Bunyan Lecture: The Destiny of Man
R. N. Bracewell, Stanford University, Feb. 27, 1996.

Man's concern with his own future as an individual is instinctive and is often intense. It could well be lessened. The actuarial tables tell him the number of his days. His concern for the future of the *species* is now slight. It could well be increased — Harlow Shapley.

Introduction

All those here tonight have asked themselves what is the meaning of life, why are we here, what are we supposed to do, and what will happen to us. Some of us have also wondered about where the *human race* is going. Connected with our human origin and destiny are the origin and destiny of the *Universe*.

Not everyone asks this question, "What is my life all about?" Children don't, and people raising children may be too busy. Over most of the existence of the human race, life was too short for deep thoughts. Even so, a lot of people have thought about these matters, a great deal has been written, and before writing began to spread, much was transmitted by word of mouth from generation to generation. Oral tradition ultimately came to be written down and is available today from several different cultures, going back 3000 years and more.

Not all human minds have the same power. Every century or so exceptional thinkers spring up, for example Archimedes [~287- ~212], Newton [l642-l727], and Einstein [1879-1955] (to mention some mathematical physicists) who are recognized by their peers as having had exceptional ability. Therefore, we can be sure that in the course of thousands of years, great minds have thought about the destiny of man.

When Mr. Bunyan [1898-1977] came into my office in 1970 and said that he was getting on in years and wished to endow a Lectureship on the Nature of the Universe and the Destiny of Man I realized immediately that he had put his finger on the main questions. (Well, there *is* another, the Destiny of the Universe, that goes beyond the Destiny of Man, though the two may be connected.)

The fact is that the great minds of the past have not transmitted to us a consensus. Why is that? One explanation is that cosmology, which has passed into the care of astronomers only recently, has barely begun to make progress. In past centuries, when little was known about our location in astronomical space, reasoning about our destiny was seriously handicapped. Let us look back on cosmology in earlier times and different places.

Traditional Cosmology

Our Nordic fore*fathers* saw themselves as destined for Valhalla if they died in battle and they certainly exposed themselves assiduously to this end, judging by the vigor with which they assaulted their neighbors. On arrival in Valhalla, they would drink and fight each other happily and feast daily on boar flesh until Doomsday, when Odin would lead them against the Giants for even more fun. One notes a gender bias in the Nordic concern with destiny; perhaps women are less concerned about tribal destiny.

The destiny of many Roman and Greek heroes was to arrive at divine status and wind up as stars or planets in heaven. Our current names for the planets Mercury, Venus, Mars and Jupiter are all names of Italian gods. Ancient Egyptian theories, depicted in stone engravings and paint, also show that the well-to-do prepared for destinations in celestial regions.

Our ancestors walked out of Africa 60 or 70 thousand years ago. Those who reached Australia left cave paintings and engravings that have remained undisturbed by the turmoils of other continents for 50 thousand years, records that are consistent with modern aboriginal tradition, that heroes have moved up to celestial regions, where they remain visible as stars.

What ordinary people expected or believed as regards their own personal destiny must have varied from time to time and from place to place, but the practice of ritual burial in prehistoric times is taken as an indication that some future was widely expected. Many different prospects were no doubt entertained.

Mythological beliefs can be dismissed as primitive religion, paganism, or other lowly -sm, but from a more generous viewpoint we can discern human activity akin to what a scientist does when devising a theory. It is an act of scientific creativity to imagine circumstances that are compatible with what is already known, and that is what the original speculators about the future were doing with what little information they had to go on. Of course, a scientific theory these days does not normally become dogma, because scientific theories get tested and indeed are esteemed more highly the more readily testable, or refutable, they are. This aspect of scientific method has only been practiced for a short time (Galileo [1564-1642] generally gets the credit, while Francis Bacon [1561-1626] gets honorable mention) so it seems perfectly appropriate to respect the inventiveness of the mythmakers. As regards those who *transmit* traditional myths, they are only doing what comes naturally — believing what they are told. There is no tradition of testing religious dogma, and thereby widening the circle of believers by appeal to rationality, as in science. Human credulousness has survival value — a child is more likely to leave descendants if it obeys an injunction not to eat that mushroom than if it exhibits scientific scepticism in a rational experiment.

The major religious traditions teach refined beliefs about heaven and hell, the soul, resurrection, free will, Satan and Lucifer, predestination, reincarnation, the mind, the personality, good and evil, and other matters relevant to our destiny. But many of the topics have attracted attention in nontheological contexts.

Astronomical Cosmology

More recently astronomers have entered the picture, in connection with the origin of the Universe and of life on Earth, because it is they who have been garnering the knowledge about the larger environment in which human life thrives. This branch of scientific knowledge has been advancing rapidly.

