

“WHEN THE STARS BEGIN TO FALL”

THE WANING OF THE ENLIGHTENMENT

Gerald E. Marsh

*My Lord! what a morning,
My Lord! what a morning!
Oh, my Lord! what a morning
When the stars begin to fall.*

*Oh sinner what will you do
Oh sinner what will you do
Oh sinner what will you do
When the stars begin to fall.*
—Traditional

As fundamentalist religious thought strengthens its hold on U.S. politics, and increases its role in politics around the world, enlightened values that form the very foundation of modern society are coming under attack. In the United States the wedge issue being used by fundamentalists is a pseudo-debate over creationism and Darwin’s theory of the descent of man.

The controversy over evolution and creationism—or its recent incarnation as “intelligent design”—has raged since the Darwinian revolution of the nineteenth century. It is really a continuation of the reaction against the Enlightenment. As put by Isaiah Berlin in his essay *The Counter-Enlightenment*,

“The proclamation of the autonomy of reason and the methods of the natural sciences, based on observation as the sole reliable method of knowledge, and the consequent rejection of the authority of revelation, sacred writings and their accepted interpreters, tradition, prescription, and every form of non-rational and transcendent source of knowledge, was naturally opposed by the Churches and religious thinkers of many persuasions.”¹

This is the branch of the Enlightenment whose impact on society was ultimately to liberate most people in the western world from the terrible fear generated by rampant superstition, not the branch that, Berlin and others have argued—not entirely convincingly—led to the tyrannies of the twentieth century.

Today, when one thinks of opposition to Enlightenment values the Islamic world—and particularly the Arab countries—immediately come to mind. Fareed Zakaria, the editor of *Newsweek International*, in his book *The Future of Freedom: Illiberal Democracy at Home and Abroad*,² characterizes the Arab world as “trapped between autocratic states and illiberal societies, neither of them fertile ground for liberal democracy. The dangerous dynamic between these two forces has produced a political

climate filled with religious extremism and violence. . . . Since September 11 the political dysfunctions of the Arab world have suddenly presented themselves on the West's doorstep."

The reaction against the ideas forming the basis of modern thought is not limited, however, to the developing or Islamic world: about 48% of the American public believe in creationism and another 25% aren't sure but tend toward creationism. And this is in a nation that prides itself on innovation and its scientific contributions to the world.

The New York Times of March 19, 2005 tells us that: "A number of Imax theaters, including some in science museums, are refusing to exhibit movies that mention the subject [evolution]—or the Big Bang or the geology of the earth—fearing protests from people who object to films that contradict biblical descriptions of the origin of the Earth and its creatures." It seems that it is permissible to talk about dinosaurs, but not the 65 million-year-old clay layers they are found in.

Evolution and Creationism

The conflict between evolution and creationism has always been between two fundamentally different and mutually exclusive world-views: one based on science, reason, and observation; and the other on what might charitably be characterized as an interpretation of religion that has an almost mediaeval quality. The dispute is over how humanity came into being and whether or not we are imbued with an immortal soul. It is not over how or why the universe came into being, or whether its development as elucidated by science reflects God's will—science doesn't address those questions. Science only answers the question "How?" not "Why?"—first causes are not within its domain of discourse.

The "debate" over creationism, while it is often presented as having opposing sides, is really only one-sided since the scientific debate over evolution ended more than a century ago. Few remember that soon after the publication of the *Origin of Species* the Scottish engineer Fleeming Jenkin showed that its basic thesis was seriously flawed.

Being unaware of the discrete nature of mutations—as was Darwin himself, Jenkin³ argued that a newly manifested character possessed by a few individuals would rapidly be diluted out of existence when those possessing the new character mated with the large number of individuals in the normal population. Without an answer to this criticism, the whole conceptual foundation of Darwin's theory of evolution—that new species arose through variation and selection—would be lost. The debate ended with the rediscovery of Mendel's work showing that mutations resulting in trait alterations had a discrete character that did not blend during reproduction.

Biology moved on, but unfortunately many people and institutions did not.

The basic thesis of variation and selection by environmental conditions is accepted today by anyone with a modicum of scientific education and no predetermined, religious bias—it can be readily demonstrated in any biology laboratory, and is illustrated daily by the emergence of antibiotic-resistant organisms and new viruses. The same principle that leads to new varieties of microorganisms underlies the formation of new species and the development of such complex organs as the eye—the organ that people espousing "intelligent design" seem to have so much trouble believing could evolve naturally.

Those who are still fighting the nineteenth century battle against evolution haven't yet realized that science has moved far beyond their concerns. An even more fundamental challenge to their world-view is at their doorstep. It is one that far transcends the challenges of the Enlightenment: we are now on the verge of creating life in the laboratory—and indeed, have essentially already done so; and having expressed a number of biological principles non-organically, it may soon be possible to understand the origin of consciousness, and—at least in principle—to show that it can be made to appear in a non-organic context.

