A R T I C L E

.1

Macro-Perspectives beyond the World System

Joseph Voros
Swinburne University of Technology
Australia

Abstract

This paper continues a discussion begun in an earlier article on nesting macro-social perspectives to also consider and explore macro-perspectives beyond the level of the current world system and what insights they might reveal for the future of humankind.

Key words: Macrohistory, Human expansion into space, Extra-terrestrial civilisations

Introduction

This paper continues a train of thought begun in an earlier paper (Voros 2006) where an approach to macro-social analysis based on the idea of "nesting" social-analytical perspectives was described and demonstrated (the essence of which, for convenience, is briefly summarised here).

In that paper, essential use was made of a typology of social-analytical perspectives proposed by Johan Galtung (1997b), who suggested that human systems could be viewed or studied at three main levels of analysis: the level of the *individual person*; the level of *social systems*; and the level of *world systems*. Distinctions can be made between different foci of study. The focus may be on the stages and causes of change *through time* (termed *diachronic*), or it could be *at some specific point in time* (termed *synchronic*). As well, the focus may be on a *specific single case* (termed *idiographic*), in contrast to seeking regularities, *patterns*, *or generalised "laws"* (termed *nomothetic*). In this way, there are four main types of perspectives found at any particular level of analysis. This conception is shown here in slightly adapted form in Table 1.[1]

Table 1: Three Levels of Social Analysis

		Synchronic	Diachronic
Level 1. Person systems	**Idiographic**	Interviews	Biography
	Nomothetic	Psychology	Microhistory, genetic psychology
Level 2. Social systems	**Idiographic**	Anthropology	History
	Nomothetic	Sociology, economics, political science	Social macrohistory
Level 3. World systems	**Idiographic**	Yearbooks	World system history
	Nomothetic	International relations	World macrohistory

Source: Adapted from Galtung (1997b).

The earlier paper initially examined some of the ways in which different models and perspectives could be used in a "nested" manner in order to generate deeper insights for use in social, strategic or policy analysis. The approach was then demonstrated by sketching the application of the method using a variety of perspectives, mostly at the world system level (i.e., Level 3), as well as mentioning a few perspectives on social macrohistory (Level 2, nomothetic-diachronic). Thus, the earlier discussion dealt with a single world (ours) as its focus of interest, and the world system level was taken as the endpoint of the discussion. The approach described there was an attempt to bring together into a unified technique the four main kinds of perspectives present at any level of analysis in Galtung's framework – as seen in Table 1 – and considered the concerted use of these different types of perspectives, as well as different modes of generalisation, both within and across levels of analysis. While that paper was not solely about macrohistory as such, nonetheless the use of macrohistorical perspectives was one key element of the overall analytical method. Toward the end of that paper, we noted an observation of Galtung's that, with respect to the world system level of analysis (i.e., Level 3):

> *The macrohistorical approach also makes sense beyond this. Imagine if we discovered other worlds with historical processes. We could then move up one level and write an interworld history as raw material for a macrohistory of interplanetary or even intergalactic systems, incorporating biological and physical systems, and their rhythms (1997b: 3).*

This observation thereby invited our thinking to consider perspectives beyond those at the world systems level, but this was not pursued at the time.

The purpose of this present article is to continue that discussion, by now examining perspectives which explicitly look beyond the level of the world system – to use the planetary level as merely the *starting* point for further exploration, as it were, rather than as the endpoint. While the earlier paper described and demonstrated an analytical-methodical approach to nesting perspectives, the present one adopts a somewhat more open and exploratory stance. The intention here is not to analyse perspectives for their utility in strategy, policy or social analysis. But, rather – in keeping with Galtung's observation – to explore a few of the grander macro-perspectives which seek to take a broadly generalised quasi-macrohistorical view beyond the level of the world system, and to examine these perspectives for any insights they might yield with respect to the long-term future for humankind.

Extending the Galtung Typology: Kardashev Civilisations

As can be seen in Table 1, Galtung's three-level social-analytical framework (1997b) extends from the level of person systems, through social systems, and up to the level of world systems. If this framework were to be extended to higher levels of social analysis, as suggested by Galtung's comment above, it would be useful to have some sort of organising principle. Astrophysicist Nikolai Kardashev (1964) proposed a typology of technological civilisations which also considered three levels of analysis: planetary; stellar; galactic. We can see that the lowest of Kardashev's levels, planetary, is also the highest of Galtung's levels, world systems, and this observation immediately suggests a possible extension of the Galtung typology based on the Kardashev schema.

Kardashev's classification of technological civilisations is based on the amount of energy which is used or can be controlled by such civilisations. The original schema has been refined by many others over the ensuing decades.[2]

- **Type I: planetary.** A Type I civilisation is one which is able to make use of use all of the available energy of its home planet, estimated to be on the order of 10^{16} watts (i.e. 10,000,000,000,000,000 W). This would include harnessing, for example, tidal, thermal, atmospheric, nuclear, fossil, internal and other planetary sources of energy.
- **Type II: stellar.** A Type II civilisation is one which has managed to harness all of the energy output of its home star, something like 10^{26} W. This might include collecting all of the radiant energy of the star, and/or perhaps even harnessing the energy contained in its gravitational field. Such a civilisation might even be detectable from Earth (see later).
- **Type III: galactic.** A Type III civilisation is one which has managed to harness the energy of an entire galaxy, something like 10^{36} W, although because galaxies vary considerably in size, this figure is somewhat variable. A civilisation capable of using energy at this scale could probably make itself visible, if it chose to, throughout most of the observable universe.

The energy differential between these levels is ten orders of magnitude, or a factor of 10 billion (i.e. 10^{10}). Astronomer Carl Sagan suggested (1973a: 234) that a logarithmic interpolation be introduced between the major levels, wherein each factor of 0.1 represents a ten-fold increase.[3] Thus, a Type I.5 civilisation uses 10 times more energy than a Type I.4, which uses 10 times more than a Type I.3 and so on. In this view, Earth is considered to be a Type 0.7 civilisation.

One of the most interesting things about this classification schema for our present purposes is that it seeks to take an inherently more general and explicitly *nomothetic* perspective on planetary/world systems and beyond, using as its organising principle a physical observable–energy–which should be common to all forms of intelligent life.

An extended set of possible levels of (macro-)social analysis arises from simply repeating the basic pattern of increasing spatial scope begun in Galtung's typology, informed by the Kardashev schema. Level 1 is the level of individual persons. Level 2 is the level of multiple-persons interacting as social systems (on a single world, which is the next level up). Level 3 is the level of multiple social-systems interacting as a (single) world system. Thus, Level 4 might be the level of multiple world systems (within a single stellar system, which is the next level up); Level 5 is then the level of (single) stellar systems; so, Level 6 is thus the level of multiple stellar systems (in a single galaxy, which is the next level up); and Level 7 the level of (single) galactic systems. (Other ways to extend Galtung's typology are also possible, of course.) Table 2 shows in schematic form what such an extended version of Galtung's framework might look like. For simplicity, although they are implicitly present within each level, the Galtung sub-classifications – Idiographic, Nomothetic, Synchronic and Diachronic – are not shown.

Table 2: Increasing Spatial Scope of Perspectives

Level 1: person systems
Level 2: social systems (on a single world)
Level 3: (single) world systems
Level 4: multi-world systems (in a single stellar system)
Level 5: (single) stellar systems
Level 6: multi-stellar systems (in a single galaxy)
Level 7: galactic systems

⋮

Source: Adapted from Galtung (1997b) and Kardashev (1964).

There is an obvious difficulty in drawing nomothetic conclusions at level 3 by way of comparisons–an approach which makes sense at levels 1 and 2–owing to our lack of knowledge with respect to any other cases which might exist. Instead, attempts at nomothetic generalisations at these and higher levels have traditionally relied upon abstracting from our present (idiographic) experience and understanding by way of scientific principles and rigorously careful thinking based upon these.

The Kardashev classification invites us to consider whether these levels of social organisation might have been attained elsewhere by other intelligent beings. It also implicitly lays out a possible trajectory for our own collective future evolution and brings us to the edge of an enormous new macro-social and macrohistorical vista. Whether or not one believes in the possible existence of such beings–which belief is quite irrelevant to the substance of this discussion–it is nonetheless a very interesting and provocative thought experiment to consider whether and how a hypothetical "galactic macrohistorian" might characterise the evolutionary development of intelligent civilisations through the implied trajectory shown in Table 2. In such a view, humanity is to be considered just one example of how life and intelligence might arise and evolve in the cosmos, and this very broad pan-galactic, "cosmic" perspective thereby invites our thinking to move beyond the (mostly planetary) level of our current experience to consider the human move into space.

In the discussion below–which will parallel the contours of this implied trajectory – we will take such a generalised "cosmic macrohistorical" perspective as our guiding principle, using a few selected examples (from a quite extensive literature) to illustrate and exemplify different levels in the developmental sequence. The key idea therefore is to try to "locate" the specific case of life on Earth within a much more general cosmic perspective of how life might arise and evolve on many worlds, as a way to gain conceptual "distance" from our own specific history, to see the present situation of humanity as inherently contingent, and thereby to open up our thinking about the future potentials and possible long-term destiny of humankind.

The Drake Equation

The Kardashev schema inherently invites consideration of the possibility of the existence of intelligent extraterrestrial technological civilisations–a somewhat controversial subject about which this discussion is agnostic, preferring rather to treat the idea as a provocation for thought experiments and perspective shifting.

Astronomer Frank Drake (1961) developed an equation–which has since naturally become known as the "Drake Equation"–that yields an estimate of the number *N* of extant technological civilisations in the galaxy capable of and willing to undertake interstellar communication. The terms in the equation require us to consider important scientific as well as sociological questions.

