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THE POSTBIOLOGICAL UNIVERSE

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Abstract

The Drake Equation for the number of radio communicative technological civilizations in the Galaxy encompasses three components of cosmic evolution: astronomical, biological and cultural. Of these three, cultural evolution totally dominates in terms of the rapidity of its effects. Yet, SETI scientists do not take cultural evolution into account, perhaps for understandable reasons, since cultural evolution is not well-understood even on Earth and is unpredictable in its outcome. Thus SETI programs typically assume the existence of flesh-and-blood intelligence considerably older than our civilization, a paradigm part of what I have termed the biological universe (Dick, 1996).

Yet, the one certainty for technical civilizations billions, millions, or even thousands of years older than ours is that they will have undergone cultural evolution. Cultural evolution takes place in many directions, but in sorting priorities I adopt what I refer to as the Intelligence Principle: the maintenance, improvement and perpetuation of knowledge and intelligence is the central driving force of cultural evolution, and that to the extent intelligence can be improved, it will be improved. Applying this principle to life in the universe, extraterrestrials will have sought the best way to improve their intelligence, and may have long ago advanced beyond flesh-and-blood to artificial intelligence, constituting a postbiological universe. MacGowan and Ordway (1966), Davies (1995) and Shostak (1998) have broached this subject, but it has not been given the attention it is due from its foundation in cultural evolution. Nor has the idea of a postbiological universe been carried to its logical conclusion, including a careful analysis of the implications for SETI. SETI scientists, social scientists, and experts in AI (such as Hans Moravec, who has spoken of a postbiological Earth in the next several generations) should consider the strengths and weaknesses of this new paradigm.

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INTRODUCTION

Throughout history scientists and the general public have debated whether intelligent life exists beyond Earth. Some, including most SETI scientists, have concluded that such life is likely, and that cosmic evolution has resulted in a biological universe (Dick, 1996; Dick, 1998), defined as characterized by abundant life beyond the mere physical universe of planets, stars and galaxies. However, another possibility exists: that cultural evolution over the long time scales of the universe has resulted in something beyond biology, namely, artificial intelligence (AI). Such a postbiological universe cannot mean a universe devoid of biological intelligence, since humans are an obvious counterexample. Nor does it mean a universe devoid of lower forms of life, what I have termed the 'weak biological universe' (Dick, 2000a), as advocated by Ward and Brownlee (2000). Rather, the postbiological universe is one in which the majority of intelligent life has evolved beyond flesh and blood intelligence, in proportion to its longevity.

This argument has been broached by MacGowan and Ordway (1966), Davies (1995), and Shostak

(1998), and advanced in more detail by Dick (2003). But the possible role of artificial intelligence in the universe was completely overshadowed by the publication of Shklovskii and Sagan (1966). Although the last chapter of their book *Intelligent Life in the Universe* included a chapter on Artificial Intelligence and Galactic Civilizations the AI thesis was very general and lost in the midst of the exciting – and at the time more verifiable and realistic – implications of the other chapters, which assumed biological beings. Over the last 40 years SETI has focused almost exclusively on the biological paradigm, especially the radio SETI technique, as opposed the postbiological paradigm.

THE GENERAL ARGUMENT

My argument in this paper is simple, but firmly founded in the naturalistic evolutionary worldview. The overarching argument may be stated as follows: Advanced intelligence – defined as at least at the level of *homo sapiens* – implies culture; indeed some consider culture part of the very definition of advanced intelligence. Moreover, wherever culture exists there will be cultural evolution. Therefore, if extraterrestrial intelligence (ETI) exists, it must have undergone cultural evolution, most likely in direct proportion to its longevity. Because nothing is more important in cultural evolution than intelligence itself, any society will tend to increase its knowledge and intelligence. Because of the limits of biology and flesh-and-blood brains, notwithstanding advances in biotechnology, cultural evolution will eventually result in methods for improving intelligence beyond those biological limits. If the strong Artificial Intelligence concept is correct, that is, if it is possible to construct AI with more intelligence than biologicals, postbiological intelligence may take the form of AI. It has been argued that humans themselves may become postbiological in this sense within a few generations (Moravec, 1988; Moravec, 1999). This may be optimistic (or pessimistic depending on your outlook). But if ETI exists, and, as seems likely, it exceeds the age of terrestrial technological civilization, we may already live in a postbiological universe.