Because these developments are not generally known, they are discussed more extensively in two supplements to this essay titled *Synthesizing Life and Non-Organically Expressed Biological Principles*. Of course, these supplements are by no means exhaustive. They are included here—even in their limited scope—because the topics they discuss are central to the body of this essay. Once one accepts Darwin's theory of evolution, the role of divine creation is pushed back to the creation of life itself.

Similarly, consciousness is central to the concept of the soul. The creation of life in the laboratory and the possibility of non-organic forms of consciousness raise fundamental challenges to the conceptual foundations of all religion. Science, and in particular the biological sciences, are now beginning to challenge religious world-views in a way that is unprecedented in history.

The creation of life in the laboratory, far more than the theory of evolution, threatens to destroy the creation myths of mankind. While this may seem trivial to those who have long accepted that humanity is not a central part of God's creation, and that the existence of the immortal soul was at least somewhat suspect, it is worth rereading again the statistics given above on the belief in creationism. When people come to understand what is at stake, they will not take it lightly.

Why?

It is important to realize that what is really behind the conflicting world-views is what I have said science doesn't address—the question of “Why?” Those who believe in creationism fear the loss of meaning and direction in their lives and fear especially a future without a personal immortality. If the origin of life, and humanity in particular, has a natural explanation, how can one believe in the immortal soul, or that humanity is central to God's creation? As put by Omar Khayyám—a doubter of long ago—in two of the quatrains of his *Rubáiyát*:

“There was a door to which I found no key:
There was a veil past which I could not see:
Some little talk awhile of me and thee
There seem'd—and then no more of thee and me.

Then to the rolling heav'n itself I cried,
Asking, “What lamp had destiny to guide
Her little children stumbling in the dark?”
And—“A blind understanding!” heav'n replied.”⁴

A “blind understanding” is not enough for most people, and even not for some scientists. Many suffer from what I have called Weinberg’s lament. In his book *The First Three Minutes* the physicist Steven Weinberg⁵ complained that: “The more the universe seems comprehensible, the more it also seems pointless.” But he found some solace in the fact that “The effort to understand the universe is one of the very few things that lifts human life a little above the level of farce, and gives it some of the grace of tragedy.”

That the universe seems pointless to those who do not hold to the traditional faiths may be the inevitable consequence of the reductionist approach implicit in the scientific method. Science has been able to reveal the evolution of the universe back to the first moment of creation, but cannot offer any explanation for what Fred Hoyle⁶ derogatorily called the “big bang,” other than it might have been a random and meaningless quantum fluctuation. What this “fluctuation” was supposed to have taken place in, since neither space nor time, as we understand it, had yet come into existence, is left unanswered.

Attempts have been made to transcend the limitations imposed by reductionism, the concept that the nature of complex phenomena can always be reduced to, or explained by, simpler more fundamental ideas. This approach is fundamental to the scientific method. Perhaps the most promising is a cross between Arthur Koestler’s⁷ concept of an open hierarchy* and what is known today as emergent behavior. Such an approach offers hope to many thoughtful people that there may be a way to transcend Weinberg’s lament—the rather gloomy conclusion that the existence of the universe, and of intelligence in particular, has no meaning. But it does not, and can not answer the question “Why?”.

Religious Belief and Secular Democracy

In the beginning of the twenty-first century, we live in an age when the Enlightenment is slowly fading: *The New York Times* of January 1, 2002 published a picture of a book burning in Alamogordo, New Mexico—the city made famous by the first atom bomb test. The photo shows a large crowd of people standing around a bonfire lit in front of a church. The people were watching a large pile of Shakespeare and Harry Potter books burn. The Rev. Jack Brock had characterized the books as “satanic deception.” And the caption states that “at the Vatican, the Roman Catholic Church’s most famous exorcist said the Devil was behind young Potter.” Today, some 68% of Americans believe in the devil. How do you think they feel about evolution? About creation of life in the laboratory? About the possibility of artificial intelligence?

One would hope that such abysmal ignorance and the fear that exposure to Shakespeare and Harry Potter could compromise their immortal souls, would be fading with the education now available to all. But this is not the case. Often the teaching of evolution and even geology—where one must explain the existence of fossils—is simply avoided in many schools so as to not offend the religious sensibilities of the pupils or their parents.

* Koestler defined open hierarchies as being multi-leveled with semi-autonomous sub-levels of ever decreasing order. The rules that govern the behavior at one level are not reducible to the rules at a lower level.