Following, for example, Dick (2003), the Drake Equation can be written as the product of three main types of terms: the number *N* of extant communicating technological civilisations is given by

$$N = \underbrace{R_* \times f_p}_{\text{astronomical}} \times \underbrace{n_e \times f_l \times f_i}_{\text{biological}} \times \underbrace{f_c \times L}_{\text{cultural}}$$

where R_* is the average rate of star formation in the galaxy; f_p is the fraction of those which have planets; n_e is the average number of planets in each of these star systems with conditions favourable to life; f_l is the fraction of these planets which go on to actually develop life; f_i is the fraction of these inhabited planets which go on to develop intelligent life; f_c is the fraction of planets with intelligent life that develop technological civilisations which are capable of interstellar communication; and *L* is the average communicative lifetime of such a civilisation.

By choosing fairly conservative plausible values for each of these factors, it is possible to generate quite large values of *N* (e.g., Sagan et al. 1973; Franck et al. 2001). Debate has continued over the values which should be assigned to these factors ever since the equation was first written down, which was, of course, its original intent. Subsequently, several authors have sought to extend the Drake Equation, usually by adding new terms or by generalising it (e.g., Kreifeldt 1971; Bracewell 1979; Walters et al. 1980; Brin 1983; Ashkenazi 1998; Ćirković 2004; Hetesi & Regály 2006). For humankind, considering the current value of *L* in our own case (≒60 years) is of quite some significance and importance, and acts as both a reminder and a warning. As a species, we have had the ability to listen and potentially communicate for around the same amount of time we have had the ability to destroy ourselves (e.g., through global thermonuclear war). If our situation is typical then it is quite possible that many nascent technological civilisations might destroy themselves fairly soon after they attain the ability to communicate over interstellar distances.

The three kinds of terms–astronomical, biological and cultural–represent the main sequence of phases in cosmic evolution since the beginning of the Universe in the Big Bang (e.g., Jantsch 1980; Kauffman 1995; Chaisson 2001), and require quite different forms of and approaches to knowledge. Thus, the study of the possibilities of life in the universe–known variously as "astrobiology", "exobiology", "cosmobiology", or "bioastronomy" (see, e.g., Des Marais & Walter 1999; Chyba & Hand 2005)–is an inherently multidisciplinary framework of inquiry, in which there is a major role for the social sciences to play, including Futures Studies (Dick 2000; Harrison et al. 2000). This field of study has many present implications for understanding our own evolution, past and future. Many of the extensions or terms added to the Drake Equation have been of a sociological or cultural character–for example, the 'interstellar colonisation' parameter of Walters et al. (1980)–and in recent years a good deal of discussion has become focussed on the implications of the later cultural terms. Indeed, Dick (2003: 66) has specifically suggested that "aspects of cultural evolution are critical to understanding the nature of extraterrestrial intelligence", and that "cultural evolution must be seen as an integral part of cosmic evolution". As a result, he posits that cultural evolution–which of course includes the development of scientific knowledge – eventually supersedes biological evolution, giving rise to a post-biological form of intelligence, and therefore a universe in which the majority of intelligent sentience is post-biological. There will be more to say about this point later.

Decades after it was first written, the essential point of the Drake Equation remains the same (Drake 1997), and it continues to both guide and challenge our thinking. What might the process of estimating how many intelligent civilisations are out there teach us about ourselves? About our place in the universe? Our potential? And about our destiny and future as a species?

Humanity beyond Earth

Provided humanity survives what Sagan frequently referred to as our "technological adolescence" (e.g., 1973a; 1995), we will likely be moving out into space for more extended periods of time–as opposed to brief missions like Apollo or low-Earth-orbit extended forays on the International Space Station–which represents the next logical step in the sequence shown in Table 2.

There are a number of imperatives which have been considered to lie behind such an expansion of human presence. For example, Ehricke (1981) argued for the economic, social and environmental benefits of a human move into space, while, more recently, a study by the International Academy of Astronautics (IAA) sought to articulate a vision for human exploration of space for the first half of the 21st century CE (Huntress et al. 2006). This report recognises the existence of three main imperatives–scientific: to understand; cultural: to explore; and political: to unify – and seeks to use the scientific objectives to determine the destinations to which human explorers will be sent (as opposed to the underlying political objective of, for example, the US Moon program). The science goals in particular are worth repeating here: where do we come from? Are we alone in the Universe? What will happen to us in the future? These are also the major themes of NASA's Astrobiology Roadmap (NASA 2003) and, of course, expressions of the three temporal domains which intersect in Futures Studies: the past (where did we come from?); the present (are we alone?); and the future (what will happen?). And they are also implicit in any attempt to take a truly long-term macrohistorical perspective on the emergence of life, intelligence and civilisation, including human.

The Foundation for the Future – as part of its Humanity 3000 Program, which focuses on issues concerning the longer-term future of humanity – considered the question of humankind and its role in space over the next *thousand* years (Foundation for the Future 2006). Such long-term thinking is particularly valuable because it forces us to abandon short- or near-term biases in favour of considering what may really be important over the long run. Stephen Baxter (2001), noted as a writer of science-fiction, also turned his attention to considering the far human future both in and beyond the Solar System, while Sagan (1995), too, imagined a time when Earth became but a "pale blue dot" from a space-based perspective at or beyond the edge of the Solar System. The question of human expansion into and beyond the solar system was considered in considerable detail at a conference held in 1983 which considered interstellar migration from not simply engineering or scientific perspectives, which were typical of much of the early literature, but also from sociocultural and anthropological perspectives (Finney & Jones 1985). The similarities to human exploration of the oceans of Earth were noted there on more than one occasion; perhaps we therefore have access to some useful models to guide our thinking about human expansion into space (Finney 1985).

One of the key themes which emerges from these and other sources, such as the popular book by Glenn and Robinson (1978), is that of a staged expansion into outer space–a "stepping-stone" approach to establishing a permanent human presence off the Earth, making use of incremental gains in knowledge, and new advances in technological capabilities. There will be more to say about these ideas later. For now, as a precursor, our attention turns to what may be learned from studying the other planets in the solar system, and what this might reveal about world system history or even macrohistory at the world system level.

Lessons from Planetary Astronomy

Any perspective on (the Earth's) world system history–and, indeed, any model of world macrohistory–would be aided enormously by a comparison with the histories of other worlds. Planetary astronomy and interplanetary probes in the latter half of last century revealed startling images and data about the other bodies in our solar system and brought us new information about the processes and events which have taken place during their histories. Sagan (1995) was a high-profile advocate of the need for human beings on planet Earth to learn the lessons which the histories of our sibling planets reveal:

If we're stuck on one world, we're limited to a single case; we don't know what else is possible. By contrast, when we explore other worlds, what once seemed the only way a planet could be turns out to be somewhere in the middle range of a vast spectrum of possibilities. When we look at those other worlds, we begin to understand what happens when we have too much of one thing or too little of another. We learn how a planet can go wrong. We gain a new understanding (P. 219).

Sagan called this new understanding "comparative planetology". One of the most important rationales for such research is, in his view, to try to understand, and thereby to find a way to successfully negotiate, the major environmental issues facing humankind at this point in its history. For our present purposes, let us look at just a couple of the lessons we can learn from the Earth's sister planets Venus and Mars, and from some of the other bodies in the solar system, with respect to possible implications for the future of humankind (cf. e.g., chap.14 of Sagan 1995).

Ever since human beings have been observing it, the surface of Venus has been hidden by clouds. For much of the early 20th century CE, it was commonly assumed that these clouds were made of water (since, after all, atmospheric clouds are essentially made of water here on Earth). This led to a belief that the planet must be very wet, such as a prehistoric jungle on Earth must have been like (as we know from the geological record). Thus, a popular romantic view–expressed in a good deal of the science-fiction of the day–was that the planet Venus was a lush paradise of tropical jungles. This view was eventually overturned when data from spectrometry revealed that the clouds contained not water but *sulphuric acid*, and that the atmosphere is not the life-giving nitrogen-oxygen mixture we have here on Earth, but is over 95% carbon dioxide. The early Venera space probes which landed on the surface lasted only a very short time before being cooked and crushed by the atmosphere, which is nearly 100 times more dense than the Earth's and has a surface temperature of nearly 500˚C. Scientists now surmise that sometime earlier in its history Venus suffered a "runaway" greenhouse effect. Any oceans it might have had at that time would have boiled away, with the rising temperatures releasing even more carbon dioxide from the rocks of the outer crust in an ever-increasing feedback spiral of planetary doom. The romantic-poetic view of Venus as Paradise was thus replaced by the realistic-scientific view of Venus as Hell. The lesson to contemporary Earthlings–currently arguing about whether or not a greenhouse effect on Earth is "really real", or about the supposed economic disadvantages about greenhouse gas reduction–couldn't be any more stark. Venus stands as a reminder and a warning to our present civilisation about the possible consequences of certain technological choices.

