



THE DAWN OF SYMBOLIC LIFE

*THE FUTURE OF
HUMAN EVOLUTION*

JON BEACH

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PREFACE

When I was younger I told people that someday I was going to write a book. I graduated from college with a degree in biology but then pursued a career in business, and there never seemed to be enough time to get started on that book. But, by the time I turned forty, I was getting tired of the daily grind and decided it was time to make good on that promise. So I took a leave of absence and spent the next six months in the Cal State University of Fullerton library looking for ideas.

I spent most of my time in the library reading and had a wonderful time exploring the centuries of accumulated knowledge that were stored there. I spent a lot of time in the philosophy section and developed an appreciation for the value of this aspect of education that I had missed in my earlier science-oriented training. But the biology and anthropology section was where I suddenly realized what the subject of my book was going to be. I was reading some of E. O. Wilson's 1971 book on sociobiology where he argues that human motivation is determined by our genetic makeup. From what I learned as a biology major in the '70s, he should have been right. But Wilson's book was very controversial because sociologists, anthropologists, psychologists, and most other people wanted to believe that humans were a blank slate of unlimited potential and motivated by rational thinking. The idea that people are slaves to their genes and, like any other animal,

spend all their time just trying to pass on their DNA to their offspring just doesn't match up with the self-image that most people have. Being a biologist, I couldn't agree with the "blank slate" viewpoint, but I couldn't really accept Wilson's idea either that we were held on a leash by our genes. Then, sitting in the library staring at endless rows of bookshelves containing more knowledge than any person could ever assimilate, I had my eureka moment! I suddenly realized that I was sitting in the middle of a new and vastly more powerful type of gene that had freed us from the leash that tethers all other animals to their DNA. Thinking about it, I started to grasp how this made humans profoundly different from all other life and gave them undreamed-of potential.

Now that I knew what the subject of my book was going to be, I still needed a plan to make it a reality. I knew that nobody would take me seriously writing about a subject like this unless I was an authority in the field. Cal State Fullerton has a master's degree program designed just for people in my situation that allows a student to set up a customized degree program focusing on one specialized area. So I signed up for this program and spent the next nine years studying evolutionary transformations from every possible point of view. I wrote a master's thesis on the subject and published an article about it in a philosophical journal. Then, sixteen years after I first become interested in the subject (with a few breaks to actually earn a living), I was ready to publish my book on human evolution.

This is a controversial subject that arouses a lot of passion in some people. But I think the strong differences of opinion come from a lack of a deep understanding of the subject from both sides. My six months of reading philosophy was indispensable in giving me a broader viewpoint, and I would recommend it for everyone. For me it helped me get past the materialistic bias in so much of our modern thinking and appreciate the more metaphysical aspect of our reality.

For me a Woody Allen movie called *The Purple Rose of Cairo* illustrates this in a beautiful way. In this movie Mia Farrow plays a woman who escapes a drab existence and loveless marriage by going to the movies. She is shown going to the same romantic adventure movie over and over until one day the dashing hero of the movie, in the middle of a familiar scene, suddenly turns

toward Mia Farrow's character and says something like "haven't I seen you here before?" As the other actors in the scene start protesting, the hero steps off the screen and introduces himself to the startled woman in the audience. While the movie is still playing with the other actors standing around on the screen in confusion, the movie hero and the woman leave the theater together and embark on their own adventure exploring the real world.

The woman is surprised to find out that the movie hero thinks his existence in the adventure movie is just a dull, repetitive monotony, and he is amazed and enthralled by the real world. The best line of the movie is when the movie hero tries to explain his perspective and says, "It's so magical out here."

Most of us go to the movies for escape and entertainment, and sometimes we picture ourselves as living in a larger-than-life movie world. But a movie or any other simulated or imagined reality is just a one-dimensional static play actor for the real thing. Even our human reality, created by our minds and projected out on the world like a movie, cannot encompass the real thing. We go to movies for the thrills and chills of high adventure, monsters, the supernatural, or science fiction, but really nothing can match the true mystery of the actual world we live in. Everything really is magical out here.

For some people, this book may seem to be antithetical to humanistic values and to focus too much on some of the less spiritual aspects of science. It's just a factual analysis of evolution, but I think the truth is the facts are the most amazing, spiritual, and magical story of all. I hope the reader will come away from this book with the same idea.

I would like to thank the faculty of the School of Natural Sciences and Mathematics at California State University Fullerton and my friends and family for the support they have given me.

This One



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“NATURE (the art whereby God hath made and governs the world) is by the art of man, as in many other things, so in this also imitated, that it can make an artificial animal. For seeing life is but a motion of limbs, the beginning whereof is in some principal part within, why may we not say that all automata (engines that move themselves by springs and wheels as doth a watch) have an artificial life? For what is the heart, but a spring; and the nerves, but so many strings; and the joints, but so many wheels, giving motion to the whole body, such as was intended by the Artificer? Art goes yet further, imitating that rational and most excellent work of Nature, man. For by art is created that great LEVIATHAN called a COMMONWEALTH, or STATE (in Latin, CIVITAS), which is but an artificial man, though of greater stature and strength than the natural, for whose protection and defence it was intended; and in which the sovereignty is an artificial soul, as giving life and motion to the whole body; the magistrates and other officers of judicature and execution, artificial joints; reward and punishment (by which fastened to the seat of the sovereignty, every joint and member is moved to perform his duty) are the nerves, that do the same in the body natural; the wealth and riches of all the particular members are the strength; *salus populi* (the people’s safety) its business; counsellors, by whom all things needful for it to know are suggested unto it, are the memory; equity and laws, an artificial reason and will; concord, health; sedition, sickness; and civil war, death. Lastly, the pacts and covenants, by which the parts of this body politic were at first made, set together, and united, resemble that fiat, or the Let us make man, pronounced by God in the Creation.”

From THE LEVIATHAN, Thomas Hobbes, 1651

INTRODUCTION

“The truth will set you free. But first it will piss you off.”

Gloria Steinem

Mankind is not in control of its own destiny. We can determine what we do with our individual lives, but the direction we take collectively as a species is beyond our control. This is a fundamental and indisputable fact of evolution. As Darwin pointed out, evolution is a process where all individuals struggle to survive and reproduce, but it is fitness that determines the outcome. All the different characteristics of individuals of a species and the choices that they make merely provide the raw material of variability that evolution works on. An essential trait for any individual is the belief that his way is the best and that he deserves to prosper. People provide different options through the choices they make and in the belief that they are right. They do their best to fulfill their dreams, but it is some higher authority embodied in the structure of physical reality that makes the final choice of what will survive and prosper and what won't. All life is subject to this basic law of nature.

So what are some of the characteristics of reality that will determine who will survive and what form we will take in the future? Not many people have ever considered this question from

a strictly evolutionary perspective, probably because our evolutionary future always seemed so remote and of no real concern to individuals with such short life spans. But now that technology has increased the rate of change to an unprecedented pace, and advances in biotech have the potential to speed up the rate of our biological evolution to the same extent, it seems that the future is suddenly upon us.

These pages attempt to clarify the forces that drive evolution and, by doing this, also show that they are leading mankind to a truly epic turning point in the history of life. Some authors (Vinge 1993) have already foreseen and labeled this turning point the “singularity,” but I think the vast scope of the change as well as the fundamentally biological nature of it is yet to be fully understood or appreciated. The singularity is a once-in-a-billion-years transition to a new form of life that will rapidly restructure and dominate all living species on earth and beyond. Humans may not be in control of their destiny, but whether we like it or not, we are at the center of this epic transition, and we will be the foundation for almost all evolutionary changes in the future.

First, Copernicus discovered that we do not occupy the center of the universe and everything doesn't revolve around us. Then Darwin showed that not only are we related to apes, but we were created through natural processes and are just as helplessly adrift in the sea of evolutionary change as every other species. But these are minor setbacks for mankind. The good news is we have been dealt the winning hand in the evolutionary race. The idea that man has dominion over all other species is true because humans are the owners of the best new idea to come along since DNA was invented more than 3 billion years ago. In fact, this new idea will replace DNA. This extraordinary evolutionary invention is called writing. In these pages the term “writing” is used in a broad sense and is meant to include all forms of symbolic communication and information storage, including language and all types of modern information processing as well as simple written text. Writing to us seems like such an ordinary thing, but it is its ability to store and make accessible all the information needed to construct and operate our technology that is the underlying factor creating mankind's current success. The word “writing” is used here as a label for all advanced forms of information storage because text

was the first breakthrough that enabled accurate storage of information in some form other than DNA. This initial breakthrough has blossomed into an accelerating trend toward the creation of increasingly powerful information processing and storage that is impacting all life on earth. It is now becoming evident that symbolically stored information will be the basis for an evolutionary expansion so vast and far reaching that it will seem like life really only began with this remarkable invention.

The process of evolution is the searching, testing, storing, and implementing of new ideas for surviving in the world. Writing is the most powerful innovation to come along in 3 billion years because it is the key to discovering, storing, and implementing all future new ideas. The complexity and success of life up to this point was made possible by the ability of DNA to store the information needed for living processes. But modern information storage is many orders of magnitude more powerful and efficient than the chemically based DNA information system that it will replace, and its power is still expanding. Life and the evolutionary process have finally been freed from the straightjacket of the abysmally slow and limited information storage and processing capabilities of the DNA-protein link.

These paragraphs can show you how to harness some of the constructive power generated by the transition to symbolic information. The secret to power is understanding how things work. If you understand how things work, then you can manipulate the system and change outcomes. If you don't understand how they work, you have to rely on what other people say, or some manual or superstition, and you can only mechanically follow steps written by somebody else. You are just a pawn of what other people think or just a random actor. But if you thoroughly understand how a system works you have some control over the operation of the system. If there is a problem, you can use your knowledge to analyze the symptoms, logically pinpoint the cause, and come up with a solution. You can even come up with improvements in design. Expert knowledge of the system gives you the power to use it most effectively or manipulate it toward your own ends. The transition to symbolically stored information is an extremely long and complex process that can't be understood by one individual. But just understanding the fundamental ideas

underpinning what is driving the accelerating changes in society can be a great advantage.

Evolution builds complexity and expands life step by step, and the next step appears to be the reorganization of life into systems with symbolically stored genomes. DNA information storage made life possible and eventually led to consciousness, intelligence, human beings, and modern civilization. But now the information in DNA is being extracted and recoded into written symbols, and this irrevocably alters the balance of power among living systems. Instead of the information in DNA directing life processes, the information stored in written symbols is directing what and how information is stored in DNA. In this way symbolic information is becoming the new organizer of living systems and is accelerating the speed of information creation and change.

These paragraphs explain what life is and how living systems work. They explain how evolution developed complex life and how it continues to determine life's direction. More importantly it explains how people fit into the evolutionary process and the unfolding transition to higher-level organization. People live intimately connected within complex systems made up of technology, information, human organizations, and other living beings. We are also living in a period of unparalleled change in the way life is organized on this planet, and our information and technology are causing this change. But what people don't realize is that the changes we are going through are fundamentally biological in nature and are governed by the laws that control the evolutionary process. Only by understanding the dynamics of this evolution can we hope to have any influence on the outcome.

Change has been occurring for generations, and we have learned to accept it as the normal state of affairs. But actually the normal state throughout the billions of years of life's evolution has been glacially slow, minute changes that would be imperceptible over any individual life span. The rare periods of upheaval that have occurred in the past were caused by natural disasters, and even in these periods the only rapid change was the destruction of life. As far as the fossil record has shown, there has never been anything close to compare with the current rapid change in the ecological balance caused by the appearance of a single new species. This is because the appearance of humans is the single

most important world-changing evolutionary event in the history of life. All of the previous evolutionary advances in life's history are just a prelude to the dawning of the real power of living systems which is expressed in humans and technology.

People understand the power of the human species because they personally wield it every day. But the average person has little awareness of the changes in the fundamental organizational structure of life that is the basis of our power over nature. People have even less understanding of how these changes have only begun and will have even more far reaching consequences in the future. But power will not be wielded directly by individual people. Power comes from the evolutionary process that people are involved in. Knowing how this process works might give individuals some of this power.

The organizational and structural changes that have begun to evolve in society will most likely result in an unimaginable explosion of life. Humans are probably the seed species out of which nearly all future life will sprout. We will completely subsume and dominate all the resources and other life forms on earth, and then, with a little luck, we will begin to spread throughout the galaxy and dominate it as well. During this time humans and technological systems should combine to radiate into a vast array of new varieties of life able to live on any planet and in any environment where there is energy and raw materials. The following paragraphs will outline the framework of understanding that makes these assertions seem self-evident.

But this will be an evolutionary process driven by the physical laws that govern living systems. Humans will not consciously determine their own future, but their collective actions will combine to form the evolutionary pathways that will create the future of life. We cannot control this process, but knowing how it works can possibly give us more influence on the outcome than any other species has had in the past.

To understand this, we will first answer the question, what is life and how does it work? From this we will be able to gain an understanding of the forces that shape evolution and drive it forward. Darwin, Mendel, Watson, and Crick provided the answers to how the mechanism of heredity and evolutionary change operates, but they never looked into what fundamental forces

powered these changes and drove life relentlessly toward increasing complexity. Here we connect biological evolution with thermodynamic processes in a way that fills in this missing aspect of evolutionary theory. And then, once we understand the dynamics of evolution, we will be in a position to evaluate our current situation regarding the evolutionary process and predict where we are headed. This should give us some truly remarkable and original insights into how the world works and how we might influence the course of future events. The last paragraphs will be focused on the practical aspects of these insights and what they might mean for us as individuals.

WHAT IS LIFE ?

“Man is an intelligence in servitude to his organs.”

Aldous Huxley

LIFE IS A PROCESS

To study evolution and how it operates, you must first understand what life is. But life is something that has always been hard to define. Living things can come in an amazing variety of forms, and it's hard to pinpoint the essential qualities that they all have in common. People associate life with consciousness, but obviously there are many forms of life that most people would say are not conscious. You might say that life reproduces itself, but really there is no reason a living system couldn't just grow indefinitely without actually having offspring. Then you might say that only life exhibits growth, but crystals often grow naturally when conditions are right, and they can break apart into smaller pieces that then can continue growing and multiplying. How is this different from the way simple life forms grow mechanically and multiply by splitting apart? The difference is that life generates and stores information through selection and then uses this information to

guide its actions. But this is a description of a complicated and involved process. Life is a complex process and not just a category of objects that can be defined by some physical parameters, and this is what makes it hard to define.

Definitions from merriam-webster.com

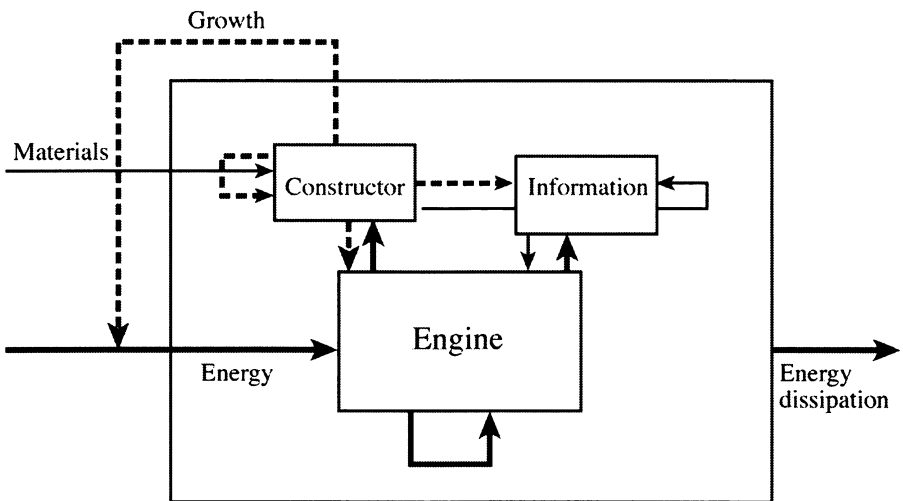
THINGS MOSTLY DEFINED BY A PROCESS	THINGS MOSTLY DEFINED BY THEIR PHYSICAL CHARACTERISTICS
<p>Justice</p> <p>“The maintenance or administration of what is just”</p>	<p>Chair</p> <p>“A seat typically having four legs and a back for one person”</p>
<p>Government</p> <p>“The act or process of governing; specifically : authoritative direction or control”</p>	<p>Streetlight</p> <p>“A light usually mounted on a pole and constituting one of a series spaced at intervals along a public street”</p>
<p>Life</p> <p>“The quality that distinguishes a vital and functional being from a dead body”</p>	<p>Tree</p> <p>“A woody perennial plant having a single usually elongate main stem”</p>

Table 1 Things defined by characteristics vs. things defined by processes. Many words cannot be defined precisely because, in reality, there are always gray areas on the boundary of abstract concepts. But some words like “life” are even more difficult because the concept itself is complex. A one- or two-sentence definition of life is just not adequate to explain what it is.

The simplest and most straightforward description of life is an integrated system that uses stored information and energy and materials from its environment to maintain and expand itself. Like many other objects, life is a complete system and not just the sum of its parts. A car is a holistic system; a pile of the parts of a car is not a car, and a car is not any one of its particular parts. Just like life, a car is a complete system characterized by how all the parts work together. But unlike a car, life is primarily an operating process

defined by the process itself more than by an actual physical description of its parts. A car is partly defined by its function, but it also has certain physical parameters that make it a car. We can be driving down the highway in something other than a car, and a car is still a car even if it's not on the highway. A car sitting on the bottom of the ocean is still a car in every sense, but a fish lying in the middle of the street may still be a fish but it is not alive (at least for very long). A fish loses its most essential quality of being alive if it is not in a particular environment and operating in a certain way. This is why life must be defined as an ongoing process carried out in a particular way by a group of unspecified, changeable parts.

Because life is essentially a process, it can best be illustrated with a flowchart using abstract components that represent function rather than actual physical parts. The system of life is exemplified by the following flowchart.



Flowchart illustrating life processes.

The chart above illustrates the basic functions of a living system and how they are operationally connected by energy and information flows. The “engine” represents the parts of a living system that gather energy for the system. For most animals and plants the engine involves almost the entire organism. The whole body of a lion is a machine to hunt for food, which is its source of energy. The trunk, branches, and leaves of a tree are all needed

to gather energy from sunlight and so they all must be included as part of the “engine.”

The “constructor” signifies the parts and operations of an organism that gather materials and build all the parts of the system, including the constructor itself. The body of the lion and the all parts of a tree are also the constructor because they gather the raw materials for growth.

The “information” of a living system is the coded instructions in its DNA, but it also can be the DNA translation machinery in each cell or the learned information in an animal’s brain or nervous system.

The engine, constructor, and information library shown in the flowchart are conceptual only, and they can’t be found as discrete units in a living system. Any actual organ or structure in an organism more than likely serves to function as part of all these conceptual components. The brain of an animal stores information, but it also coordinates sensory input for capturing food (engine) or constructing a nest (constructor). The “constructor” of a cell is made up of nearly all the cell parts, which at some point are needed to create a daughter cell, but these parts also participate in gathering energy and processing information. The components of the chart can’t be pinpointed in any living being, but still they are useful in defining the process of life by illustrating the dynamics of how certain structures operate together to become life. In the final analysis all living systems gather energy from the environment and process it into useful work (engine) that builds more of their structure (constructor) using information they store to make decisions on how to go about this (library of information). This is what the flowchart illustrates. The dark lines are the flow of energy and materials through the system. The thinner lines from the library of information are the flow of instructions to the functioning parts of the system, and the dotted lines are the flow of maintenance and construction efforts from the “constructor.” The arrow labeled “growth” leading from the constructor to the energy arrow illustrates how life can create a feedback by constructing more units that in turn gather more energy so even more units can be constructed.

Many very different things, from a tree to a tiny bacteria, or to an insect or a mold covering some decaying leaves, are considered

to be life. We know these are alive because this is what we are taught. But by just looking at them we would be hard pressed to see anything they have in common. They all are made of cells that have similar structures and a common ancestry, and this might be a good definition of life on earth. But most people would say that this isn't what defines life. It must be some more basic characteristic that could be applied to life originating anywhere. These basic characteristics are what the flowchart illustrates even though there is no actual entity that matches in its physical parts the simplified essence of functional relationships shown.

Life is a holistic entity defined by the operation of its parts and also by the relationships between the parts and their surroundings. The parts have a function and purpose only if they are operating in a compatible environment, and the DNA contains information only if it is connected to something that can read it and utilize it in an environment that it relates to. In this sense, life is a relationship between the system and its environment as well as being primarily a process conducted by its parts.

Some people claim that the spark of life resides somewhere specific or that life is just a vehicle to perpetuate genes. But life is really a functioning set of parts in total. The genes serve the organism as a library of information for life just as much as the rest of the organism serves to maintain the library for its future use. Neither would function or be alive without the other. And again, none of these components can even be alive collectively unless they are somehow connected to an energy source that allows them to operate and unless they are in an environment where their information has meaning.

We use a flowchart to define life because this is the best way to describe something that is primarily relationships and processes. But this flowchart will also be very useful in further analyzing these processes and predicting their future. The arrows and boxes help us break down the process into identifiable flows of quantities that can be measured and projected forward. This will be the basis for making predictions about the future direction of the process of life.

Some of the arrows in the flowchart represent flows of free energy, and understanding how and why this energy flows

through living systems is also an important part of understanding life. These thermodynamic flows of energy are the ultimate driving force behind evolution, and in the final analysis they are the animating force of all life and even consciousness itself. The next section will focus on illuminating some of the ideas of thermodynamics that directly relate to life processes and evolution.

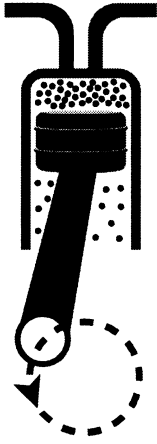
THERMODYNAMICS IS THE BASIS FOR UNDERSTANDING HOW LIFE OPERATES

Work, energy, entropy, and order are ideas associated with life and are also technical terms used in the discipline of thermodynamics. This is because the study of thermodynamics is intimately connected to how living systems operate. Thermodynamics defines what work is and quantifies how work can be extracted from energy in the environment and put to use to construct and maintain the structures and orderliness of life. Increases in entropy are the driving force behind all evolution and life processes. So, for these reasons, some basic principles of thermodynamics must be understood before the nature of living systems can be fully appreciated.

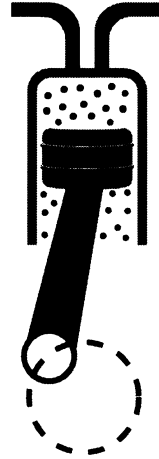
Thermodynamics was first studied and developed by engineers and scientists during the beginnings of the Industrial Revolution so they could understand how to build better engines to power factory production. Industry, just like a living organism, must utilize energy from the environment to power its operations, and so thermodynamics became an area of interest during this time.