Within living memory it was debated whether the nebulae were minor objects in the starry heavens or whether they were very remote and therefore huge. Now we know that our Milky Way defines a galaxy comprising a hundred billion stars and that for every star in our galaxy there is another whole galaxy. These galaxies are distributed through space to remote distances and are flying apart. They seem to have been flying outward for about 15 billion years. According to the Big Bang scenario, hydrogen atoms, which were formed shortly after the expansion began, are the most numerous kind in the human body, and have remained unchanged since their formation. We know that the oxygen atoms in the human body, which make up a bigger percentage of the body by weight than any other kind of atom, are less ancient; they were formed as a byproduct of nuclear reactions inside stars like the Sun. Nuclear fusion taking place inside the Sun at this moment is creating oxygen in the course of generating energy that, when it reaches the surface, will pour out as sunlight. Human protoplasm is thus a profoundly astrophysical substance. As time elapses, more and more of the matter of the Universe is being converted to human protoplasm.

Exploding knowledge about our whereabouts in the scheme of things has put cosmology firmly in the hands of astrophysicists, depriving philosophers of some of their students. Many religions account for the origin of the Universe while some do not. However, the catholic church survived its collision with Galileo, and why not? Cosmology, as sketched briefly in the accounts in Genesis, does not impinge on the day-to-day activity of the church and, as for the solar system, it matters not whether the planets revolve around the sun or around the Earth. Indeed neither Venus nor Jupiter (due to become great celestial gods for the Greeks and Romans), nor any other planet, is mentioned by name in the Bible; the same appears to be true of the Qur'ān.

The Astronomical Almanac, which has been published every year since 1767, tells where the planets will be every night, but does it tell where the will be in its approximately elliptical journey around the Sun? No, it does not; it tells where the Sun will be each day, listing its changing celestial longitude. Viewed from our spaceship Earth, the Sun does indeed move against the starry background, dropping back through one sign of the zodiac each until it completes its annual cycle of the seasons. So why the fuss over Galileo? The charge of heresy against the hypothesis that the Earth was not fixed but moved was a pretext, the real purpose of which was to suppress Galileo's other message: that God's intentions could be determined not only from church traditions and occasional continuing direct revelation to hierarchy, but also by lay experimental appeal to Nature — God's handiwork. In 1982 Pope John Paul moved to exonerate Galileo; he did not talk about the motion of the Earth but squarely confronted the real issue by asserting there could be no conflict between the teachings of the Roman catholic church and the ongoing findings of science. This attitude, which Galileo had unsuccessfully advocated in Rome, may seem the only safe and reasonable way to go; nevertheless, traditions die hard and discredited beliefs are still alive and well in some communities.

As geography, geology and astronomy developed it became apparent that the Underworld, which had plausibly been placed on the River Styx in Arcadia, below Mt. Etna in Sicily, or near Mount Vesuvius where Dante [1265-1321] descended into the

Inferno, could not be located. The horrors of Hell, so graphically depicted in medieval paintings such as those at the Field of Mars in Pisa, slowly faded from attention and are less often mentioned today. Heaven had been a *terrestrial* Paradise in Biblical times, but by Dante's time had risen to occupy the concentric spheres often depicted diagrammatically in the Middle Ages and later. Even so, vestiges of Paradise were still noted by Dante at the summit of the mountain of Purgatory (traditionally located far away at the antipodes of Jerusalem). Needless to say, when the circumnavigators reached the South Pacific two centuries later, no mountain was found; and in our own century when conical peaks were mapped on the ocean floor, none was opposite Jerusalem. From the top of the mountain Dante saw Venus rising in the East in Pisces, which fixes the year exactly (1201?). Then, turning to his right and looking South he saw four tars never before seen save by Adam and Eve. These must have been the four stars of Dante, Vespucci [1454-1512] wrote, when he himself saw them from the coast of Brazil in 1501. Good marks to Vespucci for being up on Dante and good marks to Dante for noticing the four stars of the Southern Cross in Ptolemy's star catalogue.

Geology raised questions about the rate of erosion of river valleys and the rate at which the sea was getting saltier. There did not seem enough time for the landscape to have formed if creation took place around 5000 BC as suggested by the chronologies of the Bible.

Telescopic astronomy, followed by space exploration, failed to encounter the seven heavens and the music of the spheres. These days, when we view the Byzantine mosaics in Mediterranean countries, it requires an effort to recall that contemporary belief placed the abode of God not so very far up, say at the level of a high mountain, and close enough for God's voice to be audible.