In January of 2005, Alvin Saperstein published a commentary in the newsletter of the *Forum on Physics and Society*⁸ where he gave the example of a bright young drama student he had had in his introductory astronomy class:

“Earnest and hard-working, she struggled with the material (especially its minor quantitative aspects) and eked out an A grade. At the end of the semester, after the final exam, she came up to me, respectfully and seriously, with a question: What was she to do, since her upbringing and personal commitment led her to believe that our world was only 5000 years old, even though I had spent the semester explaining to the class why they should believe our solar system to be a 4 1/2 billion year old unit of a 13 billion year old universe? She was bright enough, serious enough, concerned enough, and trusting enough, to raise the question. What about the students in that class—or in many, many other such classes, who don’t have such trust in their teachers or betray any such concern?”

Saperstein goes on to note that “Similar, though more concrete, dichotomies in students’ minds are well known. The physics pedagogy research group at the University of Washington has amply documented, through post-teaching interviews with students, that they reply to questions about aspects of the physical world with: “How would you like me to answer—as I’ve been taught, or as I really believe?” And this is among those who are privileged enough to be able to attend fine colleges.

One might think that in the United States it is only fundamentalist Christians that believe such absurdities, but they have company. Some ultra-Orthodox Jews—while they could well differ with Christians over the exact details of the chronology—believe the world, as of 2008, is exactly 5768 years old. Twenty-three ultra-Orthodox rabbis signed an open letter denouncing the books of Rabbi Slifkin, an Israeli scholar and science writer. According to the *New York Times* of 22 March 2005, the letter said in part: “He believes that the world is millions of years old — all nonsense! — and many other things that should not be heard and certainly not believed. His books must be kept at a distance and may not be possessed or distributed.” A relatively enlightened viewpoint in that they are not suggesting that the books be burned.

Why be concerned even if a majority of people believe in creationism? Because creationism is a wedge issue. Underlying it is the same literal interpretation of scripture that is behind the rise of intolerant Islam, or the belief by some Jews that Judaea and Samaria were given to them by God. Millions believe that once the Jews reoccupy all of their biblical lands, the legions of the Antichrist will attack, thus leading to the final conflict in the valley of Armageddon. It is no longer possible to dismiss such beliefs as delusional or marginal. They now play a role in the corridors of power.

There is an implicit tension between the modern, secular state and an individual’s religious orientation since the obligation to God must, by its very nature, transcend any duty to the state. Communist states resolved the conflict by viewing religion as inherently subversive; Islamists view liberal democracy—with its secular rule of law—as an impiety. Implementation of the Sharia resolves the implicit tension between secular law and religious belief by replacing secular law with laws derived from Holy Scripture. In the end, fundamentalist religious belief and secular, liberal democracy are

incompatible. The modern world has thus far been able to gloss over this contradiction, but the strains are beginning to make themselves all too apparent.

The coexistence of religion and liberal democracy has been achieved in the west by the creation of the modern secular state. Over time it was learned through bitter experience that this must be an inclusive form of secularism, one that offers protection to all religious beliefs provided they remain in the personal domain. Either explicitly or in practice, a separation was maintained between religion and state. Today, almost everywhere that liberal democracies exist this separation between religion and state is increasingly coming under pressure by the rise of fundamentalist religious belief.

The problem can no longer be ignored. It is a serious threat to modern civilization. And it may well be a reaction to the modern world, a world that has come upon most societies far too quickly to allow them to adapt socially and intellectually.

The Modern Rise of Fundamentalism

Despite the many benefits in health, technology, longevity, and wealth, people's beliefs and customs are being destroyed. Many who suffer such dislocation and anomie do not believe that what the modern world has to offer is worth the loss of their way of life. And, to quote a South African Basuto proverb:⁹

“If a man does away with his traditional way of living and throws away his good customs, he had better first make certain that he has something of value to replace them.”

It is up to those who would have the world follow in the footsteps of the Enlightenment to show that the modern world has more to offer in cultural and moral values than traditional beliefs. But how can this be done? The western world has had ample time to adapt gradually to the changes wrought by the transition from an agrarian to an industrial society; time to come to terms with market capitalism and the industrial revolution; and most especially, time for at least the educated elite segments of the population to absorb the changes in world view associated with the Enlightenment.

The developing world does not have that time, it is being forced to absorb cultural dislocations of a magnitude almost unparalleled in history. At first glance it all seems to be working. Cell phones and other forms of modern technology seem to be readily integrated into developing nations. Absorbing what lies behind that technology, however, is not at all easy. Given domestic politics in the developed world and the cultural rigidity of much of the developing world—not to speak of the realities of international economics, formulating and executing a policy that would have a reasonable chance of success in dealing with this problem may not be possible.

It may also not be possible because the forces behind change are not under anyone's control. The transformation of the world economy is being driven by what goes under the rubric of “globalization.” Beginning with manufacturing, this recent development was made possible by the revolution in communications and transportation over the last few decades—it is now profitable to manufacture goods and transport them to markets from many different world locations. As the cost of communications drops, the same is becoming true of services. Globalization is comparable to the industrial revolution in its scope and impact on the societies of the world. And it is no more under

the control of individual corporations than the industrial revolution was to the barons of that age. Globalization is an historical process made possible by the evolution of modern technology in the broadest sense. And while the world as a whole may ultimately benefit from this development, the transitions may be difficult and painful for many people, as was the case during the industrial revolution.

