The Biomolecular Implications on Human Volition

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The human being is a complex system comprised of many moving parts that must intimately work together in order to function properly as a unified structure. Blood moves through our veins, oxygen through our blood, nutrients through our digestive system, and electricity through our nerve cells, all of which are happening without our intention, and in most cases, outside of our awareness. The ability to act at one's own discretion and control the body according to one's own will seems immediately at odds with a body that operates like clockwork whether we instruct it to or not. Do we possess any level of autonomous control over our body? Does a molecular system like the human body require a decision making faculty to exist in the first place? To me, it makes much more sense to say that there is an overarching property that can upkeep the perpetual preservation required for human life, one that is universal and entirely natural, one that we can not only extend to the movement of blood, but to the movement of our feet, to the words that we say, and to the memories that we make.

Although the idea that humans have control over their actions may be a prettier thought than the alternative, I argue that any sense of volition that humans believe they have is illusory based on the energetic principles of the natural world, a place that we too belong to without exception. By *volition*, I am referring to the autonomous faculty of the human subject to have complete, conscious, and deliberate power to control his or her own actions. By *human*, I refer exclusively to modern humans, the animal with the binomial designation of *Homo sapiens*, and the only extant species of the genus *Homo* that possesses the necessary biological characteristics required to hold an individual taxonomical classification. However, later discussion will consider what exactly does it mean to be human and what significance is there to be had in being a human subject if there is any; therefore some latitude in this definition of *human* can be expected in future conversation.

As we move forward, the validity of my thesis lies in the integrity of a single chemical property: as molecules interact, the resulting product will always reflect the most energetically efficient composition given the specific constituents of the reaction, both physical and energetic. By energetically efficient, I mean that once atomic systems have interacted and subsequently rearranged their bonding structures, the resulting molecular structure will be lowest in energy given the environmental context. Thus, there is only a single mode of conduct that molecules will adopt once placed in a novel energetic environment, invariably resulting in the necessary structural accommodations that can account for the components newly introduced, and because of this, I argue for the philosophical stance of determinism. Determinism is the doctrine that all events, which includes the actions conducted by humans and all forms of life, are caused by something external to the will. By scrutinizing our own evolution, I argue that the aforementioned chemical principle can be directly applied to the construction and manipulation of body, metabolism, growth, and reproduction, and in turn, is also responsible for the actions committed by all lifeforms from bacteria to insect to human being, not some autonomous, third-party force as put forth so often in theological and spiritual discussion.

For my thesis, I wanted to explore a topic that served as an intersection between my three focuses of study, specifically, to make a philosophical claim and support it using biological and evolutionary means. It is my belief that these areas are intimately connected, and throughout the course of this paper, I will be sure to touch on all of them. To begin, I will examine recent literature concerning experimental data on the biological processes observed in the brain and otherwise when a subject is "making a supposed decision." Next, I will turn the discussion to the chemistry responsible for such biological processes in an attempt to organize these ideas in a fashion that makes logical sense within the context of my thesis and the literature of the scientific

community. Then, heeding the aforementioned information, I will begin to construct a picture of the evolutionary emergence of life, highlighting why it is, according to my logic, less likely for humans to possess volition, and instead, is more akin to a complex Pavlovian machine.

Experiments

As of late, the scientific community has conducted a myriad of experiments exploring the fundamental relationship between brain activity and the "conscious" decisions that we make as humans. The timing of these neural events is imperative because most of the studies outlined below operate from the premise that if there is detectable activity in the brain before we as autonomous agents are aware of the decision that has been made by us or otherwise, we can further conclude that we hadn't been the ones in control of such a choice considering that the brain is already mounting a response before we are cognizant that a decision is required. Beginning in the 1960s and carrying through until today, I have selected what I consider the most important literature on the topic and outlined them below in support of my thesis.

Bereitschaftspotential[1]

It was in the 1960's when neurologists Hans Helmut Kornhuber and Lüder Deeke at the University of Freiburg in Germany studying the cerebral potentials in humans recorded for the first time what is now called the Bereitschaftspotential (BP), also known as the readiness potential or pre-motor potential. The BP is a measured activity in the brain, specifically the motor cortex and supplementary motor area, that precedes "voluntary" muscle movement. This small measurement of activity begins as early as a second earlier in the brain for very simple muscle movements, like the flicking of a finger as conducted by this study itself, or even longer

for a more sophisticated series of movements. The study itself was simple enough: a subject was asked to flick his or her own finger, and the entire time, brain activity was recorded and later reconciled with the timing of the flick. The results showed signals occurring consistently before the muscle movements, thus the discovery of the BP[1].

Libet Experiment[2]

In the 1980's, neurophysiologist Benjamin Libet organized a team of scientists to conduct a perhaps the most famous scientific experiment concerning human volition, and they used the information that was pioneered by Kornhuber and his team at the University of Freiburg. Although it was already determined that the BP could be observed before the physical action itself, Libet was more interested specifically in how this BP value correlated with a subject's conscious intention to move. Libet's team asked the subjects of their experiment to randomly flick their wrist at any point they so desired, and the BP in the subject's brain would be recorded. The subjects were also required to report at what point they had felt the conscious intention to move by looking at the second hand of a clock.

Even today, the main conclusions of this experiment have yet to be refuted. Libet and his team had determined that the brain already demonstrated activity half a second before the subject had consciously made the decision to conduct an action. This suggests that any action or choice that a subject translates into a conscious decision is first made on a subconscious level. Libet himself made the claim based on these results that any feeling a subject has that he or she "willed" something to happen is based on the necessary perspective of viewing the past through a retrospective lens, therefore, we are innately biased when reviewing our own sense of volition.

