Biological Imperatives for Humanity

Introduction

As we surpass 7 billion humans on Earth, numerous severe problems need to be solved. Having enough nutritious food to eat, having enough pure water to drink, having enough clean air to breathe, having ready access to medical treatment, having education available for all young persons and having an equitable, stable economic system are just a few of these problems. The World Heath Organization states that hunger is the single greatest threat to world health, with nearly 1 billion persons severely undernourished. Deficiency of protein consumption in children severely impairs their development both in their bodies and in their brains. Starving, uneducated persons do not have the luxury or the capability to contemplate how humans fit into the continuum of life on planet Earth.

Independently of how you define the middle class, it is estimated that over half of the population is in the middle class worldwide. Most of these persons are so mired in their quest for economic advancement and material wealth that they barely comprehend their biological ties to existence and instead imagine that their day to day lives are defined exclusively by advancement in their careers and wellbeing in their private lives. Today, economic turmoil is worldwide. The middle class too does not have the luxury of contemplating how humans fit into the continuum of life on planet Earth.

In order to have a chance at solving the major problems facing humans today, and eliminating armed combat, it is necessary for humans to understand their biological imperatives. Which features tie humans to the evolution of all life on planet Earth and which features are uniquely human? How can humans behave in a way that will improve their chances of coping successfully with the challenges we face. These are the questions to be addressed in this essay.

What are the biological imperatives?

The Earth is over 4.5 billion years old. Around 500 million years ago, the first vertebrates evolved in the seas. These creatures had three components that made them novel: muscles, bones and nerves. Muscles and nerves are tissues that require high levels of metabolic energy to function. The metabolic energy is based on the element *phosphorus* (P) in the molecule *adenosine triphosphate* (ATP). Regulation of this chemical energy carrier in metabolic processes is determined by several factors and the primary such factor is the element calcium (Ca). This circumstance is also true for all life that preceded vertebrates, going back nearly 4 billion years, and remains true for all life since the emergence of vertebrates during the Ordovician period. Ca and P have a strong chemical tendency to co-precipitate, along with traces of a variety of impurities, as the mineral apatite, the basis for bone and for tooth enamel.

I have mentioned these chemical facts early in this essay in order to emphasize how tied to chemistry our human existence is. The chemical metabolism in all living creatures is based on the same general chemistry, called biochemistry, and on a relatively small number of elements in the periodic table. Over 99% of the atoms in living organisms, of all kinds, are accounted for by *hydrogen* (H), *carbon* (C), *nitrogen* (N), *oxygen* (O), P, *sulfur* (S) and *iron* (Fe). The biochemistry of life on Earth is universal and is so because it is based on the elements that are most readily available as a result of stellar synthesis of the elements and because of the chemistry of these mostly small elements. The molecules they readily form, such as amino acids, sugars, and nucleic acid components are also universal to life. There is also an energy driven tendency, based on ATP, for small molecules to form polymers that can be of macromolecular size, including *proteins*, *polysaccharides* (sugar chains), *polynucleotides* (as DNA and RNA) and *lipids*. These substances are again universal in life on Earth. Humans are made out of the same materials found in all living organisms. This is a biological imperative.

It does not require keen powers of observation to recognize that all terrestrial vertebrates have bilateral symmetry, four limbs (excepting snakes and eels), a brain, a heart, lungs, a stomach, a liver, kidneys, intestines, sex organs, eyes, ears, a nose, jaws and teeth. Often the fore limbs and the rear limbs are differentiated for function, as in birds. Human have two arms and two legs. Even a squirrel can sit on its haunches and hold an acorn in its front paws in order to eat it. A kangaroo does something similar as if it had arms and legs too. Because the basic biochemistry of metabolism in all organisms is the same, it is no wonder that at the organ level all vertebrates have the same organs, and similar skeletons with limbs, spines, rib cages and crania containing teeth. This is another example of a biological imperative.

Plants get their basic energy from the Sun as sunlight trapped by leaves, or other types of photosynthetic centers, and thereby converted to the chemical energy of ATP, and the reducing potential of a molecule called NADPH (included here only for completeness). This is not a very rapid conversion and plants do not have tissues that require high levels of rapid energy turnover such as do muscles and nerves. As a result plants are mainly sessile and passive energy harvesters and converters. Animals, on the other hand, do have muscles and nerves and concomitant rapid energy turnover requirements. Some have evolved to eat plants and possess specially evolved teeth needed to cut off plant parts and teeth needed to grind up the plant parts for later digestion. Animals that exclusively eat plants have specialized stomachs for the purpose of digestion and spend most of their waking existence eating, digesting and excreting. One could imagine that that is the end of the story, an edenic existence: sunlight, plants and herbivores. With time, evolution of muscles, bones and nerves could lead to giant dinosaur herbivores such as brachiosaurs and to their smaller cousins such as hadrosaurs. These developments are associated with advances in energy metabolism necessary to adequately power these mobile organisms.