While the rise of fundamentalist religious belief in the developing world may be due to the rapid pace of change, this is not the case for Europe or the United States.

Europe has always had indigenous segments of the population that continued to harbor superstitious beliefs in one form or another. But the recent rise there in Islamic fundamentalism is primarily a result of the politically motivated activity of a small minority of Islamic immigrants who hold intolerant beliefs, and their attempt to impose those beliefs on members of their own communities as well as the generally secular society within which they are embedded. The problem has been summarized by Jean-Louis Bruguiere, the French magistrate specializing in Islamic terrorism and widely acknowledged as a legal expert on the subject. In an 8 January 2005 interview with the *Financial Times* he stated that:

“One of the strategies of *al-Qaeda* is to demonstrate to the world, but especially the Muslim world, that democracy is a false concept, and it wants to force western governments to act in an undemocratic way. . . . The threat is before us, not behind us. The threat is more mobilised and scattered. There are more and more targeted countries. I am not very confident about the future.”

Of course not all Muslims holding intolerant beliefs are members of al-Qaeda, although they may well sympathize with their goals if not their methods.

In the United States the problem is multifaceted and is currently centered not on Islamic *jihadis* but on Christian fundamentalists. Their gain in political power is due to a variety of factors including the lack of participation in the electoral process by sizable minorities of the population and the generally poor and deteriorating quality of education on the elementary and high school levels. Poor education is not restricted to poverty-stricken inner city areas, being also found in relatively wealthy and homogeneous suburbs.

Contributing factors to the rise of fundamentalism in the United States are the reaction to the liberalization of the sixties and the generally low and deteriorating quality of the media. The most important factor, however, is the leveling of the old elite segments of the population clearing the way for the rise of mass culture. The silent and generally uneducated majority have been given a powerful voice by radical changes in technology and the character of the media. And, unfortunately, their gain in political power and influence has risen far faster than their level of education. The impact of these changes has been captured in Fareed Zakaria’s quote of Edmund Burke,¹⁰ “Your representative owes you, not his industry only, but his judgement; and he betrays instead of serving you if he sacrifices it to your opinion. . . .” Today there is a vast industry trying to capture people’s opinions and—independent of whether they reflect good judgement—impose them on elected representatives. Political parties sway to the wind of populism counterbalanced only by the pressure of special interests.

Science and Its Credibility

An additional, troubling and increasingly serious problem is the loss of credibility of science and its findings with the general public. One reason for this is a misunderstanding of scientific truth, which is often viewed as absolute rather than the best explanation for a given set of facts. Another reason is the confusion of causation and correlation in many scientific studies and certainly by the general public when they hear about these studies. For example, beneficial therapies are often later found to have unintended consequences. Perhaps the best known case of this in the recent past is hormone replacement therapy. Once touted as good for women even if they experienced none of the problems of menopause, it is now viewed as far too dangerous—and even some of the beneficial effects were found to not exist.

The fact that given enough political power or money it is always possible to find credible scientific testimony on any side of an issue does not help to establish trust with the public. The average person, as well as judges who preside over the court system, do not have the background to judge issues involving stem cell research, nuclear power, nuclear weapons policy, whether the high costs of medicines properly reflect the costs of development, or if one fiscal policy or another makes sense. They must rely on experts. But the general view today is that such experts are either bought or driven by a political agenda. Informed opinion has lost its credibility. The public often feels powerless and lost, unable to decide about such issues, and as a result they simply opt out or follow the people they hope they can trust—increasingly only their pastors, rabbis or priests.

It isn't only ignorance and the lack of trust in science and scientists that drives people to religion, it is their need for certainties in life. The past shows us that most people feel unable to live without the comfort of the belief in the immortal soul and that human beings are somehow central to God's plan. Many come to believe that true knowledge can only be gotten through revelation. This must change if the modern world is to survive.

The kind, gentle, and charitable religious beliefs that most people hold would hardly seem to be a threat. Who cannot be moved by the beautiful music and often deeply moving rituals of some religions? Or by the kindness and good works of many religious institutions? But a literal belief in angels comes with a belief in the devil. And those who believe in the devil are susceptible to the claim that actions and beliefs that challenge one's own true belief may be due to the influence of dark forces. Beneath the gentleness of today's religions lies the burden of their often violent and intolerant past.

