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Neuronanotechnology to Cure Criminality and Mental Illness

Nancy Woolf, Ph.D.

This article was adapted from a lecture given by Nancy Woolf, Ph.D., at the 2nd Annual Workshop on Geoethical Nanotechnology, on July 20th, 2006 at the Green Mountain Retreat of Terasem Movement, Inc., Lincoln, VT.

Dr. Woolf, a Neuroscientist with the University of California at Los Angeles, shares her explorations and theories addressing the latest advances in neuronanotechnology concerning some of the important mental illness issues of our society.

My talk on neuro-technology to cure criminality and mental illness will cover a conceptualization that is motivated by nanotechnology[1] and what this very exciting new field may be able to afford us. I want to point out first that in order to elucidate potential cures, we have to first have a physically detailed model of mind and we don't yet have that.

What I'm going to present today is in essence a simpler, rather than a more complicated, conceptualization of how the brain might encode a single thought. I want to stress that this is an idea, not established fact, and I welcome your constructive criticism.

Neural [2] networks are part of the solution of figuring out how the brain produces mind but a bio-molecular or biophysical approach is ultimately going to be the most complete.

These different approaches are in their earliest stages.

> ***"One biomolecule of interest is the microtubule and there has been a number of research forays into how the microtubule might participate in higher consciousness."***

I'm going to talk in particular about data that I collected over the past ten to fifteen years relevant to how microtubules participate in learning and memory.

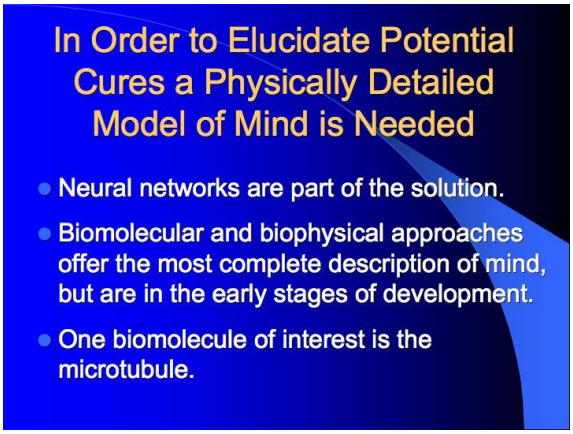


Image # 1 - Neural Networks

There are empirical data that I'm going to present, which I'm going to combine with a theoretical conceptualization. The current approach I'm taking is to define the mind as a unique, interwoven collection of thoughts. I'm going to have as a goal the understanding of a single thought.

Some people in the field have been talking about starting with the single molecule or starting with the single neuron [3]. I'm going to start with the single thought and try to come up with some kind of fingerprint or blueprint for a single thought. I'll give you a little heads-up, I'm going to conceptualize a single thought as a pattern of electromagnetic current transmitted and amplified along some length of a microtubule [4], let's say, a few microns to five, maybe even ten microns, which in some cases might be the full length of the microtubule inside of a neuron. We call the transmission of current along a microtubule "conductive signaling."

"The conceptualization is that we have a fingerprint consisting of a microtubule that stores a template for an electromagnetic wave."

And much like you would have for a sound wave, a complex sound wave with timber, there would be a fundamental frequency along with sub-harmonic components. You have something specific that could represent information.

Then I would envision that this would be redundantly expressed. Let's compare the present notion to the "grandmother" cell, that's the neuron that represents your grandmother. This idea of a "grandmother cell" has been widely disputed, but the present idea is that there are a lot of microtubules bearing a particular fingerprint in a few, maybe even as few as one neuron, like a "grandmother cell," that would be central to a specific idea or piece of information stored somewhere in our brain.

But memory storage is also highly distributed, so exact copies of this template for a pattern of transmission along a stretch of microtubule would also be expected to occur in multiple neurons and in multiple brain areas. We'd have both storage in a highly concentrated form and wider dispersal. I'll talk more about this and show a picture illustrating what I'm talking about.

Now, the advantage of looking at microtubules is that microtubules lend themselves to nano and neuro-nanotechnology, which is the new frontier for understanding cell function...

...and they are a good starting point for looking for treatments, and even possible cures, for neurological and psychiatric disorders. I'm going to eventually talk about how the nervous system is plastic, and how microtubules seem to be able to permanently encode information. And that's something for which I will present empirical evidence.

If nanotechnological approaches could permanently change the structure of microtubules and alter transmission and amplification of information, then such an approach could conceivably offer a potential

cure or long lasting treatment for certain neurological and psychiatric disorders. I'll talk a little bit more about that, but bear in mind that's a long way off, this is an optimistic forecast.