The ferocity of Ca and P

Organisms needing rapid energy turnover to power muscles and nerves (brains) carried the evolution of vertebrates in another direction. In the Cambrian period this progression already occurred with the evolution of carnivores, animals eating other animals. Indeed, even during the pre-Cambrian stage of unicellular organisms there was carnivorism with unicellular life engulfing other unicellular life as food. This process of carnivorism reached truly impressive proportions with the fishes during the Cambrian, Ordovician, Silurian and Devonian periods.

When we look at the fossil fishes we easily see the importance of teeth and jaws and the ferocity of their actions in their shapes and sizes. This manifest ferocity reaches its apex on land with allosaurs during the Jurassic period and with tyrannosaurs during the Cretaceous period. Their teeth and jaws are incredible, as are their skeletons and musculature.

Are these evolutionary products features inherent in the latent ferocity of Ca and P? Are they biological imperatives? The brains that go with this apparatus of teeth and jaws (and bodies) must be designed by evolution for stalking, killing and dismembering. By the time the dinosaurs had gone extinct, animals life was on its way to dominance by mammals. There was no shortage of carnivores exhibiting fierce predatory tactics. Watching a lion bring down an impala, or a great white shark kill a sea lion, is a sobering sight. Those powerful jaws and huge canine teeth of the lion, ideally spaced for severing the spinal column of the prey, are emblematic of the ferocity of nature. Can we say that the evolutionary tendency towards ferocious carnivorism is another biological imperative, the natural outcome of the inherent properties of Ca and P and of bones, muscles and nerves?

A change in the progression of life does take place with the evolution of hominids, six to seven million years ago. These creatures are not particularly imposing as physical specimens. They are of modest size and weight, lacking large canine teeth and strong jaws, and altogether at a considerable disadvantage against the prey animals or the other predators existing on Earth with them. The advantage that they do have is that they are social creatures with relatively big brains. This means they are cooperative and smart. Working together they can compete satisfactorily against their imposing prey and against other predators. They learn from experience and they teach their offspring. Over those six million years or so evolution experimented with about 20 species of hominids, and *Homo Sapiens,* we modern humans, alone dominate the present day. The fossil record shows us anatomically in Africa about 200,000 years ago and it is thought that we became behaviorally modern about 50,000 years ago. The genus *Homo* appeared about 2.5 million years ago and at least six *Homo* species (*H. habilis, H. egaster*, *H. erectus*, *H. heidelbergensis*, *H. neanderthalensis* and *H. sapiens*) had their day in the sun. *Homo erectus* managed to survive for 1.5 million years, and recent genetic evidence suggests that 1% - 4 % of the DNA of modern humans (other than the root source of humans that stayed in Africa) is from interbreeding of *H. neanderthalensis* and *H. sapiens*. All of this evolution is attended by a great increase in brain size and function, especially cognition in the cerebrum.

The transition from bones and muscles to brains isn't simply out of the blue. Controlling bone motions with the muscles required a nervous system. That nervous system had a control center called the cerebellum that coordinated movement of the bones and muscles. It also had other centers for hearing, seeing, smelling and making sounds. The cognitive center, called the cerebrum, is what became especially prominent and large in *H. sapiens*. With it a new mechanism for evolution emerged.

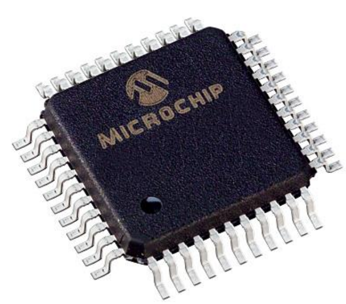
Cooperation and competition

The social nature of hominids engenders cooperation. Groups of hunters working together are able to bring down large dangerous prey animals and are able to defend them from other powerful predators and scavengers. Communication, the transfer of information, is a key capability that strengthens cooperation. It is not a uniquely human trait. For example, elephants communicate and even exhibit cultural memory, as do Japanese macaques. Humans have taken this trait to extraordinary levels. Nevertheless, cooperation is only half of the story. The other half is competition. As cooperation advanced into larger and larger groups, from families to clans and then tribes, competition developed between these groupings. Competition for prey, for territory and for status creates an outlet for that innate ferocity and leads to strife, even armed combat. The history of modern humans is so rife with strife that if it weren't for a very strong desire for cooperativity the record would be one of endless war. Humans go to battle over race, religion, kinship, political affiliation, nationality and gender. Some of the same persons who balk at capital punishment are quite willing to support the military and kill their enemies in war.