And those in the western world who believe in the literal interpretation of scripture live in that past. Unfortunately, they are not alone. Globally, most people continue to embrace the idea that there is another parallel ghost world in close proximity to ours, and that interaction between the two is not only possible but also routine. Mythopoeic thought, as described by the Frankforts in *Before Philosophy*,¹¹ is alive and well. It continues to instruct the outlook of most of humankind. Western secular culture—so strongly influenced by the scientific world-view—is an aberration.

More than half a century ago, Homer Smith wrote a beautiful book called *Man and His Gods*.¹² It had a forward by Albert Einstein who characterized Smith's exposition as follows:

“The work is a broadly conceived attempt to portray man’s fear-induced animistic and mythic ideas with all their far-flung transformations and interrelations. It relates the impact of these phantasmagorias on human destiny and the causal relationships by which they have become crystallized into organized religion.”

In the *Epilogue*, Smith captures what must happen if the modern world is to avoid what might well be characterized as a social form of Armageddon:

“As a fallen angel, man would be ludicrous. As an intelligent animal, he has reason to be proud because he is the first who can ask himself, ‘Whither, Why, and Whence?’ and confident because he can know himself as a creature of earth who has risen by his own efforts from a low estate. If he would rise higher he must be true to earth, he must accept that he is its creature, unplanned, unprotected and unfavored, co-natural with all other living creatures and with the air and water and sunlight and black soil from which their dynamic pattern has been fabricated by impersonal and indifferent forces. In every wish, thought and action he is seeking to escape the same protoplasmic disquietude that impels the meanest flesh crawling beneath his feet. He must find his values and his ends entirely within this frame of reference.”

The alternative is unpleasant. Book burnings may be just the beginning. On March 7, 2005, Tony Barber of the *Financial Times* observed that “the Regina Apostolorum Pontifical University in Rome began a training course for priests to help them fight devil worship and diabolical possession amid signs of satanism’s rising popularity. Several officially recognized exorcists are to lecture.”

Return to the Inquisition?

While modern social strictures continue to function, one must hope that the drift towards the modes of thought of the Middle Ages will reverse itself. But should the social fabric be torn by unforeseen events, we may yet see *autos-da-fé* return to plague those who persist in following in the footsteps of the Enlightenment. The emergence, for example, of a pandemic with a high lethality could well cause a great enough dislocation in world order to allow the forces of ignorance again to dominate men’s minds. They are not far below the surface. And, as we are constantly reminded in the coverage of H5N1 bird flu, such a pandemic is long overdue.

While the Inquisition has formally ended, not so the “Holy Office,”—the Roman Congregation of the Inquisition, renamed in 1965 as the Congregation for the Doctrine of the Faith. Cardinal Joseph Ratzinger, who headed this organization since being appointed by John Paul II in 1981, has now become Pope Benedict XVI. Conservative church organizations such as Opus Dei can be expected to receive even greater support than they did under John Paul II.

The warning to those who persist in pursuing the path of reason and science may yet be the verse:

Hide! Hide, witch!
The Good People
Come to burn thee.
Their keen pleasure,
Hid beneath the
Gothic mask of duty.
-Anon.

For those who doubt this possibility, keep in mind that we already have killings in the name of religion in much of the world including the United States, and a rising number in Europe. And then there is the worldwide rise of Islamic intolerance and the September 11, 2001 attack on the World Trade Center, and what lies behind it. Other examples are not hard to find.

Should the forces of ignorance and intolerance rise again, the victim's only solace may be the words from Shelley's *Prometheus Unbound*:

“To suffer woes which Hope thinks infinite;
To forgive wrongs darker than death or night;
To defy Power which seems omnipotent . . .
Neither to change, nor falter, nor repent,
This . . . is to be
Good, great and joyous, beautiful and free;
This is alone Life, Joy, Empire and Victory.”¹³

Weinberg's lament will have become irrelevant.

Supplement I: Synthesizing Life

Because the creation of life would be a direct challenge to creationists and to almost all others holding fundamentalist religious beliefs, it is important to review just how close we are to creating life in the laboratory.

In 1828 Wöhler's synthesis of urea, previously thought to only be produced by living organisms, was the first in a series of discoveries that destroyed the concept of vitalism, the idea that a “life force” was necessary for living creatures to exist. Although urea is a simple molecule, its synthesis was intellectually an enormous breach in the barrier between the animate and inanimate world. The chemistry of life was shown to be no different from normal laboratory chemistry.

In 2002, Eckard Wimmer¹⁴ and his colleagues at the State University of New York in Stonybrook successfully synthesized infectious polio virus particles. The experiment showed that it was possible to synthesize a simple life form. This is only a first step in the creation of life, but the philosophical implications are phenomenal. In thinking about viruses, it is important to recognize that their origin is not yet really understood. They could be plasmids—small circular molecules of DNA—that have evolved to live outside a host cell by producing a protein coat, or they could be degenerate descendents of normal cells that have lost all metabolic functions in favor of a parasitic existence.