Despite this monumental discovery, there has been a slew of critiques loudly vocalized in regards to Libet's methodologies. The biggest of them was the capacity of the subject to judge their own time of awareness, something critics call "subjective recall." Second, Libet assumes the BP measured in the brain is causally linked to decision making which to some is not a grounded claim. This is perhaps the most difficult obstacle for the experimenters to justify, that the brain activity isn't just linked to muscle movement, but that it can be an indicator of our will to move as well[2].

Matsuhashi and Hallet[3]

Almost thirty years after Libet conducted his experiment, a pair of scientists, Masao Matsuhashi and Mark Hallet managed to replicate the conclusions put forth by Libet with the exception of not having the bias of each individual participant's subjective account of when the clock hands coalesced with their own intentions which, as previously mentioned, had been cause for controversy in the community. They operated under the premise that if the cause of our motions is willed intentionally, then it will follow that this intention to move will temporally occur before the movement itself is manifested with the body. If the opposite would be concluded, then in no way could something that happens after the fact be directly responsible for such an already existing action. Matsuhashi and Hallet took care to define two terms, movement genesis, and intention. The term *movement genesis* is the neurological process of generating movement, and *intention* is the actual thought that you are about to make a movement.

With this framework, the pair told subjects to quickly extend their index fingers at intervals about five to ten seconds in length, although they should avoid keeping track of time specifically. Tones would be played randomly throughout the experiment. If a tone sounded

while a subject was waiting and not thinking about making a movement, they were to ignore the tone. If a tone coincided once a subject had already started to think about his or her next movement, he or she were to stop, cancel the thought, and wait another five to ten seconds. The experimenters found, for each subject, a value "T" which stands for the average time of intention by applying an algorithm to the measure of time between sounds and actual finger extensions. They further correlated this figure with an acquired measure of a subject's event-related potential using an EEG.

The results demonstrated that the time of intention relative to the actual movement itself was about -1.5 seconds, meaning that the brain had mounted a response 1.5 seconds earlier than the measured physical reaction. Ultimately, the study came to the conclusion that it isn't one's awareness directly responsible for movement based on the experiment's hypothesis that if an intention is measured after movement genesis, then intention could not have been responsible for it. This study managed to snuff out many doubts that others had towards Libet's initial experiment. Further, Matsuhashi and Hallet did put forth the idea that it may be likely our awareness is responsible only for observing bodily motions take place just like any other environmental stimuli as opposed to having a direct effect on their genesis[3].

Kühn and Brass[4]

An experiment conducted by Simone Kühn and Marcel Brass explored the possibility that it is not our own volition that has the power to cancel certain actions at the final moment before the action is exhibited by the body. Kühn and Brass worked from the premise that as agents of volition, we should have access to certain information about our actions, in this case, the ability

to intentionally veto an action before it's conducted. In other words, Kühn and Brass wanted to test self-knowledge; how much do we *know* about ourselves and the actions that we make?

The experiment asked subjects to react to a visual stimulus, specifically, a green light on a traffic light. When the go-signal appeared, the subject was to respond by pressing a button as fast as they could. Of this, reaction times were compiled for all subjects. This concluded the primary test which was then followed by a second test that was carried out like the first with an added variable. Kühn and Brass added a random second single after the go signal, either a designation to stop (red light) where the subject must immediately cancel his or her decision to react to the go signal and refrain from pressing the button, or a "decide" signal was shown (orange light) in which the subject had the decision to push or not to push, a randomly determined judgment made by the subject in that moment. After each "decide" trial, the subject was asked if they had acted on impulse or if they truly thought that they had time to consciously decide whether to abstain or to follow through with their action, and thus, two categories were created for each decision signal: failed to or successfully decide. In theory, all trials in which a subject either reacted to the go signal alone, to the go followed by the stop signal, or the decide signal but claimed that they had failed to make a decision should yield similar if not the same reaction times. In trials where a subject feels as if he or should make a conscious decision after seeing a decide signal, then a slower reaction time would be expected, an allotted time to actually conduct the contemplation.

The resulting reaction times were that for impulse trials, the subjects reacted at an average of 600 milliseconds. For the successful decision trials, a much longer time was noted: 1400 milliseconds. What Kühn and Brass did next was compare the participant's response to whether or not they believed that had consciously made the decision during decide trials with the

two determined reaction times to test whether or not the subjects themselves had access to the knowledge of having made a decision. Further, many participants stated that they had made the conscious decision during decision trials while still reacting with impulse reaction times. The reason this is significant is because, in theory, no participant should have any issue in classifying whether or not they had actually made a decision, and yet, many times over, a myriad of subjects claimed they had consciously made a decision and hadn't, reflected in their reaction times appearing as impulses and not distinct contemplations[4].

Soon, Brass, Heinze, and Haynes[5]

Startling results from research recently conducted by scientists Chun Soon, Marcel Brass, Hans-Jochen Heinze, John-Dylan Haynes has led to the conclusion that there is notably activity in the prefrontal and parietal cortexes of the brain up to ten seconds before such a decision even enters our awareness. Their experiment was simple enough: subjects were asked to freely choose between a left or a right button whenever they so desired to do so. After a decision was made, another trial began, and a period of time to make a decision was allotted, after which the subject would again make the same decision. Each subject was hooked up to an fMRI machine which measured activity in the specific sections of the brain already having been determined to be correlated with either left or right button press.