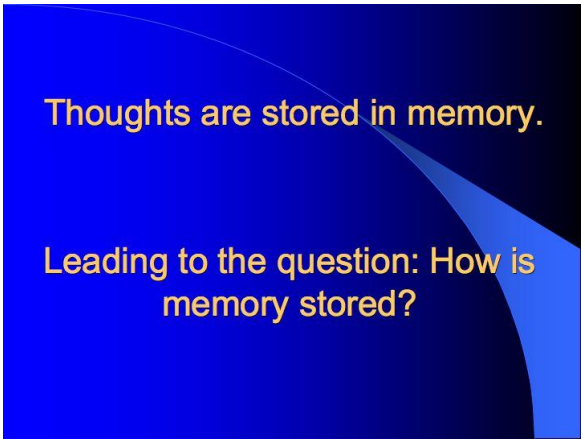


Image # 2 - Thoughts

Thoughts are stored in memory, we all know this. That leads to the question how was a memory stored in the first place? Lots of people have been talking about synapses today. I was trained as a neuroscientist and we learned all about synapses [5] and almost all we talked about were synapses, but I'm going to make arguments for sub-synaptic storage of memory rather than synaptic.

This means moving the storage site from the synapse to the microtubules in the dendrite [6] that lie beneath the synapse. Many of our strongest synapses are on something called spines. These are appendages on dendrites that are filled with actin filaments rather than microtubules, but the actin filaments connect with the microtubules.

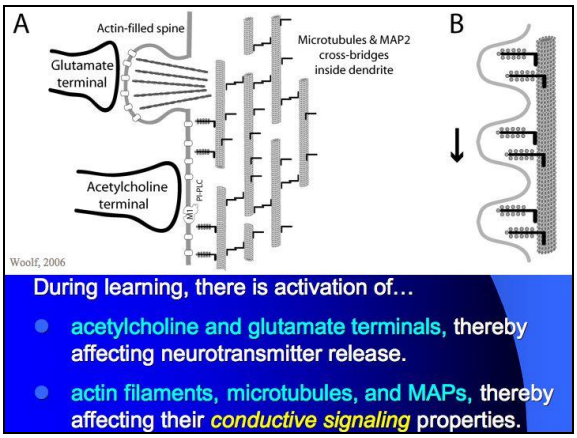


Image # 3 - Learning

Since we have good evidence that memory might be stored in microtubules, it follows that perhaps memory is stored in the sub-synaptic zone. Now, it would further follow that these microtubules could still serve very basic housekeeping functions, for example, transporting receptor proteins like the AMPA glutamate receptor protein or the NMDA [7] glutamate receptor protein.

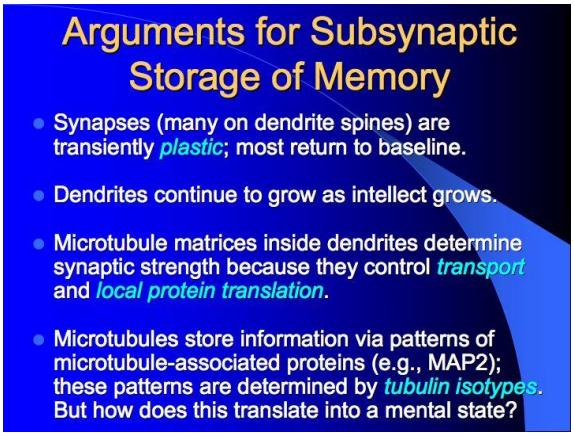


Image # 4 - Arguments

These microtubules, if they indeed store information, could then do more than just transport receptors. They could store information that tells those tracks how and when to start transporting excessive amounts of receptors, and to which synapses.
Even though synapses are plastic, and it has been documented that they change with learning and memory, many studies that have

looked at these changes over the long-term show that these changes disappear within hours or days. Even when we're looking at synaptic efficacy, that is changes in synaptic strength, these changes also disappear in a matter of days to weeks.

Now, I don't want to argue this point too much, because there are studies that do seem to suggest long-term storage in synapses. On the other hand, it is unequivocal that dendrites continue to grow as we mature and presumably as we learn more and more.

Why should we expect information storage to occur in microtubules? For one, microtubules occupy the vast majority of space the inside of the dendrite, along with a few mitochondria [1] there aren't too many competing sub-cellular organelles. The microtubule tracks fill up the neurons and in particular the dendrite shaft. The neurofilaments lie alongside the microtubules in the axons, but in the dendrites there is an abundance of microtubules and their associated proteins.

Information storage in microtubules also enables them to govern transport functions. There's transport of proteins important for maintaining synaptic strength. There's also transport of messenger RNA. Messenger RNA [2] transported in dendrites enables proteins to be translated right on the spot. I won't go into any more detail on this.

What I am going to talk about more is the fact that there are different tubulin isotypes and that these indeed are important because they determine the binding patterns of microtubule associated proteins (MAPs). The MAPs decorate the microtubules and varying concentrations of different tubulin isotypes will produce different patterns.

What does this mean? How could the patterns along microtubules made by the MAPs translate into a mental state?

Well, before I address that directly, I want to go over the empirical data that we collected. What happens inside of neurons when animals learn? What I mean by learn is that animals show improvement on such tasks as fear conditioning, avoidance conditioning, and spatial navigation. These are well known training paradigms that are routinely used in the laboratory. We and others found that MAP2 [3], which is a microtubule associated protein, and tubulin are reorganized with memory tasks.

We showed, for example, that both the MAP2 and the tubulin proteins are proteolyzed [4]. In other words, the protein is broken down with fear conditioning. This indicated to us that what's probably happening is the protein is broken down, then a new structure is formed, and that is the new architecture of the neuron. That would be important for memory storage.

