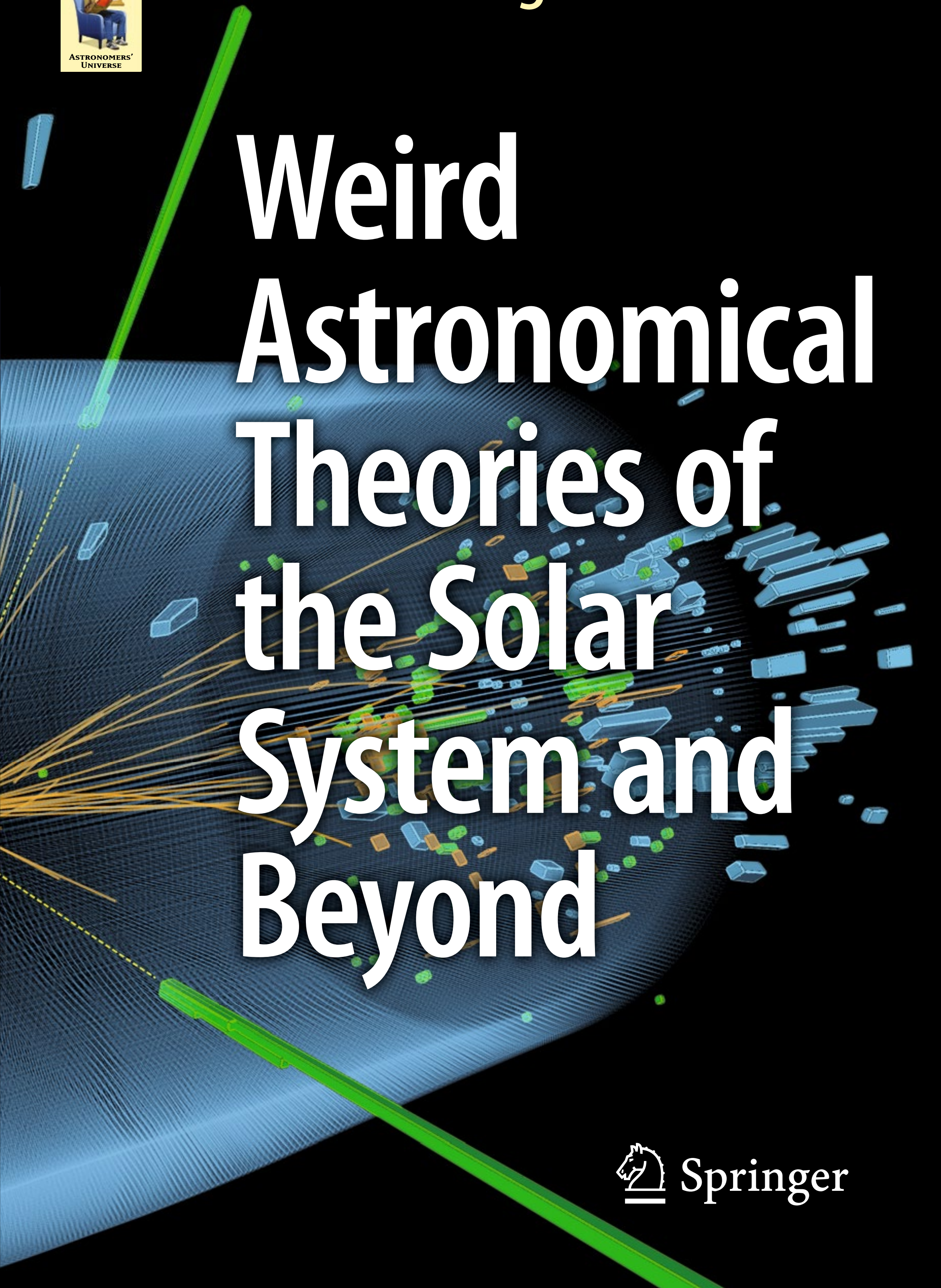
Astronomers' Universe

David Seargent

Weird Astronomical Theories of the Solar System and Beyond



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For Meg

Preface

As the title of my previous book *Weird Universe* demonstrates, our cosmic home is a strange place. The human mind, accustomed as it is to understanding our familiar surroundings, sets out on an adventure every time it tries to comprehend the broader picture, the wonderful wider universe that is our ultimate physical environment. Here common sense goes out the window! Ideas which seem strange—which *are* strange—are often the only ones that in the end make sense of what our observations and experiments reveal. As Professor Max Tegmark wisely counseled, we should not dismiss theories just because they seem weird to us, lest we dismiss something that would prove to be a real breakthrough in our understanding of nature. Tegmark was speaking specifically about the elusive Theory of Everything when he made this remark, but his statement remains true for lesser theories as well and should be remembered whenever astronomical and cosmological speculations start to look more like science fiction than what we might normally think of as sober fact.

Nevertheless, there is another side to this as well. Just because a theory is strange does not *necessarily* mean that it is on the right track. To assume this would be to go too far in the direction away from common sense. First of all, there are the truly "crackpot" ideas which diverge so far from the overall corpus of scientific discoveries as to be ruled out immediately. What person having even a rudimentary degree of scientific literacy could accept, for example, the "cosmology" of Cyrus Teed who taught that the Earth is hollow and that we live on the inside? Yet, other ideas cannot so readily be dismissed and it is not always easy to know where to draw the line between genuinely crazy theories and those which only superficially appear so because of their counterintuitive nature. This was summed up by the scientist who wondered if physicists living a century from now will look back on some of the leading ideas in contemporary physics and be impressed by the insight of today's scientists or whether they will instead ask what these folk were smoking in the early twenty-first century! Which contemporary theories seem weird because of their deep and counterintuitive insights, and which are truly outlandish?

In this book, we journey through several hypotheses which, for one reason or another, seem strange, out of the mainstream or counterintuitive. Some of these have already been proven incorrect through the accumulation of observational evidence acquired since they were initially put forward. Others remain controversial while still others are widely accepted by mainstream science even though the jury is still out concerning their validity.