It was as recently as the late l800s that the fearsome Alpine peaks, home of the dreaded fire-breathing, winged dragons, were scaled (by intrepid tourists) and much later still before the rest of the world's inaccessible heights were examined. No-one now believes that a divine abode will be discovered on Earth. Likewise the frontiers of space have been pushed back; clearly Heaven is not situated where it was once thought to be. However, the modern concept of a fourth dimension offers a new spatial location with the old characteristics: not much is known about the fourth dimension, and it is difficult of access.

The Astronomical Outlook

With the former custodians of eschatology in retreat, opportunities have been taken by occasional astronomers to express views arising from advances in physics. Sir James Jeans [1877-1946], Sir Arthur Eddington [1882-1944] and Harlow Shapley [1885-1972], the best known popularizers of astronomy before Carl Sagan and Paul Davies, all had ideas about the ultimate fate of the Universe and thus of man.

Thermodynamics suggested that the energy of the Universe would be progressively degraded into heat and that all structure would be smoothed out — the so-called heat

death. This metaphor attracted a lot of public attention. Reassuringly, it would be well into the future.

More recently, Freeman Dyson has cautioned that what could happen in principle need not necessarily happen in practice. For example, Newton's law of gravitation says that the Sun attracts the planets and satellites of the solar system with a force that increases indefinitely the closer they come. Therefore, you might think that the Earth is doomed ultimately to fall into the Sun. Dyson's approach is to calculate the time required, whereupon one finds that other disasters are bound to occur sooner. The apparently inevitable attraction of the planets into the Sun may never happen.

Instead, some billions of years from now, the Sun's nuclear furnace will explode, ceasing to sustain the Earth at the comfortable temperature to which it has become accustomed. But even before this, an accidental collision with a passing star could disrupt the Sun, and even before that a passing comet or asteroid could seriously damage the Earth or cause mass extinctions; and it is even more likely that in the available time there will be devastating natural catastrophes including episodes of mountain building, with the attendant earthquakes, volcanism, lava flows, floods, and atmospheric alteration. Even before that, we may ruin the atmosphere, or there may be world-wide epidemics, crop diseases, insect plagues, and famines. The price of oil may go up.

Despite these uncertainties, which supply endless scenarios for the prophets of doom, there are enough optimists among us to continue giving thought to the meaning of existence. The personal extinction that each of us faces has been the focus of traditional concern; the extinction of our whole civilization, which would seal the destiny of man, is more remote.

The Biological Outlook

I would like to describe a theory about the soul elaborated most recently in *The Astonishing Hypothesis: the Scientific Search for the Soul*, a book by Francis Crick. The idea of a soul, which is a spiritual counterpart of the physical body and which survives death, is a central theme of Christianity and Islam and, to some extent, of Judaism. It was a philosophical question with the Greeks, expounded by Plato [~427- ~347] in the *Phaedo*, or The Immortality of the Soul. In a charming passage, Simmias likens the soul to the music of the lyre, and the body to the strings (but Socrates does not buy this). In Buddhism, the soul not only survives but is recycled through many physical reincarnations until it reaches enlightenment and its individuality is submerged in a state of Nirvāna. Not much can be ascertained about this state, which sounds a bit like the heat death, but possesses features that are specified in various ways in the major branches of Buddhism.

Crick develops the proposition that all the functions ascribed to the soul are explicable by reference to the neurons of the brain and nervous system, and lays out plans for research to elucidate the functions of the numerous parts of the brain. In a way, the brain is like a modern computer, but when one realizes that there are as many neurons in the brain as

there are stars in the galaxy, hundreds of billions, it is evident that the brain allows for behavior far beyond the performance of a computer. In addition, engineering design is quite different in character from the structure of organs developed by biological evolution.

Consciousness

Consciousness is an experience that suggests an "I" that is distinct from the body. We do not consider that computers have consciousness, and supposedly neither do plants and lower animals. The situation with cats and dogs is less settled. It is uncomfortable for some people to accept that their dog is not conscious but, if the soul is the seat of consciousness, they find themselves in conflict with the widespread belief that animals do not have souls. If consciousness could be shown to be a property of our neurons, as Crick hypothesizes, then the soul as an independent entity could be dispensed with. Consensus on this is not likely to be reached soon, given the primitive state of brain science. Computer science, on the other hand, is pushing ahead, as witnessed by the recent chess match between Kasparov and Deep Blue, and may become influential on opinion before neuroscience. The mechanistic view, adopted by Crick as a basis for the planning of future experiments in brain science, goes back to the mid-nineteenth century and is gaining ground in biology.