Different laboratories replicated and extended our initial findings on MAP2 and memory. One laboratory found that the involvement of MAP2 was essential to fear conditioning. Another laboratory found that passive avoidance, a different kind of learning, reorganized the patterns of MAP2.

MAP2 is a cross-bridge. If microtubules are the sides of the ladder, then the MAPs are the rungs of a ladder. The MAPs act to strengthen the structural integrity of the microtubule matrices, but they may also play a role in transmitting and amplifying information as discussed earlier. Just as these MAP cross-bridges reorganize with learning, kinesin [5], which is a microtubule motor protein, plays a role in learning. Kinesin is a motor protein that walks along the microtubules.

Here is a picture of our data. It's immunohistochemical data showing that in a

naïve control rat, there's little in the way of breakdown of the MAP2, whereas in these two trained rats, there is increased breakdown of the MAP2 showing up as a darker stain because broken down protein has more antigenic binding sites. We also confirmed these results with the immunoblots, which measure actual protein levels so we know that the intact protein was broken down.

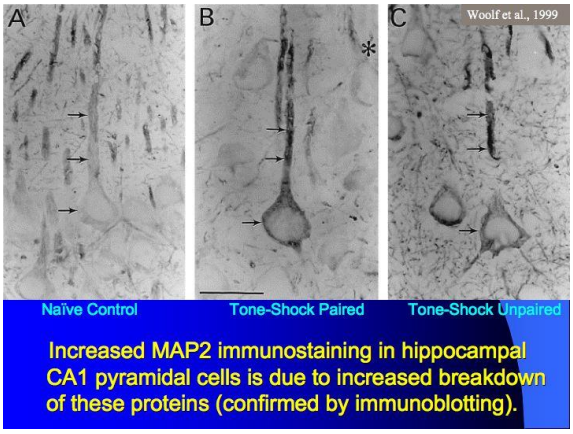


Image # 5 - MAP2

Here is an example of reorganization. These MAP2-enriched cells in a module of cerebral cortex are surrounded by regions of the cerebral cortex that show lesser amounts of this protein and lesser amounts of break down of this protein. We have observed that the modules showing enhanced staining differ from animal to animal and staining appears to be based on the most recent experience of an animal.

Let me spend a bit more time on this particular diagram. This diagram is a schematic showing the synapses involved with learning. We have the glutamate terminal, that's the terminal that releases the neurotransmitter glutamate. And we have this
[6] acetycholine terminal, that's the terminal that releases acetycholine.

It's known that during learning, there is often co-release of both glutamate and acetycholine. Often there are other neurotransmitters involved, as well, but to keep this reasonable simple, I've limited discussion to these two.

In the spine, there are actin-filled microfilaments. These can communicate with the microtubules inside the dendrite shaft and, as I mentioned, these microtubule associated proteins, like MAP2, form bridges, but they also do more that I want to talk about.

The MAP-2 bridges attach to the microtubule and when they are phosphorylated [7], they extend outward. When the MAPs are de-phosphorylated they fold inward. Microtubules have about 43 phosphorylation sites determining how much they extend out or fold in.

The extent to which MAPs extend out or fold in provides a physical basis for a contour along the microtubule which could indeed represent information. This essentially is the idea that I'm developing, that we could have a contour that would represent information inside of the cell that would then coordinate with housekeeping functions like transporting receptors to synapses. This physical contour would be capable of transmitting and amplifying information in the form of electromagnetic waves.

How could these proteins be phosphorylated with learning or synaptic activation? During learning we have activation at both glutamate and acetylcholine terminals leading to more neurotransmitter release. After these neurotransmitters bind with their receptors, they activate second messengers, which in turn phosphorylate microtubule proteins, such as MAP2.

And then there is conductive signaling along microtubules, which will be affected by the phosphorylation of MAPs. Rather than microtubules being mere structural entities or

even transports tracks, they may transmit information according to their semi-conductive properties.

I also mentioned there are different tubulin isotypes, especially in the brain. But why are there so many isotypes in the brain? Most cells in the body only have the most prevalent tubulin isotype. Beta-1, for example, is a tubulin isotype that's found in all cells. There are rarer Beta-2, Beta-3, Beta-4, and [Beta-6] tubulin isotypes that are specifically found in brain. Why?

"I propose that these multiple tubulin isotypes in brain enable a semi-periodic distribution of these rarer tubulins such that there can be varied information storage."

Where there's too much orderliness, this interferes with the potential for diverse information. In other words, you need some chaos or randomness for there to be specific information.

If there is only the most prevalent type of tubulin, the Beta-1, the microtubule structure is too orderly for there it to represent many different examples of specific information; that's the idea. Another idea is that when these different MAPs are de-phosphorylated, the microtubule acts as a universal cable—transmitting nearly any information. However, when these MAPs are phosphorylated and the contour is exposed, then only specific information that matches this contour can be amplified.

Based on what is known about microtubules, one would expect that information can flow longitudinally down the microtubule, as well as transversely, from one microtubule to its adjacent neighbor.

Now, I want to spend some time talking about bipolar disorder and then I'll get back to how the microtubules might be involved in this disorder.