It was concluded that 88.6% of participants showed activity in the correlative section of the brain an average of 1000 milliseconds before they had "decided" to press either button. These results suggest that when the decision of the participant had reached the level of conscious awareness, it had already been influenced by unconscious brain activity for as long as ten seconds beforehand. When compared to the previously mentioned studies, this predictive time is

significantly longer than earlier conclusions, and also, the results of this study suggest that during the preparatory time period in the subconscious brain, the activity is not “unspecific” and instead directly influences if not encodes how a participant is going to manifest an action[5].

Soon, He, Bode, and Haynes[6]

Soon and his company conducted a novel study under the pretense that all previous findings that neural activity precedes subsequent choices of free will were restricted to very simplistic motor choices like finger flicks or image recognition. This team of scientists wanted to explore if these findings remain steadfast in the wake of more complicated and abstract decisions. This study had subjects deciding to add and subtract numbers to determine whether or not this free choice could be decoded from brain activity before the subject is even aware that they had made a choice. Ultimately, the study confirmed this suspicion, concluding that unconscious preparation in the brain is not limited to simple motor activities and can be extended to “multiple scales of abstraction.” [6]

Bode, et al. [7]

A team of scientists led by Stefan Bode conducted a study which aimed to uncover the consequences of a decision in a perceptual task from “spatially and temporally distributed” brain signal patterns. The team used an approach called multivariate patterning when analyzing the human electroencephalogram, and they used this to measure the brain activity of subjects presented with a multitude of stimuli. Participants were asked to categorize presented images; for example, an obscured image would be shown, and a subject would have to label it as either

an image of a chair or a piano. Sixty-three site electrodes were planted on the subject's scalp to read brain activity as these processes were carried out.

When real object stimuli were presented to a subject, information about the specific choice was encrypted in spatially distributed brain activity appearing about 140 - 180 milliseconds after the stimulus had occurred. These results present the first ever evidence of specific information about choice outcomes being reflected in EEG signals themselves. The team believes that exploring this approach further could pave the way for developing deeper ways of predicting our choices using EEG technologies before we ourselves are aware of the decisions that we make[7].

In summation, there is a wealth of established and ongoing experimental work aimed at unveiling the molecular secrets behind our choices. The scientific community seems in agreement that there is certainly chemical activity preceding the conducted action in our brains and in our muscles, activity that precedes even our own awareness of such action. Next, I will dive into a discussion concerning the chemistry itself. In my discussion, I seek to explain this source of motion in chemistry in hopes of eventually stimulating an evolutionary conversation to outline how the following principles directly apply to the molecules of the body and can account for anything that could be attributed to a volitional faculty.

Atoms

An *atom* is the smallest unit of matter that defines the chemical element[9]. To begin, it is imperative to first discuss the components of an atom because atomic properties and the implications of these properties on the interactions between other atoms is where the crux of my

argument lies. Simply put, the atom is primarily composed of two parts: the electron cloud and the nucleus. The electron cloud houses the quantized unit of negative energy called the electron, whereas the nucleus contains neutrons, bearing no net electrical charge, and protons which are quantized units of positive energy[9]. Any components smaller than these, although in existence, will not benefit this discussion.

The quantum electrodynamics of the atom are organized in such a way that the energy of one proton "cancels" the energy of one electron, begetting an energetically stable system when an identical number of electrons and protons are present in the same atomic system[10]. The electrical relationship between the negatively charged electrons and the positively charged protons is paramount in the emergence of the molecules and macromolecules responsible for the construction of bodies and metabolisms that will eventually propagate life.

When an atomic system has the same number of protons and electrons, it is in energetic equilibrium, so when the number of protons and electrons differ, the resulting system is unstable at an energetic level. Therefore, the uncomfortable atom is now considered "reactive" and is willing to change its electrical situation to beget a lower energetic state[10]. This is the source of complexity: energetically unstable atomic systems organizing in such a way as to create the most energetically efficient orientation as possible given the environmental tools at hand.

Molecules

A *molecule* is a collection of two or more atoms chemically bonded together, representing the smallest fundamental unit of a chemical compound allowed by natural law to take part in a chemical reaction[9]. It is important to note that natural law is to be regarded as nothing more than regularity. In the sciences, we observe this regularity and attempt to give

logical meaning to it by creating formulas that can account for the collected observation of this regularity. With that said, when natural law is referred to, it is under the pretense that there is no definitiveness in the laws of the universe, and we can only carry forward piecing together our empirical data.

As we climb from the atomic to the molecular level, we are forced to ask the question: why do these atomic systems associate in the first place? This question can be answered applying the fundamental quantum electrodynamics outlined previously. The electron clouds of atoms are composed of electron shells that can be thought of as the houses that electrons are likely to be found in at any given time. These shells have a limited capacity, meaning they have a finite number of electrons that they can hold[9]. For example, the first electron shell, the one closest to the nucleus, has the ability to hold two units of quantized negative energy. So when two electrons are contained in an atomic system, such as in the element Helium, the first electron shell is considered "full." After this point, an electron shell proximally further away from the nucleus begins to house the subsequently added electrons, such that Lithium, which has three electrons in its naturally stable state, will have two electrons housed in the first electron shell, and since this is the maximum capacity of electron density that this shell can contain, that third electron will be found in the second electron shell further from the nucleus. This second shell, unlike the first, can hold eight electrons maximum[9].