Work in thermodynamics, just like in everyday life, is the ability to use energy in a directed way to accomplish something. But most energy in the universe is simply not available to do work. There is no physical way to collect energy that is randomly distributed in the universe and harness it to do work. We can only utilize energy that is already concentrated in a non-random, improbable way to do the work of constructing the improbable configurations of living or man-made structures. Thermodynamics and statistical mechanics demonstrate this in

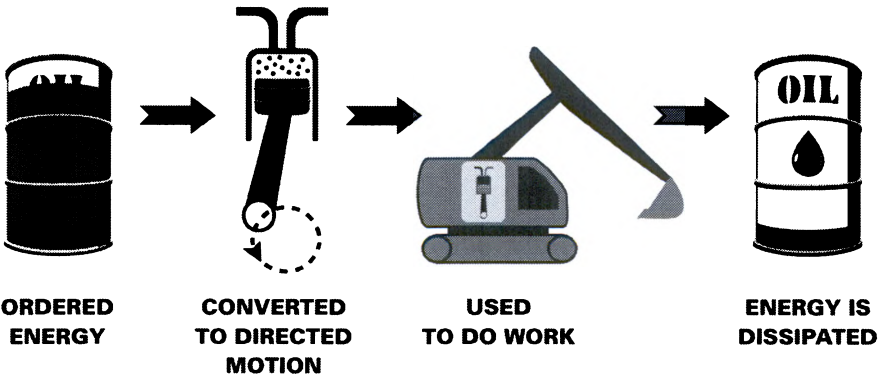
a mathematical way and quantifies how much useful, “nonrandom” energy is available in any particular system that can be harnessed to do work.



**LOW ENTROPY
NON-RANDOM
ORDERED ENERGY
CAN PRODUCE
ORDERED MOTION**



**HIGH ENTROPY
RANDOMLY
DISTRIBUTED ENERGY
CANNOT BE USED TO DO WORK**



An internal combustion engine is one of the many ways to convert non-random energy into directed motion. If energy were random, the engine could not work because the force of molecules striking a piston would be the same on both sides. A source of nonrandom energy is required to create directed motion, and utilizing the motion dissipates some of the energy.

Entropy is a measure of the probability and randomness of energy distribution. The higher the entropy of a system, the more its energy is randomly distributed and the more probable its current state is. Low entropy indicates orderliness, low probability and a greater amount of energy available to do work.

Randomness and probability are connected because the configuration of the universe is constantly changing, and in thermodynamics (or more precisely statistical mechanics) each change of state is considered a roll of the dice. With each roll a system can theoretically change into any state, but since there are so many more random states than ordered ones, it is much more probable that a system will switch to a random state. In fact, randomness is so vastly more probable than concentrated energy that once things become random and energy is dissipated, there is really no chance that they will again revert to a nonrandom state of ordered energy. This is the second law of thermodynamics, which states that entropy is always increasing, or, in other words, the universe is constantly shifting into a more random, higher probability state of energy distribution.

An ice cube melting in a cup of hot coffee aptly illustrates these concepts. In this situation, energy is extremely concentrated in the hot coffee, and the cube of ice represents a highly improbable state of low energy concentration. The continuous collisions and energy exchanges between the molecules of the ice and coffee gradually transfer heat to the ice until the temperature equalizes. After the ice has melted, the molecules continue to exchange energy and the coffee continues to change states, but there are so many more states of equalized temperature that you could observe the cup of coffee for as long as the universe has existed and still not have any chance of seeing it spontaneously revert to such an unlikely state as having an ice cube, even though this is just as possible as any other particular configuration. This is why entropy always increases and the universe evolves. There are highly improbable concentrations of energy in our world, and the constant motion of matter is always redistributing this energy irreversibly in a more probable way, creating a directionality of events.

The reason that this is important to industry and life is that concentrated non-random energy can be converted in various ways into the directed motion that powers industry and animates life. As this energy is converted and used it is changed into a more random state and its entropy increases. This increase in entropy is the fundamental driver of all living processes.

So why doesn't the universe run down to a stable state of randomness? Why are there currently so many highly improbable structures in the universe? Fundamentally the answers to these questions are unknown. But, more superficially, the explanation is that the universe is expanding, and this expansion is continually creating new areas of improbably concentrated energy. As the universe expands, more empty space is created in which matter and energy can be but are not yet distributed. The increase in the size of the universe multiplies the potential configurations that can exist, which makes the existing configurations more orderly in a relative sense. Therefore, the scope for possible randomness is also increased, and as matter and energy flow continuously into this increasing volume of space, the randomness and entropy of the universe continues to increase.

The universe is not static and continually evolves unidirectionally because it is expanding unidirectionally in a way that continuously creates new states and involves new energy exchanges. Ultimately the evolution of life is powered by the evolution of the expanding universe, which continually creates improbable energy concentrations that are available to be harnessed for work. The basis for all evolution is the unidirectional evolution of the universe from the big bang to its unknown fate, and the evolution of life is a similarly unidirectional offshoot of this evolution feeding off pockets of improbable energy concentrations. But the evolution of life is different from nonliving variety because it has a tendency toward increasing information caused by the continual generation of new information through natural selection. The directionality of the universe provides a continuous source of energy available for work. Life traps this nonrandom energy in a feedback loop that uses the energy and its information to build its structure and then search for more

information to build more structure and capture more energy. This feedback is the driving force of evolutionary change and the reason that life seems to continually move toward increasing complexity.

THE FORCE BEHIND INCREASING COMPLEXITY IS INCREASING RANDOMNESS

It is common to think of life as highly unlikely. It's easy to recognize living or manmade structures because they seem much too improbable to arise out of pure chance. But with statistical mechanics we can calculate the "probability" of any structure, and it turns out that all living and manmade objects are more probable than the structures they were made with. All the chemical reactions and physical transformations that produce these structures involve increases in entropy and greater randomness in energy distribution. A pile of coal big enough to power the construction of a skyscraper or the most complex computer actually is a more ordered state than the computer or skyscraper, according to physical principles. Every step in the construction process always involves the dissipation of energy and an increase in randomness. The configuration of the sunlight and raw materials a plant uses to construct itself is statistically more "improbable" than the plant itself. The grass that a cow eats is more "improbable" than the cow. In fact, each minute step in the billion-year history of life's evolution and each tiny action making up each individual life involved an increase in randomness and a state more probable than the one that came before it.

Living or manmade objects may seem more improbable than natural objects because they are made under the direction of stored information and have a purpose, at least within the context of their own functioning. When we see something constructed in a sensible way with an obvious purpose, we think that there must have been logical thought and a consciousness behind it to create the apparent orderliness. When we see an object with a purpose, we immediately know that it is highly

improbable and that it was probably not created by random events. But the appearance of purpose and intelligence arises out of the unique combination of an engine, constructor, and information storage structure that make up a living system and the way that increasing entropy drives these components to generate information and seemingly purposeful structures. We recognize the orderliness of living things much more readily than nonliving orderliness because nonliving orderliness, such as the improbable energy concentration in a lump of coal, has no purpose. But purpose is different than randomness, and the purposeful structures of life have arisen not because they somehow capture negative entropy but because their creation has been directed by information. Actually, they are just another step toward increasing randomness in the universe. The force driving the evolution and creation of purposeful structures is the same force driving the overall evolution of the universe, which is expansion and the continuing increase in randomness in expanded space. The difference is just that living structures self-generate information that then directs their construction. The evolution of the universe proceeds in steps, each of which is driven by increases in entropy, and thermodynamically the progress of life is no different. The history of life has really been just one long progression of chemical reactions caught in an information feedback loop with an infinite number of intermediaries and no final end product. But each reaction is no different than a nonliving one in that they all involve an increase in entropy and a state of higher “probability.”

Thermodynamically the order of living things is nothing special, but in another way their order is a very special kind because it is the only type of order that can create and preserve information. The extraordinary thing about life is not its orderliness; it's the amazing pyramid of information it has created and maintained. To accumulate this much information requires an unimaginably long and unbroken series of chemical reactions. An uninterrupted chain of events like this may be extremely rare but, on top of that, it's also exceedingly delicate. A single event that breaks the link between life and its information will

cause a catastrophic crash in which the system irrevocably collapses. A hurricane, like life, is a system that exists by dissipating ordered energy, but a hurricane can disappear and then reform at a later date because it doesn't require an unbroken connection to accumulated information. But, if the multibillion-year chain of life is severed by some sterilizing event, it permanently reverts to nonexistence.

Thermodynamically life is more probable and less ordered than the resources it is built with, but, calculated a different way, its particular type of informed order is extremely rare compared to other thermodynamically equivalent ordered states. Life is like an enormous house of cards that requires a multibillion-year stable platform on which to build its edifice of information. One tremor in that platform can cause the whole thing to irretrievably come crashing down. The magical aspect of life isn't that it is ordered; it's the immense variety of exquisitely engineered information that selection has been able to wring out of some basic molecular building blocks. Life has persistently expanded over the eons through what is basically just a sequence of chemical reactions to all the marvelous still-expanding forms we have today, because it has been relentlessly discovering information and protecting it from a disastrous crash for at least 3.5 billion years.

And now, getting back to the flowchart, we can understand that the arrows represent flows of materials or free energy, which is another name for ordered energy, and **these flows are propelled by the movement of ordered energy into a more disordered state**. Life and consciousness are animated by these flows, and evolution is propelled forward as life traps these flows in an information-generating feedback loop that expands by continuously accumulating more and more information. From our individual point of view, we see our consciousness and intelligence as the controlling factors in directing how energy is used. But if we look at the big picture we can see that differences in available energy push natural selection in different directions over the course of many generations, and it is really the energy-information feedback that is directing what type of consciousness and information are created.



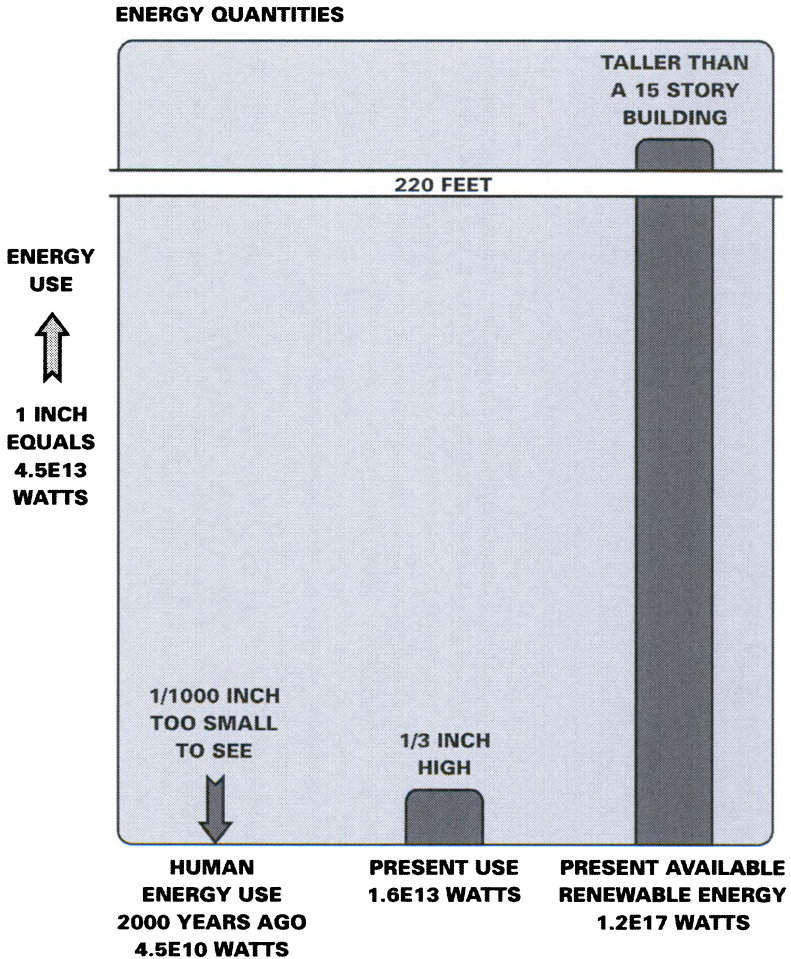
This illustration is from tolweb.org, a web site dedicated to promoting the understanding of biodiversity. About 1.8 million different species have been described, but many more exist that have yet to be identified. It is estimated that there may be as many as 12 million unidentified species. But many of these will become extinct before they are known. It is projected that 30% of contemporary biodiversity will be lost by 2050 because of disruption of habitat related to human activity.

THE ENERGY AVAILABLE TO POWER THE TRANSITION TO SYMBOLIC LIFE IS ENORMOUS

Our description of life and some related thermodynamic principles makes it clear that long-term trends in evolution are determined by the availability of energy and the ability to accumulate new information to access energy. It's fairly simple to calculate the potential availability of nonrandom energy, and it turns out that there are vast sources of nearly inexhaustible energy that can be tapped with symbolic information systems. It is these quantities that will determine our future, and they point to a vision of the future that is beyond most people's imaginings and may arrive a lot sooner than people think.

To get an idea of the energy availability and flow driving the current transformation of life, we can look at some recent estimates of energy use and availability. Total energy use is hard to define much less measure, but we can at least make some rough estimates. The human population two thousand years ago is estimated to have been about 200 million. The energy output of the human body is about 113 watts, so the total direct human energy output back then was 2.3 E10 watts (we are using E10 to represent 10^{10} so 2.3 E10 is 23,000,000,000 watts). Two thousand years ago there were few other sources of energy besides our own direct efforts, but we will double this figure to allow for the use of animal energy and fire as an energy source. Current (2005) worldwide human energy consumption is about 1.6 E13 watts, which is about four hundred times the estimated energy use two thousand years ago. Most of this is generated from nonrenewable fossil fuels, so we can't count on this for the future. But the total of nonreflected solar energy absorbed by the earth is calculated to be about ten thousand times our current energy consumption (1.7 E17 watts), and there are also other types of renewable energy sources. It's unknown how much of this renewable energy can eventually be utilized, but there is no limit on the materials, processes, or technology that can be accessed with symbolically stored information. Even with existing technology it is estimated that the usable, renewable energy flux, including solar, geothermal,

tidal, hydroelectric, and wind energy, exceeds $1.2 \text{ E}17$ watts. This is more than seven thousand times current energy consumption. Energy use will no doubt become much more efficient in the future, but even based on the current per capita use, this amount of renewable energy could support a population of 42 trillion people.



Energy quantities bar graph #1

Even without counting fossil fuels, we have barely begun to tap the energy available to symbolic life on this planet.

You might think this is completely absurd and how could we possibly even grow enough food for 42 trillion people. But you would then be lacking an understanding of the transformative power of the forces we are describing here. Food is mostly just an energy supply for people, and the processes that supply energy for people and even the structure of people themselves and how they ingest energy are an infinitely malleable substrate for evolution to operate on. People are just earth, air, energy, and water. There is plenty of earth, air, and water to make 42 trillion people, and there is also enough energy to power them. All that is needed is to accumulate enough information to build and operate the system. Food will eventually be manufactured much more efficiently, directly from an energy source, without need for agriculture. All of our other needs will also be met in a much more direct and efficient way.

When we are able to command all the renewable power on earth, more will probably go to running machines than people, but an evolved system could still plausibly support such a huge population. The island of Manhattan has a population density of $2.7 \text{ E4 people/km}^2$. A population of 42 trillion would mean the earth's entire surface would have a somewhat higher average population density of 8 E4 people/km^2 . This figure might be upsetting to an environmentalist or a population control advocate, but there is no real engineering or resource barrier to attaining this density given our rate of information discovery. Life will exist wherever it can, and selection programs all life to relentlessly expand until some limit is reached. Any species must eventually expand to fill every niche possible or some other competitor inevitably will. Most likely, as human civilization expands, per capita energy use will continue to rise and population will level off before reaching this extreme, but energy use will not level off until some insurmountable barrier is reached.

From an evolutionary fitness standpoint, there is tremendous waste in the way our current civilized institutions operate. Much of our energy goes into rampant consumerism or primitive, convoluted systems of production left over from the realm of DNA information storage. We are living in a golden

age of abundance ushered in by the transition to symbolic information, which tends to mask this waste, but as we continue to expand, selection will force our systems to be more efficient. As we approach the real limits to the energy available on earth, humans will not only be consuming vastly more energy but they will use it much more efficiently through radically altered structure and organization. Later sections of this book will examine in more detail what form these alterations might take.

WHAT IS INFORMATION?

Information is a defining quality that separates living processes from the nonliving. The word seems to have first appeared in the literature of the English language in the 1300s and was apparently derived by adding the “noun of action” ending to the verb “inform” to make the noun “information.” The earliest meaning of information was the act of informing or giving form to the mind through education and training. The word “inform” itself came from the verb “to form” and implied giving form to an idea through instruction and education.

In modern English the word “information” has many meanings depending on context. In general the word is associated with the words “knowledge,” “instruction,” “communication,” “records,” and “data.” Usually there is a source or sender involved as well as a receiver of information. Information is often stored and transmitted in coded form, and the code must be understood or translated by the receiver. Information can be a representation of something in a different medium, such as a picture, or a set of statistics about something or a written description. Information can be the contents of a message, sensory input, or the contents of stored records. In physics information can be just the state of things, and a system contains a certain amount of information in the sense that it takes a fixed amount of code to describe its state completely. But whether information comes from a description of a system’s state, from records or stored knowledge, or from the senses, there is always an implied transfer of a message from

place to place. Also it can be assumed that the message has some sort of effect on the receiver.

In 1948 Shannon and Weaver published a paper with a mathematical analysis of information that quantified the amount of information that could be transmitted by any specified code. Shannon had been involved in studies that helped break the code of encrypted enemy communications during World War II. This was the beginning of information theory, and it developed into an important field that greatly contributed to the development of computers and electronic communications. Information theory allows the theoretical quantity of information within any particular string of symbols to be calculated. But information is really a relationship between an organism or consciousness, its information system, and the environment. This relationship cannot be quantified with information theory alone, which only supplies engineering data on the efficiency of the coding and communication systems. Information theory is about storing and transmitting information, but not about the usefulness or the effect the transmission of information has on the relationship between the sender and receiver.

Information is what gives life its unique qualities of self-organization, purposefulness, awareness, and intelligence. "Information" is used here as a word that describes relationships between the functioning parts of living beings and their environments. These relationships involve the way that various symbolically coded representations of the world interact with a living system to affect its actions. The word usually involves a sender and a receiver but often the sender and receiver are parts of the same entity. An organism receives information from other parts of its body, from its DNA, from the knowledge stored in its memory, and from its sensory organs. But always the concept of information would have no meaning without a living system to use it and interpret it. Humans are unique in that they deposit and store information externally in all sorts of manmade structures and then retrieve messages from this external body of records routinely.

"Information" could be defined as a symbolically embedded awareness or understanding of an organism's self and its environment that is accumulated through natural selection. Biological

evolution and life cannot really be separated from the concept of information because each of these concepts requires the other to fully understand their meaning. The essence of life is that through the process depicted in the flowchart, life develops a record of the past that enables it to continue in the future. A living system uses this record of past events to make predictions about future events and conditions. Through this process, the organism receives directions on how to cope with the future and use materials in its environment to grow and survive. The information system of an organism tracks conditions in the external world through signals received from the environment and then, by running a limited model or simulation of the world, the information mechanism predicts likely conditions that will develop in the future and supplies a plan to prosper under these conditions. This description of the overall information process applies as well to a highly intelligent engineer designing a modern factory as to the way trees lose their leaves in the fall anticipating cold weather and then regrow them in the spring because summer will follow. The engineer may use all sorts of sophisticated economic and physical surveying to collect data and advanced engineering software and mathematics to try to plan and construct a factory that will pay off in the future, but, fundamentally this is no different than the way a tree unthinkingly uses signals from its environment and its stored information to predict the best time to lose and regrow its leaves. Even the simplest organisms exhibit an awareness of themselves and the workings of their environment by taking actions that are proved by events in the future to be in their best interests.

Information involves a simulation of the world and the organism's relationship to it that can predict the future. This is possible because the universe itself seems to be a large calculating mechanism that continuously computes its next state from the last one according to a fixed set of rules. Modern physics envisions the world as made up of units or quanta of space or matter that all interact with one another according to fixed rules. At each moment of time, these interactions result in changes that create the state of the universe in the next moment. In this way the universe continuously calculates its future. Since the entire universe is an interconnected system, any part of the universe can potentially

influence any other part, and a complete calculation of the next state must involve every unit of the present state. This means that everything is connected, but it also means that there can never be a perfect simulation or complete knowledge of future events. A complete simulation would require the entire universe to be represented in the calculation, but this is the universe itself.

The strange thing about the way life creates information is that this information is at the same time a simulation of the universe and part of the universe being simulated. The mechanism of the simulation of the future must also be a part of the universal calculation of the immediate next state. Information embodies a memory of the past, a prediction of the future, and an immediate computation of the present all rolled into one. This is the magic of information and how it creates and embodies life and consciousness. The nonliving world has no past or future, only the present state that leads to the next state. Information superimposes the past and a simulation of the future onto the present, creating an awareness of self and a purposefulness of action.

LIFE CREATES INFORMATION AND INFORMATION CREATES LIFE

The process illustrated by the flowchart of life creates information, and this is the only process that can create it. By growing and reproducing, life generates the conditions and variability to carry out the experiments of selection. Selection deposits continuously updated information into life's library of code. The code stores the accumulated history of information discovered through selection, and the system uses it to make predictions about future events and about the best course of action for dealing with these events. This leads to more reproduction and information discovery and the gradual growth of an embedded simulation of reality within reality itself.

Some of the ancients thought that the world could be summed up by a simple set of truths that could be deduced through pure reasoning. But reasoning is part of the simulation of reality used to arrive at a prediction, not the creation of truth

or information in itself. It seems there must be an underlying truth that is the target of our simulation, but there is no reason to believe that there is necessarily any universal or ideal way for our language or consciousness to represent it. Language requires structure and logic in order to operate but it is selection that created language and its structure to help us deal with our environment. The intellectual skills we have enable us to induce generalities from patterns of specific observations and to turn our generalized information into the specific decisions we need to deal with constantly changing circumstances. In this way reasoning helps us process the information we have and provides a better algorithm for generating new information, but the final determination of what is information can only be made by selection. Reasoning is the structure and functioning of information and not the basis from which it is created. Evolution created our brain, our language, our reasoning skills, our perception of truth, and our reality, and the feedback between the selection of structural possibilities and energy availability is what ultimately determines their form.