Truly crackpot ideas are not, however, included here. All of the hypotheses discussed in the following chapters were at one time put forward as serious explanations for certain astronomical observations by people with credible scientific qualifications. In the majority of instances, the originators of these theories were leading scientists and experts in their field of study. As such, their ideas are not to be lightly dismissed. Even those hypotheses which have subsequently been demonstrated as being incorrect remain valuable. They not infrequently contain an element of truth which may not otherwise have been considered and, additionally, they forced others in the field to take notice of new ideas and approaches which might have been overlooked had no such challenge been presented. The more radical ideas of Fred Hoyle are acknowledged to have exercised precisely this effect—the challenge to "prove Fred wrong" provided the stimulus for quite a deal of research. Even if they serve no other purpose, theories from outside the mainstream at least force us to keep our minds open.

Cowra, NSW, Australia David A.J. Seargent

The point is that if we dismiss seemingly weird theories out of hand, we risk dismissing the correct theory … (Professor Max Tegmark).

Acknowledgments

My thanks are extended to the staff of Springer Publishing, especially to Ms. Maury Solomon for encouraging me to consider a book on the "weirder" astronomical theories and to Ms. Nora Rawn for her encouragement and guidance in bringing it to publication. I would also like to offer special thanks to Mr. Michael Mattiazo for his permission to use his image of Comet Finlay. My thanks are likewise extended to Professor Hans Pflug for sending me copies of his transmission electron microscope images of organic structures found within the Murchison meteorite and for providing me with information to which I would not otherwise have had access. My contact with Professor Pflug took place more years ago than I would like to admit, at a time when I was researching the circumstances surrounding the fall of this meteorite. Unfortunately, I no longer know of his whereabouts, but I am most grateful for his assistance back then and for the opportunity to use some of the provided material in this present work. I would also like to thank my wife Meg for her continuing support and for all who have contributed in any way to the preparation of this book.

Last, but by no means least, I would like to acknowledge the courage of all those throughout the years who have gone against the prevailing tide of opinion and put forward "weird" ideas as to the nature of the universe or of some of its constituent objects. Whether these ideas have turned out to be correct (as some have) or whether they have eventually been disproven, they have all served to stimulate further thought and in that way at the very least, have made genuine contributions to our understanding of nature. For that, we can all be thankful.