This overarching argument harbors many assumptions: 1) that evolution by natural selection results in intelligence beyond the Earth; 2) That ETI is older than human intelligence 3) that intelligence results in culture; 4) that culture evolves; and 5) that increasing intelligence is a central goal of cultural evolution. Each of these assumptions can be addressed by subsidiary arguments.

EXISTENCE AND AGE OF INTELLIGENCE BEYOND THE EARTH

The existence of ETI has been debated for millennia (Dick, 1982; Dick, 1996; Crowe, 1986; Guthke, 1990) and the debate need not be recounted here. Suffice it to say that the Drake Equation, which estimates the number of technological civilizations in the Galaxy, has in the past yielded answers ranging from 1 (ourselves) to a billion or more. Never in the history of science has an equation given answers differing by 9 orders of magnitude, an indication of the uncertainties involved. But with the discovery of nearly 200 extrasolar planets over the last decade, one of the Drake Equation parameters, the fraction of stars forming planets, has been increasingly informed by empirical data. While these new discoveries are believed to be mainly gas giant planets, new instruments such as NASA's Kepler spacecraft will soon yield numbers on Earth-size planets. That will still be only the beginning in determining whether they have life, much less intelligence. But for this part of the argument we make no more assumptions than standard SETI science arguments.

The age and longevity of ETI is important for the overarching postbiological universe argument, since ETI somewhat older than humans is a necessity for more advanced cultural evolution. SETI scientists have had much to say about this too, and there is general consensus that ETI would indeed be much older than us (e.g. Tarter, 2000). Cosmic evolution is our guide to the maximum age of extraterrestrial civilizations. Recent results from the WMAP spacecraft place the age of the universe at 13.7 billion years, with one percent uncertainty, and confirm that the first stars formed at about 200 million years after the Big Bang. The first Sun-like stars probably formed within about a billion years, or 12.5 billion years ago. By that time enough heavy element generation and interstellar seeding had taken place for the first rocky planets to form (Delsemme, 1998, p. 71; Larson and Bromm, 2001). Then, if Earth's history is any guide, it may have taken another 5 billion years for intelligence to evolve. Some 6 billion years after the Big Bang, therefore, some 7.5 billion years ago, the first intelligence could have emerged. By the same reasoning, intelligence could have evolved in our Galaxy 4-5 billion years ago, since the oldest stars in our galaxy formed about 10-11 billion years ago (Rees, 1997).

These conclusions are in line with those of a number of other astronomers using various methods. Norris (2000) argued that the median age of ETI is 1.7 billion years. Livio (1999) concluded that the first civilizations would emerge when the universe was about 10 billion years old, or 3.7 billion years ago. Kardashev (1997) concluded that cosmological models yield an age for civilizations of 6-8 billion years. Thus, several lines of evidence agree that extraterrestrial intelligence could have emerged several billion years ago. Even uncertainties of billions of years would not affect the argument for taking cultural evolution seriously.

But civilizations do not necessarily reach this age. The maximum age of ETI is mitigated by L, the lifetime of a technological civilization (typically defined as radio-communicative). Sagan, Drake and others generally assigned L values in the neighborhood of a million years, and even some pessimists admitted 10,000 years was not unlikely (Dick, 1996, p. 441). L is thus hardly an objective parameter, though studies by social scientists might contribute to the debate. That a man-made disaster would totally wipe out civilization seems unduly pessimistic, though natural phenomena such as mass extinctions, supernovae and gamma ray bursters are more problematic (Norris, 2000; Scalo and Wheeler, 2002; Chapman and Morrison, 1989, 1994).