The importance of this comes from the combined notion of valence and a property known as the octet/duplet rule. The outermost electron shell is called the valence shell[9]. If, for example, we take the second electron shell, which has a maximum capacity of eight electrons, a system with a *full* valence shell (all eight electrons present) is going to be lowest in energy compared to other systems with incomplete shells. A complete valence system is fundamentally

lower in energy than one that's incomplete[10]. For instance, Neon is a more stable atomic system than Fluorine because Neon has ten electrons, whereas Fluorine has nine. Two electrons are placed in the first valence shell, and eight in the second. Neon would have a full valence, whereas Fluorine would be one short. The implications of this are that Neon will not react to be more energetically stable because it is in an already stable state. Fluorine, on the other hand, is very reactive because it makes energetic sense to reach that state of stability with a full octet, or eight electrons in its valence, hence, the octet rule[10]. The reason atoms amalgamate to create molecules is to establish the lowest energy state possible.

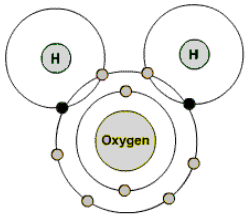

Figure 1. Diagram of molecular water demonstrating how atoms share negative density to be more energetically stable. The black circles are the electrons being shared. Note how Oxygen now has eight electrons in its valence and Hydrogen now has two.

Atoms have a way of filling their valence shells completely while alleviating the need to impose a further negative burden upon their nucleus where the protons are housed. Through what is known as ionic bonds, atoms can share electron density with one another, where the valence shells of atoms overlap and the negative energy is shared amongst the atomic systems[10]. Water, for example, is the product of two Hydrogen atoms each with one electron in its valence shell but requiring two for a complete first shell, and one Oxygen atom, which has six valence electrons requiring eight for a full outer shell, overlapping their valence shells to create a more energetically stable system than if the atoms were to be apart from one another with incomplete valences (Figure 1).

It is because of this valence concept that Carbon, for example, is found so abundantly in organic life. Carbon possesses four valence electrons, meaning that it can form ionic bonds with

up to four other atoms, possibly begetting long, complex molecules, great for tissue creation and other structures that are necessary to maintain life.

Acidity and Basicity

When an atomic system has an abundance of positive energy, meaning that the system has more protons than electrons, it is called an acidic system[9]. Acidic systems are considered reactive because of the energetically unstable state that the atoms and molecules of the system are in; the same can be said for basic systems, except that they contain an abundance of negative energy, more electrons than protons. The implications of this phenomenon are such that when an acidic system interacts with its environment, it will do so in such a way that it will obtain as much energetic stability as it can given the resources available. This can lead to a heavy rearrangement of bonding patterns and energy allocation.

To illustrate this, if a strong acid like hydrochloric acid were to come into contact with the complex of hydrocarbons in your skin, once the acid particles have ionized, the hydronium atoms, which is a single proton without a counterbalancing electron, will begin to ransack the chemical systems in your flesh, redistributing the chemical bonds in a new way that now *includes the added hydronium* in order to find the most energetically stable state that it can. The result is a "chemical burn," but what has ultimately happened is that an energetically unstable system interacted with its environment and created a new bonding structure, all in the name of energetic stability according to the laws of quantum electrodynamics. Before interaction, the hydronium and the hydrocarbons of the skin were both in situations that made the most energetic sense at that time, but once the two systems came into contact with one another, the hydronium now has a means to eliminate its positive burden with the newly introduced hydrocarbons in your

skin. The repercussions of this are that the orientation of molecules in your skin has to now change *necessarily* based on natural law since a new environment with new components has been introduced, and if a different bonding structure would be more energetically stable with these newly introduced components, we expect a change to take place[10].

To give a biological example, the cells of your body divide constantly throughout your entire life and undergo apoptosis when it is considered necessary. This process carries forward outside of our awareness, and it is imperative in maintaining a healthy body. Then why would anything ever go wrong? Why would cells ever become cancerous and lose the ability to replicate properly? Cells divide appropriately until the body is put in an environment where the energy equation that properly carries out cell function is changed[11]. That's why certain tanning lamps and other sources of harmful ultraviolet light can cause melanoma; in exposing your natural energetic system to a foreign energetic field, the molecules of the body must accommodate. Cancer arises from the chemicals in tobacco smoke as well. By introducing different molecules into your system continuously, the body's natural molecular constitution is forced to accommodate the energetic principles of the newly received chemicals which can result in all kinds of molecular compromises, some of which do not promote the viability of the biological system[11].

A Discussion of Evolution and Other Things

The famous quote by Theodosius Dobzhansky that has resounded through Biology lecture halls for decades now seems an appropriate way to begin this discussion: "Nothing in biology makes sense except in the light of evolution." Although it may now be an overused sentiment, Dobhansky's declaration is unforgivingly true and is a statement of both scientific and

existential proportions. It screams out that the human system is a marble carved into sculpture by the principles of the natural universe over billions of years of trial and error, wings and scales, life and death which, of course, is a topic not for the philosopher's table, but the biologist's. I will take this opportunity to synthesize all of the ideas put forth so far in addition to some knew ideas from both a scientific and a philosophical perspective.

Shall we begin with a simple question: what is life? Life is merely a category, an organization of matter[12], just like the mountains or the rivers or the clouds, all just an organization of molecular systems. In the previous section, I touched base on why it is that atoms create complexity; it's a function of energetic stability. Life too can be explained in the wake. What often confuses is the seemingly autonomous mobility of life when comparing the organic and inorganic. Humans and birds and fish move around whereas rocks and soil stay put unless acted upon by an outside force. So why is it that humans and birds and fish move around in the first place when rocks do not if they are both made of the same physical particles organized in different patterns? It's because of the nature of the specific organization of matter that makes life *life*.