Cooperation has led to agriculture, both with plant crops and with animal herds. It enables exchange of goods and services. In the last hundred years it has made possible automobile travel over roadways, a most remarkable result, hardly predictable a hundred years ago. That we can travel 70 mile per hour a few feet apart in adjacent lanes going the same way, and in oppositely directed adjacent lanes with a relative speed of 140 miles per hour, is an outstanding example of cooperativity. Modern distribution of fresh food, of manufactured products and of fuel are others. These feats requirement sophisticated communication. Complex oral exchange using thousands of distinct utterances and the written word are uniquely human capabilities. With them mankind's ability to significantly alter the environment has reached unprecedented levels. Humans represent information symbolically, then codify it, transcribe it and disseminate it. Protocols are modified and extended. In short, the manipulation of information by humans has created a new mechanism of biological evolution, operating at an unprecedented rapid rate. Compared to this rapid rate of information utilization, the genetic information processing done with DNA and RNA is glacially slow. Human societal evolution is much much faster than the standard genetic evolution that took millions of years to produce hominids.

Is the exchange of information exclusively beneficial to humans? Clearly the answer is no! Perhaps the most sophisticated utilizations of information are carried out by the militaries of the world, with the goal of killing other persons. Highly computerized reconnaissance, communications and execution of missions by the military represent the highest levels of information processing. Soldiers living in New Mexico can drive to work where they control drone aircraft in Afghanistan and they are able to do considerable damage with the drones thousands of miles away. At five pm they drive home and play with their kids. Don’t forget that the internet was developed by DARPA (with the help of several universities) and not by AL Gore. There are a great many peaceful uses of the internet and it is an extraordinary enhancer of humanity’s ability to communicate and exchange information. Which way will our societies evolve, towards even greater military might, including government sponsored electronic surveillance of the general public, or towards even greater cultural and educational harmony? What does the fact that a major use of the internet today in the US is for pornography say about the answer?

The preceding questions bring us back to biological imperatives. In parallel with the intrinsic effects of Ca and P on living organisms, i.e. the ferocity of carnivorism based on bones, muscles and nerves, we must ask about the corresponding effects of copper (Cu) and silicon (Si). There are other elements that are as important but these two will serve to make the point. It is true that Cu and Si are relatively rare components of living tissues. We find Si, as silicates, in the spines of cacti, in the exoskeletons of sponges and in many grasses where it incorporation has co-evolved with herbivores as a defense against being eaten (by wearing down grinding teeth more rapidly). We find Cu, as an essential metallic cofactor, in critically important enzymes such as *cytochrome oxidase* and *tyrosinase*, to name just two. Where Cu and Si really make an impact is in the recent development of electronic micro-circuits,



found in computers and the internet hardware and based on microchips of copper circuits on silicon substrates. Just over a hundred years ago, electrification of society took place because of a copper wiring. Again we can think about all the boons to mankind that came with electricity: lighting, refrigeration, telephones, radioes, TV, X-rays, MRI, lasers etc., or we can think about the banes instead: e.g. cattle prods, electronic spying and tasers (there really aren't very many negatives). Is the internet a boon or a bane? Will the future reflect the ferocity of Cu ad Si, or the felicity of Cu and Si? When we contemplate the use of the internet for military purposes it makes our ability to kill almost limitless and very impersonal, but when we contemplate its use to form a "flash mob" in order to have peaceful protests, as in some instances of the recent Arab Spring, then it is a tremendous enhancer of human cooperativity. Which way Earth's humanity is going to go with the internet remains to be seen, perhaps relatively soon. Will it be the ferocity of Cu and Si, or the felicity of Cu and Si that determines the next chapter?

The brain as a rapid simulator

The purpose of the brain brings in another biological imperative. The many centers and components of the brain control many activities, including seeing, smelling, hearing, feeling, breathing, moving, reproduction and thinking. The cerebellum controls movement (bones, muscles and nerves) and reached dominance as a brain component during the era of reptiles and dinosaurs. Thinking is the province of the cerebrum and has reached its most impressive proportions in humans, although chimpanzees, elephants, mammalian dolphins and crows and parrots have impressive cerebrums as well. Since the 1970's the science (and mathematics) of *nonlinear dynamics* has taught us many new facts. One of these is that our mathematical models of the physical world are often given as nonlinear equations, and because of the nonlinear feature there is no way possible to find closed form solutions to these equations. If one wants to predict the future outcome of the dynamics there is no simple, or complex, solution into which the future time can be input and the future state read out. The best possible strategy, the only strategy, is to simulate the dynamics and allow the future to be determined by all of the past up to the future time. These simulations have been made possible by modern computers and for that reason a deep understanding of the necessity for simulation emerged with the capability to do computations with computers. The key realization is that a simulation of a dynamical process can be run at a speed much faster than the real process actually takes place when it really occurs and is objectively observed. The accuracy of the simulation decreases with the amount of time one goes into the future but there is a range of future times during which rapid simulation provides a good account about what will eventually happen in the real process, before it actually happens.