If we did not have consciousness, would we not be deprived of free will and become mere automatons, reacting to inputs received from our sense organs as responded to under the control of our genes and by memories of earlier sensory inputs? A colony of bees could be so described; the individual workers obey sensory instructions and do not, we suppose, have the slightest conscious notion of their role in the life of the colony. Nor does the queen, whose indispensable egg-laying role is conditioned upon stimuli mindlessly applied to her by workers tending the brood. The colony itself, conceived of as a superorganism with a life of its own, would seem to have even less consciousness than its parts. Yet this handicap does not prevent the colony from looking after itself in wonderful and admirable ways. Ants can organize themselves similarly. It is conceivable then, that the sensation of free will is a mental manifestation accompanying human consciousness.

That the whole brain should have consciousness, though the individual neurons do not, is paralleled by the proposition that a living organism is made of nonliving atoms, inhaled or ingested. Clearly, organization of parts can manifest new properties not possessed by the parts alone. At a lower level, surely saltiness is an emergent, or holistic, property of the sodium chloride molecule, not possessed by either sodium or chlorine; and consciousness, whether the neuronal machinery is traced soon or not, could be a holistic phenomenon.

One might wonder whether the whole of the World Wide Web could develop holistic properties such as consciousness or intelligence. This idea could be the basis for a science-fiction horror story in which the Web exhibits a will of its own, far exceeding the stature of its component computers and data bases. What I think will happen is this. A university has overall properties not possessed by its parts: the professors, students,

dining halls, libraries and laboratories. Universities will gain new attributes as a consequence of incorporation of the Web. The Web will be no more autonomous than a library. The changes occurring are visible right now and are already profound.

Deep Blue is no more trying to win than the Green Library is trying to educate; each is an artifactual component of our culture, not an independent entity.

My friend John Pierce points out that the Post Office, Amtrak, and government departments act as a unit in ways that are beyond the grasp of any single employee. These are superorganisms that do not have consciousness as we are familiar with it, and are surely soulless. They do act as if they have free will, not acting as automatons. The concept of free will needs to be rethought in terms of the recently developed chaos theory, a branch of mathematical physics that establishes that fully determinate systems can be unpredictable. This is a discovery that has rich implications and was utterly absent hitherto from discussion of determinism and free will.

Scenarios of Disaster

Most natural catastrophes become worse when there are more people. Earthquakes and lightning and forest fires offer examples. In fact it is hard to think of a serious problem affecting humanity that would not be mitigated if there were fewer people. Take toxic waste; the impact increases as the square of the number of people. In the U.S. today there is more toxic waste than can ever be cleaned up and in the meantime the problem becomes worse because of population increase.

Clearly people do not know how to control population increase. Government does not know either, but in fact the government is not trying. It is a favorable statistic for the economy when there is a rise in the number of housing starts — it is not something that government economists or business people connect with the population explosion. 'Growth' is necessary for international competitiveness and maintenance of the standard of living. The same is true for Asia. While the standard of living is going up for Asia it is going down for North America.

The world population is often thought to be rising exponentially, but fact it seems to be rising hyperbolically. Back in 1970 the population curve was following a hyperbolic course which, if continued, would go to infinity in the year 2026. Since then, there is no clear indication that this catastrophic course has wavered. (P=5.74 billion in February 1996, corresponding to P=190/(2026-y) billion.

Economists ask, "If the outlook is so bad, why is this not indicated by the market through rising prices for food and other resources?" The answer to this may be that when the pinch is felt in places like Somalia and Rwanda lots of people are eliminated, donations are attracted from outside, and the normal patterns of supply and demand that characterize functioning markets elsewhere are distorted. One way or another, the population is not going to go infinite; but the pain will not be distributed evenly over the Earth's surface.

Extraterrestrial Life

Much thought has been given since 1959 to the possibility of extraterrestrial life. There is no general agreement as to whether there is intelligent life or any sort of life other than life on Earth, but there has been a concerted effort to find out. The SETI institute in Mountain View, founded by Barney Oliver [1916-1995] is a leader in this effort; John Billingham, Frank Drake and Jill Tarter are principal actors. A separate initiative sponsored by NASA is to obtain images of nonsolar planets by infrared interferometry; this project is led by Roger Angel, who will be speaking at tomorrow's Symposium.

By the principle of mediocrity, there would be communities living in space that are still in the Stone Age, or earlier, while on the other hand there would be communities that long ago passed through our level science and technology; the latter are targets that SETI hopes to detect.

On the other hand, human culture may be unique— we may no more be an average representative of a population of galactic communities than we are an average representative of living species on Earth. We *are* at the top of the life-tree on Earth; in this one case where we can test the principle of mediocrity, it fails.