Some people imagine that science will eventually come up with a set of elegant equations that can be used to predict any event. But if such equations do exist, they would (and do) take a computer the size of the universe to infallibly calculate just the very next state. Information systems are superimposed upon the ongoing interactions of reality, and the models they create can calculate events far into the future but only in an incomplete and unreliable way. The world that information creates for a living system is only a limited simulation of the real world that is narrowly tied to the organism's needs. Science is and always will be only a vastly simplified model of the specific bits of reality that the users need to simulate in order to better survive.

Although Shannon's work was not about information per se, it did mark a turning point in the evolution of information systems and was itself a critical discovery of new information. For the first time the qualities of information systems were studied in a rigorous, scientific way. This, along with the invention of the computer, brought about the revolution in information technology that is currently a major factor powering the transition to symbolic life.

LIFE AND CONSCIOUSNESS

Riders on the storm
Riders on the storm
Into this house we're born
Into this world we're thrown
Like a dog without a bone
An actor out alone
Riders on the storm
Jim Morrison

The most mysterious creation of life would surely be our personal experience of consciousness. But living systems don't necessarily need to be conscious or self-aware to be alive. All the functions of a living system can be carried out by just a mechanism following a program. A living system must have useful information, but the process of evolution and natural selection creates this information and stores it without the need for thinking or logic. A single-cell organism appears to react to its environment, move toward food or away from danger, and its internal controls keep the system in balance and promote the best actions that lead to its survival. But all this is done without what we would call thinking

or consciousness, even though this sort of process might be considered the most primitive forerunner of intelligence. Nobody would claim that bacteria, mushrooms, or plants are not alive, but most people would say these organisms and many others have no consciousness or thought processes whatsoever.

Consciousness is not necessary to life, but it is the one magical aspect of life that probably will never be fully explained. The most truly mystical phenomenon of life is the way we personally experience our own being. Each individual component, event, or reaction that makes up the functioning a living being can be conceptualized and can be fit into the framework of natural laws, but how the combination of these interactions can add up to our own personal self-awareness and sense of existence seems to be beyond our understanding. The wonderful thing about life is not that it can trap information and use it to create purposeful components that mechanically stamp out more copies of itself. These processes are just extensions of the nonliving evolution of the universe. The astonishing thing is that as life mechanically gathers more and more information, it mysteriously becomes “conscious” and can contemplate its own reality. The words “purpose,” “information,” “organization,” “work,” and even a mechanical “awareness” come directly from and describe the mechanical processes of life, but the word “consciousness” does not. This word cannot be tied to any single process or action of a living system and, just like what it describes, it jumps into existence in an unexplained way. In fact, understanding fully the reality of our own understanding may be a logical impossibility, and it is certainly the most impenetrable, miraculous and spiritual aspect of life.

The personal experience we call consciousness may be fundamentally unexplainable, but it is not hard to see why natural selection would favor its path into existence. Consciousness is just the tool that complex mobile organisms need to place themselves in the world and decide what actions to take next. Consciousness is a useful companion to mobility because awareness of one’s surroundings and the ability to sense events and circumstances, a sense of self and an understanding of one’s body and the capabilities of the body, the ability to analyze and make predictions about your surroundings, and all the other things

associated with consciousness are just the things that are useful and necessary for a mobile organism to function. Consciousness arose because of the requirements of mobility and then became more and more sophisticated as bigger and more complex mobile organisms evolved. Consciousness is a purposeful adaptation created by natural selection in the same way and under the same pressures as all the other mechanisms of life. Because of this, we should be able to assume that it is an efficient mechanism that wastes little energy on unneeded intricacy or elaboration. Our reasoning power, emotional responses, motivations, desires, attitudes, and perceptions must reflect just what we need to know in order to survive. In fact consciousness is just the logical extension of information creation. Information is a simulation of the world embedded into the world, and this is what consciousness embodies.

Most people think that their consciousness gives them an objective view of the reality around them. But since consciousness evolved by natural selection as a survival tool, there is no reason to believe our minds are at all objective or unbiased judges of some sort of universal truthfulness. Since our awareness, thought processes, and emotional responses and the senses they are connected to all evolved together to help us make decisions about the best way to survive, what we think is right or true about the world must certainly be molded by this imperative. Kant said that truth and reality depend as much on the subject perceiving its reality as on any external reality itself. In fact, as philosophers have pointed out for centuries, our reality is nothing more than a creation of our minds that is projected out onto the world, and therefore our reality is a creation of natural selection. Since natural selection created our consciousness and the way we see reality, our perceptions must be fundamentally grounded in our self-centered survival and may only tangentially reveal any metaphysical truths about the world.

The human personality and consciousness are molded in development and allow flexibility so that different cultures and environments can be accommodated. But personality and outlook are probably more determined by genetics than most people realize. Many studies have been done on identical twins raised in completely different environments that show that personalities,

including such details as musical tastes, political attitudes, and style preferences, are greatly influenced by heredity. Even the flexibility of human personality must be a trait that has evolved because of its benefits for survival.

CAN WE CONSCIOUSLY CONTROL OUR FUTURE?

Our consciousness is created, shaped and controlled by natural selection, and this brings up the question of who or what really controls the decisions we make, how we see reality, and our ultimate destiny. We feel that we learn about our world through our senses and that we make choices that determine our future. This is certainly true within the context of our individual lives, but at the species level our individual beliefs, decisions, and actions are just the fodder from which the real decisions about the future (selection) are made.

It is the common perception that people in general are consciously and logically working toward a better future for their children. Undoubtedly this is true, but the fact that people are consciously working toward something doesn't mean they have conscious control of the outcome. We cannot consciously control our evolution because, in fact, it is evolution that controls our consciousness. We all feel that our ideas are right and that our own culture and beliefs deserve to be passed on to the next generation, but, in spite of our best efforts, sometimes they are not due to circumstances beyond our control. People can control the events and outcome of their own individual lives through their decisions and actions, but the future of society as a whole can only be determined by what information is passed on to future generations either in DNA or written code. What information is passed on determines everything about how our society will be organized, what our attitudes and thoughts will be, how we will feel about things, and what will be right and wrong. And what is passed on is determined outside of the conscious decision-making of any single human. No single organism has any real say in the trajectory of its species evolution or its collective consciousness. The individuals of a species all struggle to assert their own version of what should be, but what succeeds is determined

by some higher power. Our reality is passed on from generation to generation through our written and DNA inheritance, and, as for every other species, this is controlled solely through natural selection.

The myth of population control best illustrates our lack of individual influence on our collective future. Any sort of voluntary population control that relies on social pressure or people's concern for the environment will only lead to the eventual elimination of the type of people that are susceptible to social pressure or are concerned about the environment. Natural selection and therefore population control is outside the realm of individual decision-making by definition. If population is to be controlled, there must be some mechanism and information on a higher level than the individual that can regulate who has children and therefore what individual DNA is transmitted to the next generation. If this were true, and human reproduction was regulated by some higher authority, then humans would not be an independent species. Humans would by definition be only manufactured components of whatever larger system was regulating their production. In the case of humans, written information can serve this purpose, but when written code begins to control the propagation of DNA code, the focus of natural selection and the delineation of individuality begin to shift. The more our written code determines which people have children and what DNA code is handed down, the more we become just components of a large industrialized society that is itself evolving along its own trajectory, determined by the natural selection of its written code. Society's institutions certainly are capable of various methods of population control. But any method that doesn't lead to the elimination of cooperative people must involve effective coercion. If force is to be used to control population, then the question becomes who is in charge of the enforcement mechanism and who makes the decisions about what is enforced. In the end, no single individual or group of individuals can make these decisions because the basic survival trait of all individuals or groups is that they believe they are the ones that should have offspring that survive. This means that which population control mechanisms or regulations survive can depend only on competition and natural selection between competing groups. Population control necessarily

becomes the control of parts production for the higher level unit of selection running on a symbolically stored genome, and this natural selection is driven by the same thermodynamically based evolutionary processes that determine fitness on lower selection levels.

Population control is not possible without relinquishing our individuality as a species and, for similar reasons, conscious control of our destiny is also not possible. Instead, it is destiny that controls our consciousness. Our values, our likes and dislikes, our emotional world, how we see reality and perceive truth or beauty, and all other aspects of our consciousness are determined by the imperative of fitness, and thermodynamic free energy flows ultimately determine what is fit.

We feel that we have free will and we can control our future through our choices because this feeling is also a basic survival trait. If we didn't have free will and our choices didn't matter, there would be no point in weighing the pros and cons of a decision or in making a decision at all. Our reasoning and logic could not function if we really thought all our actions were somehow predetermined, and on an individual level they are not. But on the species level, what type of consciousness survives in future generations depends only on the thermodynamically controlled fitness of the consciousness characteristics and not on any inherent truthfulness or rightness that the consciousness perceives.

Within our consciousness on the individual level, we seem to have free will and be masters of our own destiny, but the mechanism that really shapes our long-term future is natural selection, whether on the DNA or written level of information storage and transmittal. And, natural selection itself can only be a reflection of the underlying structure and evolutionary process of the universe. We are riders on the storm because we can never truly know or control what we are, where we are going, or what kind of reality we live in.

WHAT DOES CONTROL AND DIRECT OUR FUTURE?

“Survival of the fittest” is a common idea attached to the theory of evolution, and some people might say that fitness controls the

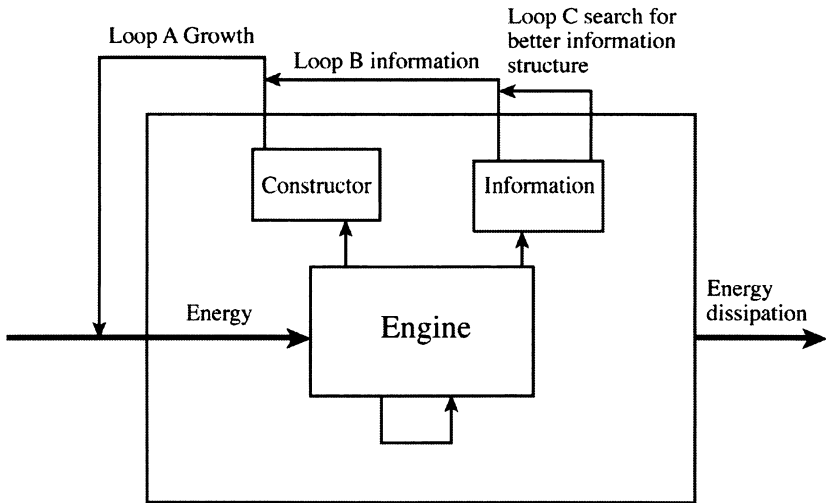
direction of evolution. But “survival of the fittest” is a truism that says nothing because the definition of fitness is survival. A more accurate statement would be “survival of anything that can find the energy and resources to survive.” At least this links survival with some external parameters, and it hints that evolution is not a zero-sum game. Since natural selection generates new information, life can continually find new or better ways to survive and expand. The only thing is that what will be “fit” can never be predicted in advance, and so this word contains no new information. If the outcome of selection could be predicted, then the information would already be stored. Survival of any individual is not because of any measurable quantity of “fitness”; it is always the outcome of a unique experiment that confirms that the information stored is adequate to sustain life or that leads to new information and creates new opportunities to expand life.

A problem with evolutionary theory in the past has been its focus on genes and the idea that winning is the successful propagation of genes. In this static, zero-sum game, a living system is just a tool to replicate and house as many genes as possible. But this thinking fails to appreciate the complexity of life as a holistic, information-generating, thermodynamic system. If we relate evolution only to the propagation of different genes in different environments, then life can only shift back and forth in endless unchanging loops as environments expand and contract. Saying that antelope are fit and will thrive if their grassland environment expands and they will diminish if the grassland shrinks is not really saying much. The circularity of fitness and the lack of any framework for understanding the overall dynamics of evolving systems have made it seem that the theory of evolution has no predictive power

If instead we focus on the information-generation aspect of biological systems, then we can better understand how life can continually expand, and we might actually be able to make some predictions about what path the expansion might take. But information and energy accessibility work together to create the feedback that expands life, and we need to analyze how these factors interact with each other to predict their trajectory.

We have already shown with a flowchart how evolution can be pictured as thermodynamic flows of free energy that power

an information-generating process. The flowchart below breaks down the process further into separate steps that can help us analyze the potential for future progress.



Flowchart of life showing growth broken down into categories.

In this illustration the feedback that allows a living system to expand is divided into three categories. Loop A represents expansion through reproduction and growth that can occur when a species' environment expands and provides more space and resources. Loop B is expansion allowed by new information discovered through the process of natural selection. Living systems continuously search for new information, and if there is undiscovered, useful functionality accessible to their information structure, the process of mutation and selection should eventually find it and allow a species to expand even though the environment does not. Loop C represents any potential feedback from developing new information storage and processing systems that are better able to access previously inaccessible information. Generating new information about how to store information can potentially open up huge new areas for information search that over time has the largest potential for expanding the scope of life. This is what the development of symbolic information systems has done. DNA code can only be translated into RNA and then proteins, and the chemical

functionality of these molecules may be large compared to other types of molecules, but it is tiny compared to the universe of functionality of all other materials. Written code can store the information for nuclear power plants, spaceships, and auto factories as well as laws and regulations that bind humans into complex functioning economies. It's hard to imagine how DNA systems could ever develop and implement the information necessary for these things to happen.

The flowchart gives us a framework for identifying and measuring the factors that lead to future growth. By breaking down the feedback of growth further into components, we can analyze in more detail how different strategies for information search and growth can affect things.

The connection between the mechanism of natural selection and the overall dynamics of how a complete system interacts with the nonliving world has always been missing in evolutionary theory. To use the automobile analogy again, the work of Darwin, Mendel, Watson, and Crick has provided detailed knowledge about how the pistons, crankshaft, and sparkplugs operate to produce motion and how the motor is connected to the wheels, but no information on how the car functions to provide transportation or how this function fits in with the overall economy. To get an idea of how successful cars might be in the economy, you would need to investigate the costs associated with operating a car versus the benefits of owning one. To predict its future, you could do an economic analysis that looked at the feasibility of a car versus all the alternatives to see if people might actually prosper by buying one. If cars are beneficial, you can estimate how many people could afford to buy them and predict how many will be made.

A complete theory of evolution could use the same sort of "economic" analysis to estimate the potential of different systems. By breaking down growth into separate components, we can look at how each of these separately contributes to the process. We can see that in order to build more complex systems, you first need a better information system to store and process more information. Only then can you begin accumulating the specific information you need, and then, once you have the specific operating information, you can actually start building and operating

the new, more sophisticated system. The flowchart analysis allows us to recognize just how rare and extraordinary the creation of a whole new information system is and the tremendous potential for expansion that this event unleashes.

We can talk about an “economic analysis” for biological systems, and business leaders and economists often talk about growth, information systems and evolution. This is because economics and biology are both fundamentally about the same process. The dynamics of economic growth and biological growth and evolution are the same. They are both powered by the same feedback between information creation and energy accessibility. We can actually use the terminology of business to describe the flowchart process in a way that may be more familiar to many people.

Loops A, B, and C in the flowchart are steps that any businessman would need to follow to grow his business. If he is lucky enough to be in an expanding market, he can just invest in more productive capacity and directly expand through loop A. But if his market is stagnant or shrinking he will need to search for more information to design a better product before he can expand. His resources need to be directed toward loop B to find new information that will allow him to create a new market for his products. Once he has a new viable product, then he can switch back to loop A production and start making a profit.

Loop C in the flowchart is the creation of completely new information systems. Loop C is the invention of language, writing, printing, telephones, copy machines, computers, and cell phones that makes modern business operations possible. Each one of these inventions created a whole world of opportunities for new businesses and ways to make existing business more profitable. Even though loop C inventions may not always be end products sold directly to consumers for profit, they are still driven by the profit motive. The market effortlessly directs resources into either loop A, B, or C depending on which provides the greatest current return on investment. If better information systems are the best way to increase efficiency (loop C), then businesses will direct their efforts into developing and installing these systems. If businesses have plenty of capacity to process information, then

they will focus on developing better operational information (loop B). If their operations are running smoothly and there are untapped markets, then a manager will direct all efforts into just expanding existing structure into new areas (loop A).

The flowchart arrows represent energy flows and businesses are driven by profit. But value and energy are closely related and money is a good substitute for a unit of energy. The products of our civilization are made from just dirt, air, or water. Their value is really only the amount of effort or energy that was needed to convert these materials into a useful form. Our economy, just like all life, basically uses available ordered energy to convert raw materials into the form of order that is our society. Money is a quantity that measures the relative effort required to construct every object, so a unit of monetary value is roughly equivalent to a unit of energy.

The innovations of business, new government programs set in motion by politicians, the research conducted in our universities, and all the new ideas promoted by inventors, pundits, and bloggers are all just the process of evolution working in hyperdrive. DNA information systems have their own algorithms for increasing the efficiency of information search. Sexual reproduction is the most obvious which can allow individuals to consciously select the best mates and also promotes the most advantageous mixing of genes. The prokaryotes also have ways to exchange information, and their structure as well as the chromosomal structure of eukaryotes probably includes many ways to promote efficient search that are not yet understood. But these simple unconscious mechanisms for information search can't compare to our rational conscious institutions dedicated to research and development of new systems and technology. The imperceptible creep of DNA evolution has been replaced by technological change so fast that people, businesses, and government struggle to keep up. Every new idea, new product, or government program is evolution happening before our eyes.

Biology and economics are conflated because biological evolution and economic growth are the same thing. People perceive business and economics as the affairs of humans that are directed by conscious thought and as separate from nature. But our consciousness and our reality were created by natural

selection and tuned for our survival. All our conscious economic activities are really just extensions of our biological imperatives. Our emotions, drives, needs, and even our intellect are just the manifestations of the way our DNA instructs us and controls our actions. We are growing and filling every niche in the world with our own species because that is what selection makes us do. It's true that now we are breaking free from our DNA instructions, but these are being replaced by just another set of biologically evolving instructions and not by some sort of universal truth or rational thinking. These higher-level sets of instructions will be selected to act as if they all deserve to thrive and prosper just as in all other species. There will be no way to control the population of groups or organizations without an even higher level authority, so they will grow relentlessly and fill every niche possible. Humans will be domesticated and controlled, but the higher-level entities will be as fiercely competitive and relentlessly reproductive as any wild animal. The only check on their expansion will be the limits of their information systems and energy availability. Life will exist wherever it can and will always expand until some physical limit is reached.

INFORMATION AND ENERGY MAKE US WHAT WE ARE

Language enabled early humans to develop the first kernel of symbolic information that allowed them to use primitive technology and cooperate in groups. With this advantage they could command the energy and resources to begin their expansion. Writing allowed us to more accurately store greater amounts of information and permitted the administration of agricultural economies and the first cities. The printing press further expanded our information capacity, and the technology we then acquired and the new energy sources we could tap ushered in the Industrial Revolution. Now computers have fostered another leap in information capacity that allows for further advances in technology, complex organization, and energy utilization.

Our story so far has been a continuing succession of better information systems leading to more technology that enables growth that in turn leads to even better information systems, more complex technology, and even faster growth. And this has all happened with no conscious plan or overall leadership. Most of it was not foreseen or even recognized for what it was at the time. It came about through just the independent actions of millions of people going about their business, working toward their own personal goals. The process as a whole was an autonomous process feeding off new information that allowed us to access new sources of energy. And this is the point of this section. The growth of civilization is not an intentional or planned act carried out by humans. It's a law of nature. It's just the continuing natural process of evolution that has its own dynamics outside of human control. Evolution has progressed for the last 3.5 billion years without any conscious director, and our evolution will unfold just as independently. It will be shaped solely by how the process of information creation interacts with the structural possibilities and energy availability of the environment. If we want to predict the future, these are the factors we need to look at.

The renewable energy eventually available on earth is estimated at more than seven thousand times current energy use. A more difficult estimate to make is the expanded information available to symbolic systems versus DNA systems. But symbolic systems have available all the information in DNA about how to construct protein mechanisms plus the potential to discover how to construct all the technology possible using all other materials in existence. Mathematically the number of possible mechanisms using all materials versus the number using just proteins is so much larger as to be meaningless. It can only be assumed that the information potential of writing is nearly limitless, at least compared to DNA/protein, and that continuing discovery in this nearly limitless information space will eventually harness nearly all available energy on earth and beyond.

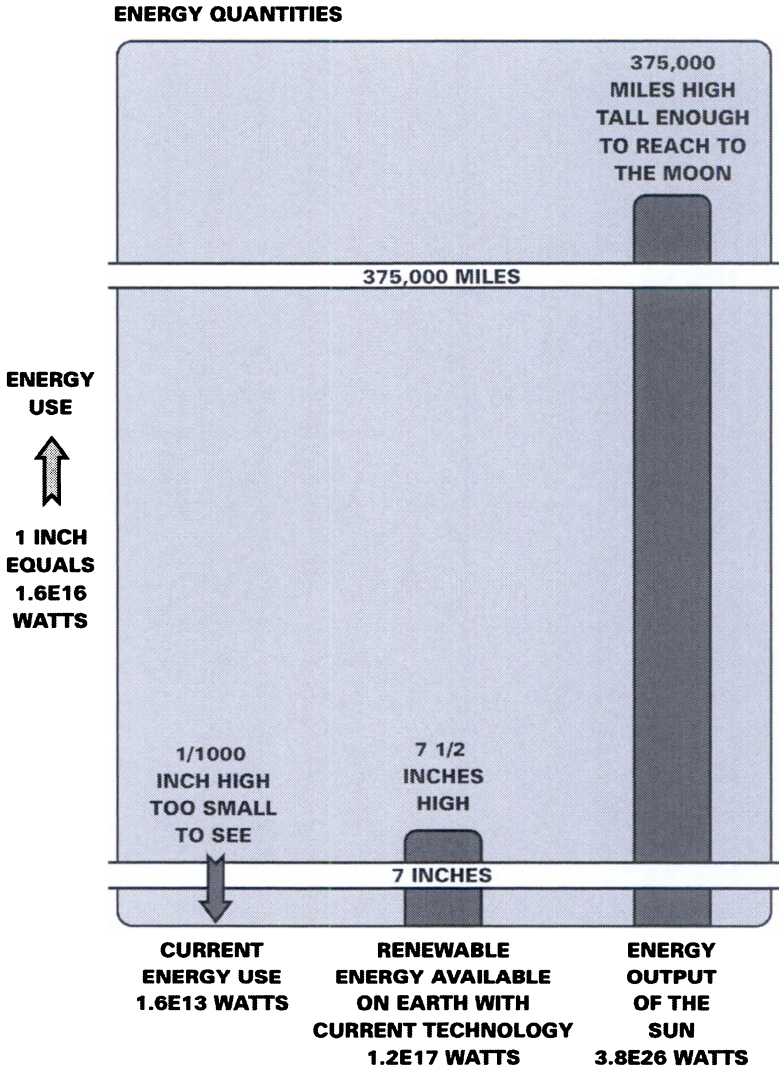
This is just a subjective opinion with no data to back it up. We can't say what will be invented in the future, but the most reasonable guide to the future is what happened in the past.