Life is a perpetually fluctuating energetic system, meaning energy is constantly being transferred between the molecules of the body. This is called *metabolism*, one of the three requirements to be allowed under the category of *life*[12]. The other two requirements are a *body* and an inheritable *genetic code*[12]. If an organization of matter possesses all three of these qualifications, then we can call theses groups of atoms *life*. I will briefly explain these three concepts.

Metabolism is the chemical reaction that converts the energy of the sun into an sugars the body can use to carry out its functions[12]. All of the energy used to propagate the chemical

reactions that keeps life as it is comes from the sun. Plants and cyanobacteria can undergo photosynthesis which is a process that converts the sun's energy into sugars. Animals can then metabolize these sugars, meaning the energy stored in the bonds of the sugar molecules can be released and transferred to the animal body. Even animals who eat other animals are still getting their energy from the sun because their meal had eaten the sugars in plants themselves (for example, cornstalk creates sugars from the sun, cow eats the corn and gets the sun's energy, human eats the cow and gets the same energy albeit in a lower quality state). Next, *body* is the barrier between this metabolic chemical reaction and the environment from which the metabolic energy is derived[12]. A *genetic code* is a molecular pattern that contains the information necessary for the construction and orientation of the body. This code must be inheritable, meaning that new bodies must be able to be constructed to replace preexisting ones[12]. As time goes forward, bodies accumulate physical changes because of its constant interaction with the environment. For example, to obtain an energy source, locomotion is required which, in many cases like with terrestrial animals, requires limbs. Limbs are made of molecules that undergo physical changes based on its energetic requirements given the environmental context. The longer and more often the components of an animal's limbs are exposed to environmental stressors, the more opportunities for physical accommodation there would have been, and so after time, the body undergoes molecular changes and no longer can function. This required a need to create new bodies, and this is what reproduction is. In passing on this genetic code, new bodies can replace the old damaged bodies[13]. If this component didn't exist, then life wouldn't be a long lasting phenomenon, and the spark that started life in the ocean would have led to a single body and metabolic system that quietly died out after the system was degraded from an accumulation of environmental stress.

It is the function of the genetic code to organize the body. It is the function of the body to procure the tools necessary to acquire metabolic energy. But why is this the case? Why is it that these molecules have organized in such a pattern? It comes down to the point I've been articulating this entire time: molecules always organize in the most energetically efficient means possible, so what does this mean for life? Given the goldilocks principle of Earth's conditions, life is just a manifestation of this energy principle given the context. Given the physical resources and the energetic situation at the site of the origin of life, it made most energetic sense to carry on as a body and metabolism[12]. The word for this specific means of molecular progression is evolution[13].

At one point after the Earth had been established, the molecular connections based on these laws of electrodynamics deemed it most stable to carry on in the dynamic system of life. The origin of life was conducted under the ideal conditions, with the necessary molecules, and the proper energy equation, that at that quantum moment, an enzymatic system emerged from inorganic material present at the site. I say enzymatic because of the nature of the enzyme: it is a molecule that undergoes chemical change but is not consumed or changed into another isomer in the process. It maintains itself. So the early emergence of life was just a contained dynamic energy equation manifested as a chemical reaction (metabolism) within a body.

To dispel confusion, I believe at this point it is pertinent to also define *time* according to these laws, considering that life emerged as a function of time. Time is a sequential organization of space and the matter within it. Time is dependent upon space, but space is independent of time, the arithmetic in which the geometry can exist. As atoms move through space and associate with one another, their motions are organized one after another, and the "longer the duration," the more atomic associations have occurred. Complexity is directly correlated with

time; the more time, the more complexity has the chance of existing because atoms have had more opportunity to find themselves energetically stable situations. This being the case, when comparing the human body with, say, a molecule of water, the human system has taken more *time* to come about than the water molecule because it is more complex, or perhaps it's better to say it is more complex because it has taken longer to make.

One may then ask, why do both molecules of water and the human body exist simultaneously if both have been given the same amount of time to associate atomically? It's because both water and the human body are both the best energetic system that could have possibly existed given the specific and complete history of their atomic collisions. Most molecules of water bouncing about our oceans haven't been given the opportunity to beget complexity because all they experience is other water molecules. The same cannot be said for the evolution of life.

If we analyze the progression of life as time carries forward, we can empirically observe how complexity increases with the number of atomic associations that occur. If, at the origin of life, we had a very simple manifestation present, like a bacterium, we see that there is not much difference between this "organic" enzymatic reaction and an inorganic one, say, that occurs in a chemistry lab. The only real difference is that the organic chemical reaction is occurring within the confines of a body, which is a separator between the semi-closed chemical reaction (metabolism), and the now apparent environment. But, in essence, there isn't much of a difference between the contained chemical reaction and the uncontained.

A body, in the bacterium's case, is really a cell membrane made of phospholipids[14]. These phospholipids are molecules that, again, arose from the random associations of atomic systems according to Earth's conditions. These phospholipids are special because they have a

hydrophilic (water-attracting) head, and hydrophobic (water-repelling) tail[14]. This property can exist as such by the quantum electrodynamics of the atoms that make up the molecule, and it is this precise property which is a good means of separating the environment from the enzymatic metabolism. If life began in the oceans of Earth, then within the confines of a water-repelling compartment, the arrival of a contained chemical reactions (again, metabolism) doesn't seem so far-fetched.