Contents

1 Is There a Cosmic Web of Life?

If the advance in astronomical knowledge acquired during the course of recent decades has taught us anything at all, it is surely the undeniable fact that we are an integral part of the universe. We are not isolated from the stars and the galaxies. We might even grudgingly admit that the astrologers got it a little bit right after all, though not in the manner that they would have us believe. The position of the constellations and the planets at our birth might not determine whether we will be happy and outgoing or moody and a general pain to work with, but the nature of the universe at large played a very large part in you and I being here at all. The picture that has emerged from relatively recent astronomical research is one in which the entire cosmic environment has played and continues to play a vital and indeed determining role in the existence of life here on Earth. The nature of our home planet, our home star, our location in a relatively quiescent region of our home galaxy and even the immediate cosmic environment of this galaxy itself (viz. its location in a small galaxy group rather than a large galaxy cluster where collisions between major systems tend to strip these of the interstellar material so important to maintain a healthy rate of star formation and to ensure plenty of material for the accumulation of planetary companions of new stars) all conspire to secure our home in the universe.

But what of life itself? Does the universe connect with life on Earth in ways beyond "just" determining the suitability of its terrestrial home? Could life itself have a cosmic connection? Some daring scientific thinkers theorize that indeed it could!

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The Panspermia Hypothesis

Early last century, in 1903 to be more exact, Swedish physicist and founder of physical chemistry, Svante Arrhenius (1859–1927) put forward the radical hypothesis that life is indeed cosmic. He theorized that the seeds of life are carried through space, taking root on any suitable planet upon which they might land. Like grass seed carried in a prairie wind, the germs of life distribute through the universe. Actually, Arrhenius was not really the first to come up with this proposal. As long ago as the fifth century BC, the Greek philosopher Anaxagoras mentioned the idea in his writings, as did the more recent thinkers J.J. Berzelius (in 1834), H.B. Richter (1865) and H. Von Helmholtz in 1879. However, it was through the developed formulation of Arrhenius that the idea truly blossomed into a scientific hypothesis, known as *panspermia* (Fig. 1.1).

This blossoming came forth in Arrhenius' article *The Distribution of Life in Space*, published in 1903, in which he argued that microscopic organisms are theoretically capable of being transported through space by the pressure of stellar radia-

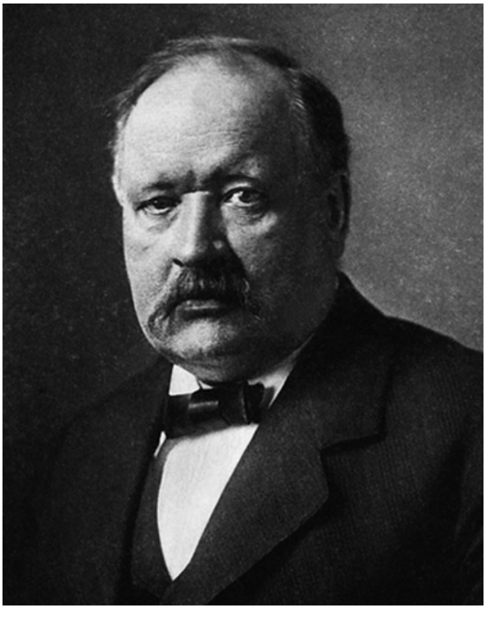

Fig. 1.1 Svante Arrhenius circa 1910 (*Courtesy*: German Wikipedia)

tion. The existence of radiation pressure and its ability to transport very small particles is well established. The anti-solar dust tails of comets and the clearing of star-forming nebula in the near vicinity of bright young stars are proof enough of that, so the basis of the hypothesis rests squarely on good science. Arrhenius argued that particles smaller than 1.5 μm in diameter would be susceptible to this pressure and could be accelerated to high speeds away from the Sun or similar stars. Larger particles are less affected however, so the process could only work for the smallest biological entities. Nevertheless, as bacterial spore fall within the acceptable size limit, and as these can be wafted high into the atmosphere of Earth, it seems reasonable to expect that a certain percentage of these spore could be blown away from the upper atmosphere by the pressure of sunlight and accelerated through the surrounding void of outer space.