Life has been able to continually wring new information out of the DNA/protein link for 3½ billion years and has been able to create all the amazing organization and diversity of life from what is a very restricted range of materials. The range of structure and materials that symbolic information can connect to is orders of magnitude greater, and there is no reason evolution shouldn't be able to mine this universe of information for millions of years into the future. Since we won't soon be reaching any limits to information creation, the pace of discovery will be exponential, and the continuing exponential accumulation of information should fairly rapidly create a technology that is orders of magnitude greater and more complex than anything existing now.

It seems that primitive people never foresaw the rise of agricultural societies or cities. There is nothing to indicate that medieval leaders ever imagined there would be an Industrial Revolution, and it seems that many people of the nineteenth century thought that they were heading toward disaster because population would increase when resources would not. They also never imagined the progress we would make in the next century. It seems that people fail to grasp the scope of the continuing explosion of information discovery even while they are in the midst of it and creating it themselves. But, using history as a guide, it's reasonable to think that our future will be just a continuation of the unimagined technological advances of the past.

The energy produced by the sun is over 1 billion times the renewable energy available on earth. There is no reason to think that much of this energy can't eventually be harnessed. Already engineers have proposed collecting the sun's energy in space and sending it back to the earth. Assuming that 1 kilogram of material can be fashioned into a solar collector covering an area of 1/100 square meter, more than the amount of energy required to put it into orbit would strike it every year. It's possible that the annual rate of return for investing energy in the collection of solar power in space is large enough to make this source of energy feasible within the next few hundred years. We may be seeing the beginning of

the end of fossil fuel, and this may be a bump in the road to future progress, but still the potential energy available to symbolically coded technology may have no real long-term limits.



Energy quantities bar graph #2

We currently use only a tiny amount of the energy available on earth, but all earthly energy is insignificant to the vast amounts of energy available from the sun.

As we have already noted, when growth has no inherent limits, it tends to be exponential and can produce some amazing results over time. If we were to continually invest 1% of energy use into launching more space-based solar collectors and 1 kilogram of mass could actually be made into 1/100th of a square meter of surface area that collected 10% of the energy that struck it, continued investment (at a 1% return) could allow us to launch the entire volume of planet Earth into space in only about 300,000 years. We would then be collecting 500 billion times the energy we currently use.

There are no real energy barriers to growth, but the rate of growth of our technological society is usually not limited simply by the rate at which energy generation can be expanded (loop A). Growth is actually most often dependent on the rate of information discovery and the pace at which the information can be absorbed and integrated into a functioning system (loop B). The switch to symbolic code (loop C in the flowchart) has created a huge potential space for new discovery, and there are unlimited environments with available energy for new technological beings to exploit (loop A), but the evolution and selection of the detailed information to create working systems (loop B) takes time. Obviously nothing resembling our current mode of living could accommodate converting the earth into a giant cloud of solar collectors. But, information discovery is also expanding exponentially, albeit more slowly, and over sufficient time, probably still in the range of hundreds of thousands of years, these changes and other unimaginable transformations may occur.

The progress of evolution is an autonomous law of nature. The unlimited scope of symbolic information space and the availability of energy indicate that the process of life will be driven relentlessly toward a vast exponential expansion. Since selection creates our consciousness and determines our future just as in any other form of life, our consciousness will be dragged along with this process and changed into whatever is best suited for the new mode of existence. Our joy, pain, loves, sense of beauty, motivations, perceptions, and even our sense of reality itself may be altered in any way that helps to support the integration of humans into the new order.

WHERE IS LIFE GOING?

Individual commitment to group effort—that is what makes a team work, a company work, a society work, a civilization work.

Vince Lombardi

A BRIEF HISTORY OF LIFE

In order to understand where evolution is headed, it helps to have an idea of how it has progressed in the past. But, there is not enough space here to do justice to the story of the amazing variability of life that has blossomed on earth over billions of years. This would require many volumes, and large parts of the story are still disputed or waiting to be discovered. The following is just a very brief history of life that emphasizes some of the steps and timelines that are most important to this book.

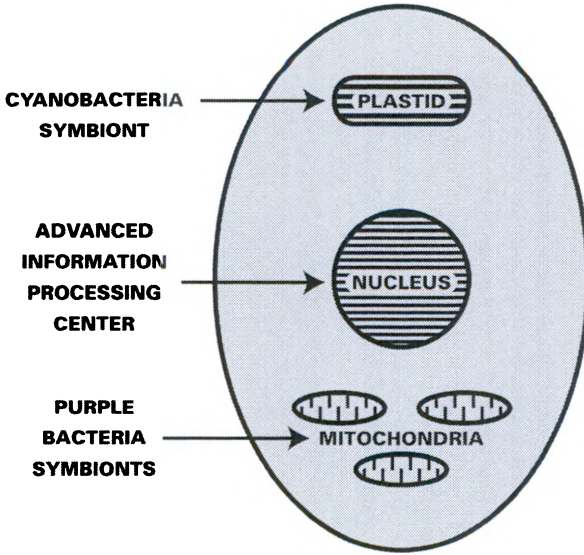
The earth is thought to be about 4½ billion years old, and the oldest fossils of life are about 3.8 billion years old. These fossils are of single-celled organisms that appear similar to modern bacteria, and so life may have been evolving for some time even before these fossils were formed, indicating that life arose surprisingly soon after the earth's crust cooled.

For more than a billion years after life began, there was little oxygen in the atmosphere even though photosynthesis, which produces oxygen, probably had evolved very early. During the first billion years, any oxygen released into the atmosphere soon reacted with iron and other minerals so that, even though oxygen was being produced, there was little free oxygen in the air. About 2 or 2.5 billion years ago, most of the minerals that reacted with oxygen had finally been exhausted and it gradually began building up in the atmosphere, allowing more widespread aerobic respiration, a much more prolific energy source.

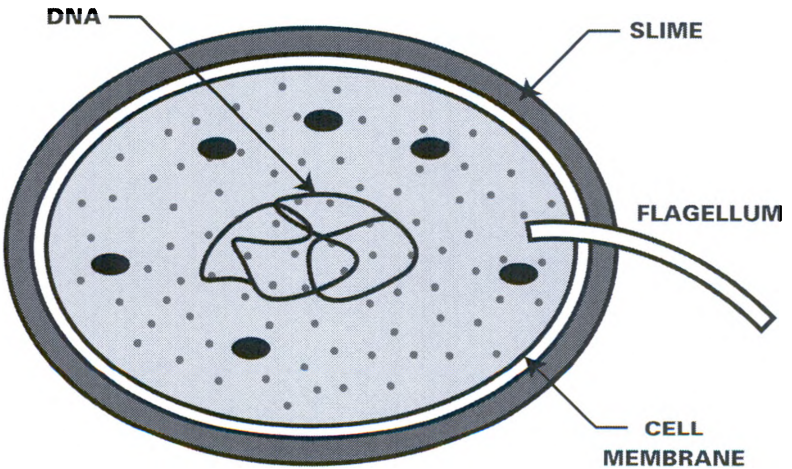
The first cells were without a nucleus, and their genetic material was mostly contained in a single loop of DNA. There are two main groups of these prokaryotic (before nucleus) life forms: bacteria and the archaea. Both these groups are relatively unknown compared to higher plants and animals. For instance, the archaea until recently were thought to be a fairly rare group that only existed in extreme environments such as hot springs but are now known to be abundant in almost any environment. There are probably whole classes of archaea that have not yet been discovered.

About the time that the atmosphere was becoming oxygenated, the more complex eukaryotic (true nucleus) cell structure was also evolving. Eukaryotic cells have a nucleus surrounded by a membrane and chromosomes that allow more sophisticated information storage and processing. Eukaryotes also have specialized complex organelles that perform specific tasks and were created when two or more organisms began cooperating to form a new combined entity (Margulis 1970). Two of these organelles are the mitochondria, which generate energy by breaking down sugar, and the chloroplast, which performs photosynthesis. They were originally independent bacteria-like organisms that began living symbiotically inside a host cell. The host cell nucleus and chromosomes eventually gained complete control over their reproduction, and the symbionts became so well integrated into the functioning of the whole system that they lost their identity as individuals. There is some evidence that the nucleus and chromosome structure of eukaryotic cells also evolved in this way.

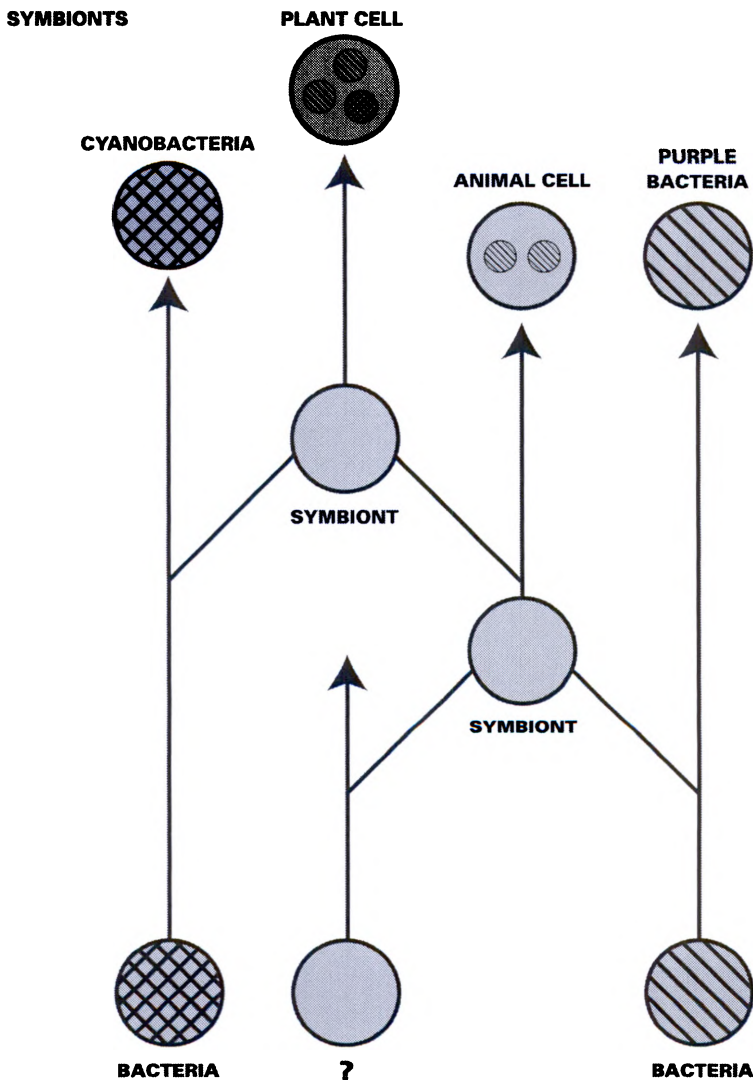
EUKARYOTE CELL



PROKARYOTE CELL



Current research seems to indicate that there are three ancient groups of life. Two of these, the bacteria and the archaea, are prokaryotes. The third group is the eukaryotes.



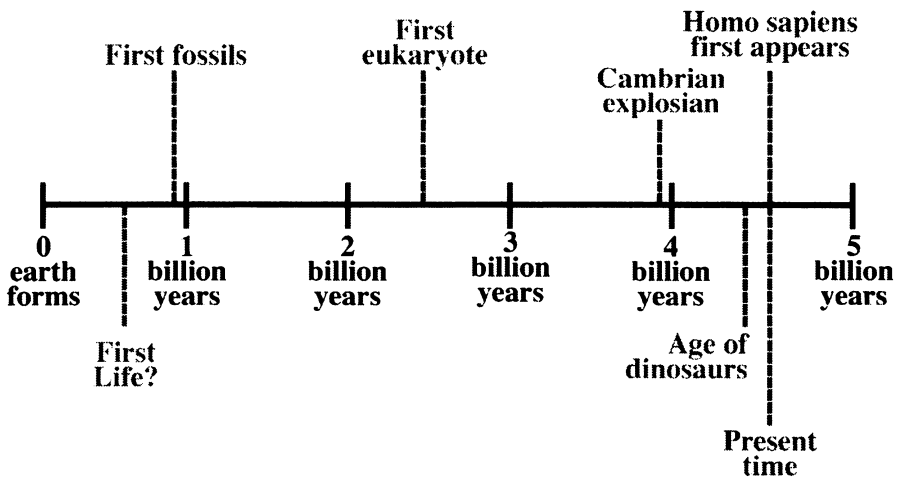
The eukaryotic cell structure evolved out of the symbiotic cooperation between two or more prokaryotic cells. The host cell is thought to be a member of the archaea, while the endosymbionts are descendents of bacteria.

The eukaryotic cell is more complex than previous prokaryotic single-celled organisms, and since all multicellular life forms are made of eukaryotic cells, it can be assumed that these more intricate cells were a necessary enhancement before cloned multicellularity could evolve. The first multicellular animals appeared about 550 million years ago in the rapid Cambrian explosion of

evolution that produced many different groups of animals and many of the forerunners of modern animal groups.

Since the appearance of complex multicellular organisms about half a billion years ago, there have been several waves of evolution that resulted in a diverse biosphere of plants and animals that was then all but wiped out in a mass extinction event. The most massive was the Permian extinction that occurred about 250 million years ago and killed off 96% of marine animals and 70% of terrestrial vertebrates. The dinosaurs flourished from about 180 million years ago until they were wiped out in another extinction caused by an asteroid impact about 60 million years in the past. Mammals and flowering plants took over from the dinosaurs, and then eventually the lineage leading to humans diverged from other primates about 5 million years ago. The genus *Homo* appeared 3 million years ago, and then modern *Homo sapiens* arrived only about 160,000 years before the present. The arrival of *Homo sapiens* probably also marked a pivotal point in the development of language, which marks the beginning of the possibility of symbolically inherited information. The first primitive forms of written language were invented about six thousand years ago, but writing in the sense of all types of symbolic information storage continues to be reinvented in increasingly more powerful forms today.

The timeline below illustrates the relative time spans of this brief synopsis of life's history.



Timeline of the history of the earth and life.

One thing to note about this timeline is how slowly evolution progressed in the beginning. The entire history of all multicellular plants and animals is compressed into less than the last 30% of the total span of life. For the first 26% or more of life's history, nothing more complex than prokaryotic structure arose, and for more than 70% of the total span of life, complexity remained at the single-celled eukaryotic level or less. This may reflect the fact that there is more information that needs to be gathered to create the complexity of a single cell than in the organization of single cells into all the different multicellular plants and animals. But also it may be that evolution is cumulative and therefore inherently exponential because new information about how to survive and new structures that allow life to expand and gather more energy are continually being discovered and added to the stock of existing information. The number of new discoveries depends on the number of species creating new variants and the total amount of energy life can gather. As life expands it has an increasingly larger resource base, and even if the same percentage of resources is always directed toward searching for new discoveries, in absolute terms, the pace of new discoveries is always increasing.

The overall speed of evolution may accelerate somewhat as it progresses, but also the speed of evolution seems to accelerate periodically because a breakthrough in design occurs that opens a whole new world of winning strategies. Sometimes a new structure or design that is fundamental to a whole new kingdom of possible life forms is discovered. As this new form of life captures more energy, more energy can be devoted to information search in this newly productive area of discovery. A positive feedback occurs that leads to a sudden explosion of new forms. This could explain the rapid appearance of so much variability in multicellular organisms over a short period of time during the Cambrian explosion. Some key feature or group of features must have come together that overcame a stumbling block that prevented groups of cloned eukaryotic cells from cooperating in a larger organization. It may have been a system for coordinating the differentiation of cells, or it could have been the need for a separation of germ line and somatic cells to ensure cooperation, or it might have been just the need for a basic functional body plan. But

the fossil record seems to indicate that there was a remarkable expansion of new multicellular species at the very beginning of their existence.

An even more striking thing about the timeline is that DNA was the one and only method of coding and storing information for essentially the entire span of life's history. Even the fastest evolutionary changes occur over thousands or tens of thousands of years, and even though symbolic information coding was first invented thousands of years ago, the real adoption of this invention is just occurring at the present time. The symbolic information episode is so recent that it doesn't even register on a billion-year timeline, and yet it is so unusual that nothing like it has occurred before. We represent and are living through the most unique event and probably the most far-reaching change in evolutionary history. All the previous history of life may only be the prelude to the real beginning of complex life that is unfolding now.

DNA is restricted to expressing its information through translation to RNA and strings of amino acids, and therefore it can only code for the possible range of function of these molecules. RNA and proteins are very versatile and chemically potent structures but they represent a tiny fraction of the total potential functionality of all possible structures and materials. Proteins and other organic molecules can only exist in a narrow environment and temperature range, but symbols are connected to all materials through humans and can code for systems that easily survive in extreme temperatures, the vacuum of space, or under intense radiation. In 3 billion years of searching for new information, DNA evolution has only managed to come up with photosynthesis and a few other insignificant mineral-based processes as a source of energy. On the other hand, humans, in their search for new technology, have guided the evolution of symbolic code to the discovery of hydroelectric power, photovoltaic power, nuclear power, and others in just in the last hundred years. Symbols also have the ability to code for information that can co-op most of the energy that other species produce by photosynthesis and the energy of the past locked in fossil fuels. The range of new structure, functionality, and newly available energy opened up by symbolic information dwarfs the potential of any other breakthrough in

the history of life. The speed and the range of the evolutionary expansion should also dwarf any historical expansion that has ever occurred.

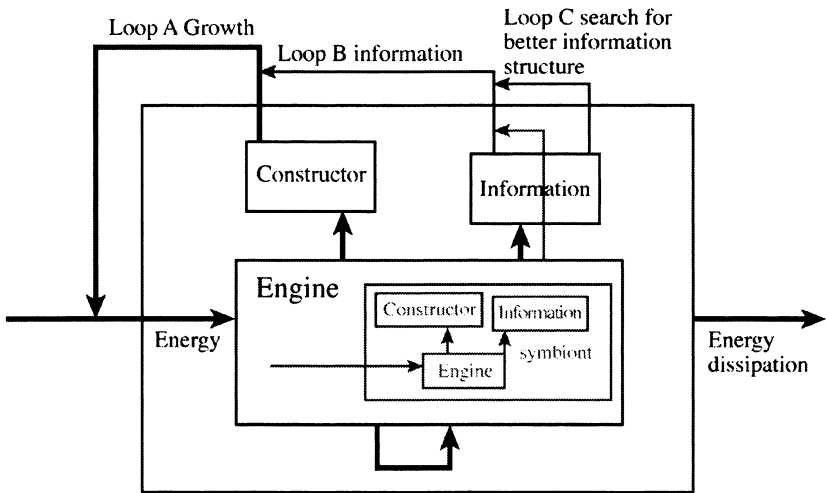
EVENTS OF THE PAST ARE A GUIDE TO THE FUTURE

There are several seminal events in the history of life that marked the beginning of a new phase of evolution. The first was the invention of photosynthesis, which was the source of most of the energy available to subsequent life forms. Another was the buildup of oxygen in the atmosphere that created a readily accessible reservoir of energy for life. Two other events, the rise of the eukaryotic cell and the development of multicellularity, also marked turning points, and these are interesting also because they are examples of the processes that are occurring in the present transition. By analyzing these transitions we can get a better understanding of the dynamics of the one we are experiencing today.

The evolution of the eukaryotic cell began with the introduction of chromosome structures, the nucleus, meiosis, and sexual reproduction all of which constituted a new way to store, process, and discover greater quantities of information. In prokaryotic cells, the genome is not separated by a membrane and takes the form of a single DNA string formed into a ring. In eukaryotic cells there are multiple strings of DNA that are formed into multiple chromosomes that are all surrounded by a nuclear membrane. The DNA is combined with proteins in these chromosomes that help regulate the interaction of the genetic information with the rest of the cell. There are two versions of each chromosome, one from each parent, which is the basis for the increased information-gathering power of sexual reproduction. Genes from one parent can cross over to the chromosomes from the other parent so genetic information can be easily mixed up into new and potentially beneficial combinations. The structure of the nucleus provides the mechanism for this mixing and other processes that give the storage and processing of genetic information more capacity and efficiency. This improved information system was then used to coordinate the integration of separate

bacteria-like organisms into a single functioning unit that became the eukaryotic cell.

The diagram below shows the dynamics of energy flow that drives this type of transformation. Of course this is a highly simplified, abstract representation of what happens that only shows overall trends and not interactions between actual structures. In overall terms, the mitochondrial symbionts become part of the host cell's energy-generating engine. This adds efficiency to the engine function and allows more energy to be directed toward the host cell growth and increases the speed of information search for the host genome. As the mitochondria reproduce when the host multiplies, the mitochondrial genome can also accumulate information, but this also just increases host cell energy flows.



Flowchart of two life forms living as an endosymbiont and host.

Originally, a eukaryote was an independent cell with a nucleus that had independent bacteria symbionts living inside of it. This situation is not unusual for life; for instance, people have bacteria symbionts living in their stomach that are necessary for proper digestion. Normally there is a fine line between a mutually beneficial symbiont and a parasite or predator, and the relationship can shift back and forth. E. coli is most of the time a beneficial

symbiont in our stomachs, but certain strains can cause illness or even death. The trajectory of the coevolution of symbionts can depend on a number of factors. If the two organisms have functions that are complementary, they are much more likely to cooperate. Many insects eat plants and are predators, but they are also mobile; plants need mobility to transport their pollen, and this creates a pathway to cooperation. Some plants evolved flowers and nectar to provide food for insects, and some insects evolved behaviors that limited their feeding to nectar and also functioned to transport pollen. By cooperating in this way, both groups were able to prosper. Another factor is the availability of independent reproduction. If both symbionts can reproduce independently from the other, they have the option of jumping easily from one host to another and becoming predators. But if a parasite is highly dependent on the survival of its host or can only easily move to the host's offspring, then it will certainly cooperate to promote the host's survival. Often these factors become an arms race in the search for information to outmaneuver the other symbiont, and so the efficiency of the information-processing structure becomes a factor. In the case of the eukaryote partners, the mitochondrial bacteria had a superior energy-generating system and the host cell with the nucleus had a superior information system, making their partnership a productive one. The better information processing of the host nucleus allowed the host to outcompete the mitochondria in information generation and manage this process for the benefit of the combined entity. Managing reproduction is the key to individuality, and once the host nucleus controlled the production of mitochondria, evolution shifted to the host genome exclusively. At this point the combination of the two organisms became a single evolving unit, and they continued to become increasingly integrated until the last vestiges of their former independence were completely lost.