Our cerebrums have evolved for cognition. This process involves having a mental representation of external things, events and processes. Having language probably facilitates this capability greatly (each of those other organisms with impressive cerebrums mentioned above has rudimentary language skills). Our mathematical theories of the physical world exhibit how well we are able to do this representation with our brains (For a trained physicist there is probably nothing more impressive about science than the incredibly accurate treatment of electromagnetic events given by the Maxwell equations, and the quantum generalization of the same. This knowledge is responsible for the existence of computers and lasers among myriads of other things.). When it comes to the daily events we experience in society our brains also serve to allow us to rapidly simulate outcomes to behavior on a time scale faster than that for real events. Thereby, we can take decisions and take actions before real events would have transpired. By thinking fast enough we can affect later outcomes by the choices we make earlier. Thus, we can anticipate, plan and change the future outcomes of events. The brain's ability to do rapid simulations, aided today by the same ability of computers, provides us with the chance to solve our collective problems. Modern science is the output of an incredibly cooperative human enterprise that transcends the individual and gives society the opportunity to better its condition. With the internet this capability reaches new levels as has been recently observed in the phenomena of the flash mob and the occupy movement.

Nonviolent protest

Modern governments have usurped the rights of the individual person, whether these governments are democratic or totalitarian. Powerful economic forces, or powerful military forces or both dominate the politics. The populace can correct this state of affairs by working cooperatively to repair it. In democracies this can be done by voting into office a better informed and less self-serving group of politicians. In totalitarian regimes overthrow of the extant government is necessary. By cooperating in large enough groups the populace can take charge of the situation. History teaches us that when the protests become violent revolutions the new regimes rarely become better than what they replace. Violence begets more violence. A military solution to an unjust situation usually creates the basis for a new type of unjust situation. Albert Einstein lived through two world wars and the dropping of two atom bombs on civilians. In his youth he was a staunch pacifist but after World War II he was more inclined to permit some form of military, preferably controlled by a single world government, such as the United Nations. His views on pacifism, nonviolent protest and world government have been masterfully summarized by David Krieger. The reader is urged to study the Krieger essay.

Nonviolent protest has been advocated by the major religions for hundreds of years. In recent times it has worked as a strategy for change in significant cases, some of which follow:

Gandhi overcame British rule in India in the 1940's.
Martin Luther King advanced civil rights in the 1960's.
Cesar Chavez improved the condition of farm workers , also in the 1960's.
A number of anti-communism nonviolent revolutions took place in eastern Europe in 1989.
Leymah Gbowee defended the rights of women during the Liberian civil wars in the 1990's.

The recent Arab Spring benefitted from the internet dissemination of Gene Sharp's timeless essay regarding the transition from dictatorship to democracy using nonviolent techniques. The reader is also urged to study the Sharp essay. Sharp makes one point in particular extremely well, a group of persons who want to protest need to carefully consider the possible responses of the regime in power before acting. It is foolhardy to provoke a regime that will use violence against the protestors. Consider the contrasts among e.g. Syria, Tunisia and Libya this past year. Success in nonviolent protest is more likely the larger the number of protesters. The greater the percentage of the total population involved, the greater the effectiveness. The same is true for the occupy movements. It also matters whether the unwanted regime has a military taken from the citizenry or uses mercenaries, many of whom are foreigners. The latter are less inhibited about shooting protesters than are the former. Both Einstein and Sharp develop this theme in greater detail.

So what is the biological imperative for humanity? Cooperation of large percentages of the populace worldwide can bring about a globally healthier economic, political and environmental state of existence. Cooperation is a human imperative and human creativeness has resulted in computers and the internet that allow for globally instantaneous cooperation across nationalistic, and ethnic lines. Actions based on this cooperation can be and must be nonviolent. Using our wonderfully developed cerebrums as rapid simulators we can collectively contemplate the consequences of our actions and anticipate the reactions of unhealthy regimes. Our legacy can be the felicity of Cu and Si, and the cooperativity of humanity..

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