Of course, what applies to Earth presumably applies to any life bearing planet. In effect, a planet rich in bacterial life could be thought of as possessing what we might call a "bacterial tail": a plume of spore sweeping away from the planet in a direction opposite to that of the central star. Any planet orbiting outside of the biologically active one would (other things, such as orbital inclination, being equal) periodically pass through this tail, at each passage sweeping up some of the spore which would then filter slowly down through its atmosphere, eventually settling on the planetary surface. Assuming that conditions on that surface were not too hostile, some of these spores might survive and multiply, eventually resulting in a flowering of life on that planet. Eventually, presumably after the passage of many millions of years, the seeded planet would have developed such a teeming biosphere that it would be shedding its own microorganism spore into space—maybe seeding another world beyond its orbit. In this way, as science writer Poul Anderson long ago remarked, a single original life-bearing planet could theoretically seed an entire galaxy. All that is needed is plenty of time and the ability of a percentage of dormant microbial spores to survive the rigors of space for eons of time while remaining capable of revival upon reaching a friendly environment.

Time is something that the universe has in abundance, but the ability of spore to remain viable over the required periods of time, especially considering the constant exposure to cosmic radiation and the other hazards of space, is certainly questionable. The reaction of most scientists was one of strong doubt that bacterial spore could make the journey from one planet to the next without suffering fatal damage to their DNA. So, while it is probably quite widely agreed that spore are indeed wafted into outer space from the upper atmospheres of Earth and other biologically active planets, the general consensus of opinion has traditionally been skeptical that any of these organisms could survive long enough in the space environment to allow this form of panspermia (now known as *radiopanspermia*) to work.

Some critics also raised the objection that the hypothesis does not account for the original genesis of life. Actually, given the belief in eternal matter and the sort of steady state universe prevalent in Arrhenius' day, it might then have seemed legitimate to suggest that life never had a beginning. Like the universe itself, it has always been here! Such an escape route is not available nowadays, in view of Big Bang, cosmic inflation and such like.

Also, for the hypothesis to be capable of accounting for life on Earth, it must assume a biologically active Venus. If Earth picked up spores on their journey away from the Sun, they could only have come from Venus or Mercury (or from comets and Sun-approaching asteroids, but that hypothesis is a later addition to the original). Mercury does not appear a likely source and, in any case, transportation from there would involve a longer trip and a consequent multiplication of the dangers encountered along the way.

Another difficulty is raised by the fact that radiopanspermia relies on the repulsive force of stellar radiation. This means that it is not a good way of accounting for life on any Earthlike inner planet of any Solar System. Planets such as Earth—traditionally considered to be the most likely places where life might be found (not surprisingly—after all, we are here!)—exist in regions where the pressure of stellar radiation is quite strong. Therefore, one would expect bacterial spore to be blown away from those planets deemed to be the potentially most life-friendly.

Radiation pressure is not, however, the only way that we can imagine life to be distributed through space. Another and somewhat more promising means of cosmological transportation makes use of the inside of boulders several meters in diameter. This form of the hypothesis is known as *lithopanspermia* and it solves in one fell swoop several of the difficulties faced by the earlier model.

For a start, rocks do not depend on the acceleration acquired from stellar radiation pressure. A rock can wander through space along a wide variety of orbits. It can venture close to a star; even falling into it if the periastron of its orbit has been reduced to a distance from the center of gravity of its system smaller than the radius of that system's central star. Not a happy outcome for the rock, but at least it could accomplish something that naked bacterial spore driven outward by the pressure of radiation could not.

A less extreme accomplishment would be for the rock to collide with one of the inner planets. If that planet possessed an atmosphere worthy of the name and if the rock was large enough, strong enough and hit the planet's atmosphere with a sufficiently low velocity, some fragments of its inner parts could survive to the surface. Of course, this is happening all the time on Earth. We call those fragments meteorites. Moreover, we know from experience that, although the flight through Earth's atmosphere raises the temperature of the surface of a space rock to incandescence, the flight itself is too brief for the heat to penetrate very far beneath the surface and therefore the interior of a rock of sufficient size remains cold throughout the entire atmospheric trajectory. Contrary to what is popularly thought, meteorite fragments are not "red-hot and glowing" when they fall. Those with a high metal content might, for a short while, be too hot to hold but the more common stony kind have temperatures ranging from pleasantly warm to freezing cold. After all, it is not unheard of for a meteorite, even one falling to Earth on a hot day, to be coated with a layer of frost.