Wimmer's work was rapidly followed by that of Craig Venter¹⁵ and his colleagues who synthesized the genome of the bacteriophage phiX174 in the short period of 14 days. Like the polio virus, the synthesized particles of phiX174 were infectious and could reproduce. And although one might argue that viruses are not free-living creatures but require a host organism to multiply, it is likely that the creation of organisms that are self-reproducing is not very far in the future.

It is interesting to speculate on how creationists might view the creation of life in the laboratory. A quote from *Creation Illustrated* might be indicative:

“The laboratory experiments related to theories on the origin of life have not even remotely approached the synthesis of life from nonlife, and the extremely limited results have depended on laboratory conditions that are artificially imposed and extremely improbable. The extreme improbability of these conditions and the relatively insignificant results apparently show that life did not emerge by the process that evolutionists postulate.”¹⁶

While the article does not specify the experiments in question, it is likely that it is referring to the classic experiments of Miller¹⁷ in 1953 and Miller and Orgel¹⁸ in 1974. These produced organic compounds including amino-acids from a reducing atmosphere of methane, ammonia, molecular hydrogen and water by using an electrical discharge—conditions that were not in the least bit “unusual and extremely improbable” on the early earth. Amino-acids are the building blocks of all proteins that make up living organisms.

Others have duplicated such experiments with many variations and found that so long as there is a reducing atmosphere similar to that of the early earth, along with energy available from ultraviolet light, ionizing radiation, or electrical discharges, the organic compounds are formed. These experiments showed that simulating the pre-biotic synthesis of amino acids is simple. The same cannot be said for simulating the pre-biotic synthesis of the nucleotides needed to build up the molecules that carry the genetic code. While nucleotides will spontaneously form under the right conditions, they also readily degrade in solution to their constituent components.

This difficulty has led Freeman Dyson to propose in his book the *Origins of Life*¹⁹ a double-origin hypothesis. Dyson's model is a variation of the older Oparin idea that cells evolved from “coacervate” droplets that accumulated molecular populations that were later organized into self-sustaining metabolic cycles by enzymes. Only later were genes added. A summary of the synthesis of life along these lines was given in *Nature* in 2001 by Jack Szostak, David Bartel, and Luigi Luisi.²⁰ Their discussion is based on the RNA world hypothesis where primordial cells lacking protein synthesis use RNA to function as enzymes that catalyze metabolism and also serve as the repository for genetic information.

But even if we were able to simulate the creation of life along these lines, it may well be impossible to prove that whichever method finally succeeds was actually the way life evolved on the earth. For one thing, there may be more than one way for life to evolve. But as a consequence of this essential uncertainty, even if fully living creatures are soon produced in the laboratory, it is unlikely that creationists will change their views. As for the direct synthesis of life *à la* Wimmer and Venter, the heavy hand of man would surely be considered “artificially imposed and extremely improbable.”

Supplement II: Non-Organically Expressed Biological Principles

Intelligent thought has long been believed to be restricted to human beings. Those with a religious orientation believe that human beings are free to choose between good and evil. Such a choice would, of course, be meaningless without the innate ability for conscious, intelligent thought. Consciousness and the ability to learn are the essence of what one means by the immortal soul, although from a strictly religious perspective the soul might be called a consequence of God's grace. But these religious beliefs would be directly challenged if it were found that consciousness and thought could be expressed in a non-biological context. This supplement explores how close we are to showing that this is possible.

A most intriguing experiment was performed many years ago by carefully tracing one of the neural networks of a simple invertebrate organism. Although relatively simple, the electrical behavior of this network was rather complex. After characterizing the electrical operation of a typical neuron, the whole network was electrically simulated using readily available electronic components. The functioning of the neural network *in vivo* and the artificial network simulating the biological system were then compared. They two were essentially identical! My memory of this is more than thirty years old and I can no longer remember where the article appeared, but it has been overtaken by more recent developments.

This example is of a “hard wired” neural network, one not fully capable of changing its behavior on the basis of changing synaptic functioning—it had minimal or no learning capacity. Nonetheless, it showed that at least in principle it was possible to simulate the nervous functioning of a living creature. Since this experiment was conducted, there has been much work on neural networks—however, generally not until recently along the lines of simulating biological neural networks. There has also been a good deal of work on hybrid systems using biological neural networks connected to the outside world with electrical interfaces. Thomas DeMarse²¹ at the University of Florida has used a network of some 25,000 rat neurons to actually operate a flight simulator. But two key problems remain unresolved in understanding the far more complex neural networks that make up the brains of higher creatures: the mechanism of memory and the origin of consciousness.