The reason why we are unique on Earth is that our ancestors, who are believed to have walked out of Africa, reached virtually the entire habitable zone in a time, around 10,000 years, that is short compared with the time that it would have taken for bears, raccoons, rats, dolphins, wolves, or any other mammal generally noted for some intelligence, to evolve along a path analogous to that of the primates.

Now that our race has entered the space age we can calculate that, at moderate speeds of space travel, humans can reach the center of the Galaxy in much less time than the 3.5 billion years that it took for the Earth to produce man. Just as on Earth, the travel time is short compared with the evolution time.

No human individual will complete the trip, but neither did any individual African complete the walk to Patagonia. Nevertheless, human culture spread across the world and it may be the destiny of human culture to spread through space. Once this spread begins, Earthly catastrophes need no longer be terminal. We may be on the threshold of a magnificent destiny.

Where Did Life Come From?

When Darwin's book, *The Origin of Species*, appeared in 1859 it became possible to allow for biological evolution when theorizing about where life came from. Before evolution was noticed, life forms were thought to be created full-fledged; Plato's story about mice being generated by the nourishing mud of the Nile is an example. Darwin, however, pictured a warm little pond in which life began at a most humble level, and ascended from there. A succession chemists, starting with Harold Urey [1893-1981] and Stanley Miller, later developed this scenario by applying electricity and ultraviolet light to mixtures of pure water and primitive gases and they found that organic molecules

would have fallen with the rain that filled Darwin's pond. Consequently the pond theory became well known and is widely accepted as an alternative to creationism.

The discovery of DNA by Watson and Crick in 1953 removed a further handicap to thinking about where life came from. Attention now centers on bacteria, especially archaebacteria. A warm little pond would not be a good place for bacteria to originate. Although it is true that there is pond life today that can survive flooding and freezing in winter and complete desiccation in summer, a small pond is too much at the whim of the elements to provide the stable conditions that would favor the construction of photosynthesis and the evolution of life. Also, the bacteria thought to be the most ancient have the curious ability to withstand very high temperatures, even above the sea-level boiling point of water. This points to an origin in the vast realm of subterranean rock, deep enough down that the temperature favors chemical reactions in unimaginable variety, some of which might form building blocks for later biochemistry to feed on. The shear body weight of all the bacteria living below Earth's surface today is comparable with that of all the surface plants and animals. They do not need sunlight and photosynthesis, but live on chemical fuel. Some of them form the base of the food chain of the creatures that cluster around the hot-water vents that were found on the l980s on the ocean bottom. Others live miles down in the rock, far from the sea.

Professor T. Gold, who noticed the appearance of bacteria at corresponding depths in boreholes drilled down through granite in Sweden, initiated the modern discussion of the deep hot biosphere in a 1992 paper in the *Proceedings of the National Academy of Sciences.* As the interior of the earth warmed up as a result of radioactivity, compression by the overburden, and the sinking of denser components through the gravitational field, buoyant liquids and gases were released. Chemical reactions that were previously limited by the temperature could then proceed, generating even more warmth, and giving rise to vertical mobility of the fluids (water, soluble metal oxides, sulfates and sulfides, hydrogen, sulfuretted hydrogen, carbon dioxide, hydrocarbons, helium, and hydrocarbons). Squeezed upward to levels where bacteria can survive, these ingredients are being used by them today as their sources of energy.

The deeper zone that is too hot for living organisms, but where chemical equilibrium has not been reached, is a factory for the products that bacteria in the deep hot biosphere have learned to feed on. But in addition, chemical evolution, sustained over eons of time might also account for minerals, now found at the surface, whose origin might not have been correctly accounted for.

Certainly the life processes of bacteria in large numbers for long times down to five miles or so have left their mark on mineralogy. Bacteria may easily have migrated across down from the surface, but one has to ask whether it is possible that they originated at depth.

A subsurface origin of life would explain the tolerance of primitive bacteria to high temperatures. Some of the thermophilic bacteria have long been familiar residents in the hot geysers of Yellowstone. Gold's discussion has contributed to various recent studies.

Revived interest in an expedition to Mars to drill for signs of life is an example that has been in the news recently.

Now if life *could* originate within the Earth's crust, then not only could that happen on Mars, but it could happen in innumerable habitats throughout the Galaxy. The search for intelligent extraterrestrial life is presumed to be favored by the existence of planets like Earth, and Dr. Roger Angel will talk about such planets tomorrow, but 'lower' forms of life could be much more widespread.