If certain meteorites really do harbor bacterial spore, these will be shielded from cosmic radiation by the meteorite's rocky body in a way that naked spore open to the rigors of space will not be. A few meters of rock lying between the spore and outer space can do wonders for the former's survivability.

While we have been talking about "spore", it is not entirely beyond the bounds of possibility that actual functioning organisms could be transported between worlds in this way. Although microorganisms requiring air and/or sunlight are ruled out, something resembling the very slow-metabolic *bacillus infernus*, an organism which flourishes deep within the crust of our planet, might well remain active during a long trip deep within a space rock.

Some More Exotic Versions of the Hypothesis

The very idea of panspermia might seem pretty weird to most folk, but some versions of the idea are really out of the left field.

Perhaps spore is being transported through space within something more sophisticated than a lump of rock. The possibility of bacterial spore remaining viable is something taken seriously by those designing our space probes and planning missions to other planets. We certainly don't want to contaminate other worlds with Earth bugs. But what if ancient Earth had long ago been visited by an alien probe from a civilization that was not so careful? What if this probe landed on Earth about four billion years ago? Indeed, what if an occupied spaceship set down on this planet soon after its formation and accidentally left some bacterial spore behind? Could that act of carelessness have been responsible for life on our planet?

Although this hypothesis is highly improbable and is, in any case, almost impossible to verify or falsify, it was put forward as a serious suggestion by the well-known astronomer and cosmologist Thomas Gold back in 1960. Gold probably did not believe it, but he apparently considered it worthy of mention as a possibility.

An even more daring suggestion was made by none other than Francis Crick, co-discoverer of the double helix, for which he won the 1962 Nobel Prize for Physiology or Medicine together with his colleagues James Watson and Maurice Wilkins. Together with Leslie Orgel, Crick proposed that life on Earth may have been purposively planted here by an advanced extraterrestrial civilization. One version of this *directed panspermia* hypothesis proposes that an advanced civilization might direct capsules containing life seeds toward regions where new stars are forming. By the time these capsules reach their destination, planets should have formed around many of these young stars and at least a few of these might act as fertile fields in which the microbial passengers carried by the capsules could take root.

While this hypothesis might make a good theme for a science fiction novel, in reality it is seriously lacking in evidence. Indeed, one might suppose that if the sort of super civilization hypothesized here existed within our galaxy, there should be some other evidence of its presence. Assuming that the civilization that seeded Earth continues to exist, may we not see evidence of galactic engineering, or structures within the galaxy that defy explanation in purely natural terms? Pulsars were once thought to be beacons constructed by a highly advanced civilization and designed to act in the manner of interstellar lighthouses before these became known to have formed purely by physical processes. Of course, one could argue that the hypothetical civilization that seeded our world became extinct sometime after this event. Maybe its desire to send the seeds of life into space was a sign that it was already dying and that this project was a way of perpetuating a biological future for the Galaxy. One would like to think, however, that a civilization so advanced could find some other way of perpetuating its existence.

Be that as it may, this hypothesis strikes a difficulty in the form of galactic evolution. Galaxies are not static systems. Generations of stars are born and die within them and each generation leaves its special legacy in the form of increasing amounts of heavy elements (traditionally but rather inaccurately termed "metals" by astronomers) within the interstellar medium. As it is from this medium that new generations of stars are formed, it is inevitable that each succeeding generation of stars contains an increasing proportion of these heavier elements; ashes, so to speak, of their predecessors. Although not constant across a galaxy, the general evolutionary trend is for galaxies to increase in metallicity over cosmic time. Because living organisms require a relatively high concentration of heavy elements in their environment, a galaxy does not become life-friendly until it reaches a certain state of development. Our home galaxy obviously reached that stage about 4.6 billion years ago when the Sun was formed. Or at least, based on the very existence of life on Earth, the part of the Galaxy in which the Sun formed had then reached that stage of metal enrichment. However, the Sun appears to be a little more enriched with metals than most stars of its age and type, so there is reason to think that its galactic nursery was somewhat ahead of the average in its holdings of life-friendly elements. In short, the Sun (and with it of course, the Earth) was an early starter in the race toward life friendliness. That does not preclude the possibility of life-bearing planets older than Earth or, for that matter, of civilizations older than ours. We are not constrained to believe that our Solar System was the *very* first to possess a life-friendly metallicity. But it does cast doubt upon the existence of a civilization of such great age as to be capable of bio-engineering the Galaxy at the time the Sun was just forming.