Mars presents some other lessons. When the Viking probes landed there in the mid 1970s and, as part of their mission, searched for organic molecules in the soil, they found none at all. This was quite a puzzle, since it is known that cometary impacts deposit organic molecules, and had done so on Earth (e.g., Chyba et al. 1990). It turns out, since there is essentially no ozone in the Martian atmosphere, that organic molecules literally fall apart when exposed to the searing flux of ultraviolet rays from the Sun, even at Mars' distance. The lesson for Earth regarding the terrestrial ozone layer is fairly clear. Fortunately, humankind seems to have responded in time to this particular threat, although it has been estimated that atmospheric ozone on Earth will not fully recover until the middle or beyond of the present century.[4] Another lesson we learn from Mars has to do with atmospheric dust and its effect on planetary temperatures. When the first US Mariner mission arrived at Mars in the 1960s, the planet was enveloped in a global dust storm. The orbiting probe continued to take measurements, including the ambient temperature of the planet and how it was affected by the atmospheric dust. This Martian data led to better computer models of atmospheric cooling caused by volcanic activity on Earth, and eventually to the discovery of the so-called "nuclear winter" scenario (Turco et al. 1983), whereby even a quite limited exchange of thermonuclear warheads leads to an extended period of darkness and cold. This prolonged nuclear winter leads to the strong possibility of the destruction of the biological support systems of human civilisation and a mass extinction of life on Earth, with human population very probably falling to prehistoric levels (Ehrlich et al. 1983). Indeed, Ehrlich and co-authors explicitly suggest that "extinction of the human species itself cannot be excluded" (P. 1293). From this perspective, we learn that even a "limited" nuclear war (the very idea of which, in geostrategic military planning, has always been quite problematic) may well be suicidal for the perpetrator. This has clear implications for global geopolitical and diplomatic activity, and highlights a need for humankind to develop much better ways of resolving conflicts than it has managed so far.

We know from observing the crater-marked surfaces of Mercury and Mars (as well as our own Moon, and the moons of the gas giant planets), that enormous cataclysmic impacts occurred in the early history of the Solar System. We also know that comets and asteroids regularly intersect the orbit of the Earth, and have impacted not only in the distant past (e.g., Sleep et al. 1989; Chapman 2004), but also in the more recent past, such as the Tunguska Event of 1908 (Di Martino et al. 1998). Thus, it is really only a matter of time–"when" rather than "if"–before one of these objects impacts our planet again, with possibly-fatal consequences for our civilisation. Sagan noted (1983) that if such a natural catastrophe occurred over a populous city today, it could–in the panic and shock of the moment, and especially at a time of high international tension–be mistaken for a nuclear detonation. This might then trigger an exchange of warheads and thus bring about a somewhat ironic end to the technological civilisation on Earth: "a strange scenario: a small comet hits the Earth, as millions of them have, and the response of our civilisation is promptly to destroy itself" (P. 96).

What we learn from these perspectives is that a civilisation which is confined to a single planet is vulnerable to extinction through endogenous environmental catastrophes (which may be self-generated) as well as through exogenous catastrophes (such as asteroid or cometary impacts). And this means that such civilisations must eventually develop inter-planetary travel–or at least the ability to both detect and deflect potential impactors (Peter et al. 2004), as well as to live sustainably within their planetary environments–if they are to survive into the longer term.

Into the Solar System

Human beings have tentatively ventured into the solar system since the middle of the last century–physically to low Earth orbit and the Moon, and via robotic probes beyond. The question of what the next steps are in exploring deep space have been considered many times since the days of Apollo, most recently in the aforementioned IAA report (Huntress et al. 2006), which sought to provide both a vision and a roadmap for the serious scientific exploration of space by human beings in the first half of the 21st Century CE, and in the Foundation for the Future's thousand-year view of humanity's role in space (Foundation for the Future 2006).

The IAA roadmap for the scientific exploration of space suggests a four-step expansion over the next half-century. Initially, this involves a move beyond low Earth orbit to high Earth orbit, establishment of a "base camp" at one or more Earth-Moon or Sun-Earth libration points,[5] and a return to the Moon, for the purposes of exploration and establishing a permanent habitation. This is then followed by missions to Near-Earth objects (comets and asteroids), further on to Mars orbit for reconnaissance, and ultimately down to the surface of Mars to again explore and establish an outpost. Mars, in particular, of all the possible destinations in the solar system, possesses many desirable features for long-term inhabitation. It would be an interesting twist if the lessons which Mars has taught us (see above) helped our civilisation survive long enough to eventually travel there and colonise it.

Missions to Near-Earth objects have a number of rationales. One is to better understand the composition of the early solar system, as these bodies are thought to have originated in the part of the solar system beyond the planets, and to be, in essence, fossils from the early stages of solar system formation. Another is to discover more about the nature and structure of these objects in order to be better prepared should the need arise to deflect or destroy a potential impactor with Earth. They could also serve, in human spaceflight, as intermediate way-stations for deeper exploration into the solar system, including on the way to colonising Mars.

As humanity expands further into the solar system, more of the solar system will likely become subject to industrialisation. Hartmann (1985) has noted that, just as the processes of evolution of the Earth's crust led to concentrations of different materials located at different parts of the Earth's surface, so the processes of stellar system and planetary formation have also produced concentrations of different materials in different parts of the solar system. On Earth, the desire to utilise these resources led to wide-scale exploration and excavation of ores and fuels. As time went on, the more easily accessible deposits were exhausted and deeper exploration and excavation became necessary, which usually meant a reduction in the grade of materials recovered, which led to increased processing costs, etc. Hence, access to and exploitation of Earth-based resources is becoming increasingly difficult and expensive. He also notes that the costs of operating in space are declining as space flight become more routine, with the result that the cost of obtaining equivalent or substitute materials in space will gradually decrease. At some point in the future, therefore, these two cost curves will cross, and "this will provide the economic incentive for the large-scale acquisition and utilisation of space resources" (P. 27). The idea of using low-Earth orbit for specialised industrial processes, or even mining the Moon for raw materials, has a very long pedigree. But, beyond these sources, as Hartmann examines in detail, asteroids and comets also contain many valuable and exotic materials. These could be mined for their intrinsic value, and other less valuable but more abundant material could be used *in situ* for redevelopment into space habitations and solar-energy collectors (Criswell 1985). At some point, permanent habitations will probably be built on these objects, and human beings may eventually live there not merely temporarily as part of specific space missions, but permanently, giving rise to a sub-speciation of humanity into an Earth-based "Earthkind" and a space-based "Spacekind" (Glenn & Robinson 1978). One can quickly see how this would eventually–with continued expansion into and colonisation of the rest of the solar system–become a more generalised distinction between those who live on planets (i.e., "Planetkind") and those who don't.

Physicist Freeman Dyson (Pp.189-90 and App. D of Sagan 1973b) has considered the advantages of large-scale engineering of human habitat from the comets found beyond the main planets of the solar system (in the Kuiper Belt and Oort Cloud). Such microgravity environments (e.g., a comet 10 km across has a quite negligible gravitational field) allow for the possibility of truly immense structures–in essence, "trees" hundreds of kilometres high–to be constructed without the need for providing additional supports against planetary gravitational fields. In Dyson's view, planets are useful only insofar as they allow life to emerge; beyond that stage, it will be comets that are the main home for technological societies, and this will fundamentally shift the perspective and focus of such societies from planetary to spaceward. Finney (1988) has suggested that this "cosmicisation" of perspective which humanity will have undergone during its solar-system colonisation phase is a necessary precursor to any subsequent migration of humankind beyond the solar system.

While human exploration of space to date has made use of both robotic missions as well as missions with human personnel, there may well come a closer joining-together of these two modes of exploration (e.g., Mendell 2004; Hubbard 2005) which may eventually involve a blurring of the distinction between human beings and machines. Hart (1985) has suggested that human beings might deliberately alter themselves genetically in order to better adapt to space-based life, which would lead to an even greater divergence from our original planetary form. There is a considerable literature dealing with the confluence of biotechnology, nanotechnology, information technology, robotics, and artificial intelligence (for a futurist's view on this idea, see, e.g., Cordeiro 2005). This confluence has for some time been seen as potentially leading to what Vernor Vinge (1993) called "The Singularity", and Damien Broderick (1997) called "The Spike". In essence, the rate of change of technological development is considered to be increasing over time and, should it continue on that path, would eventually become infinite (see, e.g., Smart 2003).[6] The term "singularity" has been borrowed from relativistic astrophysics and refers to the breakdown of meaningfulness where the mathematical functions which describe spacetime become undefined or infinite.[7] Singularity theorists hold that the Singularity represents a barrier to our thinking beyond which it is impossible to imagine let alone comprehend what may be coming. Part of this confluence of technologies leads to the eventual marrying of human being and technology into a "trans"-human form. We can see the early stages of this today with the use of some medical prostheses. Transhumanists, however, look beyond these tentative first steps to a time when this form of human 'enhancement' is routine and pervasive and, ultimately, to a time when human consciousness itself may be "uploaded" into computer systems and our biological bodies dispensed with entirely–which state is usually referred to as "*post*-human". Ray Kurzweil (1999, 2006) is one of the most well-known proponents of this view, and Dick's (2003) idea of a largely post-biological universe can be seen in this light as an obvious and natural generalisation to cosmic scale of the contemporary discussions about the emergence of transhuman, and ultimately post-human, forms of intelligence on Earth. Others, such as Ćirković (2003), also point to strong resonances between transhumanism and the search for extraterrestrial intelligence (SETI).

Considering all of these ideas, and attempting to take a macrohistorical view of the general case, we would surmise that the energy needs of a growing planetary (and increasingly extra-planetary) civilisation would likely increase to the point where it would need to look seriously beyond planetary sources of energy to the energy output of the star around which it orbits–the more so if Venus-like "runaway greenhouse" catastrophes are to be avoided. One can imagine an historical sequence wherein a planet-based civilisation begins to manufacture stellar radiation collectors ("solar panels") in order to capture the radiant energy of its star. Over time, the number of collectors on the planet would gradually increase, and at some stage they would be placed into orbit, initially around the home planet (Seboldt 2004) and then later around the home star itself. As the civilisation expanded off-world into the rest of its stellar system, asteroids, comets and possibly even planets would be re-engineered as habitat and/or stellar radiation collectors, or a combination of both. It is also possible that whole planets might be re-engineered through a generalised form of "terraforming" –the altering of unsuitable planetary environments to human habitation (e.g., Oberg 1995). Eventually, there would be a stupendous number of these habitations and collectors orbiting the star and, in the asymptotic limit, all of the available visible radiant energy from the star could be captured in this way.