Back in 1908 Arrhenius [1859-1927], expanding an idea of Spallanzani [1729-1799] proposed that the seeds of life were everywhere, including outer space, and adopted the term panspermia. Suppose that bacteria did not evolve on Earth, but that spores (precursors) from interstellar space have been raining down since the time, 5 billion years ago, when the planets were accumulating from the dust and other solids of the protosolar nebula. For the first billion years this would have been fruitless. But as subsurface conditions stabilized and became suitable, precursors from space may have fallen on fertile ground and hastened the birth of terrestrial life.

It used to be objected against panspermia that living spores would be sterilized by stellar ultraviolet radiation and cosmic rays during a long transit through space. The discovery that Halley's comet was almost black, possibly because of organic matter, suggests one mode of protected travel. Another is within a solid body such as an asteroid. The cargo might be germ plasma in suspended animation or even breeding colonies.

The discovery of subsurface living organisms or fossils on Mars would be of extraordinary interest. Would Martian life prove to be an independent branch, or would it share a common ancestor with ours? Would that ancestor trace back to before the birth of the solar system, or would it be a daughter of our Sun?

A Conscious Universe

Life is a very strange phenomenon; we do not yet understand the anatomy of life, especially the brain, let alone the *significance* of life. A human being is a subset of atoms of the Universe, some dating back to the Big Bang and some synthesized inside stars. Is it not odd that natural objects such as ourselves are gazing out on the rest of the Universe, observing it, describing it, beginning to understand it, and even to control parts of it as we remake the surface of the Earth for agriculture? We are also converting inanimate matter to conscious human protoplasm at an unprecedented rate. We are not separate from the Universe; our science is a consequence of a part of the whole observing and dimly comprehending the whole. Richard Feynman expressed this thought as follows.

Growing in size and complexity
Living things, masses of atoms, DNA, protein
Dancing a pattern ever more intricate

Out of the cradle onto the dry land
Here it is standing

Atoms with consciousness
Matter with curiosity.

Stands at the sea
Wonders at wondering
I

A universe of atoms
An atom in the universe

We are left with the remarkable idea that part of the Universe is now conscious and more is being converted to consciousness. It seems improbable that the part should comprehend the whole, and perhaps a theorem can be proved denying the possibility. But, undeniably, a rough description of a large part of the Universe now resides here on the surface of an insignificant planet forming part of the Universe. What is more, an understanding of *life* is emerging with the unraveling of DNA, and an attack is beginning on the machinery of the mind. That one should dare to speculate on the future to which these astonishing steps will lead seems ludicrous, but such is human behavior. The destiny of man, the individual, shrinks in significance relative to the destiny of mankind, or should we say the destiny of the Universe.

At the same time that the mind is being reduced to neurons, the perplexing developments in experimental quantum mechanics are forcing physicists to contemplate the role of consciousness in the outcome of experiments where the act of observation of *one* particle may influence the spin or the polarization of a remote and as yet unobserved *other* particle.

The discussion of extraterrestrial life reminds us that the awareness of the Universe that resides in our small corner may not be unique. There may be other pockets of space where the inanimate matter is also being converted to living matter with awareness of its habitat. If so, the process may have started more recently than it did on Earth, or it may have started billions of years ago. It is therefore possible to imagine that a living entity of awesome maturity already exists somewhere. It may be aware of us, not as individuals, but as a colony, and may even possess a benevolent interest in our destiny.

Good and Evil

We do not know whether life on Earth arrived from space nor whether human culture will spread back through interstellar space after having been nurtured for years on Earth. Any one of the environmental hazards could be terminal, but so also could a failure of the human mind.

We have limitations. Our makeup contains both good and evil; as individuals we recognize an innate personal sense of right and wrong. The world religions emphasize this characteristic in humankind and I would say that religion has worked to keep the issue of what we *should* do before us.

There is virtually no lay instruction in the schools and universities on morality or ethics. The Institution of Electrical and Electronic Engineers, said to be the world's largest professional organization, has a code of ethics, but professors of electrical engineering do not read it or teach it. Whatever is taught in law schools and business schools has little impact. Medicine does have a tradition that could be built on. A large reservoir of truthful practice is found in the practice of science, where it is maintained in individuals by the discipline of experiment and spreads through publication and personal interaction. The example of the scientific ethic is the basis of Bronowski's rule that what we *ought* to do is that which uncovers the truth. But some admirable behavior, such as maternal love and courage is in our genes and does not need a rational basis. Perhaps genetics and the rational culture of truth taken together suffice as bases for all generally-agreed behavior.

As de facto guardians of moral teaching most churches have accommodated to the practical necessity of speaking with certainty and authority. People are uncomfortable with changing rules in changing circumstances; we are more comfortable with strict taboos and being told what to do than we are with rational thought. Watching the behavior of a baboon colony makes me suspect that we inherit this respect for, and submission to, authority from our primate ancestors.