First, some very basic facts: Bipolar disorder is an effective disorder, in other words, it's a mood disorder. It afflicts as much as four percent of the population. It's characterized by dramatic changes in moods, shifts from depression to mania, hypo-mania or mixed states to periods of normal mood. Bipolar disorder has been shown to involve changes in the cingulate cortex, orbitofrontal cortex [1], hippocampus [2], and amygdala [3].

"There are a number of studies that suggest there are deficiencies or problems with both tubulin and the MAP2 in bipolar disorder."

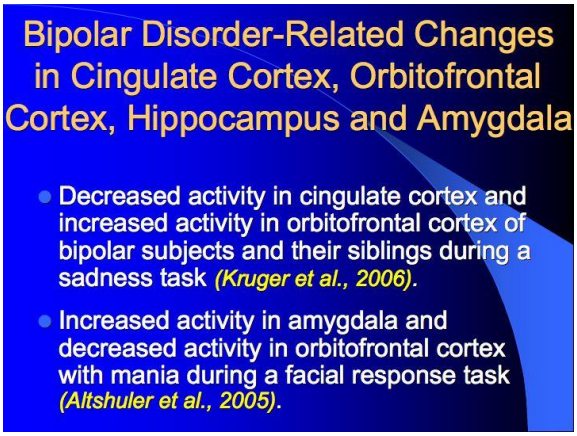


Image # 6 - Bipolar Disorder

The drugs that are used to treat bipolar disorder are collectively called mood stabilizers because they treat both the depression, as well as the mania (they normalize mood by bringing up depressed mood and decreasing mania).

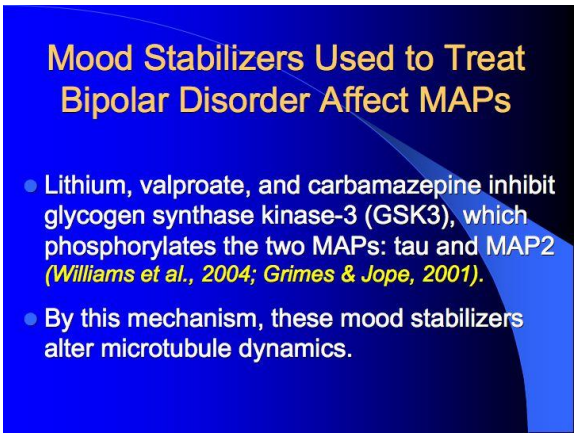
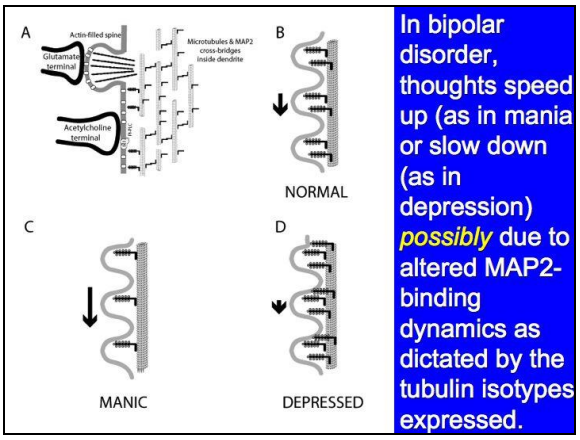


Image # 7 - Mood Stabilizers



Images # 8 - Tubulin

All of the known mood stabilizers that include lithium, valproate, and carbamazepine, inhibit a protein kinase called GSK-3, which primarily acts on microtubule-associated proteins, both the MAP2 I've been talking about and another one that's called tau protein. GSK-3 acts to phosphorylate MAP2 and tau [4] (protein). By this mechanism mood stabilizers alter microtubule dynamics, and they may indeed exert their therapeutic effects by this means.

Interestingly, when you look at meta-analyses of genetic studies on bipolar disorder, you find that many of the different gene loci that have been implicated as showing possible insertions, deletions, or polymorphisms overlap with loci that code and transcribe the various tubulin isotypes, for example, the Beta-2, Beta-2 A, B, and C, the Beta-3, and the Beta-6 tubulin. There is also overlap with some other tubulin-related proteins.

"[W]hen a person's thoughts speed up during mania and slowdown during depression, we may be able to model this as altered MAP2 binding dynamics as dictated by tubulin isotypes."

We know some things about what triggers a manic or depressive episode (bipolar disorder is also called manic depressive illness). We know that these episodes are frequently triggered by stress. It's conceivable that there's increased polymerization and de-polymerization of microtubules with stress, and that this exacerbates problems with microtubules transmitting and amplifying information.
After a stressful catalyst, thoughts either speed up or slow down. We might expect this to occur because of increased orderliness due to a lack of rarer isotypes of tubulin.

And too much orderliness would be expected to lead to either too much or too little binding of MAP2s to the microtubules. That's going to affect the dynamics of the microtubule's housekeeping functions, information processing, and presumably interfere with mental activities.