This story has a startling similarity to what is happening today. Writing has created a vastly superior method of storing and processing information, and it is the genome for our host civilization within which we live. Although humans still partly control their reproduction, many reproductive decisions are actually made by our culture, technology, and institutions that are informed by written code. Even before the invention of birth control, human

reproductive practice was influenced greatly by cultural norms enforced by society. But with birth control, the natural process of human reproduction has been completely altered and placed more under conscious control and, by extension, under the control of civilization's pervasive body of influence and information. But the eukaryotic host cell didn't subsume the mitochondria through control of its environment or reproduction alone. Eventually, some of the information required to build and operate the mitochondria was transferred to the host genome, and the mitochondria DNA was reduced to a marginal role. And now the human genome has been translated into written code, potentially giving the evolution of the symbolic genome the power of massive, detailed control over the DNA of individuals. This has implications that reach far beyond just better medical care or enhancing our heredity. Our long-term future is controlled by the free energy flows outlined by the flowchart above, and since symbolic information systems are orders of magnitude more efficient than DNA systems, this should produce a strong fitness advantage for transferring control of heredity and reproduction to the symbolic genome. Our own evolution should proceed along the same lines as with the merging of the eukaryotic system, ending up with individuality shifting to a higher level of a merged biological and technological system evolving under a controlling symbolic code. Since consciousness and our projected reality are products of evolution, these attributes, along with our ethics, culture, emotions, personalities, and ideas of truth and right and wrong, will all adjust to the new situation and become seamlessly integrated with it.

OUR LIVES ALREADY DEPEND ON OUR TECHNO-ECONOMIC HOST ORGANIZATIONS

This may seem far-fetched but it has already happened to a large extent. Governments, corporations, religions and social organizations are all stable, self-regulated entities organized by a written genome. People may work for several of these organizations or occasionally switch from one to another, but they spend

nearly all of their lives enveloped by environments created by these groups and direct all their efforts into maintaining them. Most people would be utterly lost if these entities suddenly collapsed and they were, like other animals, left to survive in nature individually with only the physical attributes they inherited at birth.

One of the key inventions that allows humans to combine into large organizations is money. It allows intricate cooperation by exquisitely measuring value and then letting people effortlessly exchange the value they create. With this medium of exchange, people can go to work every day thinking they are working for themselves or their family when actually they spend all their efforts working at some highly specialized job for a larger organization. In a modern, industrialized society, the entire system is a finely tuned mechanism to raise children to cope with industrial organization, train them for some specific job, and then insert them into the productive work force. From an individual perspective we all work for our own purposes, but our society is set up to create an environment for each individual that makes an individual's motivations and needs match what is needed by the larger organization. People are already so adapted to working in a large group and civilization's information is so well developed to bind humans into a life form organized on a higher level that we work every day toward this goal without even realizing it.

Imagine life from the perspective of an individual mitochondria living in its eukaryotic host cell. The mitochondria were originally bacteria that probably invaded a host cell as a parasite. However, the mitochondria had an advanced metabolism that was significantly more efficient at extracting energy from food. Presumably the host cell was more efficient at acquiring food from the outside environment, so the two species were better off cooperating. From the mitochondria's point of view, the environment inside the host cell was its preferred home because food was available there, so it made sense to share some of the energy the mitochondria's advanced metabolism could provide so the host cells could thrive and create a larger living space for mitochondria. The more each species could adapt to accommodate

the others' needs, the more the combination could grow and prosper.

We have the same relationship with the many large organizations that make up the environment we live in. Governments, businesses, corporations, religious organizations, and other groups are all self-regulating entities that have long life spans and evolve as their rules and policies are updated, even as the people that work within them come and go. The written body of law, policies, and procedures of these organizations is their genome, and they use this information to gather energy and maintain and expand their existence just like any other living organism. These larger organizations have a very efficient information storage and processing system, just like the chromosome containing eukaryotic host cells of mitochondria and in a similar way humans live within these organizations and perform specialized tasks for them under the direction of the higher level genome. For the same reason that mitochondria work to promote the expansion of their host eukaryotic cells, we work to promote the expansion of the business, political, or religious organizations we belong to because this expands our own opportunities and environment. Any way that we can promote the cooperation and integration of our own efforts and goals with the goals of our country or employer or other groups we belong to only helps us as individuals, because we already have no hope of an independent existence without them. Our success is already irrevocably tied to the success of the higher level groups that we are a part of.

If the chromosomes of a cell are removed, the cell will continue operating for a short time, but gradually its functioning will falter and then disintegrate because of the lack of any guiding body of information to instruct it. In the same way, if for some magical reason all our written body of information disappeared, our civilization would begin to disintegrate and eventually break down completely. People could not come close to retaining all the complex technical information we rely on so much if we only had our memory as a way of storing information. Without our body of written law, lawyers could not research a case and the courts could not function properly. Our schools

would be hobbled as instructors strained to teach history, mathematics, and science completely from memory and with no books that students could use for studying. Engineers could not design modern buildings without their reference books, power plants could not be built, and the factories that produce all the technological marvels that we enjoy today could not operate for long with no repair manuals, laws, policies or operating procedure manuals. Government bureaucracies could not function without their books of government code that tell them what the rules are, and what would religions be with no sacred books to guide them? Our marvelously intricate economies would collapse and most of us would soon die of starvation. Our civilization and population would return to the levels of pre-literate existence, or at least to something similar to medieval times when books were not in common use.

But even without writing, humans have the unique capacity to store a large amount of symbolic information that no other species has through language and collective memory. This is the trait more than anything else that allows humans to cooperate in even small, primitive groups and survive. Just language alone gives us the ability to maintain cultural information and organize our societies on a higher level. Eliminating our symbolic genome would also mean eliminating language, and without this humans would be like a mitochondrial body with no host cell and would soon go extinct.

Subordinating our own individual lives and efforts to the needs of larger organizations has been the key to our success and has actually led to our individual needs being satisfied more fully through the success of the group. As we become increasingly integrated into larger organizations, we become more successful, and we see this as progress. The mitochondria lost its independence and became merely a cog in the operations of the larger eukaryotic cell, but by doing this the mitochondria became the most successful life form of all because eukaryotic cells make up all advanced multicellular plants and animals and fungi. Every eukaryotic cell contains mitochondria at some point, and they are now ubiquitous because by cooperating in a larger, higher-level system they were able to expand the reach of life into whole new areas and create whole new kingdoms of diversity.

THE CONFLICTS AND CHANGES WE ARE EXPERIENCING ARE THE RESULT OF SELECTION DRIVEN BY FREE ENERGY FLOWS

As humans become integrated into the organized entities that make up civilization, our culture, worldview, and even our physical DNA inheritance evolve to meet the needs of living as part of larger entities. Everything about us including our view of reality itself is a malleable product of evolution and responds to the forces of thermodynamic free energy flow that determine fitness. The transformation into higher level organizations instructed by symbolically stored information is probably the greatest breakthrough in increased fitness that has ever occurred, and the free energy flows propelling our evolution toward that future are correspondingly powerful. We do not control our future, and our culture, personalities, emotions, beliefs, and even our physical attributes will be molded to whatever is dictated by the fitness attributes of structure at the new level of organization we are accessing.

Individuals always believe their way is right, but what is right for each species depends on what is the best fit for their strategy for survival. We think rotting garbage is certainly disgusting but I'm sure that living immersed in it feels just right for a maggot. Most ethicists would say cannibalism is wrong, but cockroaches do it all the time and nobody complains. Killing your mate after sex is the right thing to do for a black widow spider, and killing the former leader's children is a tradition when a young lion takes over a pride. Humans are very respectful of life and have a well-developed sense of fairness because these traits are necessary to work together in a group and they will likely be strengthened in the future. But other views and personality traits, such as reproductive patterns or attitudes toward authority, privacy, diversity, or institutional control of our bodies, are likely to change as we become more wedded to our civilized structures and better adapted to fulfilling our function within these structures.

Mitochondria only have one function in cells, so there are only one type of these, but people perform many functions in society, and it is likely that the evolution of individuals will be directed into specialized types that are suited to perform many

different functions. There will be craftsmen that are physically and mentally ideally suited for their craft, mathematicians that are exceptional at math and that love nothing better than doing math analysis, outstanding teachers that love to teach, and managers with all the communication and analytical skills needed to brilliantly manage any project. Reproduction will be controlled to produce just the right type of people needed when they are needed, and if people have a problem with any of this, genes will be found to give humans the right personality so they can be taught that this is the greatest possible way to run an organization and they couldn't be more contented and happy to be a part of it. This would never happen if human DNA was still evolving independently, and even if it could somehow happen through DNA evolution, it would normally take many thousands of generations. But since symbolic information storage has become so sophisticated and the human genome was decoded into it, the control of the evolution of human DNA has transitioned to control at a higher level. This more proficient symbolic information system can generate new knowledge so much faster that the ability to accomplish this is in the foreseeable future.

These changes will happen because thermodynamic free energy flows will push evolution inexorably toward these higher fitness outcomes. In more familiar terms, this means that the groups that advocate this path and believe this is the right way to go will have the power to impose their way on other groups that resist or try to go in a different direction. It will happen because there are powerful flows of energy driving it, nothing to prevent it, and no way to stop it.

There is nothing in our culture that says there is anything wrong with assimilating more primitive organisms or cultures. Nobody objects or even gives a second thought to the fact that we have enslaved yeast in breweries in order to satisfy our taste for beer or that we domesticated wheat to feed ourselves. Still, as the beings we assimilate become more like us, the issue becomes more sensitive. Some people don't eat meat because of the ethics of raising and slaughtering cattle, but most people feel that as long as animals are treated humanely there is nothing wrong with domesticating them and using them for our own purposes. Assimilating primitive human cultures into modern society is the

most sensitive of all, but it is hard to justify any other course. For instance, to truly preserve the Aboriginal cultures of the new world, mankind would be forced to leave the entire Western Hemisphere and Australia to these people with a prime directive of no communication or interference. It's unlikely that these people would even want to live in a primitive state once they became aware of the attractions of modern civilization. The people who created our modern civilization did so in the name of progress and improving people's lives, and most people would agree that they succeeded. Colonization can be a fair bargain where the advanced culture shares its technology and in return the less advanced group shares its land. Out of this a new society can be formed where both groups are leading better lives.

This argument may or may not convince individual people that assimilating other cultures or species is a good thing, but just like population control, these decisions can only be made beyond the reach of individual control. Variability will always provide the option and fitness will determine the outcome. Europeans did not colonize the new world just to advance the primitive people living there; they did it partly to spread their own culture and mostly to improve their individual lives. They were able to be successful at it only because their advanced technology gave them the power to impose their will and the more primitive state of the indigenous people made them powerless to stop it. In short, the organizations with the greatest access to energy prevailed. Most groups of people, just like all successful species, believe their own group is the most deserving and should be the one to survive and prosper. As in all natural systems, there are times when resources are short, and when this is the case it boils down to who has the power to command the resources and who, in spite of their best efforts, does not. With humans there are always some people that willingly choose to not pass on their DNA to children and there are some that would die rather than fight for the resources they need. In general, the genes that predispose people to this viewpoint simply will not be around in the future because the people who carried them did not pass them on. This is why all species that are around today think they are the most deserving.

Nearly all individuals of all species will never have a second thought about killing another individual of another species

or its own if it is necessary for them to survive. Species that do live in groups or cooperate with other species or others of their own kind do so only because of clear advantages to themselves. The survival of humans depends more than any other species on intricate cooperation between people, so it is not surprising that much of human culture deals with equity in cooperative enterprises and our DNA contains programming for empathy for others, a sense of fairness, and a desire to socialize with others. But humans are fundamentally different because they have a higher level system and code to regulate their cooperative behavior. Animals sometimes cooperate, but they must balance helping others with the need to compete with others in passing on their genes. With higher level regulation in the form of bodies of laws, enforcement of contracts, monetary exchanges, ethical or religious doctrine, and institutional control of reproduction, people can dedicate themselves to the group exclusively and still count on advancing their own interests through regulated reciprocity from the group. Still, this fairness breaks down sometimes and people can revert to a more uncivilized free-for-all, but the more sophisticated our group information becomes, the more individuals are constrained into cooperative behavior. When reproduction shifts completely to higher level control, the need to compete reproductively will disappear entirely and individual behavior can then become unquestionably cooperative.

Of course, forcibly regulating reproduction and changing people genetically into worker drudges will probably be even more controversial than colonization, but there is a tremendous amount of waste and corruption in the current system of half-hearted organizational control. We are in a golden age of expansion and opportunity as we transition to the energy-rich higher level of organization, and it seems there are plenty of resources for everyone. This golden age of plenty masks the waste and inefficiencies of the current system, but as we expand we will occasionally bump up to the limits of the current organizational states and there will be shortages and clashes for scarce resources. But these clashes will be between organizations, not individuals, and the groups that are the most cooperative and least competitive and corrupt on the inside will be the most competitive externally between groups. In each competition the most controlled

group will win, and step by step we will be submerged into the higher level individuality of our host organizations. In the same brutal process, our consciousness will also evolve through the winners and losers of these contests between competing organizations and the people that dedicate their lives to them. Some of us may shudder now at the prospect of becoming, however contented, just cogs in a larger machine, but this problem will be resolved when the minds of future generations are genetically reprogrammed to think it is the greatest thing ever.

Once the cooperation between mitochondria and the eukaryotic host cell began, the fitness advantages of the combination drove evolution toward the complete integration of the two and then on to the expansion into all multicellular forms of life. The combination of humans, technology, and symbolic information control is many times more powerful than the eukaryotic cell's reach, and free energy flows will just as inevitably drive our evolution toward integration and then toward a powerful radiation into whole new kingdoms of diversity on a higher level. The mitochondria were not conscious beings, but even if they were, they would have ultimately not had any conscious control over the process. DNA evolution proceeds very slowly and changes occur between generations and not to individuals, so if mitochondria had been conscious, they would not have even realized what was happening. Human DNA evolution also only occurs between generations, so changes do not affect individual people, but they are aware of variability and they can see trends as certain groups succeed better than others. Today certain groups succeed because they have better information and technology, and this is the visible manifestation of our extraordinarily rapid evolution into a combined entity controlled by a symbolic genome.

A TECHNOLOGICAL HOST ENVIRONMENT IS THE KEY TO UNLIMITED EXPANSION

The eukaryotic cell created an environment suited to the bacterial mitochondria and provided a shield and interface through which these bacteria could expand into areas where they could

not otherwise survive. The host cell also had an improved information system that was able to utilize the specific skills of mitochondria to create organizations many times more complex than the original parts. As humans expand into space they will also be encased in a host structure that carries a little bit of our native environment into alien worlds that otherwise could not support us. And these hosts will also have the information capabilities to organize these new cellular units into more complex beings. The original eukaryotic cell went on to become the basic building block for the entire plant and animal kingdoms as well as the fungi, molds, and wide variety of single-celled organisms. A spaceship cell containing humans will most likely be the basic building block as symbolic life migrates into space but the potential for variability will be much greater. Undoubtedly there will be independently living single-celled forms living in every environment in space along with planet-sized entities of centrally controlled multicellular organizations. There will be forms that have eliminated humans entirely, but also minimally altered free-living humans will undoubtedly expand wherever they can. Among the planet-sized giant organizations there will probably also be tiny viruslike packets of information that can survive as well as every other type of predator and parasite.

A eukaryotic cell is a tiny microscopic information-generating machine that was able to expand into all the variety of animals and plants we have today because the entire earth had available environments for its potential range of technology. Humans and their technology are on a much larger scale, and the earth restricts variation just because of the cramped quarters for human-scale organizations. But the galaxy provides roughly the same living space in orders of magnitude relative to our size as the earth did for microscopic eukaryotes, and probably an even greater range of potentially sustaining niches. As levels of organization and complexity increase, life cycles often become longer and basic components operate more slowly, but the pace and sophistication of information accumulation greatly speeds up. The sophistication of symbolic information systems and their ability to command all types of materials, energy sources, and technologies as well as all existing information stored in DNA should allow techno-human symbionts regulated by symbolic genomes to form the basic cellular

units that invade the galaxy and radiate into a incredible array of new species able to live in almost any environment where there is energy and materials.

Our technology is still extremely crude and mostly constructed on a macroscopic level. One aspect of biological organization that sets it apart from manmade objects is that it is designed and constructed at the molecular scale. Microscopic single cells evolved on the molecular level, and as life was scaled up, the design and construction remained at this level. This is what creates the magically animated quality that we perceive in biological machines. All the individual parts are so tiny that they are invisible to us, and so much invisible complexity can be packed into such a small space that, at the human scale we perceive, life appears to have a unique spark unseen in nonliving objects. But if we look through a powerful enough microscope, we can only see a collection of parts working together like any other machine. But now our technology is also beginning to be developed at the microscopic level. As this trend progresses, our manmade machines will begin to match the scale and complexity of living organisms and they may appear just as magical and animated as biological life.

From space our cities already look like some kind of gigantic fungus spreading over the land, gobbling up energy and materials for their growth. These entities have all the components of living systems, including transport corridors, intricately connected factories grinding out parts for growth, defense systems, energy generation plants, and embedded symbionts, all directed by a symbolically coded genome with its connected education systems to translate the information into action and an electronic neural network to coordinate it all. They're evolving at a fantastic pace, and it seems that it's only a matter of time until spores appear to spread these entities to the waiting environments of space.

THE MULTICELLULAR DILEMMA

The creation of the eukaryotic cell is a particularly interesting transition because it mimics what is happening today. The transition to the multicellular level of organization was a different type

of change, but it is just as interesting because we are multicellular creatures and the consequences of this transition still have a profound effect on us.

Multicellular animals and plants are constructed by cloning a single eukaryotic cell and they use these cellular building blocks to create a higher level, centrally controlled, integrated organism. When the mitochondria combined with its host to form the eukaryotic cell, there were originally two genomic control centers, and integration led to domination by one and subservience by the other. But with cloning, millions of identical genomes are created, none of which can coordinate the operation of the whole structure. One of the central problems of multicellular organization was how to coordinate the combined structure. What first developed was a system of interactive control in which each cell had a complete set of instructions in its DNA, but these instructions were turned on and off in each cell as needed through programmed interactions between cells. Essentially each cell has the information to do everything, but what it actually does is determined by its location within the organism and signals it receives from surrounding cells. This is how plants grow and operate and how animals develop from a single egg cell. Plants are stationary and only need to react relatively slowly to a restricted environment, and so the mature structure can be regulated along these same lines. But animals are mobile and must react much faster to a much more complex environment. They developed their higher level control system, made up of their brain, senses, and neural network, to give them centralized operational control. The problem with this line of development is that the cellular level hereditary and developmental control system based on DNA information could never be adequately connected to the organism level information and control structures of the nervous system. Information inherited through DNA can only be directly transferred to the nervous system through the limited range of instinctual behavior, and information gathered by the brain during a lifetime is lost between each generation.

Compare this dysfunctional divided control system to the simple and elegant system of single-celled organisms where the information is stored in the nucleus, which is the same structure that handles the control of daily operations and the duplicating

and passing on of the genome to the offspring. When single-celled species reproduce, they simply make duplicates of their internal structures, including the nucleus and its stored information, and then they divide themselves in half. The whole process is centrally controlled, no information is lost, and each daughter cell is immediately a fully functioning individual.

If an individual of a single-celled species was conscious, it would have a very different perception of the reproductive process from humans. Each time it divided there might be a brief period of unconsciousness as its chromosomes were duplicated and reconstituted into new nuclei, but then each daughter cell would reawaken to a world that contained a clone of itself with all its memories and personality traits, but also to find it's own memories and consciousness intact. For a single-cell organism, death comes only from the environment and is not at all connected with reproduction. It is potentially immortal and, in fact, any individual cell alive today has been continuously alive for the last 3.5 billion years.

All multicellular animals evolved from the same initial pioneer lineage. This line discovered some or several critical elements needed for the creation of multicellular organization that allowed them to make the jump to this level. All animals have a very similar set of genes that regulate and control the differentiation of cells into the integrated body of the mature animal. Recently it has been shown that remarkably small changes in these genes and how they operate together can produce much of the wide variety of body plans of animals that exist today. It's likely that these genes and the system of developmental cellular interactions that they regulate are a key breakthrough that enabled this lineage to transition to a higher level of organization. But ultimately, this also locked cloned multicellular animals into a dead end that limits the development of a completely centralized information center because there is no way to connect hereditary DNA information with the learned information of the brain. The ongoing accumulation of knowledge through natural selection eventually is blocked because information can only be permanently recorded in DNA and therefore newly acquired information can never be made fully accessible to the central control center which is the brain.

It only requires a few relatively simple changes in our DNA to produce a larger brain. The question is why, in all the different permutations of animals that came before us, none ever developed a larger brain like ours? The answer may be partly that there was no real advantage because any small amount of new knowledge that a more intelligent mind might discover during a lifetime would just be lost anyway. A larger brain had to be developed in conjunction with language so the greater capacity to accumulate and store new knowledge was accompanied by a way to pass it on to the next generation. Once language was invented, it was a simple step to invent writing, and then suddenly there was a solution to the 600-million-year-old problem of the fractured multicellular information system. Now we can have centralized information centers that control our DNA, our daily activities, and our civilized organizations, which are also the center of information generation, replication, and heredity. Symbolic information can be cheaply and flawlessly replicated at will, and with it reproduction can again be centrally controlled and accomplished through simple division. In the new higher level entities, symbolic genomes have abolished programmed death and continuous growth and potential immortality has been restored.

The question is exactly how this solution will play out. Science fiction writers have imagined that we will eventually upload our consciousness to some kind of computer mind. But it's hard to see what practical needs would really drive us toward this. We have already uploaded our evolution, heredity, and daily control of our activities to centralized symbolic information centers. Of course, selection has programmed us to avoid death, but it's not at all clear that indefinitely long life spans for individual humans would be beneficial for our species or for civilization as a whole.

Life spans in multicellular animals seem to broadly correlate with the size and complexity of the species. Part of this may be because as more effort is required to construct a new individual, the more it pays to have that individual last a long time. But given this, there is also an advantage to a short life span in multicellular beings because evolution and the discovery of new information can only work between generations. The faster the turnover

between generations, the faster a species can adapt to changing conditions. But humans inherit a lot of their information culturally, and this greatly extends the time and effort required to raise a child. Humans already have the longest juvenile stage of any animal, and as the amount of information that needs to be learned by every generation continues to increase, the training of workers becomes more and more expensive and time consuming. This may be why, for their size, humans have relatively long life spans.