Dyson (1960) had also earlier proposed that just such a "swarm" of radiation collectors orbiting a star might be created by a sufficiently technologically-advanced civilisation to meet its energy needs, which Kardashev subsequently cited (1964) as an example of a Type II civilisation. This form of stellar-system engineering, or "astroengineering", has come to be known variously as a "Dyson shell", "Dyson swarm" or "Dyson sphere" (Bradbury 2001), and one also finds references in the literature to "Dyson civilisations". Several variants on the basic design have since been postulated. Dyson's main suggestion, however, was that if this sort of astro-engineering is indeed going on, then we should be able to detect it through the very particular electromagnetic spectrum "signature" that such structures would emit. He suggested that a search be mounted for celestial sources of radiation of this characteristic type as one means of searching for evidence of the existence of extraterrestrial intelligence. And there have indeed been a few efforts to do just this (e.g., Tilgner & Heinrichsen 1998; Timofeev et al. 2000), although, at the time of writing, none have identified any confirmed examples of such civilisations.

Stellar Evolution

One of the considerations implicit in the lifetimes of technological civilisations is the lifetimes of stars. There is a system which astronomers have used to classify stars, based on what is known as the Hertzsprung-Russell or "H-R" diagram. It turns out that stars generally fall into one of several main groups in this schema. There is a broad band of stars known as the "main sequence", comprising a number of distinct types; a group known as "white dwarves"; a group known as "giants"; and a group known as "super-giants". Our star, the Sun, lies right in the middle of the main sequence, which lends weight to what is sometimes known as the "mediocrity principle" – the idea that there is nothing particularly special or unique about the Sun or the Earth, so that we might plausibly regard our situation as perhaps typical.

There is now a well-developed theory of stellar formation and evolution. Stars form by gravitational attraction and collapse of clouds of dust and gas, leading to an accretion disc which spins out material that may give rise to planets. The proto-star contracts until eventually, if it has enough mass, there is sufficient density to lead to thermonuclear fusion in the core, and the new star "turns on". Thus a new star/planetary system is "born". Several "nearby" examples of this process have been found since the launch of the Hubble Space Telescope and can be seen in astonishing detail, while accretion discs have also been detected for more distant stellar systems.[8] The expected lifetime of the star depends on the amount and (to some degree) composition of the material in the initial cloud. A typical low-mass star will move through the different spectral classes of the main sequence over the course of billions of years until its nuclear fuel is used up and, again depending on its initial mass, will do one of a number of possible things. A relatively low-mass star like the Sun will eventually expand into a cooler "red giant", engulfing most of the inner planets, and then shrink to become a "white dwarf", possibly shrugging off layers of material. More massive stars burn up their nuclear fuel more quickly and their lifetimes tend to end in a catastrophic gravitational collapse when the fuel runs out. This collapse usually leads to an explosion ("nova") of the remnant materials, blasting it back out into the interstellar medium, and, in some cases, these explosions are so massive ("super nova") and so bright that they have been observed in other galaxies, millions or even billions of light-years away.

What we learn from this model of stellar evolution is that any civilisation which has attained Type II status and manages to survive will, sooner or later, have to face up to the death of its star system (e.g., Zuckerman 1995). The exhaustion of a star's nuclear fuel could be delayed by reducing the overall mass of the star, so a sufficiently technologically-advanced civilisation might undertake the removal of stellar material for storage and subsequent re-use during later stages of the star's lifetime. This process – known as "star lifting" – could conceivably extend the stellar lifetime by many tens of billions of years (Criswell 1985: 64), and is an example of a more general and intriguing concept, "stellar husbandry", which conjures up an image of a "domesticated" star. (One can even imagine, by extension, "fields" of such domesticated stars whose resources are carefully marshalled and "farmed" by sufficiently advanced technical civilisations...) Eventually, however, this too may prove insufficient to prevent the star's ultimate death due to causes other than simply running out of fuel. And this means that such civilisations will have to master not merely inter-planetary travel but also travel into inter-*stellar* space, if they intend to survive beyond such an event. This may therefore lead to a space-faring phase in the civilisation's history whereupon it leaves the confines of its initial birthplace and nursery and moves out to explore the star systems which lie beyond its own.

Beyond Stellar Systems toward Galactic Expansion

With interstellar travel attained, a civilisation which was so inclined would be able to leave its home system and move on to other nearby star systems, and thence over time further outward into the wider galaxy, whether by directed long-range spacecraft missions ("fastships"), or simply by slow diffusion ("nomads") (Jones & Finney 1985). Kecskes (1998, 2002) has described a sequence of development of a technical civilisation starting from an initial phase as planet dwellers and gradually leading to phases as asteroid dwellers, interstellar travellers and ultimately as space dwellers. If technical civilisations in general do undertake a space-faring and colonisation phase in the course of their development, then this has implications for estimates of the number of civilisations obtained by use of the Drake Equation; hence, as noted above, some authors have considered the addition of extra factors which explicitly take account of interstellar colonisation. This increases the number and types of stars which might play host to advanced technical civilisations because they would not need to have evolved *in situ*, thereby increasing the relative probability of our detecting them. In the general case, it also raises the possibility of different civilisations, which evolved independently and in relatively close proximity, encountering each other physically during contemporaneous space-faring activities, following earlier contact during their respective radio-communicative stages of development.

It has been suggested that space-faring societies which have lived for many hundreds or thousands of generations in asteroid-sized colonies or giant spacecraft would have little or no interest in returning to a planet-based existence (e.g., Kecskes 1998). In essence, the idea is simply that, having adapted so well to space, Spacekind does not usually return to its earlier Planetkind form. This suggests that the number of planets n_e which are considered "suitable" for life in a star system might be a potentially misleading or even irrelevant parameter given that asteroid-based civilisations would not need, use or even care about planets (unless to possibly re-engineer them). However, for such civilisations, the inner region of a stellar system may be much less attractive than the potentially resource-rich analogues of our solar system's Kuiper Belt and Oort Cloud.

It has long been argued that civilisations which survive into the long term are much more likely to be benign than belligerent (e.g., Harrison 2000a). It may therefore be the case that, when a civilisation establishes contact with another that is much older, this very contact could in itself actually help to lengthen the value of L for the younger civilisation. It may also be the case that civilisations which by chance find themselves in relatively close proximity could form an initially-small "community of contact" (Oliver 1975). As more civilisations emerge and join such communities, there might ultimately arise some sort of "Galactic Club" (Bracewell 1979; Harrison 2000b) of intelligent civilisations, based upon information-sharing and scientific cooperation. This might even culminate in what has been frequently described as an *"Encyclopedia Galactica"* (e.g., Tough 2000b) of the accumulated knowledge of countless civilisations, the broadcasting of which – to newly-emerging, younger civilisations such as ourselves – may be one of the major objectives of the Galactic Club. And, of course, any discussion of inter-stellar travel must also mention the theoretical work now examining how to turn the well-known "warp drive" of science-fiction into a physical and engineering reality (Alcubierre 1994).[9]

What we learn from this perspective is that cooperation, mutual support, information sharing and scientific/cultural exchange may well be key factors in the long-term longevity of intelligent civilisations, and that competition, belligerence and hostility may lead, in the long run, to inevitable extinction. One wonders how many entries there might be in the galactic catalogue of civilisations that briefly note the passing of another quasi-intelligent species which was not smart enough to choose long-term survival over short-term self-interest.

The Search for Extraterrestrial Intelligence: "SETI"

While human beings have speculated on the existence of life elsewhere in the universe for much of history, it is only since the middle part of the 20th century CE that our technological capabilities have been such that we could mount a serious search for it (e.g., Sagan & Shklovskii 1966; Morrison et al. 1979; Tarter 2001). According to Dick (2006), the beginning of the modern era of SETI can be tied to three events: the publication of the "landmark paper" of Cocconi and Morrison (1959) on searching for interstellar communications; "Project Ozma", which carried out the first such search, undertaken in 1960; and the Green Bank conference of 1961 where the Drake Equation was first written down (Drake 1961).

Of course, the discovery or detection of conclusive evidence of extraterrestrial life, past or present – what is generically known as "contact" – would in itself be an unprecedented turning point for humankind. But if this life also turned out to be *intelligent* then it would almost certainly bring about profoundly fundamental shifts in the worldviews of our species–we would have to confront The Other as never before (e.g., Morrison & McNeill 1973; Harrison & Dick 2000). Even in the absence of finding any extraterrestrial life, intelligent or otherwise, simply undertaking such a search in itself provides numerous benefits and positive consequences for humanity (e.g., Tough 1998a). Whatever the scientific merits or philosophical arguments for mounting such a search, however, the harsh reality of political expediency has aborted some attempts to do SETI (Garber 1999). Nevertheless, by the end of the 20th century CE, a large-scale international SETI project was being undertaken by the University of California, Berkeley, using screen-savers on personal computers to analyse data collected from a radio telescope with otherwise un-utilised computing power.[10] At the time of writing, over 5.5 million users worldwide had signed up, indicating the huge underlying public interest in the question of extraterrestrial intelligence. A particularly interesting notion to ponder is to consider just what questions we might ask another intelligent civilisation if we had the chance to do so (Tough 2000a).