So if we started with the bacterium, comprised of a simple metabolism and a phospholipid body, and we give this atomic system more time to associate with its environment, increasing the quantum opportunities to undergo chemical reactions, we see, naturally, more complicated systems arise. The bacterium, to the eukaryotic cell, to simple sea life like jellyfish, to traditional fish shapes, to amphibians, reptiles, mammals, primates, to humans, the complexity of the semi-closed systems increased when the atoms were given more and more opportunity to associate themselves with the molecules in their environment. More time means more quantum moments of associations, begetting more complicated chemical reactions[15].

This is why I love the phrase natural selection so very much. According to the natural laws of quantum electrodynamics, the macromolecules of life are constantly associating with the molecules that exist outside of the body (environment). When the body atoms associate with the environmental atoms through ingestion and metabolism, and the environment can provide atoms that will increase the energetic stability of the system, then nature will "select" these atoms and craft a more complex but better stabilized system.

Now, allow me to recapitulate and organize these ideas more systematically. Atoms associate with one another randomly, and when they do collide with other atoms, if the two molecules can conserve energy by working together based on electrodynamics and valence, then

they will form ionic bonds and carry on moving randomly as a molecular system. As time carries on, and more opportunities for collision have been conducted, if molecules associate with other molecules and find that crafting a macromolecule is more energetically efficient, it will, again, ionic bond together and carry on. Given even more moves, molecules associated in the depths of water deposits where a chemical reaction started that was contained within a phospholipid bilayer. This new body and metabolism continued to associate with the conditions imposed by the atoms around it and eventually, complexity began to increase. The processes of evolution continued to craft these systems into the most energetically favorable system at any moment, given Earth's conditions at the time.

Now, if we bring volition into the fray, I believe within this context, to attribute these molecules as having choice in action and motion is fundamentally flawed. With regards to the human being, just because the energy equation behind action has become so complex and subtle over time, there is no need to resort to an idea of volition as a default for the reasoning behind such action. The human being is an immensely complex Pavlovian system constantly reacting to its environment with the molecular tools evolution has provided.

This can be highlighted if we can compare the human being to forms of life not regularly associated with having a volitional faculty like a tree or even a bacterium. The human being shares a common ancestor with every other manifestation of life on this planet, including trees, bananas, koala bears, and viruses, unless of course there have been multiple origins of life which, statistically speaking, seems highly unlikely although it should still be considered, but let us assume the possibility is negligible for now[16]. The implications of this are that if volition exists, it emerged throughout the course of human evolution. If we attribute volition to the human, it is unfair to remove the possibility of our ancestors across millions of years of evolution of also

having this trait. Otherwise, somewhere in becoming human, we acquired the gift of choice which, evolutionarily, doesn't make sense because evolution doesn't hand out gifts. It acts in terms of very slow, very incremental units of trial and error. It also seems absurd to say that bacteria, trees, insects, etc. are consciously making choices. Why would the source of motion, in the long evolutionary journey that led us to where we are, somehow become billions of isolated incidents stored inside the brains of the arbitrary human when, before the advent of humans, motion can be explained energetically? It seems to me that it is much simpler to say that the actions of humans have become too molecularly complex for us to delineate easily as opposed to their being some magical point in evolution where macromolecules gained access to such a gift.

The experiments I earlier highlighted in this paper all demonstrate that the molecules in our body are already in response to our actions before we are even "aware" that such decisions are being made. This, to me, suggests that the actions our bodies conduct are not a choice that we make, and instead, just like the trees and the viruses, are a natural energetic response to our environmental situation. As to what this "awareness" actually is, that's a topic I'd like to stay away from for it is not relevant; we aren't concerned with whether we have a consciousness, just whether or not we have control of the things we do. The possibility exists that we may be aware of our specific body and the actions that it conducts without directly participating in the experience, like an isolated, third-party observer. It is because of this possibility that I separate possessing awareness and having a volitional faculty.

It is very popular nowadays for evolutionary biologists to perform experiments that seek to replicate the spark that started the perpetual chemical reaction of life in a laboratory setting. In 2010, Dr. Craig Venter demonstrated that systems can amalgamate in a lab to demonstrate life-like attributes, inspiring the race to create "synthetic life."[17] Also, last year in 2014, a study

was conducted by a team of scientists and mathematicians that, using nematica and an ATP source contained inside an unrestrained lipid vesicle, sought to replicate the complexity observed in living organisms with synthetic materials[18]. They learned that defects in the liquid crystals spontaneously move about and can be considered self-propelled particles, and such defects prompted the advent of dynamical states, such as a periodic state that oscillated back and forth between two isomeric configurations (kind of like a pseudo-metabolism) and a vesicle that would progress through manifold orientations and develop protrusions that were reminiscent of cytoplasmic projections like those seen in migrating cells[14, 18]. These types of studies accentuate how possible it would be for inorganic material to act like organic material and even evolve as their environment changes. The chemistry must accommodate, just like in biological systems, based on energetic law.