Memory, and there are a variety of types, is thought to ultimately reside in synaptic changes, and while some of the details remain uncertain, the broad outline can be had from Eric Kandel's most unusual combination of memoir and scientific exposition²² *In Search of Memory*. It is a complex problem since a given neuron and its associated synapses may play a role in different memories. Consciousness is not only difficult to understand it is even hard to define. Although a large number of experiments have been performed to ascertain the nature of consciousness, and reams of paper consumed in writing on the subject, it remains an almost intractable problem. Gerald Edelman²³ defines it as the “remembered present.” And while this may be one of the best operational definitions we have, others believe that consciousness is an “emergent” property of complex neural networks.

What makes understanding the nature of consciousness so difficult is the problem of determinism. How can consciousness, which is thought to embody free will, arise out

of a deterministic network? The concept of emergence attempts to resolve this dilemma without viewing consciousness as something metaphysical.

There has been a great deal written about emergent behavior in the philosophical literature distinguishing various types of emergence and arguing for or against a given type, but it is not possible to do justice to that literature here.²⁴ Instead, one can address the phenomenology.

Emergent Behavior

The concept of emergent behavior is easy to understand. One defines a set of rules for the interaction of a class of objects (atoms, molecules, cats, people) with each other and with the environment, and within the constraints set by the rules, the observed behavior is often very complex, transcending the simplicity of the rules themselves. A concrete and practical example is the class of artificial insects developed at MIT,^{25,26} particularly the emergent behavior displayed when central control modules are eliminated and the robots are allowed to “learn” their behavior.

Similar work has been done on simulating insect-like neural networks on a digital computer at Case Western Reserve University by Randall Beer, Hillel Chiel, and Leon Sterling.²⁷ The body plan they used is based on the American cockroach and the artificial insect they created walks with changes in gait that are an emergent property similar to the changes in gait made by real insects as they change their speed. That is, these gait changes are not “wired into” the circuitry. This complex behavior is achieved with only six “neurons” per leg, and two command neurons that are wired to all six legs. A six-legged robot duplicating the neural circuitry used in the computer simulation was constructed and it displayed a range of gaits similar to those of the insect simulated.

Studies by Deborah Gordon²⁸ show that another example of emergence is the complex behavioral patterns exhibited by ant colonies. These behaviors, and the changes in behavior as the colony grows and ages, seems to be based on the decisions of individual ants that operate with a relatively simple set of rules based on social contact and the environment in which the individual finds itself.

The various tasks carried out in an ant colony are accomplished without direction, without the chain of command implicit in an hierarchical organization. A single set of rules, at the level of the individual, is responsible for the behavior of the colony as a whole. As an ant colony ages, its responses are refined to adapt to changes in the colony’s environment. Such refinement represents a type of social learning, with the memory trace being stored in a holographic fashion across the individuals of the colony. Small modifications of the rules of interaction can lead to significant changes in the behavior of the colony as a whole. Of course this discussion is oversimplified in that the inhabitants of ant colonies have specialties and there may be several subsets of rules rather than a single overarching set.

The emergent behavior of a system, while it is determined by the elements of the system and rules of interaction between them and with the environment, is not contained explicitly in any of the rules or elements themselves, nor is the behavior explained by a simple summation over the components making up the system. Emergent behavior is characterized by being “greater than the sum of the parts.”

While the emergent behavior is completely determined by the set of rules governing the interaction between the elements of a system and the environment, a key

question is whether, at the level of the emergent behavior, new rules of interaction appear that are not, in a fundamental sense, predictable. Very simple mathematical models can exhibit extremely complex dynamics even though the behavior is completely deterministic. They have been successfully used to model the dynamics of systems in a variety of fields, including electronics, mechanics, and biology.²⁹ In each of these diverse areas, even when the behavior is chaotic (where the dynamics depends exponentially on changes in initial conditions), and the dynamical trajectories look like random noise, the behavior is deterministic.

On the other hand, it is possible that the rules that govern behavior at one level can be compared to a set of axioms in elementary mathematics. An analogy can then be made to Gödel's incompleteness theorem.³⁰ The axioms of a deductive system are "complete" if every true statement that can be expressed in the system is deducible from the axioms. What Gödel showed was that if the axioms of a system at least as complex as arithmetic are consistent, there are statements whose truth or falsity cannot be decided on the basis of those axioms, which is why it is called the "incompleteness" theorem.*

The idea of the analogy is that if one defines a consistent set of rules (axioms) the resultant behavior (a type of statement) is unpredictable from the rules, and therefore represents a higher level in a hierarchy of behavior. Such hierarchies are truly open, in the sense of Koestler, as opposed to the complex behavior of a fully deterministic dynamical system.

Analogies, of course, are descriptive tools that are not always fully representative, and it remains to be shown that the analogy with Gödel's theorem is rigorous.