Generalising from the above observations, it is quite plausible that "contact" may be a major milestone in the evolution of intelligent life on other inhabited planets as well, comparable in importance to – in our particular case here on Earth – the emergence of life from the oceans, the discovery of nuclear fission, or that "one small step" when Neil Armstrong became the first human being to set foot on another celestial body. Such a discovery may well cause a quite fundamental Toynbean "challenge" (Galtung 1997a; Michaud 1998a) to the civilisation in question, and the character of the civilisational response (e.g., Harrison 1997; Vakoch & Lee 2000) might even form part of a schema which galactic historians or macrohistorians use to classify emerging civilisations. One can even imagine a pan-galactic macrohistory that distinguishes such events in the overall lifetimes of all intelligent civilisations, referring, for example, to those periods of their histories which are "pre-contact" and "post-contact". In such a conception, our civilisation here on Earth is (at least, at the time of writing!) still in the "pre-contact" period of its history.[11]

From a futurist's perspective, the range and scope of possible detection scenarios are of some interest, as an understanding of the extent and contours of this scenario space could help us prepare for the implications of such an event. Petersen (1999: 198) considers the arrival of extraterrestrials as one of his 80 "big future surprise" "wild card" events. On the other hand, Harrison and Dick (2000: 7) suggest that "if extraterrestrial intelligence exists... its discovery may not be so much of a 'wild card' as a high probability–perhaps even inevitable–event". If this is so, then we had better begin preparing now, especially if, as suggested by Shostak (2004), such a detection is likely to occur within a generation. Drawing upon the thinking of, for example, Tough (1998b), Harrison (1999), Dick (2000), Almár (1995) and Swift (1995), one can imagine several parameters which might characterise the scenario space of contact: *proximity*, ranging from proximal to distal (e.g., terrestrial, solar system, nearby stellar system, within our galaxy, in another galaxy); *complexity* of life, from simple (e.g., bacteria), to complex (e.g., reptiles), to intelligent; and, the nature of contact, whether direct (face-to-'face'), or indirect (e.g., fossil traces, or mediated through technology, such as an intelligent probe). Additional parameters might also include, in the case of intelligent life, the *motivation* of the extraterrestrials towards us (hostile, benign, indifferent, helpful, etc.), as well as the age or stage of development of their civilisation (such as its Kardashev type, among other things). If we look beyond our own particular case and take a macrohistorical perspective, we might also include a parameter describing the developmental stage of the civilisation making the discovery or being contacted, which might include such factors as degree of sociopolitical as well as technological maturity. In our own case, we are, for example, at a pre-planetary stage of polity, have a pre-sustainable techno-economic system, and are moving through a stage of "technological adolescence" (Sagan 1973a) during which we might destroy ourselves. Combining these factors yields another, perhaps more general, parameter: the degree of age/stage difference between the civilisations, something which we have had some experience of at the level of social macrohistory on Earth (e.g., Tanner 1985; Finney & Bentley 1998). While it is clearly beyond the scope of this article, a more detailed study of the various parameters which might usefully characterise contact in the *general* case would be of some interest, and might be able to draw fruitfully upon insights from human macrohistory (Galtung & Inayatullah 1997). Such a study could help to further expand our perceptions of our place in the universe, and focus our attention upon our longer-term future and development as a species.

Communication with (Extra)Terrestrial Intelligence: "CETI"

If we do end up finding that there are (or were) other intelligent beings out there, it would be nice to be able to communicate with them, albeit perhaps somewhat indirectly owing to the large distances involved and the delays introduced by the finite speed of light (or through only having their remaining artifacts to study). The Drake Equation formed the basic framework of discussion for an international multidisciplinary conference on the possibility of *communication* with extraterrestrial intelligence (CETI), held in 1971, one of the first of many such international initiatives (Sagan 1973b). This idea raises some extremely interesting questions, many of which have strong resonances with some of the present and future issues faced by our species.

One of the central themes of CETI is that of mutual understanding and meaning-making given very different cultural contexts, a theme which also has obvious and particular relevance for contemporary Earthlings. How would a language designed for communicating with extraterrestrial intelligent beings be structured? How would we make ourselves understood, or how could we understand them? Upon what basic assumptions would such a language rest? Given that there is likely to be no common cultural context – with the possible exception of an understanding of physics and chemistry – this is a non-trivial semiotic problem (Vakoch 1998; Reed 2000). Several attempts to design specialised languages for this purpose have been made, usually based on physical laws, mathematics or logic (e.g., Freudenthal 1960, 1974; De Vito 1992; Fitzpatrick 2005). Even deliberately-planned constructed languages like Esperanto, Interlingua and Loglan nonetheless assume a common *human* context on a single planet, and have underlying linguistic bases which may not become visible to us until we are forced to consider the need to relax this assumption.[12] Needless to say, we can learn a great deal about the structure of human understanding, languages and hermeneutics from considering the sort of communication problem which the very idea of communicating with non-human or extra-terrestrial intelligence brings into focus, even in the absence of ever doing so.

And if we do detect an unambiguously intelligent message, how should the news of "contact" be announced to the world and by whom (Michaud 2003)? Should we decode the message (e.g., Carrigan 2006)? *Could* we even decode it? Should we respond to the message at all (e.g., Tarter 1998; Norris 2003)? And, if so, who has the right to speak for Earth (Michaud 1998b)? The careful consideration and discussion of these issues, carried out in a necessarily international context (Reijnen 1998) and in *anticipation* of the receipt of such a message–rather than merely as a reaction to it–could teach us much about how to get along as a species, and might even in itself help to extend the value of L in our own particular case.

What we learn from this perspective is that the time might soon come when Planet Earth will be required to speak with a united voice. The question is: Will we be ready, or even able, to do so?

The "Fermi Paradox"

One day in 1950, during a lunch-time discussion considering the idea that there must be many extraterrestrial technological civilisations in our Galaxy, Nobel laureate nuclear physicist Enrico Fermi is reputed to have said: "where is everybody?" This question is much more profound than it seems at first glance, and leads to what has since come to be known as the Fermi Paradox (see e.g., Zuckerman & Hart 1995).

The essence of the Fermi Paradox is this: if intelligence has arisen elsewhere in the Galaxy, it is most likely to have done so before it arose here on Earth. Indeed, the odds are that, if it has happened at all, then it happened many millions or even billions of years ago (Norris 2000). During that time, a space-faring civilisation would have had the time to colonise a significant part of the Galaxy, if not most or all of it (e.g., Jones 1976; Newman & Sagan 1981). If that is the case, then why have we not seen them? In other words, "where is everybody?" Thus, the belief that life is common in the universe and that there are many intelligent technological civilisations in the Galaxy is apparently inconsistent with the observed evidence. Therefore, either our initial assumption is incorrect, or our observations or search methods are incomplete or flawed.[13]

There have been many responses to and attempted resolutions of the Fermi Paradox. Recently, for example, Webb (2002) has catalogued fifty such proposed resolutions, which fall into three generic classes: (i) they are here already; (ii) they exist but have not yet communicated; and (iii) they do not exist. It will suffice here to simply give a flavour of some of the resolutions which have been proposed, some of which can be seen portrayed in contemporary Western popular culture.

Perhaps intelligent species have arisen which are not technology-using, and which would not be able to communicate (let alone travel) over interstellar distances using the technologies upon which we base our search assumptions – species which may be analogous to dolphins and cetaceans here on Earth. Perhaps we are using a technology for listening (radio waves) which is so primitive that no one in the Galaxy uses it anymore. A frequently-drawn analogy for this situation is that, in the same way that tribal societies using jungle drums to communicate are oblivious to the electromagnetic waves passing over their heads carrying messages between more technologically advanced societies, so we may ourselves be oblivious to modes of communication which are as far beyond radio as radio is beyond jungle drums. Perhaps intelligent species have arisen which have other priorities and are not interested in interstellar travel, or colonising the Galaxy, or even interstellar communication. Perhaps they have already arisen in this region of the Galaxy and died out or moved on before we arose. Dick's view (2003) of a mostly post-biological universe has also been advanced as a possible resolution of the Fermi Paradox. Ćirković and Bradbury (2006) have recently argued that such post-biological evolution leads, for computing-thermodynamic reasons, to a mass migration of the post-biological intelligences into the outer reaches of the Galaxy, with the result that the major SETI search strategy of examining stars which appear biologically habitable (e.g., Turnbull & Tarter 2003) is actually looking in the wrong place; or, at the very least, in places where intelligence spends relatively little time before evolving beyond the need for habitable planets. Perhaps post-biological intelligence is more interested in observing the evolution of biological intelligence without in any way interfering in its development. Perhaps, therefore, the Earth is being monitored and deliberately left to itself, to be studied without interference–variants of which are the so-called "Zoo" (Ball 1973) and "Interdict" (Fogg 1987) hypotheses–or until we are considered "ready" to be contacted. Perhaps humankind first needs to achieve some technological or social milestone of development. Perhaps we must demonstrate that we can manage to survive our new-found ability to destroy ourselves before anyone bothers to make contact with us. Or, perhaps we must evolve into post-biological intelligence ourselves (i.e., move through our own version of "the singularity") before we qualify to be contacted. (One particularly intriguing idea is that the invisible so-called "dark matter" which seems to form so much of the "halo" of galaxies might be made up of quadrillions of post-biological intelligences going about their unfathomable "lives".) Perhaps they have already visited the solar system earlier in our planet's history and departed long ago, leaving behind only faint evidence of their passing, such as traces of mining activity or artifacts in the asteroid belt (Papagiannis 1983, 1995; Kecskes 1998), or possibly automated "sentinels" to watch for the emergence of intelligence among the life-forms they found here–which latter is the central idea of *2001: A Space Odyssey*. Or, perhaps they are actually here right now and observing us (e.g., UFOs, silent probes in the solar system, etc.), or are possibly even living secretly among us (as in *The X-Files*). And there are many, many others. It is possible to conceive of a generalised galactic macrohistory which encompasses all of these possibilities and which is also able to account for the Fermi Paradox by assuming that everyone who has considered it is right to some degree. However, a discussion of such an "integral" approach to the Fermi Paradox is something for another time.