If these experiments can demonstrate that, given the right conditions, the inorganic becomes organic and begin to associate in the same way that biological systems do, it becomes much more palatable that life as we know it arose in a similar way. People often associate a certain significance with life, but the way that I see it, life is no more (or less of) an important or surprising compilation of molecules than the mountains on Venus, or the storm clouds on Jupiter, all of which are just the most energetically stable atomic configuration given the random association of atoms at a certain point in time under certain conditions, abiding natural law. This is also why I really enjoy the attribution of Plato regarding a God as a certain guided intelligence[19]. I am by no means a religious person, but the shape of the human, or the tree, or the mountain is a product of natural law that guides the orientation of matter. We are the way we are because of the confines of these laws, so in a way, when dogmatists say we are God's

children, or that we were made in God's image, it is, in a way, true if we consider God to be this guided intelligence of gravity, quantum electrodynamics, etc.

Another point that I believe supports my ideas can be imagined when we think of a time when Earth's conditions change to an environment incapable of sustaining life through a mass temperature change or an eradication of the atmosphere or something of the sort. What does this mean: "incapable of sustaining life?" When conditions no longer support life, this just means that the atomic associations are now occurring in such a way that it no longer makes energetic sense to carry on as a semi-closed system of body and metabolism, á la life. This being the case, the system will "die," and its molecules will be repurposed in a way that doesn't include a body and metabolism. The same process occurs when we speak of the erosion of mountains or the change from a forest to a savanna when the climate changes. Atomic systems are reacting to other atomic systems, both of which arose via random molecular collisions. There is no volition in necessity.

What's more, if we think about the process of freezing our food, we can fundamentally see this concept at work. When you decrease the temperature of a system, what is really happening is the random association of atoms is happening at a slower speed[9]. When fewer associations occur, the likelihood that the macromolecules of the system interacting with their environment and changing based on these interactions has decreased significantly. Therefore, change is hindered and complexity arises at a less rapid pace.

I believe these ideas, to a point, reconcile the views of ontological reductionism and holism or emergentism. The reason I say this is because complicated systems that produce a function, such as flight for a bird, or respiration, or any phylogenetic response to an environment; these functions are not initially accessible properties to a single atom by itself. However, they

are potential functions of an atom to be realized. Given "X" conditions under "Y" amount of time, then atoms will amalgamate to produce function "Z." In a way, life as a system emerged from the natural laws of chemistry and quantum physics, but if function is an intrinsic potentiality of the atomic unit, it appears that the atom had the capacity to perform these functions all along. So although there is a hierarchy of systems occurring (atom to molecule to macromolecule to biological response), the fact remains that the atom had the original capacity to organize in such a way if the conditions proved to be ideal regardless of what steps it took to get there.

Emergentism is often described as a nonlinearity perspective on the progression of life, but I find this to be a misnomer[20]. By nonlinearity, I am referring to an indeterminist perspective in which there are multiple ways in which something could have happened based on events not necessarily requiring a cause, as opposed to treating reality as Euclidian like in determinist thought. There is only one way that the atoms and molecules could have combined at any moment in their quantum dance, and it was the orientation that was most energetically efficient. So to treat holism or emergentism as a function of a nonlinearity conception of life, it implies that things could have carried on otherwise as opposed to the way that they did. What I'm getting at is that emergentism is a potentiality of atomic reductionist principles as it stands[21].

In opposition to my position, believers in free will claim that actions are free because they are the result of decisions formed by you[22]. This goes hand in hand with an indeterminist perspective which rejects the deterministic notion that everything has a cause by putting forth the claim that action may be *influenced* by preceding events, but doesn't necessarily have to be caused by it. Further, there are two claims that indeterminism is based on, one stating that at

least some human actions do not have causes, the second stating that those actions without causes are "free." However, this indeterminist position cannot possible work as an account of human freedom. Since, according to indeterminism, an action is free only when it is not caused, then using an example outlined by Mark Rowlands in *The Philosopher at the End of the Universe*, we can dismantle this position[22].

Scenario one outlines a person with a neurological disorder that forces his arm to randomly shoot out like a nervous twitch, thus, the action is caused because it is directly attributed to the disorder occurring in the brain. Scenario two speaks of the alternative: a man's arm randomly shoots out, but for no reason whatsoever, *it has no cause*. Either the twitch has a cause or it doesn't, and if it has no cause, as described by the indeterminist position that "free" action exists without a cause, then the twitch with no cause wasn't something that was *willed to happen* because it happened for no reason. The indeterminist has confused the concepts of freedom and spontaneity. If the arm twitch occurs randomly, you didn't will it into action, and if you did will it, then you are the cause, leading to the claim that everything has a cause[22]. This is the fundamental problem with free will:

Premise: If our actions are caused, then they are not free
Premise: If our actions aren't caused, then they are not free
Premise: Our actions are either caused or not caused
Conclusion: Our actions are not free

In biology, there are certain factors such as jumping genes, random drift, and gene mutants that have been called by some like Japanese theoretical population geneticist Motoo Kimura as being indeterminate. In the neutral theory of molecular evolution, it is outlined that variation observed in evolution is not caused by natural selection, but instead by random drift of mutant alleles that are neutral, and Kimura among others state that these events take place under

indeterminist principles which in essence implies that variation is not always the result of a direct cause and has arisen entirely randomly[23]. However, the fact remains that these parts (genes, mutations of these genes, etc.) are all molecular compounds and should necessarily abide by the same energetic laws that all other molecular compounds must follow. To claim that these "random" biological events are contraries to universal energetic principles is naïve. It is more logical to make the claim that the energy transfer that occurs to beget such phenomenon is happening in such a complex and rapid fashion that what may appear as random is just too sophisticated for the human observer to delineate.