The structure and variety of atoms are determined by the rules of quantum mechanics. And while one might argue that the behavior of atoms in forming molecules is implicit in the rules of quantum mechanics, one would be hard pressed to derive the architecture of DNA from the axioms of quantum mechanics. Similarly, while DNA surely determines the structure of living creatures, it would be impossible to derive their social behavior and organization from only the sequence of bases in DNA. The higher up one goes in such a hierarchy, the more the organization seems completely independent of the rules determining the behavior of the levels below—which, nevertheless, is not to deny that the higher-order rules are inherently determined by the properties of the component parts.

Consciousness and intelligence appear to emerge gradually as the complexity of life increases. Simultaneously, and as a parallel development, a social structure comes into existence. Social behavior can be as simple as that of slime molds when forming a fruiting body, be relatively complex as in the behavior of an ant colony, or be represented by the far more complex behavior of human societies.

Consciousness and intelligence seemingly have meaning only for individual members of the more advanced societies. But are we certain? Perhaps there is also a type of social or group consciousness associated with societies of social animals. Are the

* Any formal logical system encompassing the addition and multiplication of positive integers and zero is subject to the limitations of Gödel's theorem. Its scope is breathtaking, including as it does most of formal mathematics.

emergent behaviors exhibited by such societies complex in the sense of a dynamical system, or do they have some unknown form of associated consciousness?

In members of more advanced societies, consciousness and intelligence arise as a result of the existence and functioning of neural networks. The rules determining the neuronal interactions are thought to be relatively few. In insects and jellyfish, the networks are almost as hard-wired as the insect robots mentioned above. More complex networks, such as those in the human brain, while seemingly random on the small scale, are highly organized on the large scale. On the small scale, it is impossible for the brain to be hard-wired since the DNA molecule cannot store enough information to specify the interconnections between neurons. Thus, consciousness, while it must be due to the functioning of the elements that make up neural networks, cannot be contained within these elements, but rather must appear as an emergent property of the network as a whole.

Gerald Edelman has developed the concept of neural Darwinism to help explain the developing micro-architecture of the brain. This theory of neuronal group selection is intended to explain the biological basis of perception. In his book *Bright Air, Brilliant Fire: On the Matter of the Mind*³¹ he distinguishes two types of consciousness, primary and higher-order. Primary consciousness is “composed of phenomenal experiences such as mental images, but it is bound to a time around the measurable present, lacks concepts of self, past, and future, and lies beyond direct descriptive individual report from its own standpoint.” Higher-order consciousness “is based on the occurrence of direct awareness in a human being who has language and a reportable subjective life.” Edelman does allow that other animals can think, but since they lack true language, higher-order consciousness cannot “flourish in them as it does in us.” My point in bringing this out is to show that his concept of consciousness does not necessarily conflict with the idea of emergent behavior. Indeed, higher-order consciousness, where one is “conscious of being conscious” could possibly arise from primary consciousness and a set of rules for the responses and interaction of primary conscious sections of the brain.

Edelman’s insistence that true language is necessary for higher-order consciousness is unfortunate. The great mathematician Jacques Hadamard³² has said that “words are totally absent from my mind when I really think” and, quoting Schopenhauer,³³ maintained that “thoughts die the moment they are embodied by words.” Roger Penrose,³⁴ another great mathematician and one of the most creative people of modern times, has written in his popular book *The Emperor’s New Mind*, “Almost all my mathematical thinking is done visually and in terms of non-verbal concepts, although the thoughts are quite often accompanied by inane and almost useless verbal commentary.” Einstein maintained a similar position on his mode of thought.

Although non-verbal forms of thought may be innate and underlie even verbal thought, language and the ability of humans to communicate may well be necessary for the full development of non-verbal thinking. Scientists, engineers, carpenters, musicians, and many others use a variety of modes of thought depending on the subject matter with which they are dealing. Crows have been known to improvise tools, and myriads of animal owners have seen their pets respond to emergencies in ways that could neither be learned nor instinctive, but rather the result of mental problem-solving. The requirement that true language—as it appears in humans—be necessary for higher-level consciousness appears to be too anthropocentric.

The existence of truly open hierarchies would give us an alternative to a fully reductionist approach to understanding the universe, somewhat akin to the way the discovery of quantum mechanics ended the nineteenth century concept of a deterministic, mechanical universe, it is not obvious how even such a transcendent structure could embody a meaning or purpose. Why does it exist, and where does it lead? Does emergent behavior really represent a truly open hierarchy, or just our inability to deal with such phenomena due to years of reductionist thought, and a lack of a methodology? One is left again with Weinberg's lament "The more the universe seems comprehensible, the more it also seems pointless."

So we come to the question that underlies much thinking in the area of neural networks: Is it possible to create an artificial intelligence? That is, just as it is possible to simulate relatively simple biological neural networks electronically and obtain essentially identical behavior, can such networks ever be complex enough to exhibit consciousness and intelligence? At least in principle, the answer is, "Yes." It may not be soon, but with continuing developments in the nano-technology world, the time may not be so far in the distant future as we think, or may like.

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