So what's proposed is a novel treatment for bipolar disorder. This is necessary because certain individuals don't respond to mood stabilizers. So that's a group of people who need attention. In fact, many people don't respond to one mood stabilizer so multiple mood stabilizers are often prescribed. The problem with this approach is some mood stabilizers counteract others. Clinicians have to

increase levels of one mood stabilizer to counter its metabolism or breakdown by another mood stabilizer.

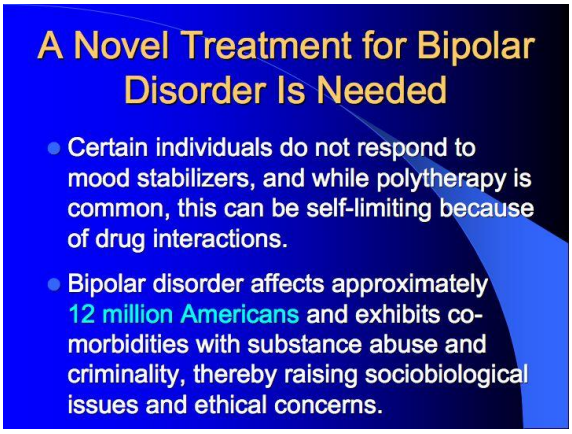


Image # 9 - Treatment

Also, bipolar disorder affects a large number of the population, around 12 million Americans, and it has serious social consequences. Bipolar disorder is often found along with substance abuse or criminality and we'll talk about that a little more because this raises important socio-biological issues and ethical concerns.

Criminality is a problem found especially in those bipolar patients that also have a serious substance abuse problem--either alcohol abuse or drug abuse.

"Quoting one study, 53 percent of female and 79 percent of male rapid-cycling bipolar patients who had co-morbid substance abuse issues, reported having been charged with a crime. And this is far higher than in the general population."

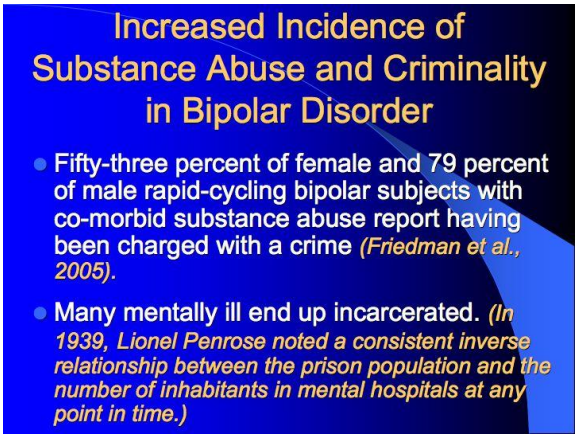


Image # 10 - Substance Abuse

An old rule of thumb proposed by Lionel Penrose [5] is that at any given time in any society, there's going to be an inverse relationship between the number of patients housed in mental institutions and the number of prison inmates. In other words, people who are having extreme difficulties, such as those with bipolar disorder and co-morbid substance abuse, are at risk of either going to a mental institution or going to a prison. So, it's in the best interest of society to pay attention to these issues and to use nanotechnology, if it's effective, at treating this disorder.

As it turns out, transcranial magnetic stimulation (TMS), which stimulates electromagnetic currents in cortical neurons, is a promising treatment for affective disorder, but since there's no clear-cut theoretical mechanism for why it works, this limits our ability to make the technique any better.

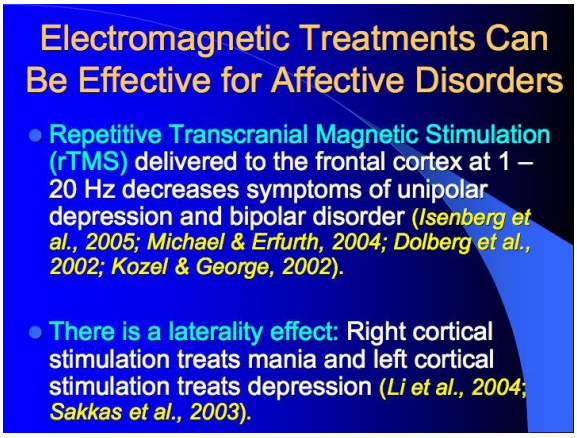


Image # 11 - Electromagnetic

Redefining TMS and other electromagnetic treatments in terms of how they affect electromagnetic currents in microtubules and how they might reorganize the structure of microtubule matrices to correct abnormal transmission and amplification patterns by microtubules could afford significant improvements to techniques such as TMS.

Now, this depends on microtubules being sensitive to electromagnetic energy, but it turns out they are. Second harmonic, generation microscopy shows that microtubules are one of a very small number of proteins that do respond to laser excitation in the near infrared range. Also, individual microtubules respond to near infrared waves by growing towards the source. So, there are two different indicators that microtubules respond to electromagnetic energy.

How could one pursue these ideas?

"One strategy along the way towards developing treatments that normalize neuronal activity would be to identify how microtubules transmit and amplify electromagnetic current."

This could be done--first in the Petri dish, where one can isolate individual microtubules in order to understand how they respond to electromagnetic current, and then eventually in experimental animals, human subjects, and patients. The good thing about building a therapeutic model based on electromagnetic current is that you can use principles like constructive and destructive wave interference. In other words, you can apply electromagnetic fields that will cancel out other fields. You can in principle cancel out maladaptive thought patterns, and train neurons to stop generating such patterns.