The main difficulties with the directed panspermia hypothesis, and indeed with any form of panspermia are the twin problems of lack of evidence for the existence of advanced life (or, for that matter, any life) beyond Earth and the fact that the hypothesis does not provide an explanation as to how life started in the first place. Even if the theory proved to be correct, it does not tell us how life first appeared in the universe. As mentioned earlier, only if life is eternal in a steady state universe could panspermia be considered complete in any sense. But that possibility is, as already noted, precluded by those cosmologies supported by the weight of contemporary evidence.

"Soft" Panspermia

Whether in its moderate or more adventurous forms, panspermia in the sense of the word which we have been using here, does not win many adherents amongst scientists. The possibility of dormant organisms being wafted from one planet to the next or being carried within meteorites is not rejected, but it is fair to say that the majority of scientists working on the issues surrounding biogenesis do not see this as a major process. If it does really happen, it is a secondary rather than a primary consideration in the opinion of most workers in the field. The principal exception to this line of thinking is Chandra Wickramasinghe and, previously, Fred Hoyle, about whom more will be said later in this chapter.

For the present however, let's look at a very modified version of the hypothesis sometimes called *pseudo panspermia* or, alternatively, soft panspermia. In contrast with the varying versions of hard panspermia considered thus far, this hypothesis does not propose that life itself was transported from elsewhere to Earth, or to any other life-bearing world that may exist. Life per se is indigenous to the planet on which it flourishes. What is transported from elsewhere is not the organisms themselves but the chemical compounds of which these organisms are composed. Proto-life chemistry, not life itself, is brought from somewhere else according to the soft form of the panspermia hypothesis.

While this hypothesis does not explain the origin of life, it does show why the necessary chemicals existed on the early Earth. The existence of so-called organic compounds on the early Earth became a problem as continued examination of the most ancient rocks failed to reveal the sort of reducing atmosphere that had previously been thought to surround our planet in its infancy. If, as widely thought until the latter years of last century, the atmosphere of our planet circa four billion years ago consisted of such gases as methane and ammonia mixed together with hydrogen, the presence of complex organic molecules presented no problem. In 1953, the famous Urey-Miller experiment, in which electric sparks were fired through a mixture of methane, ammonia and hydrogen within a flask containing water, clearly demonstrated that organic molecules were readily synthesized in this environment. If the gas mixture in their experiment matched that of the early terrestrial atmosphere, lightning and ultraviolet radiation from the Sun must surely have synthesized a great deal of organic material. Washed down into the ancient lakes and oceans, this organic soup seemed the perfect place for life to find its toehold.

The only problem with this promising hypothesis was the complete failure to find any evidence that the most ancient rocks were ever exposed to such an atmosphere. On the contrary, all evidence pointed in the opposite direction. The early atmosphere was at most neutral; possibly weakly oxidizing. Under conditions such as these, organic compounds simply could not form, no matter how much ultraviolet radiation streamed from the Sun and how much lightning flashed through the skies. Following this line of reasoning implies that Earth should be devoid of organic compounds; a striking contradiction to the facts on any assessment.

Perhaps therefore this planet's stock of organic compounds—the chemical precursors of living organisms—did arrive here from outer space. Superficially, this sounds a tad farfetched, but evidence in its favor has been steadily accumulating over the years. Much of this evidence has come in the form of organic substances found in meteorites, especially (though not exclusively) in members of that class of stony meteorites known as carbonaceous chondrites. Some surprisingly complex, not to say biologically significant, compounds have been extracted from meteorites of this class, but a perpetual difficulty that has haunted this research is the matter of distinguishing between those compounds that are indigenous to the meteorite and terrestrial material which has contaminated the stone after it reached the ground or even managed to get drawn into the object as it plummeted through the atmosphere. One problem is that the biologically most interesting meteorites are quite porous. In space, these pores are, of course, vacuous but once Earth's atmosphere is entered, air is drawn into them and anything which might be floating around in the air gets dragged in as well.