The churches have no difficulty speaking with certainty but in a world of change how can they avoid loss of confidence?

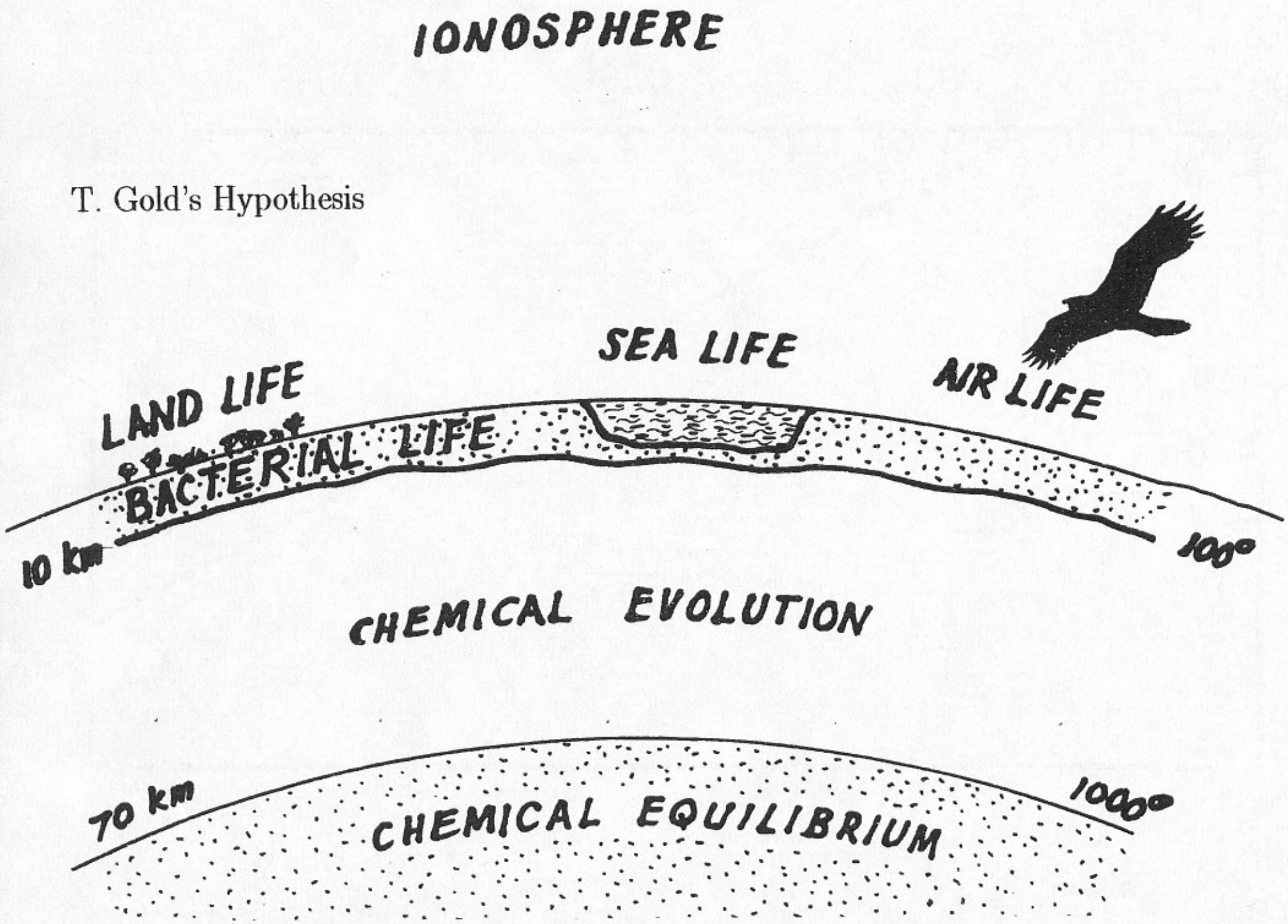
Bronowski has argued, in many beautiful essays, that rational thought is needed to replace the medieval dependence on authority. Scientific thinking, a monument to human achievement, provides a model, indeed I believe the only model, for progress in matters of human values. Science is a key component of the human superorganism — without it we would revert to the Stone Age — but it is an unfinished process. Science lacks certainty as to the outcome of what is being investigated today; this lack of certainty, and the inability of scientists to pronounce with certainty, is a mismatch with what the human mind prefers. The failure of the human mind may determine our destiny.