But the important point is that, even at our low current value of L on Earth, biological evolution by natural selection is already being overtaken by cultural evolution, which is proceeding at a vastly faster pace than biological evolution. Technological civilizations do not remain static. Therefore cultural evolution must be taken into account in the Drake Equation no less than astronomical and biological evolution. Unlike biological evolution, L need only be thousands of years for cultural evolution to have drastic effects on civilization.

INTELLIGENCE, CULTURE AND CULTURAL EVOLUTION

Despite some agreement on the age and longevity of ETI, SETI scientists have not gone the next step to consider the implications of this longevity – that intelligence results in culture, and that culture evolves. For that matter, they have done little to define intelligence except in the operational sense that intelligence results in a technological civilization that is radio communicative. This is not surprising, since the SETI community largely consists of radio astronomers, not experts on the nature and evolution of intelligence. There is, however, a considerable literature on the nature and evolution of intelligence (Deacon, 1997; Donald, 1991; Hawkins and Blakeslee, 2004; Jerison, 1973), only a small amount of which has filtered into the fields of bioastronomy and astrobiology at professional meetings (Marino, 1997, 2000). We cannot review the literature on intelligence here, but remark only that SETI as a discipline needs to take more steps to integrate research on intelligence, a step that would also be reciprocally beneficial to the cognitive and neurosciences.

However intelligence is defined, we may agree with Ward and Brownlee (2000) that it is relatively rarer than microbial life in the universe, if only because it takes much longer to evolve, almost five billion years on Earth. But 'rare' is a relative term, and given the scale of the universe, there may be many intelligent civilizations in absolute numbers. This gives us cause to worry about the long-term nature of extraterrestrial culture and its effects.

While intelligence is undoubtedly a great leap, the leaps from intelligence to culture and from culture to cultural evolution are considerably less. Given intelligence, does culture necessarily follow? It depends first of all on the definition of intelligence. And secondly it depends on the definition of culture. Anthropologists have differed on the nature of culture (Kuper, 1999), but most definitions center around learned behavior that is passed down through generations. Wilson (1998) says that "culture is a product; is historical; includes ideas, patterns, and values; is selective; is learned; is based upon symbols; and is an abstraction from behavior and the products of behavior." Some experts are convinced that certain animals exhibit a rudimentary form of culture, and primatologists in particular have made this claim based on long-term studies of chimpanzees (Griffin, 2001, p. 243; Wrangham et al, 1994). But surely everyone can agree that culture goes hand-in-hand with intelligence at the human level (Richerson and Boyd, 2005), and that it would be exhibited at higher levels wherever language and communication exist.

Accepting the link between intelligence and culture, how can we possibly apply this to extraterrestrials and SETI? This brings us to the evolution of culture, which also has a considerable literature, though much of it is controversial. Darwinian models of cultural evolution have proliferated in recent decades. Among the first modern Darwinian theories of human behavior was sociobiology (Wilson, 1975), the systematic study of the biological basis of social behavior. There have been related attempts to use the idea of gene-culture co-evolution to span the natural and social sciences using population genetics (Cavalli-Sforza and Feldman, 1981; Boyd and Richerson, 1985; Durham, 1991; Richerson and Boyd, 2005). Daniel Dennett's 'universal Darwinism' concept posits that the same general evolutionary principles that apply to biology may also apply to culture, though with a mix of mechanisms including the inheritance of acquired characteristics as well as those related to natural selection (Dennett, 1996). When applied to knowledge and its transmission, Dennett's brand of universal Darwinism leads to memetics, based on the idea of Dawkins (1976), in which culture evolves via 'memes' in the same way that biology evolves via genes. The challenge is in the details of Darwinizing culture, or in elucidating how genes and culture may co-evolve (Aunger, 2000).