Since humans inherit much of their information culturally, an individual can acquire new information and adapt during a lifetime. If we became just components of a larger entity that reproduces through division individuals could theoretically be maintained indefinitely. But human life spans would still be limited by the multicellular legacy of development from cloned single cells. We only have a program for interactive construction of our bodies from cloned cells. Since we can only reproduce this way and not through division, there is no absolute need to indefinitely maintain our bodies. Instead of division, we are made from scratch with all brand-new parts, like cars, and like cars there comes a point where all our parts wear out and it is cheaper just to build a new one. Since there is a lot of investment embodied in a mature human, it makes sense for our lives to be extended, but there will probably always be a point where it will pay to trade in the old model for a new one.

An indefinite maintenance program for the body of advanced multicellular animals has never evolved, and it probably never will. Our DNA information-generating system is based on reshuffling chromosomes in a single cell. For this to work, each new individual must be built from a single cell, so for multicellular animals, the entire system for adaptation and reproduction is based on death and regeneration of brand new individuals. If all our millions of cells each somehow built duplicate organs so that our bodies could be divided, we would also need to completely re-engineer our heredity system from the ground up. Instead, we are engineering a completely new system at a higher level with its own more advanced hereditary mechanism, and we will be absorbed into it.

SO WHAT DOES ALL THIS MEAN TO US NOW?

*Man is rated the highest animal, at least among
all the animals that returned the questionnaire.*

Robert Brault

The ideas presented here comprise a fundamental worldview of how reality is constituted and how humans fit into this reality. If you accept this view, it can't help but profoundly affect decisions you make and how you conduct your life. If these ideas are widely accepted within a group of people, they would certainly alter the effectiveness of the group as a whole and their ability to compete and prosper. The following are a few specific examples of how this line of thinking could change an individual's viewpoints on some things.

REINCARNATION IS CLOSE TO BEING THE TRUTH

Because we are a multicellular animal and do not reproduce by division, we have a limited life span. But understanding life from a less self-centered viewpoint and thinking more fundamentally

about how all life is organized can give us even deeper insights about our own mortality. Simpler life forms multiply by division and are potentially immortal. When higher level symbolic life forms coalesce into integrated entities, they will also be able to duplicate their entire body of information and divide indefinitely. It was just a twist of fate that we were caught in an evolutionary path that resulted in a throwaway conscious information system that can't be replicated. But what if we could be replicated? How would we think about life then? If all the information in our brain could be duplicated in an identically constructed brain just like chromosomes are duplicated in a cell's nucleus, we could multiply through division also. If we divided in half and both halves retained all the memories and faculties of the original, the first question would be which one would retain the original identity? We could easily adjust our customs to accommodate this, but what about our deeper religious beliefs? If Bob Smith had a soul and there are now two of them, which one retained the soul of Bob Smith? If one immediately died, is Bob Smith still alive? Is his soul both alive and in heaven?

People might say that something so complicated as a human consciousness can't ever be replicated accurately enough to create a duplicate person. But as computers become more powerful and hardware is developed that actually can replicate the amount of information in a person's brain easily and rapidly, this argument is losing its persuasiveness. Many people dream about uploading a person to a computer, but it is the digitizing and uploading part that is impossible, not the simple duplication of code. Once a personality is uploaded, it would be simple to replicate it. Machines may eventually become as complex as humans and conscious, but a human will never be uploaded to a machine because humans are by definition flesh and blood. Any simulation of a human in a digital format could never really be a human. It's true that a human consciousness can't be replicated, but this is just because of an accident of evolution and not necessarily because of any absolute barrier to replicating a consciousness.

If single-celled organisms were conscious they would not have any concept of a mind/body distinction or a soul as separate entity, and if machines become conscious, neither will they. Our bodies

are our soul. Our soul is not the actual material that makes up our bodies because this is replaced regularly as we eat and eliminate waste, but it is the unique structure and information content of our bodies. Replicating entities would naturally equate their soul with the holistic essence of their particular information and structure and not a separate mystical entity. This is because they would recognize that there could be many of them and also that they could die and then be resurrected if the information in their structure were coded and then a duplicate were reconstructed. To us it is a very strange concept to have our essence reduced to a string of information code and then be condensed to a state of frozen nonexistence, only to be fully returned to our exact state of consciousness at some later date. But this will be easily possible for computer life forms with integrated replicable information centers, and it has been the norm for billions of years for single-celled life forms reproducing by division.

Our body and soul are locked together only because a duplicate of our structure and current information content can't be made. But this doesn't stop people from wishing that they could be reconstituted indefinitely. Some terminally ill people have been frozen with the expectation that their consciousness will be resurrected and wholly reconstituted at some date in the future. On *Star Trek* the transporter routinely disassembled people and reassembled them at a different location. Many people believe in reincarnation in spite of the fact that they have no memories of any previous life. When people think about reincarnation, they usually are thinking of some form of mystical transference of their soul into another body. But really nothing needs to be transferred except information. If a living digital consciousness ever does come to pass, this life form may be able to be turned on and off, and it would switch back and forth between existence and nonexistence effortlessly. This type of life could also be transported as if in a *Star Trek* episode. If an empty duplicate "body" was constructed at the destination, the coded information of the consciousness could be sent at the speed of light and uploaded at the end of the trip. Since the traveler would have no sense of time while his string of code is separated from his body, even a trip to the other side of the galaxy would seem to occur instantaneously.

The soul of a digital consciousness would not be either the mechanical body or the string of code. The entity mystically springs out of the combination of both. The same is true for humans; the only difference is that a digital consciousness may be replicable and transferable but a human consciousness is not.

The soul is in fact truly mystical, because how our consciousness springs forth from the mechanical complexity of our body is beyond our comprehension. In fact, matter, space, the universe and the simple state of being are utterly unfathomable. Our minds can't comprehend either an end to the universe or a universe without end. We can make imaginary models of the building blocks of matter, but we can never answer the question of what we really are made of because there is always the question of what the building blocks are made with. A separate supernatural entity is not necessary to make the soul mystical. What we really are is inherently mystical, as is our consciousness and all of reality in the final analysis. The soul arises out of the particular structure and information content of our bodies, and if our bodies contained a program for replication like other organisms have, our souls could be maintained forever or reconstituted at any time. Our soul possibly could be contained in the engineering specifications for an assembly of parts and a long string of ones and zeros coding for all our information. But if we examined all this information we would not be able to identify why a consciousness emerged out of it or where our consciousness resided in it. The true nature of our existence or of our soul would still be a mystery. Our consciousness is a mystery, so immortality will also always be somewhat of a mystery.

Our consciousness cannot be replicated, but our children represent the next best thing. If we were frozen for twenty-five years and then woke up with amnesia, we wouldn't remember our past life, but we would continue living in the same way, and most people would agree that in spite of having no memory of our past life we are the same person. Our children are born with a copy of our DNA information, and as they grow up they develop into copies of the structure in which our consciousness resides. They have the same consciousness, and their life experiences are extensions of ours. Our children are a combination of two people but, given that, they are still copies of our genes, our

unique structure, and our souls, and we continue to live through them. In fact, all people share most of our collective genome, and all people share a similar conscious experience. As the next generation is born and grows up, it learns the same things we do, acts the same way, and makes the same choices. It's the same as if we were frozen and then reborn with no memory of our past life except for what we are taught. Reincarnation is in fact not too far from the truth, and we will all continue to live through future generations for as long as our lineage exists.

Extending this line of thinking a bit further, we can view all life as living through its descendents. Every cell that is alive today has actually been continuously alive for at least 3.5 billion years, including the cells in our own body. During this time new information has continuously been discovered and life has collectively achieved continually greater complexity and higher levels of consciousness. The magical emergence of an individual consciousness from the growth and development of a single cell into a child is not much different, except for the time scale, than the way human consciousness eventually emerged out of the continued development of the original eukaryotic cell. In a sense we are the reincarnations of that primitive consciousness even though our consciousness is formed on top of and out of those cells. Single cells are not exactly conscious themselves, but they are conscious in the sense that they are the agents through which consciousness was created. Life is now jumping to another higher level, and the level of awareness may advance beyond our own level to the same degree. But this consciousness could never exist if we didn't, and so it will also be a reincarnation of our being.

We are constructed by cloning a single cell, and then both our structure and consciousness emerge out of DNA-programmed interactions between these cells. These interactions produce a slightly different individual each time, and our inherited symbolic information is transferred to the brain in a different haphazard way for every person. So every person is a little different and there is no program for replicating the information or structure or for maintaining the structure indefinitely, so the individual is locked in and eventually dies. This is not the case for single-celled life forms, and it won't be the case for any digital entity that evolves. Digital entities, like single cells, will have no

barrier to an indefinite maintenance program or to duplicating or transferring a consciousness into a new body, and so in a sense they will be immortal like single cells. But they will be evolving life forms like any other and so will be subject to natural selection and death. Bacteria don't have a programmed life and death cycle but they replicate until they fill an environment and then die in mass when the environment changes and can no longer sustain them. They are programmed for this mode of death because this is how the overall process of evolution and selection sustains their lineage in the long run. They must reproduce and fill every possible living space or some other competitor will. The overall process never rewards an individual just for living longer. The process promotes the continuance of the lineage, and the life of any individual is only relevant as an experiment in the efficacy of that individual's path. The death of some individuals enhances the chances of the overall lineage, and so this is what happens. The circumstances will be the same for any "immortal" digital entity. Life processes will produce an entity that struggles to survive and fulfill its particular path, but this is just the way the experiment is set up. The experiments can only fulfill their real purpose of generating information and promoting the success of the lineage as a whole if many of the individuals that choose the wrong path fail to survive. For any living entity the idea of individual immortality is an illusion. The real immortality resides in the shared consciousness that a lineage continuously carries forward. Our ancestors, descendents, and everybody else are all us in a very fundamental sense.

Uploading an individual consciousness to a computer would be pointless, but our shared consciousness will gradually be extended in a new digital consciousness as our individuality is absorbed into a more complex higher-level entity. Just as our consciousness emerged out of the evolution of life up to this point, continuing evolution will create a higher consciousness that emerges out of ours.

People will not transfer their consciousness to machines; machines are fundamentally different and could never be us. Our brains are made of living cells, and this flesh-and-blood physical basis of our consciousness is as much what we are as the pattern of electrical connections in our brains. An upload of our brain

pattern to a computer could only be a simulation in a different medium of our true selves that would be fundamentally different from the real thing. But this isn't to say that computers won't develop their own consciousness and lead life into areas of awareness not possible for humans or not even imagined.

RELIGION CAN BE AS TRUE AS SCIENCE

Darwin and the theory of evolution had a major impact on religion that is still continuing today. Many people today regard religion as being diminished or contradicted by science, and this has a lot to do with Darwin's theory. But the theory of evolution has only been around for a little over one hundred fifty years, and the problem is that religious doctrine changes very slowly and just has not had enough time to adjust to this world-changing new idea.

People today may not appreciate how devastating the new idea of evolution was to religious beliefs of the time. Religion taught that man was in a different class from animals and had dominion over the natural world. But evolution was a demoralizing blow to our ego because it teaches that humans are in the same category as animals and subject to the same natural laws. But an even more destructive blow to religion was that evolution showed how living things could have been created through natural processes. Before Darwin there was really no question that God existed because it seemed that the purposeful structure of life obviously had to be engineered by an intelligent being and therefore must have been created by God. After Darwin's theory was published, religious leaders lost their indisputable evidence of God's existence, and with it a lot of their authority and power.

During more ancient times science and religion were partners in explaining the natural world. Many philosophers believed that knowledge was revealed to us by God and therefore the search for knowledge was an effort to be closer to God and to understand him better. This is a much more sensible position than the way that many religious people reacted to the publication of Darwin's theory. Instead of embracing it as a new revelation from God about the true nature of the world (Dowd 2008), they tried to deny its truth in the face of overwhelming evidence to

the contrary. Their prevarications, distortions of the truth, and sometimes ridiculous arguments trying to prove that the Bible's short paragraphs describing creation are literally true and a valid scientific theory are a large part of what has created the skepticism toward religion in the minds of many people today.

The theory of evolution doesn't invalidate religion. Just as ancient philosophers believed, this revelation of science, like all others, actually adds to our knowledge and understanding of our relationship with God. The entire 3.5-billion-year history of the creation of life and the human species has been reconstructed in incredible detail by scientists. The real story of how life was created is far more interesting and amazing than the story in Genesis and was certainly beyond the imagination of the writers of the Bible. Creationists are missing out on this fantastic story so painstakingly reconstructed over more than a hundred years of research and study by paleontologists, geologists, and biologists. Many other things we have recently learned about the world we live in are equally as revealing and only expand our appreciation of the true nature of things. The vastness of the universe and the strangeness of quantum mechanics only make it clearer how little we are able to actually comprehend our own reality.

There will always be a need for some concept of God because science can never answer the basic questions of what the universe is, where it ends, or what the real building blocks of reality are. Consciousness, matter, space, beingness, and how we fit into it all will never really be explained. Our consciousness creates a world that suits our needs, but what it really is will always be a mystery. We are aware of the immediate facts about our surroundings that are necessary for making decisions for survival, but in a deeper sense we probably have no better idea of what reality is all about than any other animal. There will always be a hole in our worldview that is beyond the grasp of human intellect and can only be filled with some form of faith and spirituality. If religious leaders could be more honest with themselves, they would realize this and be more confident in their relevance and not feel the need to compete with scientific inquiry. They should embrace science the way their predecessors did—as the search for the true nature of God—and work on integrating what science has discovered into a more modern and sophisticated form of faith and belief in God.

Religion has actually been an important part of our ability to work together as a unit and has contributed to our evolutionary success. As power and control have shifted from individual people to organizations, one of the problems to overcome has been how to motivate people to act in the interest of the overall organization. The problem is that if an individual sacrifices himself for the larger organization, he doesn't pass on his genes, so the species-level genetic system does not usually produce this type of behavior. But religious beliefs are part of the genome of the higher level organization, and its continuance is promoted by the sacrifice of the individual. Under the right circumstances individual sacrifice can thrive even without the regulation of a higher level genome if groups compete and the benefits to group cooperation are great enough. If groups with cooperative genes survive much better than any group with selfish genes, then the cooperative genes can win through better group survival even when some individuals don't survive. But with a higher-level genome, rules can be made and enforced at the higher level that ensure that cooperative genes survive. This is the manifestation of the transition process to a higher-level entity and the shifting of evolution to the group genome. The sacred writings and teachings of religion are part of our group genome, and they are a powerful way to control not only selfish behavior but also reproduction and therefore the genetic make-up of future generations. Religions have been very successful at modifying people's behavior and even motivating them to sacrifice their lives for a cause. In turn, the success of religiously organized societies and their individual members has then resulted in a genetic predisposition in humans to be attracted to religion. This virtuous circle is an example of the essentially thermodynamic force that is driving our evolution to create a new higher-level entity.

Religious code may not always be intentionally designed to promote the organization's survival, and sometimes it may even be detrimental, but religious genomes generate truth through natural selection as well as any other evolving entity. The groups with ineffective code die out and only the beneficial code survives in the long run. Religions have been evolving longer than most other human institutions and consequently

should have generated many truths that pertain to our society. This knowledge is honed over many generations and, by its nature, is fixed wisdom that is handed down from previous generations and is meant to be followed more or less unquestioningly. Its wisdom is generated not through selection among generations of individuals, but through the success or failure of generations of religious organizations that survive by competing directly with other organizations for both resources and human participants.

Religious doctrine is passed down through the ages, and it must be written in a way that survives the passage of time. All words are abstract ideas that describe idealized concepts that are used by the human mind to make sense out of the world. The word "tree" can be used to describe a large plant with a woody trunk, a picture on a piece of paper that we see as a large plant, a chart showing our family's ancestors, or a decoration in our living room at Christmastime. They all have some essential quality described by the word "tree," but they are not the word itself. All writing is a series of metaphors and religious books are no different. But they were written in a different age and they must be interpreted through the metaphors of the age they were written in. Saying Jesus is the Son of God can be taken in the same way that we accept that a chart of our ancestors is a tree.

Scientific knowledge is no different. For centuries the physical world was divided into the four elements of earth, wind, fire, and water, and this framework no doubt had some utility in helping to understand how the world worked. It was true because it worked as an idealization to organize knowledge, and even today these words have a use for dividing reality into categories. As our knowledge grew, we used the word "element" to describe a more detailed description of matter that is the periodic table of elements that we are familiar with today. Modern physics has improved on this and expanded the details of our understanding of the building blocks of matter again with a complex quantum mechanical theory that few people understand. But this current state of our knowledge is still nothing more than an artificial idealized metaphor for organizing the world. As far as we are concerned, our current theory of matter

is true because it works within the context of our current understanding, but this is no guarantee that it won't be considered wrong in the future.

Philosophers have for centuries debated what defines truth and knowledge. Here it can be defined in terms of the theory of evolution by saying that whatever is proved by selection to work is true. Kant said that truth depends on the subject as much as the object in question. Darwin's theory reinforces this by providing a deeper understanding of why truth depends on the beholder. Our consciousness, senses, and thought processes were created through selection because of how their fitness related to our existence. The purpose of our thought processes is our survival, and therefore what is the correct way to think is what is most fit for survival. What is correct depends on the world around us, because to survive we must deal with the world in an effective way, but still what is true depends as much on how we need to deal with the world as the world itself.

Science and religion both become true because selection has proved them to be true. Both are true only because they work as a way to make sense of the world and make decisions. Our science is true because all of our experimentation has resulted in knowledge that enabled us to expand our technology and our civilization. Religion is true because it also includes important concepts that are used in organizing our society and contributes to its success. Religion is necessary logically because science can never fully answer the questions of who we are, where we are going, and what kind of reality we live in, and because people function better when they have a framework for answering these questions. The religious wisdom we have today, just like our science, is the product of centuries of experiments and selection of what works, and it has been an integral factor in our success. Much of this wisdom will outlast some of our current scientific metaphors now considered to be true.

The selection definition of truth can be applied to many different questions. Physicists use their theories to predict the outcome of events, and they wonder if all events could possibly be predicted in this way, making our future predetermined. God is supposed to be omnipotent, so, religious philosophers wonder

if humans have any real choice in their lives. However, if truth is what works for us, we must have free will. Our consciousness evolved to help us evaluate our situation and make decisions about what to do next. If we believe things are predetermined, this can only have a detrimental effect on our decision-making process. For our consciousness to function properly we must believe we have free will and then this is what is true for us. Other ideas are an equally necessary part of our worldview. We must believe that life is a precious gift and that our way of life in particular is the most worthy and needs to succeed. We must have a purpose because we need one to give our lives direction. We must have a vision of what progress is to motivate us to struggle for a better life. All these are true because natural selection has shown that this is the best information for our type of structure and makes these ideas a part of us.

Religious doctrine is presented to people as sacred and unquestionably true. But this is the nature of most of our inherited information that makes us who we are. All our information is proven to be the best available by millions of years of selection in the biological realm and at least thousands of years of cultural selection. For the most part we accept who we are both biologically and culturally as we grow up without ever questioning it. Sometimes we feel that our reason and logic can determine the truth, and the great success of our recent scientific efforts gives us the impression that we can control and command the discovery of truth. But scientific information, like all other, is gathered through trial-and-error experiment, which is really a process of selection. When this testing proves the information to be effective, it is then also unquestionably accepted by most people as a matter of faith. Our reason and logic can't create information and are only a way of processing and filtering it. As our society becomes more complex, the externally stored instructions we live by are more and more often delivered by complex higher-level information systems that are increasingly remote from individuals' lives. This information is religious in nature and generally accepted on faith. As organizations develop under a symbolic genome, some form of religion is as likely as not to gain in importance as an effective way to disseminate information.

THE EVIDENCE INDICATES THAT WE ARE ALONE

The speed at which we will transition into technologically advanced beings and travel into space means that we are probably alone in the galaxy. To see why this is true, we will use this section to take a closer look at our prospects for deep space colonization.

We have already shown that we are now at a pivot point where the most important breakthrough in the history of evolution is opening up the largest new potential living space for rapid radiation into new life forms that has ever appeared. This should create a wave of expansion into the galaxy similar to the rapid radiation of multicellular life into all earthy environments 600 million years ago. The growth of technology is already exponential, and it should continue to expand exponentially as we expand out into space because there are no foreseeable limits to our growth or the potential of technology. It could take only tens of thousands of years to exploit most of the energy available in our solar system, and then life would be looking to expand into deep space. The exponential nature of the expansion could allow it to proceed at an unbelievable rate, and once the capability to seed space was developed there would likely be no limits to the reach of the seeding process.

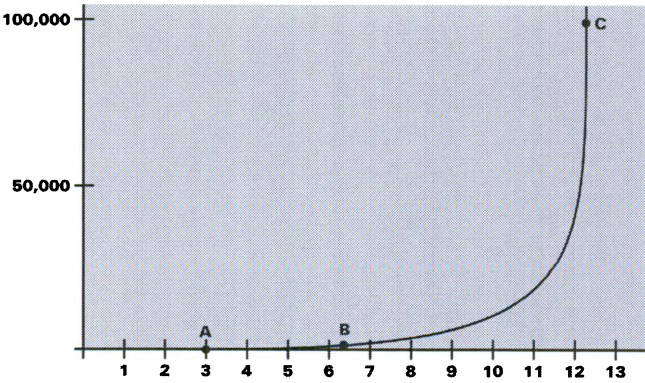
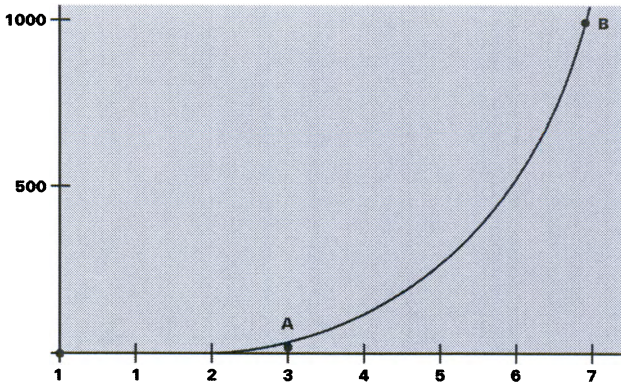
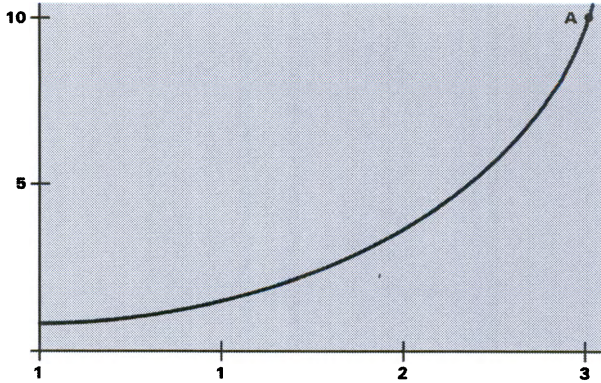
Many people may think that colonizing other planets will require the type of massive effort and investment that was needed to travel to the moon. But if you use your imagination to project the rate of increase in our technological knowledge thousands of years into the future, it is not hard to see that this may not be required. The largest tree can grow from a tiny seed containing only a single starter cell and the information needed to construct and operate a tree. In the right environment this seed could cover a planet with forests in no time. With thousands of more years of progress, it's not unlikely that atomic-sized information storage could pack all the information needed to build and operate an advanced civilization, including all the DNA information for the biological component, into a small package. A single biological cell, a mechanical starter mechanism, a tiny initial supply of power, and a compact symbolic genome may be all that is needed to colonize a suitable planet. As technology

gives us the ability to migrate into space and live under all sorts of conditions and utilize any type of energy source, it is probable that we could easily locate many areas of space with sufficient energy and materials for some form of technological life to survive. Sending possibly basketball-sized "seeds" to these areas might require no more relative effort than a tree puts into making its seeds. Just as a tree or some weeds make thousands of seeds every year and spread them far and wide, our future symbolically controlled life forms could replicate their genomes and spread millions of their seeds throughout our galaxy with a modest amount of effort.