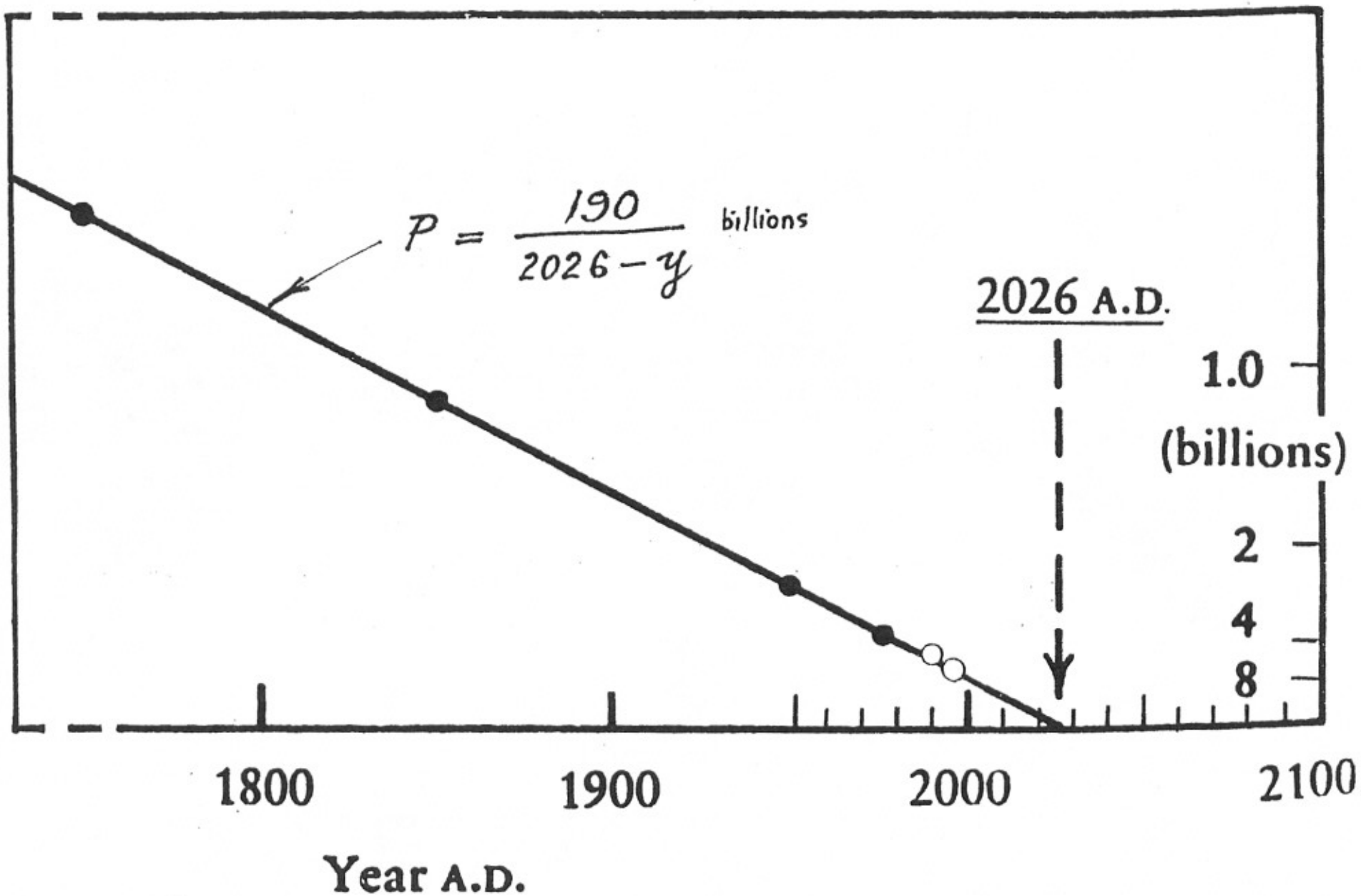
The difference between man and the animals is recognized in Genesis — we all recognize it. And yet we are animals ourselves, and several million years ago our ancestors were only marginally distinguished.

How did we acquire the knowledge of good and evil? If there was survival value in treating your neighbor as yourself, and humans evolved genetically in response, altruism may now be built into our genes, and not readily subject to genetic improvement. To the extent that enough of our sense of morality is cultural then there *is* room for slow improvement. Altruistic behavior, such as food sharing, is observed with chimpanzees but not monkeys; this needs to be thought about.

My conclusion is that the destiny of man is likely to be determined by limitations of the human mind, *if* humanity survives the population explosion. Whether rational scientific thought will be invoked is unknown.

T. Gold's Hypothesis

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2026 A.D.
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(billions)
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