All such Darwinian models of cultural evolution have considerable problems (Lalande and Brown, 2002), and while we may hope for a science of cultural evolution as well developed as current Darwinian theory of biological evolution, for now a widely accepted theory or mechanism for cultural evolution is lacking. The bottom line, then, is that we know culture evolves, but we do not know how it evolves.

THE INTELLIGENCE PRINCIPLE AS CENTRAL DRIVER OF CULTURAL EVOLUTION

Given this dismal state of affairs regarding our own highly observable cultural evolution on Earth, how can we possibly discuss how cultural evolution has proceeded over the thousands, millions or billions of years that intelligence may have existed in the cosmos?

It must first be said that there is no way to predict rigorously the outcome of cultural evolution. And, while we have listed a variety of Darwinian models of cultural evolution, for historical reasons many social scientists still resist evolutionary hypotheses of culture altogether, fearing they harken back to Spencerian social Darwinism.

Lacking a robust theory of cultural evolution, we are reduced at present to the extrapolation of current trends. Several fields are most relevant, including genetic engineering, biotechnology, nanotechnology and space travel. But one field – artificial intelligence – may dominate all other developments in the sense that other fields can be seen as subservient to intelligence.

The study of AI was rudimentary in 1966, but MacGowan and Ordway's idea as applied to humans has been broached in subsequent years as the field of AI developed. Speaking of humans in 1988, Hans Moravec, a highly respected AI pioneer and robotic expert at Carnegie-Mellon, predicted "What awaits is not oblivion but rather a future which, from our present vantage point, is best described by the words 'postbiological' or even 'supernatural'. It is a world in which the human race has been swept away by the tide of cultural change, usurped by its own artificial progeny." (Moravec, 1988, p. 1; Moravec, 1999). Our machines, Moravec predicted, will eventually transcend us, and be "released from the plodding pace of biological evolution."

A decade later Ray Kurzweil, a pioneer in AI who brought voice-recognition machines to the commercial market, came to similar conclusions in his book *The Age of the Spiritual Machines: When Computers Exceed Human Intelligence* (Kurzweil, 1999). He has recently reinforced these ideas in *The Singularity is Near: When Humans Transcend Biology* (Kurzweil, 2005)). Moravec and Kurzweil obviously adopt a strong AI position.

While cultural evolution might trend in many directions, nothing in culture is more fundamental than intelligence. In sorting priorities, I therefore adopt what I term the central principle of cultural evolution, which I refer to as the Intelligence Principle (Dick, 2003):

The maintenance, improvement and perpetuation of knowledge and intelligence is the central driving force of cultural evolution, and to the extent intel-

ligence can be improved, it will be improved.

At the level of knowledge we see this principle in daily operation as individuals, groups and societies attempt to maximize their knowledge in order to gain advantage in the world around them. At the species level, intelligence is related to the size and structure of the brain. Failure to improve intelligence, resulting in inferior knowledge, may eventually cause cultural evolution to cease to exist in the presence of competing forces such as AI. In Darwinian terms, knowledge has survival value, or selective advantage, as does intelligence at the species level. The Intelligence Principle implies that, given the opportunity to increase intelligence (and thereby knowledge), whether through technology, genetic engineering or AI, any society would do so, or fail to do so at its own peril. Culture has many driving forces, but none can be so fundamental, or so strong, as intelligence itself. Artificial Intelligence is potentially a striking example of the Intelligence Principle, since an artificial intelligence greater than ours may make biological intelligence redundant. Given the time scales of the universe, this may have long ago resulted in a postbiological universe.

IMPLICATIONS FOR SETI

Given the likely AI characteristics of immortality, increased tolerance to the environment, capacity for action on a large scale, and an intelligence far superior to our own, the implications of the postbiological universe for SETI require further serious study. We enumerate four here for further study by the SETI community, and experts in AI and the social sciences:

1) Environmental tolerance and availability of resources beyond the planetary realm means that SETI searches for postbiologicals need not be confined to planets around sun-like stars, nor to planets at all (Shostak, 1998, 201; Tough, 2002).