Fortunately, terrestrial organic material shows a specific ratio of carbon isotopes and in 2008, analysis of organic compounds extracted from fragments of the Murchison meteorite—a carbonaceous chondrite that fell in Australia in 1969—revealed a different and entirely non-terrestrial isotope ratio. This is strong evidence that these compounds at least are not contaminants. And they make an interesting group: amongst the compounds identified in this meteorite are the biologically relevant molecules uracil and xanthine. The first of these is an RNA nucleobase (Fig. 1.2).

Equally as remarkable was the identification, announced the following year, of the amino acid glycine in dust particles collected from the coma of comet 81P/Wild 2 in January 2004 and subsequently returned to Earth.

More recent discoveries include the discovery of complex organic matter in cosmic dust and, in 2012, the detection of the sugar molecule glycolaldehyde in the infrared source *IRAS 16293-2422*, a protostellar binary some 400 light years away. This molecule is required for the synthesis of RNA. Then, in 2013, the Atacama Large Millimeter Array confirmed the presence of a pair of prebiotic compounds, cyanomethanimine and ethanamine in a molecular cloud 25,000 light years from Earth. The first of these is thought to be a precursor to adenine, one of the four nucleobases forming the rungs in the ladder-like structure of the DNA molecule, while the second is believed to be of importance in the formation of the amino acid alanine. It now seems that perhaps one fifth of the universe's stock of carbon is in the form of rather complex organic materials, many of which are of great biological interest.

Fig. 1.2 A fragment of the Murchison Meteorite (*Courtesy*: Museum of Natural History, Washington)

Many of these organic molecules form on the surfaces of cosmic dust particles; the same types of particles which snowball together to form the boulder-sized bodies which constitute an early step in the process of planet formation. Perhaps the "sticky" coating of organic molecules plays an important role in causing these particles to stick together and in this way directly aids in the process of planet building. Furthermore, although the heat and compression of a newly formed planet must destroy such complex molecular structures, there is no reason to think that smaller planetesimals will not preserve these compounds. In fact, the conditions inside a planetesimal large enough to generate sufficient heat to melt ice but too cool to destroy organic substances may give rise to some very interesting organic chemistry indeed, but more about this in a little while. For the present, let us just consider how the influx into the Earth's early atmosphere of dust coated with organic substances and the sporadic arrival of organic-rich meteorites such as carbonaceous chondrites could have enriched our planet with loads of material from which the chemistry of life arose. Although it may have once appeared to be such, this scenario is no longer seen as being a weird hypothesis. We may or may not wish to include it under the umbrella of panspermia, but it certainly does not look eccentric in the light of present knowledge.

Slightly Harder Panspermia

Analysis by David Deamer and colleagues of some of the organic molecules retrieved from the Murchison meteorite revealed one particular specimen that held great interest, not merely because of its complexity but also because of its behavior when introduced to water. The molecule consisted of a long chain whose individual links could be regarded as simpler organic molecules having differing characteristics. Some of these are hydrophilic (literally water loving) while others are hydrophobic (literally water fearing or water hating). When this molecule is brought into contact with liquid water, its hydrophilic segments are attracted to the water molecules while its hydrophobic segments are repelled by them. The result is that the long chain molecule rolls itself into a ball having the hydrophilic segments on the outside, in contact with the water, and the hydrophobic segments on the inside sheltering, so to speak, from the water behind the protective wall of the former. This arrangement forms a bilaminar barrier between the inside of the globule and the surrounding water. Bilaminar globules tend to permit molecules to pass through into their centers where they can concentrate and react further with one other, building into larger molecules of even greater complexity. To this degree, they act a lot like very, very, simple biological cells. The intriguing question is whether these are in some way the precursors to true biological cells. Is it possible that, by concentrating molecules into the centers of these globules, eventually self-replicating nucleic acids emerged within them, transforming them from being mere globules into genuine biological cells, albeit ones of extreme simplicity?