Although my position may sound very materialist, I believe that there could also be a heavy essentialist argument that could be made here. I will explain this point using an analogy. Imagine that on a wall someone paints an intricate landscape with rubber cement. To the naked eye, no one would see any of the lines drawn just yet. Someone then stands twenty feet from the wall and randomly tosses handfuls of sand towards it. As the number of throws increases, the amount of landscape that is unveiled by the sand that sticks when thrown will continue to increase and increase, and the scene will get more and more complex. I believe it is possible for life to be analogous to this situation.

A final concept I would much like to interact with is Lynn Margulis's Gaia Theory. This idea outlines that all manifestations of organic life on Earth influence the environment, which in turn influences the life forms and so forth into a fractal of causes of effects, begetting a complex and homeostatic system that includes all of the molecules on Earth[20]. In my theories, the Gaia Theory is heavily supported; the complexes of life are, to me, no different than the complexes of the biosphere. Just like metabolism being the concerted chemical reactions contained within the

body, the atmosphere contains dynamic and reactive parts that influence one another based on molecular associations too.

I think that the ideas that I am postulating provide much reason to celebrate. It puts all forms of life onto a single plane, such that the human is no more important than the cow which is no more important than the ant, tree, bacterium, stone, or dust particle. We are all just forms attempting to maintain energetic stability under the watchful eye of natural law, and of this, there is equalizing reconciliation between all forms of matter. You need to look at the picture, zoom out to thirty thousand feet, look beneath you and realize that it all looks the same, and it is all beautiful. Not having choice in your actions may sound scary, but maybe it'd be better if we just sat back and enjoyed the ride.

Conclusion

I believe attributing the faculty of volition to the human subject is just the human excuse for something we do not understand entirely clearly and perhaps never will. To track every molecular pathway that occurs when we make a supposed decision would fry any supercomputer's hardware, not to mention the possibility that volition may be carried out through an unobservable channel. Maybe the human system is too complex to be able to make any surefire claims, but I will not state, in my naivety, that I am in control of the things I do. There may be unpalatable moral repercussions to my hypothesis; criminals are no longer at fault, depression is an ever-creeping and unavoidable wave of darkness that will inescapably overtake some of us, cancer and medical deformities are just energetic realities; all these things may be a hard truth to swallow, but maybe it shouldn't be up to us in the first place, that is, *if* anything is up to us in the first place.

Works Cited

[1]Shibasaki H, Hallet M. What is the bereitschaftspotential?. *Clincial Neurophysiology* 117 (2006): 2341-2356.

[2]Libet B, Gleason CA, Wright EW, Pearl DK. Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential). The unconscious initiation of a freely voluntary act. *Brain* 106.1 (1983): 623–642.

[3]v Matsuhashi M, Hallet M. The timing of the conscious intention to move. *EJN* 28 (2008): 2344-2351.

[4]Kühn S, Brass M. Retrospective construction of the judgment of free choice. *Consciousness and Cognition* (2008) 1-10.

[5]Soon CS, Brass M, Heinze H, Haynes J. Unconscious determinants of free decisions in the human brain. *Nature Neuroscience* 10 (2008): 1-3.

[6]Soon CS, He AH, Bode S, Haynes J. Predicting free choices for abstract intentions. *PNAS* 110.15 (2013): 6217-6222.

[7]Bode S, Sewell DK, Lilburn S, Forte J, Smith PL, Stahl J. Predicting perceptual decision biases from early brain activity. *The Journal of Neuroscience* 32.36 (2012): 12488-12498.

[8]Schwartz, Eric L. *Computational Neuroscience*. Cambridge, Mass.: MIT, 1990.

[9]Tro, Nivaldo J. *Chemistry: A Molecular Approach*. 3rd ed. 2013.

[10]Wade, L. G. *Organic Chemistry*. 8th ed. Upper Saddle River, N.J.: Prentice Hall, 2011.

[11]Voet, Donald, and Judith G. Voet. *Biochemistry.* 2nd ed. New York: J. Wiley & Sons, 1995.

[12]Margulis, Lynne and Sagan, Dorion. *What is Life* New York: University of California Press 2000.

[13]Zimmer, Carl, and Douglas John Emlen. *Evolution: Making Sense of Life*. Greenwood Village, Colo.: Roberts, 2013.

[14]Brooker, Robert J. *Biology*. 2nd ed. Boston: McGraw-Hill Higher Education, 2008.

[15]Ridley, Matt. *Genome: The Autobiography of a Species in 23 Chapters.* New York: HarperCollins, 1999.

[16]Shubin, Neil. Your *Inner Fish: The Amazing Discovery of Our 375-million-year-old Ancestor*. London: Penguin, 2009.

[17]Venter, J. Craig. *Life at the Speed of Light: From the Double Helix to the Dawn of Digital Life*. New York: Viking Penguin, 2013

[18]Keber, et al. Topology and dynamics of active nematic vesicles. *Science* 345.6201 (2014): 1135-1139.

[19]Jowett, Benjamin. *The Dialogues of Plato*. New York: Random House, 1937.

[20]Margulis, Lynn. *Symbiotic Planet: A New Look At Evolution*. Houston: Basic Book 1999.

[21]Kukla A. Antirealist Explanations of the Success of Science. *Philosophy of Science* 63.1 (1996): 298–305

[22]Rowlands, M. *The Philosopher at the End of the Universe*. New York: St. Martin's Press, 2004.

[23] Kimura M. Evolutionary Rate at the Molecular Level. *Nature* 217 (1968):624-6.