What we learn from this perspective is that we may well be alone in the Universe. This is a mind-blowing idea. What we also learn from this perspective is that we might *not* be alone in the Universe. This is also a mind-blowing idea. There are stunning consequences for our conceptual understanding of ourselves as an intelligent species which flow from either situation. If we *are* alone, then it may well be up to us to give meaning to what could be an otherwise meaningless Universe. This is an astonishing responsibility to discover. If we are *not* alone, then the question arises of how we will acquit ourselves as a species in the wider context of a galactic or even inter-galactic community of intelligent civilisations. Both of these possibilities raise a sobering mirror to our present behaviour. And, finally, if contemporary human civilisation *is* being observed by extraterrestrials or their smart probes, then this would seem to be a deliciously ironic new twist to the term "anthropology".

Conclusion

The purpose of this paper was to explore some of the grander macro-perspectives which explicitly look beyond the level of the current world system, in order to examine what insights they might bring forth which are relevant to contemporary human beings, and what they might portend with respect to the longer-term future of humankind.

Looking beyond the current world system to consider perspectives that take a much broader and longer view helps us to see our present world and civilisation with new and different eyes, in a much wider and greatly altered context. It is for this reason that introducing an "extra-terrestrial" perspective into analyses of international relations or global dynamics – by asking what a hypothetical dispassionate alien observer or macrohistorian would make of our stewardship of Planet Earth – can be such a useful thought experiment. Such a perspective prompts us to think beyond the passions of race, creed, religion, philosophy, culture, or even species, and instead may perhaps help us to see humankind as part of a small fellowship of travellers in what Sagan (1983) so poetically described as "the vastness of space and the immensity of time".

The perspective of the hypothetical galactic macrohistorian invites us to take a truly long-term macro view of the Earth's entire history–of its origins in the distant past; of its present (and so recognisably-transient) configuration; and of the possible futures we may end up creating for ourselves, or allow ourselves to experience. Such a perspective implies some very big questions for humankind to confront: What are our prospects as an intelligent species? How will we fare when it comes to our civilisational response to the many challenges we do and will face? What will our entry be in the galactic catalogue of civilisations?

One can only hope that, as a species, we do indeed choose to do what is necessary to survive and prosper, and to build, in the first instance, towards a planetary civilisation of which we can be justly proud. And so, perhaps, if we are careful and fortunate, to one day become explorers of the beckoning deep of the celestial night.

Correspondence

Joseph Voros
Faculty of Business and Enterprise,
Swinburne University of Technology,
John Street, Hawthorn, VIC, 3122, Australia
Tel: +61.3.9214-5984
Email: jvoros@swin.edu.au

Notes

1. The positions of Synchronic and Diachronic are reversed compared to Galtung's usage (1997b), for reasons explained in more detail in Voros (2006).
2. There are other approaches which extend the original three-level Kardashev schema–they vary in terms of what are considered the next levels, whether they be clusters of galaxies, super-clusters of galaxies, the whole universe, or even multiple-universes. For reasons of space they will not be considered here; however, the reader with access to the Internet can find numerous examples of extensions to and further refinements of this typology.
3. In Sagan's adaptation, both the type and fraction are rendered as Arabic numerals, thus one would speak of a "Type 2.5 civilisation", for example, rather than "Type II.5". He also introduced (1973a: 234-9) a further refinement based upon the amount of "bits" of

information it would take to characterise the knowledge which a civilisation possessed, rendered as a letter of the Roman alphabet. Type A is the baseline, which represents about 10^6 bits of information, and each subsequent letter increases this amount by an order of magnitude, (i.e., by a factor of 10). In this view, Sagan classified Earth as a Type 0.7H civilisation.

4. See, for example, the assessments of the Ozone Secretariat of the United Nations Environment Program at: <http://ozone.unep.org>.
5. In orbital dynamics involving two large bodies, there appear five places where the combined gravitational field has a point of relative stability or equilibrium. These are known technically as "libration" points, or sometimes as "Lagrange" points after the mathematician who discovered them, Joseph-Louis Lagrange. One of these, called L2, lies on the line joining the centers of the bodies, on the far side of the smaller body from the larger. Thus, for the Earth-Moon system, L2 always lies at a point in space on the far side of the Moon along a line passing through the centers of both Earth and the Moon at a distance just beyond the Moon's orbital distance. For the Sun-Earth system, L2 lies at a distance of about 1.5 million km in the direction directly opposite the Sun. See, for example, Huntress et al. (2006: 331), for a diagram.
6. See, for example, <www.accelerating.org>, <www.accelerationwatch.com>, or <www.aleph.se/Trans/Global/Singularity/>.
7. For example, the graphical form of the function $y=1/x^2$ is undefined at $x=0$. As x approaches the value 0, the value of y shoots off towards infinity. In mathematical terms, the function y is said to have a singularity at the point $x=0$.
8. See, for example, NASA's Astronomy Picture of the Day web page, at <http://antwrp.gsfc.nasa.gov/apod/astropix.html>, especially the image for June 4, 1999, and links therein.
9. To see the latest theoretical work, go to <www.arXiv.org>, select the subject area "gr-qc" and do an author/title/abstract search on the phrase "warp drive".
10. See <http://setiathome.berkeley.edu> .
11. Futurists could potentially learn a great deal from SETI, as there are strong resonances between SETI and Futures Studies. Both endeavours are inherently multidisciplinary undertakings and, in a very real sense, future generations are almost as alien to us as extraterrestrial beings would be–the former are distant in time, the latter in space. Both SETI and Futures Studies emerged as distinct new endeavours in the middle of the 20th century CE, and have spent at least some portion of the time since then somewhat marginalised from the mainstream of social consciousness. The pathway taken and lessons learned by the SETI enterprise in an attempt to gain wider acceptance (Pierson 2006) could also serve as a source of insights for Futures Studies in its own journey to gain greater traction in the wider world. A key element of this pathway is education and outreach.
12. Planned languages such as Esperanto are frequently referred to as "artificial" languages, an appellation which implicitly carries a somewhat negative connotation, as though the language cannot possibly therefore be a "real" one, like national languages are assumed to be. But such an appellation is disingenuous at best since, after all, *all* languages are "artificial", as the branch of linguistics known as *semiotics* tells us. The discussion is better framed as one of whether or not the particular language has been been planned or

designed to be *consistent* and regular in its structure, grammar and vocabulary. As an Esperantist, it is fascinating to observe the different reactions people have to the idea of politically-neutral, non-nationally-aligned languages designed for mutual understanding in an international context. For more information about Esperanto see <www. esperanto.org>; for more information about Interlingua see <www.interlingua.org>; and for more information about Loglan (the *Log*ical *Lan*guage), see <www.loglan.org>, which was initially designed to test the well-known Sapir-Whorf hypothesis about the relationship between the structure of language and the constraints which that structure supposedly imposes on the thinking and thought of its speakers.

13. In fact, some authors assert that this very lack of any observational evidence actually shows that there are no advanced civilisations within communicating distance from us (e.g., Martin 1985). But this argument is usually considered a logical fallacy–the fallacy of *argumentum ad ignorantium*, the argument from ignorance (that is, just because we haven't seen any, it doesn't mean there aren't any to be seen; or, in other words, "absence of evidence is *not* evidence of absence"). Others have argued, on propositional-calculus grounds, that the so-called "paradox" is itself logically ill-formed and therefore does not even exist (e.g., Freitas 1985).

References

Alcubierre, Miguel. (1994). "The Warp Drive: Hyper-fast Travel Within General Relativity." *Classical and Quantum Gravity.* 11(5): L73-L77.

Almár, Iván. (1995). "The Consequences of a Discovery: Different Scenarios." In Shostak (1995), ed., pp. 499-505.

Ashkenazi, M. (1998). "On the Applicability of Human Cultural Models to Extraterrestrial Intelligence Civilizations." *Acta Astronautica.* 42(10-12): 739-743.

Ball, John A. (1973). "The Zoo Hypothesis." *Icarus.* 19(3): 347-349.

Baxter, Stephen. (2001). *Deep Future.* London: Gollancz.

Bracewell, Ronald N. (1979). "An Extended Drake's Equation, the Longevity-Separation Relation, Equilibrium, Inhomogeneities and Chain Formation." *Acta Astronautica.* 6(1-2): 67-69.

Bradbury, Robert J. (2001). "Dyson Shells: a Retrospective." In Stuart A. Kingsley and Ragbir Bhathal, eds., *The Search for Extraterrestrial Intelligence (SETI) in the Optical Spectrum III*, Proceedings of SPIE, vol. 4273. San Jose, CA, USA: SPIE - The International Society for Optical Engineering, pp. 56-62.

Brin, Glen David. (1983). "The 'Great Silence': the Controversy Concerning Extraterrestrial Intelligent Life." *Quarterly Journal of the Royal Astronomical Society.* 24(3): 283-309.

Broderick, Damien. (1997). *The Spike: How Our Lives Are Being Transformed by Rapidly Advancing Technologies.* Kew, Victoria, Australia: Reed International Books.