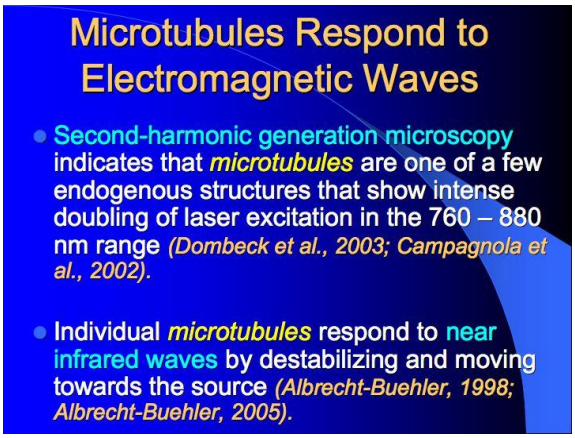
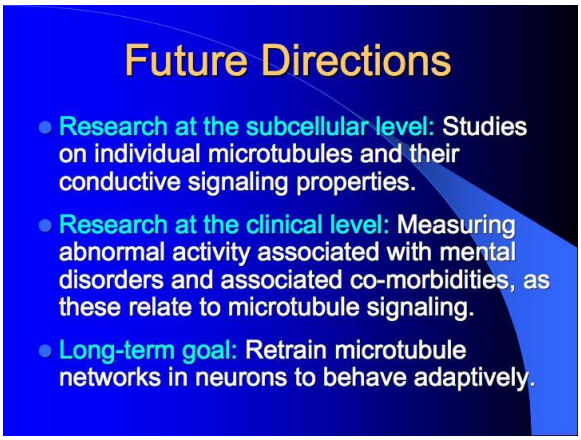


Image # 12 - Microtubules

Moreover, since microtubules are both structurally plastic, as well being capable of long-term storage, then any functional adaptations that could be produced by such a treatment might be permanently encoded in the structure of the neuron. This means that this approach may lead to a long lasting treatment or even a cure for certain affective disorders and other neurological and psychiatric disorders.



Insert slide # 13 - Future Directions

The future directions would be to step up research at the sub-cellular level, as I've mentioned already, studies on individual microtubules and their conductive signaling properties. Next, we need more research at the clinical level measuring abnormal activity associated with mental disorders and associated co-morbidities, for example, alcoholism and drug abuse, along with investigations probing how these relate to microtubule signaling. Last, techniques to re-train impaired microtubule matrices to behave adaptively need to be developed.

Endnotes

[1] **Nanotechnology** – the art of manipulating materials on an atomic or molecular scale, especially to build microscopic devices (as robots).

Merriam Webster. Collegiate Dictionary, Eleventh Edition, Massachusetts: Merriam-Webster, Inc. 2003: 284.

[2] **Neural networks** - A computer system that is designed to mimic the human brain or some other biological system in its functioning. They were developed to deal with problems, such as pattern recognition, that the brain does well but that traditional computer systems cannot handle easily.

American Psychological Association (APA): Neural networks. (n.d.). *The American Heritage® New Dictionary of Cultural Literacy, Third Edition*. Retrieved March 06, 2007, from Dictionary.com website: http://dictionary.reference.com/browse/Neural%20networks March 27, 2007 9:40AM EST

[3] **Neuron** – Any of the impulse-conducting cells that constitute the brain spinal column, and nerves, consisting of a nucleated cell body with one or more dendrites and a single axon: also called nerve cell, neurocyte.

Stedman, The American Heritage Medical dic·tion·ar·y, Boston, New York: Houghton Mifflin Company, 2004: 550.

[4] **Microtubule** – any of the proteinaceous cylindrical hollow structures that are distributed throughout the cytoplasm of eukaryotic cells, providing structural support and assisting in cellular locomotion and transport.

Stedman, The American Heritage Medical dic·tion·ar·y, Boston, New York: Houghton Mifflin Company, 2004: 513.

[5] **Synapse** – the junction across which a nerve impulse passes from an axon terminal to a neuron, a muscle cell, or a gland cell.

Stedman, The American Heritage Medical dic·tion·ar·y, Boston, New York: Houghton Mifflin Company, 2004: 801.

[6] **Dendrite** - A nerve cell, or neuron , possesses two types of processes: an axon and dendrites. The dendrites are numerous and extend from the cell body of the neuron. They allow for a large number of neurons to interconnect forming a network. The dendrites detect the electrical signals transmitted to the

neuron by the axons of other neurons.

http://www.lexicon-biology.com/biology/definition_94.html March 6, 2007 3:02 PM EST

[7] **NMDA receptor** - is an ionotropic receptor for glutamate (NMDA (*N-methyl d-aspartate*) is a name of its selective specific agonist). Activation of NMDA receptors results in the opening of an ion channel which is nonselective to cations. This allows flow of Na^+ and K^+ ions, and small amounts of Ca^{2+} . Calcium flux through NMDARs is thought to play a critical role in synaptic plasticity, a cellular mechanism for learning and memory. The NMDA receptor is interesting in that it is both ligand-gated and voltage-dependent.
http://en.wikipedia.org/wiki/NMDA_receptor
March 6, 2007 2:53 PM EST

[8] **Orbitofrontal cortex** - (OFC) is a region of association cortex of the human brain involved in cognitive processes such as decision making. This region is named based upon its location within the frontal lobes, resting above the orbits of the eyes.

http://en.wikipedia.org/wiki/Orbitofrontal_cortex
March 6, 2007 5:03 PM EST

[9] **Hippocampus** – The complex, internally convolutes structure that forms the medial margin of the cortical mantle of the cerebral hemisphere, borders the choroid fissure of the lateral ventricle, is composed of two gyri with their white matter, and forms part of the limbic system.