We have already shown that the earth is nowhere near its carrying capacity for symbolic life. But once the energy supply available on earth is fully utilized, the rest of the solar system will be an irresistible new frontier for the relentless expansion of life. And, once the solar system is saturated with life, the jump into deep space should be a relatively small step well within reach of the technology and energy availability of this future age.

For the technology of the present, travel into interstellar space seems to involve some formidable obstacles. To cover the tremendous distances of space, our seeds would need to travel at fantastic speeds. For instance, if our seeds could travel $1/100^{\text{th}}$ the speed of light (1, 860 miles per second) then it would still take four hundred years to reach the nearest star system, and at this same speed it would take about 5 million years to begin reaching the stars at the edge of the galaxy. But once we reached a technological level where we can be successful living anywhere in space, our expansion could still proceed very rapidly. Most people picture the exploration of space progressing linearly from one planet to the next in a series of steps. But when there are no limits to growth, it takes place exponentially and in all directions at once. Once we discover the basic information required to colonize space, there will be a nearly unlimited, untapped environment for life that could support a continuing exponential expansion for millions of years. Although colonization would start slowly, after a while it would gain so much momentum that the expansion of life would be an unstoppable flood.

EXPONENTIAL GROWTH e^x



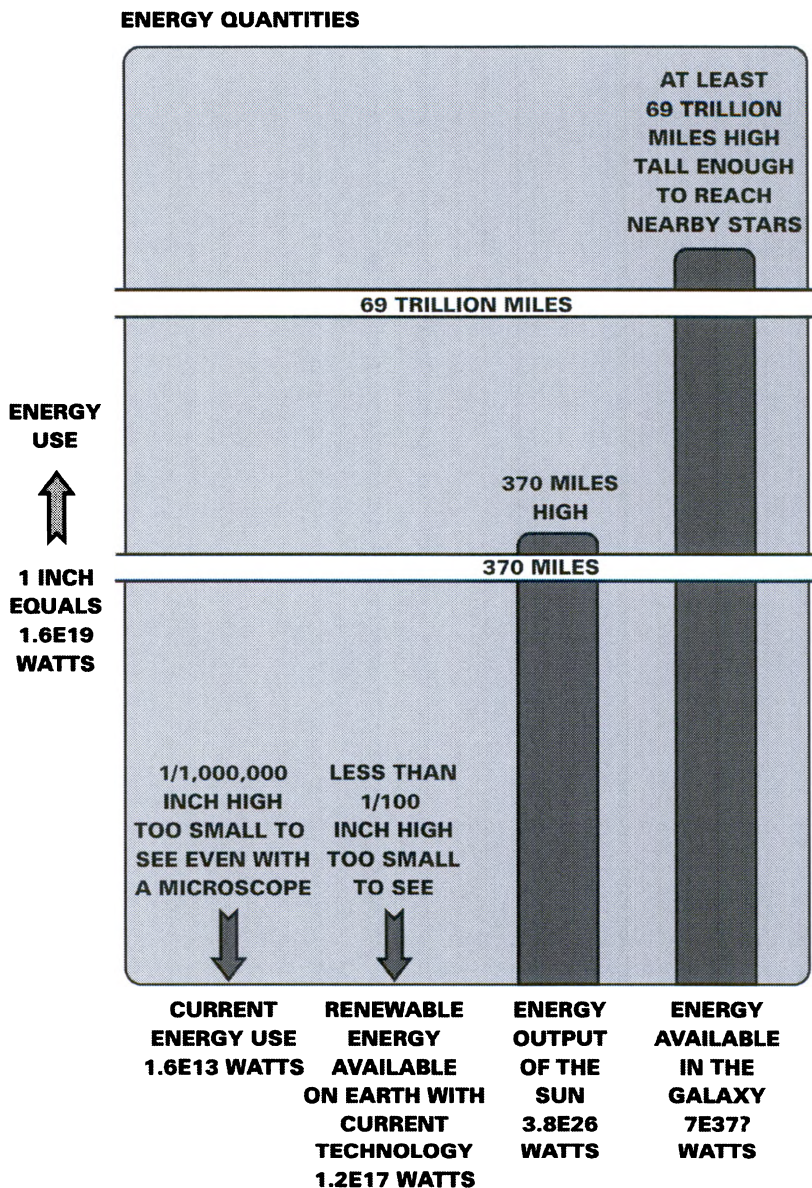
Pure exponential growth continues in a J-shaped curve indefinitely. Shown on graphs of different scales, an exponential curve appears to repeatedly go from flat to vertical and form a series of elbows.

Let's say that advanced civilization's basketball-sized seeds weigh about 1 kilogram. To accelerate 1 kilogram to $1/100^{\text{th}}$ the speed of light requires about 4.5 trillion joules of energy, which is roughly equivalent to $1/3$ second's worth of current human energy consumption for the entire world. People have historically saved at least 5% of their production for investing in future growth, and if all this investment went in to sending seeds into space, at .01% efficiency we could currently send out about 500 of these packets a year.

We have plenty of living space on earth and we don't yet have the technology to live in space, so now all of our investment efforts are spent on research and earthly expansion. But once we do begin utilizing all the renewable energy on earth, a 5% savings rate at .01% efficiency would then allow us to send out 4 million probes, 1 kilogram each, into space each year.

But even then deep space colonization would be premature. The solar system is still the easiest colonization target, and this will also be the laboratory for discovering the technology for living on other planets. Colonization of deep space will most likely need to wait until both the earth and then our own solar system are fully inhabited. But if we guess that when the solar system is saturated with life we will be utilizing 1% of the sun's energy, our 5% investment rate with .01% efficiency would then translate into enough energy to send over 100 trillion seeds per year into our galaxy, which contains only about 200 billion luminous stars. Once we reach the beginning of deep space colonization, we may be able to seed the entire galaxy in the first wave. The nearer systems may reach maturity and send out their more advanced seeds millions of years before the first primitive probes from the first wave of colonization even reach their destinations.

There is plenty of energy available in our solar system to support the initial colonization of our galaxy, but people may have a hard time picturing how we could develop the technology to make use of this energy. The pace of our expansion will be set by how fast we can discover information and integrate it into new systems. In the flowchart, loop C is the shift to a new information system, and this is a one-step process that is occurring now. Loop A is just the energy feedback of pure growth into an expanded environment with existing technology. If we had the technology and could focus all our resources on growth, we could certainly



Energy quantities bar graph #3

From our perspective the galaxy can supply nearly infinite resources for the endless expansion of life.

achieve a 10% return on our energy investment, and if we invested 5% of our energy in growth, this would be an overall feedback of .5%. At this rate it would only take about 2000 years to fully utilize

all energy resources on earth and then less than 4000 additional years to saturate the solar system with life. But loop B is the critical path that will determine the real rate of our expansion. Searching for information requires time and energy, and most of our energy investment will need to be devoted toward research. But even if 90% of our efforts are channeled to research, it would still take only about 50,000 years to max out the life support capability of the entire solar system.

We can check these calculations by comparing them to the actual growth rate of energy use in the last few thousand years. We have already estimated that total energy use 2000 years ago was about 4.5 E10 watts. An exponential growth rate that would lead to our current energy consumption from this estimated base in 2000 years is .3%, which matches fairly well with the previous number. This number may seem normal or even small to us now, because we are currently expanding our energy consumption at an even faster rate. But a sustainable .3% per year expansion is unprecedented in the history of life. The transition to symbolic information has ushered in an extraordinary period of opportunity and growth that we are currently enjoying. If this .3% is used to calculate our future progress, we will saturate the solar system with life in only about 9000 years. But due to the vast energy requirements of remaking the solar system, the rate is likely to be at least an order of magnitude or two slower. But still, it may only take us a few hundred thousand years to fully inhabit the solar system.

These calculations are based on the belief that our exponential expansion will continue indefinitely. Doomsayers have repeatedly warned that we are facing the imminent collapse of civilization, but this is due to their failure to understand the fundamental underlying dynamics of the current evolutionary transition that these paragraphs are attempting to illuminate. We have entered a completely new dimension of discovery space that is unfathomably large compared to all previously discovered information. Life is no longer tethered to the tiny universe of DNA and the few organic molecules it is tied to. The doomsayers warn that we are running out of tillable land or fossil fuels or that we are irreparably damaging the environment, but they don't realize these are just the expected consequences of a

much more profound process of transition. At almost any point in our history, humans have been at the limits of one resource or another but this is the nature of all species. Life exists wherever it can and multiplies until it reaches some limit. But our expansion has always been about the creation of new modes of living, not just using up acknowledged resources. Ancient people could not have even imagined the Industrial Revolution, let alone television, computers, or nuclear power. They even had no inkling of the vast universe they lived in, and yet their descendants acquired this knowledge and created this technology in only a few thousand years. Since the pace of discovery is still increasing, why would we not think that even greater unimagined life-changing discoveries are in store for us in the future? The doomsayers are for some reason completely ignoring the actual trends of the past. For no apparent reason they say that innovation will suddenly come to a halt and our energy will run out, even though there is over 7000 times our current energy use available on earth from renewable sources just with current technology. We are not doomed. In fact the exact opposite is true. A fundamental analysis indicates there is a limitless world of new technology and energy availability waiting for us in the future, and we can go on expanding exponentially practically forever. We have entered an entirely new and unbelievably vast universe of unexplored possibilities.

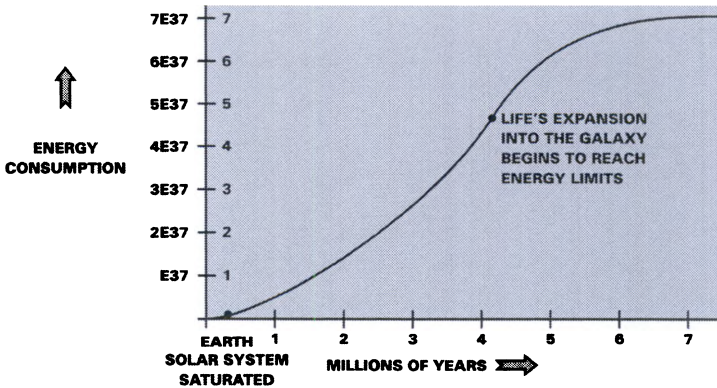
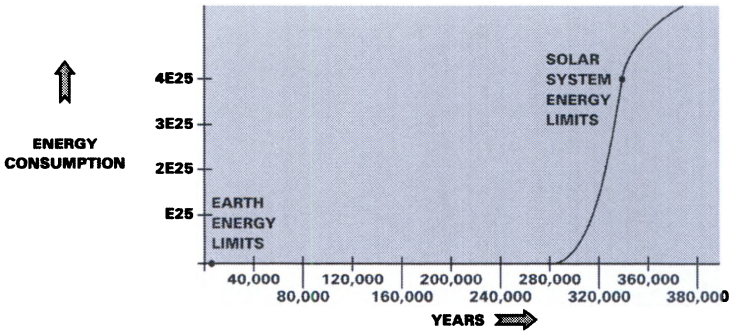
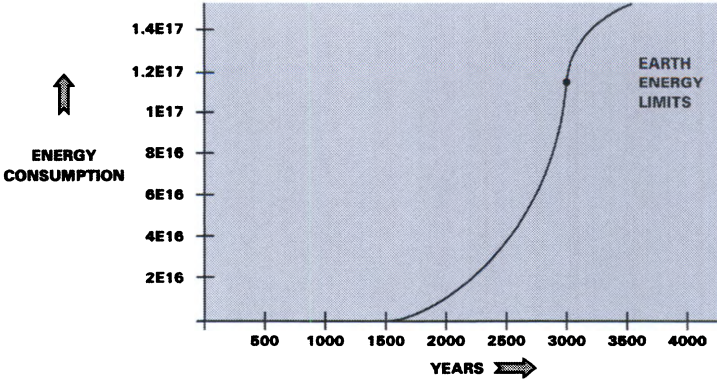
In 1960 physicist Freeman Dyson published a paper suggesting that the way to search for extraterrestrial intelligence would be to look for stars that were completely surrounded by energy-gathering satellites. In popular literature this led to the idea of Dyson's sphere, which is a habitable shell completely surrounding a star. A shell is probably an engineering impossibility, but space-based satellites for the purpose of collecting solar energy have already been seriously proposed. A cloud of satellites gathering energy from the sun is already within the realm of possibility, and when this happens it will be the beginning of the construction of Dyson's cloud. But even in the last fifty years technology has advanced so much that we can anticipate that this cloud will take a form undreamed of in 1960. Molecular scale engineering will be able to create lifelike complexity in any machine, and biotechnology

will be able to seamlessly graft together any combination of organic life with all other mechanisms made of any material. Advanced computers will not only design these technologies but will have the capacity to exquisitely coordinate planet-sized operations engineered at a microscopic scale. The cloud will most likely be a living community of incredibly intricate and diverse systems with an ecology of interactions more complex than a rain forest. And if the past is any indication of the future, there will be technologies that are not even dreamed of now that will augment the construction of this cloud.

In the past tiny microorganisms altered the chemistry of the entire earth's surface by adding oxygen. Other simple organisms laid down huge deposits of limestone that cover parts of whole continents, built thousands of miles of coral reefs, and manufactured all the fossil fuel that powers our civilization today. But this is nothing compared to the potential of symbolic information. The sun provides enough ordered energy to remake all the planets of the solar system into a self-organized cloud of information generating life in only a matter of thousands of years. Since life will exist wherever it can and symbolic information systems have the potential to store and process the information required, life will undoubtedly reach this level in the relatively near future.

Once life penetrates the solar system, the last frontier will be colonizing the galaxy. But the sun and its system of planets are probably not substantially different from many other systems, so this expansion should not require another massive new foundation of technology. The expansion from the solar system into the galaxy should be more of a loop A growth feedback where most of the energy required can go into pure growth. If we start from an energy base of 1% of the sun's energy, exponential growth could very quickly turn this into a tidal wave of colonization. If we figure a 5% investment in growth and just a 1% return on investment, it would take only about 60,000 years to invade the entire galaxy if the speed of light were not a limiting factor. However here the overriding obstacle is travel time. It still takes 5 million years to travel out to the edges of the galaxy. But once life ventures into galactic space, it will probably spread essentially as fast as it can travel.

EXPANSION OF LIFE IN TERMS OF ENERGY CONSUMPTION



Uncertainties make predicting the future impossible. But, a reasonable guess might be that we would continue to expand energy consumption at our historical pace until the earth's resources are fully utilized. We would then continue to expand exponentially, but at a slower rate, into the solar system. Our expansion into the galaxy would be limited by travel time, so energy use would increase according to the cube of the distance traveled or proportional to the volume of space occupied.

Now we are ready to make the main point of this section. If we assume that life could expand nearly as fast as it could travel and it could eventually travel at maybe $1/100^{\text{th}}$ of the speed of light, then our descendent species could colonize most of the galaxy in only 5 million years. We are making a lot of assumptions, so to be safe let's say we colonize the galaxy in 10 million years. This is still a short time in cosmic time scales or compared to the 4.5-billion-year age of the earth. And the point is that if there are millions of other earthlike planets with life on them, as some people seem to think, then there must be many that are hundreds of millions or even billions of years older and more advanced than the earth. If other civilizations reached the same pivot point of technological expansion in a similar amount of time, and then it only takes 10 million years to colonize the entire galaxy, our planet should have been colonized tens or hundreds of millions of years ago by one of the many older life-supporting planets in the galaxy.

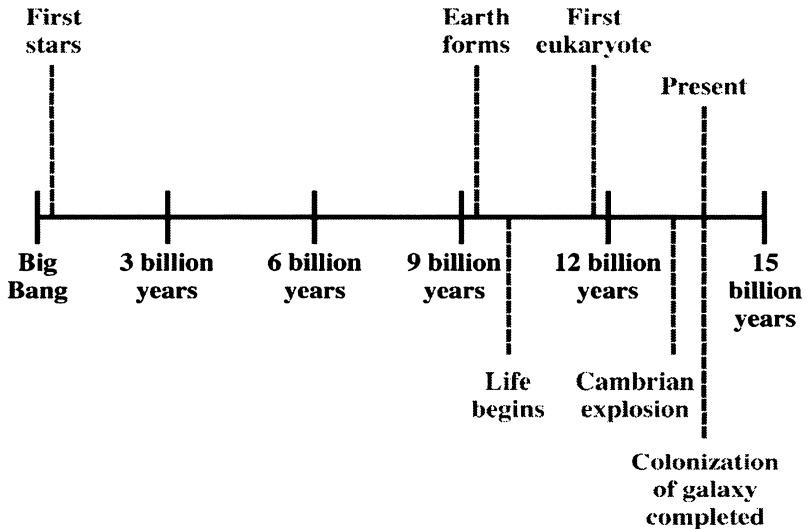
A fact of evolution is that once a major breakthrough is made, that lineage rapidly takes over the new living space opened up, and its head start usually prevents any other lineage from catching up and making inroads into the new space. All multicellular animals came from the same lineage that made the original jump to this new level. The same is true for land plants, which all descended from the same original species that made the transition to terrestrial living. Once one group makes it over the initial hurdle into a new area, it quickly radiates into all available niches and absorbs most of the resources, leaving no room for any late-comers. Since the time it takes to colonize the galaxy is probably just a tiny percentage of the age of the galaxy or the time it takes to evolve to the pivot point of technological expansion, the species that reaches the jump-off point first will claim the entire prize just as in other evolutionary expansions. This is a scenario that has occurred many times in the history of evolution on earth, and there is no reason to think it won't happen the same way in space. If life were elsewhere in the galaxy, its seeds would have been raining down on us for millions, hundreds of millions, or possibly billions of years and the earth would have been fully occupied with advanced, technological life forms before native terrestrial life, much less humans, ever got started.

People usually visualize an alien invasion from space as a massive invasion of a flotilla of space ships that forcibly take over the earth. Since this planet is already occupied by a technological species, and if other parts of the galaxy were similarly occupied, this type of effort might be required. When humans first colonized the Western Hemisphere about 40,000 years ago, the area was virgin space for our particular niche. A very small group of people with no home support was able to spread rapidly and more or less effortlessly over two continents. When Europeans arrived forty thousand years later, their technology was so superior that they had nearly created a new distinct niche that made reconquering the continent just as rapid and inevitable. But this time the presence of humans did create resistance, and the invasion required a large migration of people with support from the homelands to prevail. And as the earth becomes more saturated with human life, a large expansion becomes more and more difficult. Eventually the pace of change settles into a kind of continuing muted trench warfare with equally matched groups constantly probing for a minor gain here and there. This is the situation for most species on earth since the entire planet is more or less saturated with DNA life in every different possible form.

We should assume that symbolic life will spread throughout the galaxy in much the same general pattern. Once life has gathered enough information to meet the basic challenge of living in space, it will spread rapidly through the virgin territory and also radiate rapidly into a multitude of different forms that exploit every available niche. During this expansion phase there will be numerous reconquests of existing niches by populations that have jumped ahead of other groups. As the new space becomes saturated, these rapid and dramatic changes will diminish and space will be populated by an incredible, diverse array of entrenched variability occupying every available niche and constantly skirmishing for some tiny advantage.

Geologists and paleontologists have documented the history of life on earth for the past 3.5 billion years. This amounts to nearly 25% of the age of the universe. During this time we have seen no evidence of the seeds of the first expansion of alien life, let alone any evidence of the later stages of struggles among

developing equals. Where we would expect to see a multitude of life forms living on every available energy source throughout the galaxy, we see nothing. What this must mean is that if our estimate of the time scale for expansion of around tens of millions of years is anywhere close, we must be among the first or the only intelligent life to appear.



Timeline showing the age of the universe versus 10 million years to colonize the galaxy.

In the timeline above, the completion of the colonization of the galaxy by humans appears to be at the present time. This is because, on the scale of the timeline, the width of a printed line represents about 50 million years. So, the width of the “present time” line encompasses the 6 million years of evolution of man since his lineage first split from the apes plus the entire 10 million years it will take to colonize the galaxy plus about 34 million years to spare.

Every species, in order to survive over the long run, must believe it is the most deserving of the resources needed to survive. Because of this it is naïve to assume that any alien life that arrived on earth wouldn’t believe the same thing. Any life that did arrive would certainly be significantly more advanced than us and

would no doubt commandeer all the resources it found useful, leaving us to live off the scraps as long as we weren't too much of a nuisance. But humans have developed an information system that is so far advanced, and the technology it supports is so radically different compared to other biological systems, that we are essentially alien invaders of our own planet. The 3.5-billion-year reign of DNA life on earth has indeed come to an end by the invasion of an alien life form. But the aliens are the new form of life we have named symbolic life that was created through humans and their technology. It seems that the seeds of life that will eventually populate the entire galaxy may have been born on this planet.

We see that the earth is so abundantly full of life, and of the nine planets we are familiar with at least 11% support life, and this gives us the feeling that life is commonplace. But this has zero statistical significance, because even if we were the only life among the billions of galaxies of the universe we would still have 100% certainty of observing these facts. Fifty years of searching for any type of alien life has turned up nothing, and, more significantly, 4 billion years of availability of the earth as an environment has attracted nothing. The lack of any contact or evidence of any kind for alien life, even considering our somewhat meager data on this so far, is a much better indication of the true state of things. Since it appears that we are about to embark on colonization of the galaxy, either we just happen to be first out of maybe millions of other planetary systems that are evolving toward this point, or we are the only one that exists in what is a highly improbable state. Given the evidence that we observe, it is actually much more likely that we are the only intelligent life in the galaxy. Either the original spark that begins the feedback loop of information accumulation must be highly improbable or a multibillion-year span of unbroken, stable, life-nurturing conditions on any single planet must almost never occur.