Carrigan, Richard A., Jr. (2006). "Do Potential SETI Signals Need to Be Decontaminated?" *Acta Astronautica.* 58(2): 112-117.

Chaisson, Eric J. (2001). *Cosmic Evolution: the Rise of Complexity in Nature.* Cambridge, MA, USA: Harvard University Press.

Chapman, Clark R. (2004). "The Hazard of Near-Earth Asteroid Impacts on Earth." *Earth*

and Planetary Science Letters. 222(1): 1-15.
Chyba, Christopher F. and Kevin P. Hand. (2005). "Astrobiology: The Study of the Living Universe." *Annual Review of Astronomy and Astrophysics.* 43(1): 31-74.
Chyba, Christopher F., Paul J. Thomas, Leigh Brookshaw and Carl Sagan. (1990). "Cometary Delivery of Organic Molecules to the Early Earth." *Science.* 249(4967): 366-373.
Ćirković, Milan M. (2003). "On the Importance of SETI for Transhumanism." *Journal of Evolution and Technology.* 13(2). URL <www.jetpress.org/volume13/cirkovic.html>. Electronic article.
_____. (2004). "The Temporal Aspect of the Drake Equation and SETI." *Astrobiology.* 4(2): 225-231.
Ćirković, Milan M. and Robert J. Bradbury. (2006). "Galactic Gradients, Postbiological Evolution and the Apparent Failure of SETI." *New Astronomy.* 11(8): 628-639.
Cocconi, Giuseppe and Philip Morrison. (1959). "Searching for Interstellar Communications." *Nature.* 184(4690): 844-6.
Cordeiro, José Luis. (2005). "Future Generations Among Humans and Posthumans." In Tamás Gáspár and Péter Bakos, eds., *Futures Generation for Future Generations: WFSF 10th World Conference and Budapest Futures Course 2005.* World Futures Studies Federation. URL <www.budapestfutures.org>. Online eBook.
Criswell, David R. (1985). "Solar System Industrialisation: Implications for Interstellar Migrations." In Finney and Jones (1985), chap. 4, pp. 50-87.
De Vito, Carl L. (1992). "Languages Based on Science." *Acta Astronautica.* 26(3-4): 267-271.
Des Marais, D. J. and M. R. Walter. (1999). "Astrobiology: Exploring the Origins, Evolution, and Distribution of Life in the Universe." *Annual Review of Ecology and Systematics.* 30(1): 397-420.
Di Martino, Mario, Paolo Farinella and Giuseppe Longo. (1998). "Foreword of the Tunguska Issue." *Planetary and Space Science.* 46(2-3): 125.
Dick, Steven J. (2000). "Cultural Aspects of Astrobiology." In Tough (2000b), section V, paper 9, pp. 145-152.
_____. (2003). "Cultural Evolution, the Postbiological Universe and SETI." *International Journal of Astrobiology.* 2(1): 65-74.
_____. (2006). "Anthropology and the Search for Extraterrestrial Intelligence: An Historical View." *Anthropology Today.* 22(2): 3-7.
Drake, Frank D. (1961). Discussion at Space Sciences Board, National Academy of Sciences Conference on Extraterrestrial Intelligent Life, Green Bank, West Virginia, USA, November 1961.
_____. (1997). "Extraterrestrial Intelligence: The Significance of the Search." In Yervant Terzian and Elizabeth M. Bilson, eds., *Carl Sagan's Universe*, Cambridge University Press, chap. 8, pp. 87-97.
Dyson, Freeman J. (1960). "Search for Artificial Stellar Sources of Infrared Radiation." *Science.* 131(3414): 1667-1668.
Ehricke, Krafft A. (1981). "The Extraterrestrial Imperative." *Futures.* 13(2): 107-114.
Ehrlich, Paul R., John Harte, Mark A. Harwell, Peter H. Raven, Carl Sagan, George M. Woodwell, et al. (1983). "Long-Term Biological Consequences of Nuclear War."

Science. 222(4630): 1293-1300.
Finney, Ben R. (1985). "Voyagers into Ocean Space." In Finney and Jones (1985), chap. 10, pp. 164-179.
_____. (1988). "Solar System Colonization and Interstellar Migration." *Acta Astronautica.* 18: 225-230.
Finney, Ben R., and Jerry Bentley. (1998). "A Tale of Two Analogues: Learning at a Distance From the Ancient Greeks and Maya and the Problem of Deciphering Extraterrestrial Radio Transmissions." *Acta Astronautica.* 42(10-12): 691-696.
Finney, Ben R., and Eric M. Jones, eds. (1985). *Interstellar Migration and the Human Experience.* Berkeley, CA, USA: University of California Press.
Fitzpatrick, Paul. (2005). "CosmicOS." Web page. Published: 2005. Available at <http://people.csail.mit.edu/paulfitz/cosmicos.shtml>, accessed on 4 Nov 2005.
Fogg, Martyn J. (1987). "Temporal Aspects of the Interaction Among the First Galactic Civilizations: The 'Interdict Hypothesis'." *Icarus.* 69(2): 370-384.
Foundation for the Future. (2006). *Humans and Space: The Next Thousand Years; Proceedings.* Humanity 3000 workshop, held June 2005, Seattle, WA, USA: Foundation for the Future. Available at <www.futurefoundation.org/publications>.
Franck, S., A. Block, W. Von Bloh, C. Bounama, I. Garrido and H. J. Schellnhuber. (2001). "Planetary Habitability: Is Earth Commonplace in the Milky Way?" *Naturwissenschaften.* 88(10): 416-426.
Freitas, Robert A., Jr. (1985). "There Is No Fermi Paradox." Icarus. 62(3): 518-520.
Freudenthal, Hans. (1960). *Lincos; Design of a Language for Cosmic Intercourse.* Amsterdam: North Holland Pub. Co. This volume is called Part 1. No Part 2 seems to have ever been published.
_____. (1974). "Cosmic Language." In Thomas A. Sebeok, ed., *Linguistics and Adjacent Arts and Sciences* (4 vols), [*Current Trends in Linguistics vol.12*] volume 2. The Hague: Mouton. pp. 1019-1042.
Galtung, Johan. (1997a). "Arnold Toynbee: Challenge and Response." In Galtung and Inayatullah (1997), chap. 2.16: 120-127.
_____. 1997b. "Macrohistory and Macrohistorians: a Theoretical Framework." In Galtung and Inayatullah (1997), chap. 1: 1-9.
Galtung, John and Sohail Inayatullah, eds. (1997). *Macrohistory and Macrohistorians: Perspectives on Individual, Social, and Civilizational Change.* Westport, USA: Praeger.
Garber, Stephen J. (1999). "Searching for Good Science: the Cancellation of NASA's SETI Program." *Journal of the British Interplanetary Society.* 52(1): 3-12.
Glenn, Jerome C. and George S. Robinson. (1978). *Space Trek: the Endless Migration.* Harrisburg, PA, USA: Stackpole Books.
Harrison, Albert A. (1997). *After Contact: The Human Response to Extraterrestrial Life.* New York: Plenum Press.
_____. (1999). "Proximity, system level, and the human response to extraterrestrial life." Paper presented at Societal Implications of Astrobiology Workshop, NASA Ames Research Center, Mountain View, CA, USA, November 16-17.
_____. (2000a). "The Relative Stability of Belligerent and Peaceful Societies: Implications for SETI." *Acta Astronautica.* 46(10-12): 707-712.

_____. (2000b). "Slow Track, Fast Track, and the 'Galactic Club'." *Futures.* 32(6): 569-579.

Harrison, Albert and Steven J. Dick. (2000). "Contact: Long-Term Implications for Humanity." In Tough (2000b), section II, pp. 7-31.

Harrison, Albert, John Billingham, Steven J. Dick, Ben Finney, Michael A. G. Michaud, Donald E. Tarter, Allen Tough and Douglas A. Vakoch. (2000). "The Role of Social Sciences in SETI." In Tough (2000b), section V, paper 1: 71-85.

Hart, Michael H. (1985). "Interstellar Migration, the Biological Revolution, and the Future of the Galaxy." In Finney and Jones (1985), chap. 18: 278-291.

Hartmann, William K. (1985). "The Resource Base in Our Solar System." In Finney and Jones (1985), chap. 2: 26-41.

Hetesi, Zsolt and Zsolt Regály. (2006). "A New Interpretation of Drake-Equation." *Journal of the British Interplanetary Society.* 59(1): 11-14.

Hubbard, G. Scott. (2005). "Humans and Robots: Hand in Grip." *Acta Astronautica.* 57(2-8): 649-660.

Huntress, Wesley T., D. Stetson, R. Farquhar, J. Zimmerman, B. Clark, W. O'Neil, R. Bourke and B. Foing. (2006). "The Next Steps in Exploring Deep Space – A Cosmic Study by the IAA." *Acta Astronautica.* 58(6-7). Special issue.

Jantsch, Erich. (1980). *The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution.* New York: Pergamon Press.

Jones, Eric M. (1976). "Colonization of the Galaxy." *Icarus.* 28(3): 421-422.

Jones, Eric M., and Ben R. Finney. (1985). "Fastships and Nomads: Two Roads to the Stars." In Finney and Jones (1985), chap. 5: 88-103.

Kardashev, Nikolai S. (1964). "Transmission of Information by Extraterrestrial Civilizations." *Soviet Astronomy.* 8(2): 217-221.

Kauffman, Stuart. (1995). *At Home in the Universe: the Search for the Laws of Self-Organisation and Complexity.* Oxford University Press.

Kecskes, Csaba. (1998). "The Possibility of Finding Traces of Extraterrestrial Intelligence on Asteroids." *Journal of the British Interplanetary Society.* 51(5): 175-180.