The situation is, no doubt, a lot more complex than this, but there may be evidence that cell-like vesicles were indeed present in the parent bodies of at least some carbonaceous meteorites. Back in the 1980s, Professor H-D Pflug examined fine sections of the carbonaceous meteorites Murchison, Orguil and Allende with a transmission electron microscope and found that a significant percentage of the organic material within these bodies was in the form of tiny structures having a variety of morphologies. These structures were of micron dimensions and smaller and constituted such a large part of the carbonaceous material that contamination could effectively be ruled out. After all, the structures were literally like nothing on Earth; nothing, at least in that size range although some of them bore superficial resemblance to iron-oxidizing bacteria, albeit about an order of magnitude smaller (Fig. 1.3).

Intriguingly, many of the structures appeared to be just like tiny cells and even showed evidence of the sort of bilaminar membranes about which we have been speaking. Just as intriguing is the evidence that these were not static objects; some of them apparently multiplied. This is strongly hinted at by the colonies of cell-like structures and the appearance of what seem to be "buds" on the side of some of the isolated cells. If these features are what they appear to be, it would seem that the cell-like structures absorbed

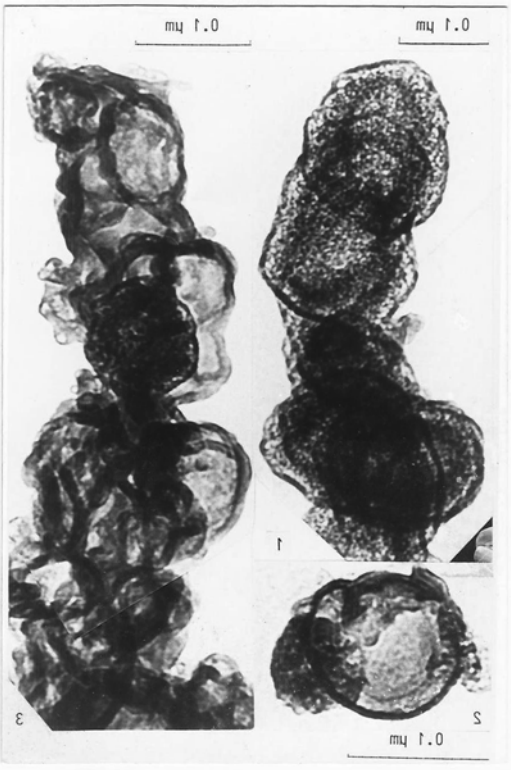

Fig. 1.3 Chain of microvesicles in Murchison Meteorite (Transmission electron microscope image. *Courtesy*: H-D Pflug)

material from their surroundings and reproduced by budding into colonies. Even if they did not possess any genetic coding, this process at least resembles the growth and multiplication of very simple living organisms. Is it possible that some of these cells (Pflug termed them microvesicles, a somewhat less contentious term) might have ended up absorbing some of the biologically interesting compounds mentioned earlier, the ones which now form part of protein or nucleic acid molecules, and brought them into a greater degree of contact than they would have experienced had they simply floated around free in a more or less dilute aqueous solution? This probably did not happen within the body of the meteorite parent itself or else true cells, not merely microvesicles, would presumably have been found within the meteorite fragments. Although some would dispute this statement and insist that genuine cells have indeed been found in meteorites, the more cautious approach favors the process taking place after the meteorites arrived at the surface of Earth or another planet. According to this line of thinking, very early in the life of the Solar System, some of the carbonaceous meteorites may still have been sufficiently fresh to contain viable microvesicles or even a certain amount of liquid within their pores. If these came down in a suitable environment, the vesicles might have continued multiplying and developing in their new home. One might even speculate that the best place for such an active-microvesicle-carrying meteorite fragment to land was in a pond of water already thick with organic molecules supplied by the general rain of such substances from the incessant bombardment by meteorites and cosmic dust experienced by the inner planets during the turbulent infancy of the Solar System. In short, the food for the microvesicles was already there awaiting their arrival; food already delivered by other meteoritic suppliers.

Are We Martians?

Although most meteorites are believed to come from asteroids, some are also known to have originated on the moon and Mars. One originating on the latter world, discovered during an expedition in 2009/2010, proved of special interest. A vein of clay within the meteorite was found, by biologist James Stephenson