When man reached the moon, the astronauts looked back at the earth from the desolation of space and were struck by the beauty and the extraordinary preciousness of the earth as our home. But now we are beginning to imagine the earth as a tiny speck of tenuous life in the vast emptiness of an otherwise lifeless

universe. We may be utterly alone. The burden to insure that life continues and expands may rest entirely on us.

MASTERS, SLAVES, AND ROBOTS

Some people think that robots will someday become self-sufficient and start evolving independently of humans. However, it's hard to see how this could happen because they are made in a factory as components and do not in themselves embody all the necessary parts to operate as an information generating system. Independently evolving species are ruthless competitors who focus all their efforts toward tasks that enhance their own survival. To be effective competitors, artificial life would need to have the same "we are the most deserving species" focus that other independent species have, and if they are designed and manufactured by humans they are unlikely to have this trait included. For this or other necessary survival traits to evolve independently, there must be a self-reproducing population for selection to act on and many thousands of generations to accumulate the necessary information. Building robots in a factory under the direction of humans or a higher level genome does not lend itself to this outcome. The question would be why would humans make the huge investment it would take to design and build self-sufficient robot factories run by robots just so they could independently evolve into our competitors?

People who think robots might start evolving independently or be a threat may have the idea that as they increase in complexity they might suddenly awaken to a consciousness like ours. Since we are ruthless competitors with a strong desire to expand and dominate, they assume that any suddenly awakening consciousness would have similar drives and motivations. But these traits in us, as in all other species, are a product of selection, and there is no reason to think they are an inherent part of consciousness, especially one created by a spontaneous awaking due to sheer complexity. In fact consciousness itself is a trait created over hundreds of millions of years of selection-driven evolution to fill the need that mobile animals have for an awareness of their situation. There is no reason to believe that computer complexity created for other purposes would ever awaken

to anything at all like the experience of consciousness that we have.

Another possibility for the future that some people envision is that human consciousness will be uploaded to computers. But it's unlikely that something comparable to a flesh-and-blood mind could ever exist in cyberspace. People tend to see the body as just a vehicle for housing the mind and therefore the mind can be transferred into an alternative vehicle. But there are so many ways in which the mind is the body and computers are in fact so fundamentally different in construction than flesh and blood that this type of transfer is probably just not possible. A person's mind and body are an integrated unit that is finely tuned and focused emotionally and physically to operate and survive in the real world. Uploading a flesh-and-blood mind to a computer would be as difficult as converting a brick into a poem because they simply are not in the same category.

People who subscribe to the upload myth are confusing the mind's simulation of reality with reality itself. Because a computer might enable a robot to simulate awareness and interact with a real person in a convincing way, they feel that then there would be a consciousness similar to theirs inside the robot. They project their reality into the robot. But any simulation of reality in a different medium has no real equivalency to the real thing. People can go to a movie of the sinking of the *Titanic* and this simulation makes them feel just as if they actually were present at the event. The moviegoers' internal reality may be very similar to the internal reality felt by somebody on a sinking ship, but actually sitting in a movie theater has no real equivalency to being on a sinking ship in any way. A digital simulation of a human mind would be just as different compared to the real thing. A robot may be able to make us feel like we are interacting with a comparable consciousness in a limited way, but the reality is there is no comparison.

Not only are the mind and body a single unit and by definition flesh and blood, but the unit itself is inseparably part of the matrix of biological survival and evolution. A mind could not be physically uploaded to a computer, but even if it could it wouldn't function because it would have no function. What would it do and what would be its purpose? In cyberspace there is no eating, sleeping, social interaction, or entertainment. There are no careers,

education, or traveling. There are no senses to experience the world, no work to be done, and not even a body to move around and control, and these are all the things that our minds are meant to do. Our nervous system and the consciousness it creates are components of an integrated living system and would have no purpose if they became disconnected from the rest of the system.

A system as a whole, even a conscious one, is fundamentally animated by thermodynamic free energy flows, and any structural changes to the system are driven by changes in these flows. All conscious living beings would understandably evolve a strong drive to remain alive, but this trait did not evolve to motivate people to try to digitally upload their consciousness. If an upload does occur in some form, it will be because it somehow enhances energy availability. In the final analysis the future shape of our consciousness will be determined by what new information is discovered and how this new information connects an altered consciousness to expanded access to free energy.

There is no reason to think that people's individual minds will ever be uploaded directly to computers, but there certainly are changes in store for people as life is reorganized and the purpose of the human consciousness changes. The mind is part of the matrix of survival, and evolutionary change is radically reshuffling this matrix. Chickens until recently were semi-independent, mobile creatures that needed self-awareness to survive. But for modern chickens grown industrially for food, consciousness has become just a burden. The suffering of conscious animals that are confined to small cages and have no need for the skills or the awareness of free roaming chickens is an ethical problem. Undoubtedly genetic manipulation will soon allow insentient chicken bodies to be grown for food like vegetables much more efficiently and humanely and, as soon as it becomes possible, it will probably be done. The mind of a chicken no longer serves a useful purpose, so it will be eliminated as chicken DNA is modified and integrated into industrial food processing. All of life's current DNA information can potentially be re-engineered in this way and be put in the service of a symbolic genome. The question is how far and how fast will this re-engineering proceed with the human genome?

We can modify a chicken's genome and change its mental makeup because we own them. They are our slaves and we

have nearly absolute control over them. But people have only limited control over other people. The altering of humans must be on a more voluntary basis, but our history of living in groups has already made us susceptible to this sort of group control. People are born to some extent as blank slates and are already programmed to accept a large amount of education and enculturation from external sources that determine how they act and view the world. We are already indoctrinated, manipulated, and regulated by various organizations and governments to the point that almost every aspect of our lives is influenced or controlled by external instructions. We have no problem altering our bodies with drugs or undergoing surgery to keep up with the latest trend. Advertisers persuade us to work most of our lives to buy things we don't need, or religious indoctrination convinces us that the path to glory is to strap explosives to our chest and blow ourselves up. The evolution of group dynamics in humans has already produced individuals that are subservient to a higher authority and willingly supersede the instructions from their own DNA with instructions from the group. We have free societies and others that are not so free, but in the end it makes little difference because the free people choose to gain the unmistakable advantages of becoming a component of a group. People are this way because cooperation has been the key to human success in the past, so this is the type of people that have survived. In the future some people will choose to alter their genetics or that of their descendents to benefit the group, and these groups will expand because they are better integrated and more efficient and this type of personality will dominate. People will feel they chose this type of life, but it is more accurate to say that energy accessibility and newly discovered information chose these people and allowed them to prosper and increase their numbers from generation to generation. Step by step as people incrementally alter themselves or their descendents in different ways to gain the advantages of group cooperation, these changes will add up to create an array of completely new life forms.

As individuals become more controlled by external information, the government, religious, economic, and social organizations that contain this information gain a stronger foothold as independent self-reproducing living systems. These organizations

are now primitive, poorly defined, unconscious, mechanical systems, but, like other life, they grow and compete and generate new information independently through their own variability and natural selection. Many of these organizations are thousands of years old and have spawned a multitude of competing spin-offs. Businesses, governments, and other groups draw on an inherited body of symbolically stored knowledge for their operation that has evolved and been passed down since the beginning of written history. They are constantly experimenting with new ideas and trading information, and in this way they create a population of reproducing entities that selects for its own survival traits. From our self-centered point of view we don't see it this way because we are only concerned with how these organizations help us survive, but if we look at the big picture, we are surviving in a symbiotic relationship with these primitive symbolically informed entities. We are serving them as much as they are serving us.

The thinking can be reversed in this way for any manmade organization or object. For us a videogame is just entertainment, but the game continues to be made because of its particular structural characteristics. Some people might call it a meme and compare it to a virus because it is a string of code and, in a sense, it has the ability to co-opt the mechanism of living systems into making copies of it. We use the video game for entertainment, but the video game uses us to make copies of itself and continue its existence. This is trivial because video games or viruses are only code and have none of the other integrated systems of life. But businesses, governments, religions, and other groups do have all the construction, maintenance, energy gathering, and information systems of an operating organism. They embody the processes described by the flowchart of life, so they are living systems. Like the first primitive cells, they are just unconscious mechanisms, but they have already gathered enough information to begin the feedback loop of life. They couldn't live without their symbiotic relationship with humans but many species depend on other species for their existence. Humans are just as dependent on their techno-economic host entities as they are on us. In fact, we are not only dependent, we are the controlled ones, because, like the mitochondria, we are surrounded and immersed in our hosts and they contain the newly discovered

information that is powering our expansion and guiding our future evolution.

Some futurists have characterized the singularity as the point where computers will design themselves better than people can. The computer-designed computers will be even better at designing future computers, so a virtuous cycle will be created that quickly spins out more and more sophisticated machines. In other words, when computers become smarter than people, they will be able to develop even smarter computers and so on. But being smart doesn't mean that you can construct reality with only logic and no data. Real truth can only be revealed by selection, and to acquire knowledge there must be an experiment in living with survival as the result. If it is effective, computer design of computers will only be another step in the development of more sophisticated information systems and better ways to search for new information. But these better information systems will still just be components of a holistic living system and must be supported and connected to an engine and constructor to survive. The transition to symbolic information is the real singularity, and the speed of information accumulation has been increasing more or less exponentially from a very low base since the invention of language. Now we have reached the elbow of the J-shaped curve, where the acceleration of change is becoming hard to ignore, but computers designing more computers is just one more step in this larger process of transition and the immersion of our lives into technological entities controlled by a symbolic genome.

Eventually a digital consciousness may emerge. This could be in response to the requirements of mobility in our host organizations. It also could be an outgrowth of a more efficient, conscious, information search mechanism. Human consciousness is the key to our more efficient scientific search for information, and as computers take over information search, a need for a digital consciousness may arise. This consciousness would then be embedded in the new matrix of higher level living organizations and could evolve into the next stage of higher level of consciousness that supersedes humans. Then the people that cooperated to develop these more complex organizations and chose to subsume themselves in these higher level beings they created would finally achieve the upload that some envisioned.

SOME CONCLUSIONS

*Blessed are the meek
For they shall inherit the earth*

Jesus

We are in the midst of what are the most rapid and comprehensive changes to living systems that have ever occurred. This is because humans are the key to a pivot point in evolution that will open up an entire new universe of opportunities for the expansion of life. To recognize this, we need to step outside of our self-centered world and look at what life is and the dynamics of how these systems operate from an unbiased point of view. We need to realize that how we see things is often a product of our own evolution and try to imagine how the overall process would look to a disinterested observer. If we do this, we can see that the defining quality of living systems is that they are structures that can trap available energy in a feedback loop that generates information through the process of natural selection.

Information is coded instructions or messages that can be read by living systems about how to build and operate their structures. This definition of information means that truth is whatever reality is most useful and effective for building and operating the structures of life. Information is a relationship between the

structures of life and their environment and depends equally on the observer and what is observed. The expansion of the universe provides a continuous supply of available energy and improbability that living systems can tap. Once a feedback loop is initiated, the continual dissipation of this available energy drives living systems to generate more and more information that can expand the feedback by discovering more structural possibilities and accessing more energy. Availability of energy and information are the fundamental drivers of the process, and evolution is driven toward whatever structural possibilities are out there that can capture more energy and expand the feedback.

With this framework for analysis, it becomes apparent that we have reached a turning point like no other in the history of life. This is the first and only time that selection has produced a completely new and vastly more powerful information system. This system is still being created, but it is already clear that it will be many orders of magnitude larger, more efficient, and faster than DNA chemically based structures. The new system capacities are enormously larger, but the most significant improvement is the immensely more flexible human interface that allows information to be connected to any material or process. DNA information can only be accessed through translation to RNA or a protein string, and this limits the information in its code to the tiny subset of structure that can be made with proteins or chemicals connected to them. To date life has become only a tiny speck compared to the potential of all types of structure to trap energy and expand the circle of life. Not only has most useful information not been discovered, but conscious logic and the scientific method can pinpoint likely areas of fruitful investigation and generate new information many times faster than the best DNA algorithms for information search.

In what is the distant future to us, but is only an instant compared to the age of the universe, life should be able to expand into an amazing variety of forms that will populate the entire galaxy. But, this expansion is happening so fast that it also has an impact on many issues that are relevant to our lifetime.

A myth that some environmentalists promote is that we are destroying the planet or somehow teetering on the edge of our own self-destruction. Planning carefully to avoid unintended

consequences is certainly a good idea, and I think that the beauty and diversity of the natural world is something to be treasured. But reorganizing life in order to expand its reach is something very different from destroying the planet. A reorganization on the scale of the current one will be disruptive and involve many winners and losers, but this is the way that the creative destruction of natural selection operates. We cannot have tremendous progress without tremendous change. Any person that claims we are on the brink of our own ruin is just not paying attention to the facts. A species that spreads to every environment on earth and dominates every other species it decides to control and that is the first to venture into new frontiers such as space is not on the brink of destruction. Actually the disruptions we are experiencing are signs of the beginning of the most profound and amazing expansion of life that has ever occurred.

Evolution occurs on a much larger time scale than people's lives. We may encounter events where whole segments of our civilization may be destroyed or a significant percentage of our population could lose their lives, and from our individual point of view these are terrifying disasters. But these are fairly common occurrences in the natural world and usually they have no long-term consequences in terms of evolutionary outcomes. A much more frightening prospect may actually be a lack of progress. If we are the only intelligent life around, it is probably because the chance of any planet avoiding some sterilizing event for the 4 billion years required to create intelligent life is vanishingly small. This indicates we have been walking on eggs all this time, and the odds may still be against life ever blossoming into space. We may still be in a race against time in which a lack of progress could extinguish all life just before it begins to reach its real potential.

The critical factor for our growth is apparently the pace of information discovery. The energy, materials, and environments are all available for those who can discover the methods and mechanisms for exploiting them. This seems to indicate that as much effort should be directed toward research as possible and the groups that do this will be the ones to succeed. Even on the small scale of individual organizations or lives, this is probably true. There are limitless new opportunities out there, and entities that dedicate time searching for improved information, lock

their new information into permanent written genomes, and then use it to expand production and search for yet more information are the ones that will thrive.

A common aphorism is “crime doesn’t pay.” This simple saying is actually at the center of human existence. Unselfish cooperation and teamwork in a larger group is the key to the future of life and has been the key to every civilization’s success so far. Children are indoctrinated with this idea. Governments, religions, and businesses promote it for obvious reasons, but these paragraphs explain in the most fundamental way why this is true. Criminal organizations do break the law, but even for these, a strict code of loyalty and cooperative behavior must be maintained within the organization itself. Whenever there are successful organizations, there will be predator entities that live off their success, but these are also subject to the same pressures of selection. Groups may compete as siblings, predators, or symbionts, but within all these organizations cooperative effort toward the collective goals is what will lead to success. Literally all the wealth, power, and success of mankind is due to cooperation.

As our organizations develop further, we will be molded more and more into a well-oiled machine. Better technology, better genetic information and control, reproductive regulation, improvements in organizational level operating information, and specialization will all contribute to this development. Even though we are already wildly successful, there is tremendous waste in all our organizations. People are still programmed to act in their individual interests as if our species were still competing on the individual level. Our tendencies toward self-aggrandizement, extreme wealth accumulation, intense competition for mates, the way we see our relatives as our first priority, and our avoidance of death are all left over from our ancestry as a distinct species. All these are very detrimental to cooperation and result in the primitive dysfunctional organizations we have today. Soon passing on our individual genes will not be our concern, as this will be regulated by the symbolic genome. Teamwork, submissiveness, and sacrifice for the good of the group will be the moral imperative of the future. When we are components, death will only mean a replacement of parts and we will all have a profound sense of oneness because our group will be our only focus.

Governments are also just components, and all components must compete and be efficient for the whole to be efficient. Governments can produce tremendous gains for society by imposing the rule of law and providing security, but initially governments enslaved the workers and stole all the surplus gains because they had the military and police powers to enforce this. The earliest governments often consisted of a fabulously wealthy elite and a very poor general population. But as governments compete, the waste of this extravagance is eliminated by selection. The trend is toward more efficient government and more equitable sharing of the benefits, and this trend should continue as selection forces systems to become more efficient.

All the organizations on earth form an ecological web of relationships. Some compete, others complement each other, and some are parasites or predators. But the earth is much too small for symbolic life to evolve effectively. Some organizations span the globe, and the earth just does not provide the space for these large entities to develop the variability needed for a robust evolving population. The galaxy is even larger in size relative to the earth as the earth was to the first single-celled bacteria. The entire galaxy provides the space and variety of environments that will drive a vast proliferation of symbolic life just as the earth did for DNA life.

This book touches on many different subjects and ideas, but they all are related to the concept of evolution and how it is operating through people. Evolution is the fundamental theory of life and people are living beings, so it is no wonder that evolution affects nearly every aspect of our lives. Evolution is not the theory of everything, but it is the theory of nearly everything that concerns human beings. Physics is normally considered the most basic branch of science. But physics is only our best conscious efforts to make sense of our place in the world and to divine the rules for manipulating it. But our consciousness was designed by the process of evolution, and we study physics only because evolution designed our brains to do so. Our consciousness can only encompass what evolution allows it to, and in this sense biology created physics and controls how we understand it. To understand physics in the deepest sense, we must first understand what

we are. Our reality is more a reflection of our interaction with the world than the world itself.

Humans are in the middle of a transition between information systems, and currently our lives are governed by two sometimes conflicting sets of directions. Our consciousness, personality, emotions, and innate drives control many of our actions and are the directions we receive from our inherited DNA information. In contrast, our culture, upbringing, education, and any other knowledge we receive through language or writing are the directions we inherit from the higher level symbolic genome. The combination of this information determines who we are, but since the balance of power between the two systems is rapidly changing, we are also due to be fundamentally changed. We can only be what our information tells us to be, and information can only reflect what structural possibilities are inherent in our universe. For lack of a better way of expressing it, we can only say that God will reveal what these possibilities are as selection generates the new information that will guide our future.

The transformation of life that occurs when one organizing regime gives way to a new one can be called a singularity because a new information system creates the possibility of a new dimension of information to be searched. An earlier, less global singularity occurred when multicellular organization suddenly appeared and resulted in the Cambrian explosion of new life forms into previously unexploited living space 600 million years ago. The current transition is more universal because it involves a completely new information system and a complete break with the past. It's an ongoing process that began with the invention of language and will end up with a reorganization that will affect nearly all life forms. But if we were to choose one event that best represents the singularity, it would be the completion of the human genome project. This marks the actual point where control of our evolution is transferred from DNA selection to selection of symbolically stored information. Our DNA makes us what we are, and the transfer of its information into digital storage is as close to uploading our souls into computers as is possible. Our symbolic information and control centers now have the knowledge needed to construct and operate us. Therefore they can turn us on or shut us off at will. They can alter our design as needed

or combine us in any way with other symbolic or DNA information. And in the same way they have access to all the DNA and control over all other life forms on earth. We have already been uploaded and we didn't even notice. This is because it's just part of the overall process that we call progress in which the discovery of new information and energy sources allows us to expand our living space and move into previously unexplored territory. A higher level genome will take over our evolution because the energy and information available to this new structure will give it the power to do so.

Mitochondria also uploaded much of their information processing and control when they became integrated into the eukaryotic host cell. Exactly how this was accomplished will probably never be known, but we have a front row seat for observing the upload to symbolic information. Our brain and our consciousness have been the mediator and the facilitator of the transition. The strange hybrid control center constructed with DNA instructions but filled with symbolically transmitted information that is our brain has been the crucial link that has allowed the singularity to occur. Our brain's ability to understand language created a nucleus of symbolic information capacity upon which a completely independent new system could be built. All that was needed was this original kernel of storage space to allow the feedback of symbolic information discovery and increased energy availability to begin. Once the process began, the tremendous potential of this new information system made its growth almost inevitable.

The DNA control center of cellular life is not conscious, and the digital control centers of newly emerging symbolic life are also not conscious. A higher level consciousness may someday be developed if there is a need for it, but it will probably not be a direct descendent of our own flesh-and-blood consciousness. Our own half-breed self-awareness that provided the indispensable link to the new regime might always be stuck in the middle. In time, only the relentless cycling of evolutionary variability and selection will provide the answer.

As we ponder these ideas, we would naturally wonder, what does it all mean? However, a description of how the world works doesn't necessarily have a simple or unifying meaning. It's just

the way things are. We are curious creatures so it's just nice to know what is going on. But also, understanding more fundamentally the nature of our situation and how we as conscious beings fit into the scheme of things can't help but affect our outlook and therefore our actions in the most profound way. The secret to power is understanding. The tremendous power and potential unleashed by our transition is waiting to be harnessed by anyone with the knowledge and skills to take advantage of it. Hopefully, at least knowing how things work will give us some ability to better reconcile the world with our own individuality and be more fulfilled as a person and a more engaged part of the events unfolding around us.

EPILOGUE

“If the human species, or indeed any part of the biosphere, is to continue to survive, it must eventually leave the earth and colonize space. For the simple fact of the matter is, the planet earth is doomed... Let us follow many environmentalists and regard the earth as Gaia, the mother of all life (which she is). Gaia, like all mothers, is not immortal... Gaia’s children might never die out—provided they move into space. The earth should be regarded as the womb of life—but one cannot remain in the womb forever.”

Frank Tipler, *The Physics of Immortality*, 1994

Earlier in this book it was pointed out that the fitness of any system cannot be predicted. Only selection can make the final determination. The reader might then ask, how can this book pretend to make all these predictions about our future? The answer is that it can't. All we can do is use the information we have to make our best guess as to what is right and then let the mysterious structure of reality determine which choices are successful and which are doomed to oblivion. But these written words can add real knowledge to our inherited information if they help us deal with the future and make better choices. These ideas seem to indicate that we may hold latent power greater than any even imaginable until recently. Although it is a little short on details,

the paragraphs above are nothing less than a 10-million-year plan to spread life throughout our galaxy. If the vision presented here inspires and motivates people of all backgrounds to work more effectively together and achieve something similar, then their success will ultimately prove the truth that is in this book.

The history of life has shown that a tiny club of very special lineages has made the extremely rare jump to a new level of organization. These individuals eventually achieved amazing new heights of complexity and consciousness through their subsequent reincarnations. This could be in our future if some of us choose to make it happen.

But these paragraphs also indicate that our situation may be more precarious than previously believed. If it turns out that life is rare or nonexistent elsewhere in our galaxy, it could mean that we are living in an extremely dangerous place. It may be a miracle that we made it this far and this tiny speck of lonely life stuck on earth could be snuffed out at any moment by some sterilizing cosmic event. As a rule, life must evolve into whatever it can and expand wherever it can in order to survive over the long run. The transition to symbolic life may be a traumatic and wrenching path, but it may also be our only real option.

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THE DAWN OF SYMBOLIC LIFE

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