Stedman, The American Heritage Medical dic·tion·ar·y, Boston, New York: Houghton Mifflin Company, 2004: 368.

[10] **Amygdalae** – 1. an almond-shaped mass of gray mater in the front part of the temporal lobe of the cerebrum. Also called amygdaloid nucleus. 2. The cerebellar tinsil. 3. Any of the lymphatic onsils.

Stedman, The American Heritage Medical dic·tion·ar·y, Boston, New York: Houghton Mifflin Company, 2004: 38.

[11] **Tau (protein) –** microtubule-associated proteins that are abundant in neurons and in the central nervous system and are less common elsewhere.They were discovered in 1975 in Marc Kirschner's laboratory at Princeton University [Weingarten *et al.*, 1975]. http://en.wikipedia.org/wiki/Tau_%28protein%29
March 27, 2007 10:03AM EST

[12] **Lionel Sharples Penrose** - (11 June 1898 - 12 May 1972) a British psychiatrist, medical geneticist, mathematician and chess theorist, who carried out pioneering work on the genetics of mental retardation.http://en.wikipedia.org/wiki/Lionel_Penrose
March 9, 2007 2:45PM EST

[13] **Mitochondria** - Mitochondria provide the energy a cell needs to move, divide, produce secretory products, contract - in short, they are the power centers of the cell.
http://www.cellsalive.com/cells/mitochon.htm
March 6, 2007 2:58 PM EST

[14] **RNA –** Ribonucleic acid; a polymeric constituent of all living cells and many viruses, consisting of a long, usually single-stranded chain of alternating phosphate and ribose units with the bases adenine, guanine, cytosine, and uracil bonded to the ribose. The structure and base sequence of RNA are determinants of protein synthesis and the transmission of genetic information.

Stedman, The American Heritage Medical dic·tion·ar·y, Boston, New York: Houghton Mifflin Company, 2004: 719.

[15] **MAP2** - This gene encodes a protein that belongs to the microtubule-associated protein family. The proteins of this family are thought to be involved in microtubule assembly, which is an essential step in neurogenesis. The products of similar genes in rat and mouse are neuron-specific cytoskeletal proteins that are enriched in dentrites, implicating a role in determining and stabilizing dentritic shape during neuron development. A number of alternatively spliced variants encoding distinct isforms have been described. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi

&
http://www.gene.ucl.ac.uk/nomenclature
March 6, 2007 3:07 PM EST

[16] **Proteolysis** – The hydrolytic break-down of proteins into simpler, soluble substances, as occurs in digestion.

Stedman, The American Heritage Medical dic·tion·ar·y, Boston, New York: Houghton Mifflin Company, 2004: 673.

[17] **Kinesin** - the founding member of a superfamily of microtubule-based ATPase motors that perform force-generating tasks such as organelle transport and chromosome segregation.

[18] **Acetycholine** - often abbreviated as **ACh**, was the first neurotransmitter to be identified. It is a chemical transmitter in both the peripheral nervous system (PNS) and central nervous system (CNS) in many organisms including humans. Acetylcholine is the neurotransmitter in all autonomic ganglia.http://en.wikipedia.org/wiki/Acetylcholine
March 6, 2006 4:12 PM EST

[19] **Phosphorylation** – the addition of phosphate to an organic compound through the action of a phosphorylase or kinase.Stedman, The American Heritage Medical dic·tion·ar·y, Boston, New York: Houghton Mifflin Company, 2004: 629.

Bio

Nancy Woolf, Ph.D., UCLA Dept. of Psych-Behavioral Neuroscience

Dr. Woolf's research interests focus upon nanoscale structures in the Central nervous System and the participation of these structures in higher cognition. Particular interests include:

- Cytoskeletal abnormalities in Alzheimer's disease
- Microtubules and microtubule-associated proteins in learning and memory
- Microtubule-based models of cognition (information processing, attention, consciousness)
- Pharmacological strategies based on proteomics

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Hybriduality and eoethics

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This article was submitted for inclusion within the Journal of Geoethical Nanotechnology by Martine Rothblatt, Ph.D., a medical ethicist.

Dr. Rothblatt illustrates the multi-dimensional, energy-consciousness of beings as hybriduals, rather than individuals, and the associated ethics powered by an information- intensive society.