_____. (2002). "Scenarios Which May Lead to the Rise of an Asteroid-Based Technical Civilisation." *Acta Astronautica.* 50(9): 569-577.

Kreifeldt, J. G. (1971). "A Formulation for the Number of Communicative Civilizations in the Galaxy." *Icarus.* 14(3): 419-430.

Kurzweil, Ray. (1999). *The Age of Spiritual Machines: When Computers Exceed Human Intelligence.* Allen & Unwin.

_____. (2006). *The Singularity Is Near: When Humans Transcend Biology.* Penguin. Originally published 2005 by Viking.

Martin, Anthony R. (1985). "The Plurality of Worlds: a Synergistic Approach to the Question of the Search for Extraterrestrial Intelligence (SETI)." *Futures.* 17(6): 618-631.

Mendell, Wendell W. (2004). "The Roles of Humans and Robots in Exploring the Solar System." *Acta Astronautica.* 55(2): 149-155.

Michaud, Michael A. G. (1998a.) "Challenge, Response and SETI." *Acta Astronautica.* 42(10-12): 681-683.

_____. (1998b). "Policy Issues in Communicating With ETI." *Space Policy.* 14(3): 173-178.

_____. (2003). "Ten Decisions That Could Shake the World." *Space Policy.* 19(2): 131-136.

Morrison, Philip and W. H. McNeill. (1973). "The Consequences of Contact." In Sagan (1973b), pp. 333-349.

Morrison, Philip, John Billingham and John Wolfe, eds. (1979). *The Search for Extraterrestrial Intelligence.* New York: Dover Pubs.

NASA. (2003). "Astrobiology Roadmap." Brochure, National Aeronautics and Space Administration, Ames Research Centre, Mountain View, CA, USA. Available at <http://astrobiology.arc.nasa.gov/roadmap/>.

Newman, William I. and Carl Sagan. (1981). "Galactic Civilizations: Population Dynamics and Interstellar Diffusion." *Icarus.* 46(3): 293-327.

Norris, Ray P. (2000). "How Old Is ET?" *Acta Astronautica.* 47(2-9): 731-733.

_____. (2003). "How to Respond to a SETI Detection." In Ray P. Norris and Frank H. Stootman, eds., *Bioastronomy 2002: Life Among the Stars.* San Francisco: Astronomical Society of the Pacific, pp. 493-498.

Oberg, James. (1995). "Terraforming." In Zuckerman and Hart (1995), chap. 10: 86-91.

Oliver, Bernard M. (1975). "Proximity of Galactic Civilizations." *Icarus.* 25(2): 360-367.

Papagiannis, Michael D. (1983). "The Importance of Exploring the Asteroid Belt." *Acta Astronautica.* 10(10): 709-712.

_____. (1995). "The Search for Extraterrestrial Technologies in Our Solar System." In Shostak (1995), pp. 425-431.

Peter, Nicolas, Andrew Barton, Douglas Robinson and Jean Marc Salotti. (2004). "Charting Response Options for Threatening Near-Earth Objects." *Acta Astronautica.* 55(3-9): 325-334.

Petersen, John L. (1999). *Out of the Blue: How to Anticipate Big Future Surprises.* Lanham, MA, USA: Madison Books, 2nd edn. Originally published 1997.

Pierson, Thomas. (2006). "SETI Institute As a Model for Managing Interdisciplinary Science." *Acta Astronautica* 58(9): 478-484.

Reed, Mary L. (2000). "Exosemiotics: an Inter-Disciplinary Approach." *Acta Astronautica.* 46(10-12): 719-723.

Reijnen, Bess. (1998). "The Nations United in the Scientific and Political Debate of the Search for Extraterrestrial Intelligence (SETI)." *Acta Astronautica.* 42(10-12): 667-669.

Sagan, Carl. (1973a). *The Cosmic Connection: an Extraterrestrial Perspective.* New York: Doubleday.

_____, ed. (1973b). *Communication With Extraterrestrial Intelligence (CETI).* Cambridge, MA, USA: MIT Press. English language transcription of the proceedings of a conference held at the Byurakan Astrophysical Observatory, Yrevan, USSR, 5-11 Sept 1971.

_____. (1983). *Cosmos.* London: Futura (McDonald & Co.). Originally published 1981.

_____. (1995). *Pale Blue Dot: a Vision of the Human Future in Space.* London: Headline.

_____. et al. (1973). "The Number of Advanced Galactic Civilizations." In Sagan (1973b), pp. 164-187.

Sagan, Carl and Iosef S. Shklovskii. (1966). *Intelligent Life in the Universe.* San Francisco: Holden-Day, Inc. Some versions have Shklovskii shown as the first author.

Seboldt, Wolfgang. (2004). "Space- and Earth-Based Solar Power for the Growing Energy Needs of Future Generations." *Acta Astronautica.* 55(3-9): 389-399.

Shostak, G. Seth, ed. (1995). *Progress in the Search for Extraterrestrial Life: Proceedings of the Bioastronomy Symposium 1993 Santa Cruz, California*, Astronomical Society of the Pacific Conference Series, vol. 74. San Francisco: Astronomical Society of the Pacific.

_____. (2004). "When Will We Detect the Extraterrestrials? " *Acta Astronautica.* 55(3-9): 753-758.

Sleep, Norman H., Kevin J. Zahnle, James F. Kasting and Harold J. Morowitz. (1989). "Annihilation of Ecosystems by Large Asteroid Impacts on the Early Earth." *Nature.* 342(6246): 139-142.

Smart, John. (2003). "Considering the Singularity: a Coming World of Autonomous Intelligence (A.I.)." In Howard F. Didsbury, Jr, ed., *21st Century Opportunities and Challenges: an Age of Destruction or an Age of Transformation*, Bethesda, MD, USA: World Future Society. Pp. 256-262.

Swift, David. (1995). "Responses to Contact: Variable to Consider." In Shostak (1995), pp. 567-571.

Tanner, Nancy Makepeace. (1985). "Interstellar Migrations: the Beginnings of a Familiar Process in a New Conext." In Finney and Jones (1985), chap. 14: 220-233.

Tarter, Donald E. (1998). "Reply Policy and Signal Type: Assumptions Drawn From Minimal Source Information." *Acta Astronautica.* 42(10-12): 685-689.

Tarter, Jill C. (2001). "The Search for Extraterrestrial Intelligence (SETI)." *Annual Review of Astronomy and Astrophysics.* 39(1): 511-548.

Tilgner, C. N. and I. Heinrichsen. (1998). "A Program to Search for Dyson Spheres With the Infrared Space Observatory." *Acta Astronautica.* 42(10-12): 607-612.

Timofeev, M. Yu, N. S. Kardashev and V. G. Promyslov. (2000). "A Search of the IRAS Database for Evidence of Dyson Spheres." *Acta Astronautica.* 46(10-12): 655-659.

Tough, Allen. (1998a). "Positive Consequences of SETI Before Detection." *Acta Astronautica.* 42(10-12): 745-748.

_____. (1998b). "Small, Smart Interstellar Probes." *Journal of the British Interplanetary Society.* 51: 167-174.

_____. (2000a). "What People Hope to Learn From Other Civilizations." *Acta Astronautica.* 46(10-12): 729-731.

_____, ed. (2000b). *When SETI Succeeds: The Cultural Impact of High-Information Contact.* Seattle, WA, USA: Foundation for the Future.

Turco, R. P., O. B. Toon, T. P. Ackerman, J. P. Pollack and Carl Sagan. (1983). "Nuclear Winter: Global Consequences of Multiple Nuclear Explosions." *Science.* 222(4630): 1283-1292.

Turnbull, Margaret C. and Jill C. Tarter. (2003). "Target Selection for SETI. I. A Catalog of Nearby Habitable Stellar Systems." *The Astrophysical Journal Supplement.* 145(1): 181-198.

Vakoch, Douglas A. (1998). "Constructing Messages to Extraterrestrials: an Exosemiotic Perspective." *Acta Astronautica.* 42(10-12): 697-704.

Vakoch, Douglas A., and Y. -S. Lee. (2000). "Reactions to Receipt of a Message From Extraterrestrial Intelligence: a Cross-Cultural Empirical Study." *Acta Astronautica.* 46(10-12): 737-744.

Vinge, Vernor. (1993). "Technological Singularity." *Whole Earth Review.* (81): 88-95.

Article is a modified version of a paper presented at the VISION-21 Symposium sponsored by NASA Lewis Research Center and the Ohio Aerospace Institute, 30-31 March, 1993. An annotated update for Whole Earth, Spring 2003, is available at <http://www-rohan.sdsu.edu/faculty/vinge/misc/WER2.html>.

Voros, Joseph. (2006). "Nesting Social-Analytical Perspectives: an Approach to Macro-Social Analysis." *Journal of Futures Studies.* 11(1): 1-22.

Walters, Clifford, Raymond A. Hoover and R. K. Kotra. (1980). "Interstellar Colonization: a New Parameter for the Drake Equation?" *Icarus.* 41(2): 193-197.

Webb, Stephen. (2002). *Where Is Everybody?: Fifty Solutions to the Fermi Paradox and the Problem of Extraterrestrial Life.* New York: Copernicus (Springer-Verlag).

Zuckerman, Ben. (1995). "Stellar Evolution: Motivation for Mass Interstellar Migrations." In Zuckerman and Hart (1995), chap. 6: 40-44.

Zuckerman, Ben and Michael H. Hart, eds. (1995). *Extraterrestrials: Where Are They?* Cambridge University Press, 2nd edn. Originally published 1982. Hart's name appears first in the first edition.