2) Postbiologicals could communicate with each other via electromagnetic signals, but the Intelligence Principle tending toward the increase of knowledge and intelligence renders it unlikely they would wish to communicate in such a way with embryonic biologicals such as humans. Young biologicals such as ourselves might be reduced to intercepting communications of postbiologicals.

3) The Intelligence Principle leads us to conclude that postbiologicals might be more interested in receiving signals from biologicals than in sending them. This conclusion should lead SETI proponents to place new emphasis on message construction, and to explore the implications for message construction if the intended recipients are AI as opposed to biologicals.

4) The vast disparity in age between postbiologicals and biologicals highlights what has been called the incommensurability problem. It is entirely possible that the differences between our minds and theirs is so great the communication is impossible.

PROGRESS AND OTHER PROBLEMS

There are, of course, many objections that could be raised to the postbiological universe scenario. Some of them are common to all SETI endeavors, such as the probability of the existence of ETI. Beyond those common problems, there are the problems associated with culture and cultural evolution as discussed here. For example, the postbiological universe assumes there will be progress in cultural evolution, but the idea of progress should not be taken for granted. This assumption is problematic both in biology and in culture (Bury, 1924; Ruse, 1996; Ruse, 2006). Many things could go wrong on the way to evolutionary progress, so that progress may be far from inevitable. Indeed, rather than ignoring the problem, it could be argued that the lack of progress in cultural evolution might be one answer to the Fermi Paradox. Yet, despite many setbacks, it is difficult to argue against the empirical observation that by any definition homo sapiens has made progress in the last thousand or ten thousand years.

Another objection goes to the very heart of the Intelligence Principle itself: perhaps intelligence is not the central driving force of cultural evolution. Perhaps, some suggest, emotions like love, fear, or desire for power are the drivers. But short of mind-altering drugs or other drastic measures taboo to advanced terrestrial cultures, it is difficult to see how cultures would try to advance their evolution by fundamental changes to emotions. By contrast, most individuals and cultures place a premium on knowledge and intelligence, because it confers measurable competitive advantage.

The argument for a postbiological universe is thus not made with deductive rigor. Neither is the argument that ETI exists at all. But, given the existence of ETI, at the very least the possibility of a postbiological universe requires serious study. It is an opportunity for AI researchers to place their work in a cosmic context. AI and SETI, after all, have much in common, beginning with their interest in the nature of intelligence. And although the difficult problem of the definition of intelligence is beyond the scope of this article, the relation of biological and postbiological intelligence gains greater urgency with the prospect that cultural evolution may have already produced artificial intelligence throughout the universe. With the symbiosis of SETI and AI, SETI expands its possibilities in new directions, and the study of the long-term future of AI becomes more than idle speculation.

Yet another potential problem is that, on the principle that nothing in the universe remains static, postbiologicals might themselves be subject to cultural evolution. Where this would lead we cannot say. Moreover, AI may not be the ultimate emergence of cultural evolution. Indeed, the chief weakness of the idea of a postbiological universe may be that it is not be bold enough. It may be too closely tied to our current world view at the dawn of the computer age. And, strong AI may be only one possible method for increasing intelligence.

Nevertheless, though we recognize AI as a concept embedded in our present techno-culture and therefore influencing the current argument, the scenario of a postbiological universe is worth pursuing. It is a robust idea given the current state of our own cultural evolution, and is at least a beginning in taking into account the evolution of culture implicit in the Drake Equation. Many eminent biologists have adopted the Darwinian mantra of Theodosius Dobzhansky (1973) that nothing in biology makes sense except in the light of evolution. Richerson and Boyd (2005) have argued extensively that nothing about *culture* makes sense except in the light of evolution. Challenging as it is, SETI may not make sense unless ways are found to take cultural evolution seriously as an integral part of cosmic evolution.

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