Contrary to what we've been taught, and contrary to what we fervently believe to be true, there is *not* just one I. We are *not* individuals, we are *hybriduals*. Each of us is a compound, collective, hybrid being. Part of us is the body we see and feel and the personality we know ("Me of I"). Part of us are the many different models of us which occupy mental space in the minds of all those with whom we have interacted ("We of I"). Part of each of us is an energy-consciousness pattern arising from our body's biochemical interactions, somehow intersecting with the physical universe ("Qi of I"). Every individual is part of the physical universe ("Gi of I"); and part of each of us is a series of moments in time that live forever ("Ti of I").

Each of us is a compound, collective, hybrid being.

It can be frightening to think of ourselves as five dimensional beings – almost like we have a kind of multiple personality disorder. But looked at appropriately, it really should be much more comforting to see ourselves this way. It means that we are never alone in life, because we are always part of a collective of human souls.

It means that we are never really going to die because we are part and parcel of a universe that will last longer than we can imagine. It means that we are so much more than our flesh and bones, because we are truly creatures of spirit, and this spirit is not limited to our body. As five dimensional creatures we can really understand that when our bodies give out, our Qi spirit is free to intersect with a physical universe in which consciousness controls what really happens and doesn't

happen. And, finally, as five dimensional beings we can appreciate that every moment we have lived really, really counts – because it lasts forever.

Bursting the fiction of individuality also has important implications for ethics and morality.

Individual morality urges us to empathize with those who will feel the brunt of our actions.

Individual morality is anchored in the golden rule: do unto others as you would have others do unto you. Immanuel Kant, a world-renowned 18th century philosopher from Kalingrad, on the coast of the Baltic Sea, phrased this concept as a Categorical Imperative: act as you would if you could make your action a universal law [1]. Individual morality urges us to empathize with those who will feel the brunt of our actions. Hybridual morality goes one step further – it tells us that we *are* others. Just as the foot cannot move without the permission of the brain, nor can a person eat well without the cooperation of the hands, hybridual morality teaches that we cannot impinge upon others without their *actual* consent. The difference between hybridual morality and the golden rule systems of Kant and Christianity, is that hybridual morality requires proof (through consent) that one's actions are acceptable to those who feel their impact.

Image 1 - Golden Rule

Geoethics is built upon the collectivist ethics theories of 20th century philosophers like Jurgen Habermas [2], Ulrich Beck [3] and John Rawls [4]. Habermas distinguished himself from John Rawls, author of *A Theory of Justice*, by noting that it was unnecessary to resort to Rawls' use of hypothetical individuals agreeing upon the rules of a society in which such individuals might occupy any possible role or status. While this would ordinarily obtain a fair result (since the individuals wouldn't want to bear the brunt of any unfair rules) Habermas considered this but an expansion of Kant's Categorical Imperative. As a result, unfair outcomes could result either from poor empathization skills, or because one was willing to risk he would end up in a better treated group rather than an oppressed group under a discriminatory set of rules. Instead, Habermas says something is morally valid if those who are impacted by it agree to it based on a full-fledged discussion. More generally, Ulrich Beck considers actions that impact others without their consent to be a kind of pollution. Since we shouldn't pollute another's space without their permission, we shouldn't impact others without their permission.

weakness of ethical systems based upon individual morality is that different people empathize differently, and some do so very poorly, if at all. The strength of an ethical system based upon hybridual morality is that the guesswork is much reduced; if our actions are going to affect another, we must first obtain the consent of the other. It may be argued that this is not always practical, but such an argument is not relevant to the many instances where consent is possible. Generally, if I have time to affect

[I]f our actions are going to affect another, we must first obtain the consent of the other.

you, I have time to ask you if you accept the effect. This is well-demonstrated in the "Antioch Code" for sexual behavior. At each state of progression from kissing to intercourse, explicit consent is required. This Code precludes the possibility of "date rape", whereas under the Golden Rule or Kant a person might well say "I would have wanted that kiss, so they should want it to."

The ethics of hybridual morality may be called "geoethics," meaning that it *takes into account the whole.* Geoethics considers the whole *directly* via communication rather than focusing only upon the atomistic part, and imaging the whole indirectly, via empathization. Geoethics is empowered by an information-intensive society because it becomes practical to seek and document the consent of others readily and frequently. Under the geoethics of hybridualism, it is wrong to impact someone without first asking their consent, whether or not that impact is believed to be harmful by you or someone else.

As noted above, contemporary philosophers like Jurgen Habermas and Rudolph Beck have paved the way for geoethics. Habermas uses the term "participatory discourse" to encompass the way he subsumes Kant's Categorical Imperative within a collective process [5]. Put simply, Habermas asks "why imagine how others would feel if I act thusly; I can just ask them and obtain their consent." Beck notes that in modern times, the imposition of risk of harm on unseen, usually geographically distant others is the palliative consequence of economic development for a fortunate minority [6]. He discovered that the new social struggle worth fighting is between those who create risks and those who involuntarily bear the brunt of them. This struggle over risk has rendered obsolete the old battle lines between workers and managers, and among nationalities and ideologies. When one suffers from technology-engendered cancers, it doesn't matter if you live in India or in Pakistan. You are united in your opposition to the imposition of cancer risks upon you without your consent. When one suffers from fear of unsafe food, it doesn't matter if you are the wife of a CEO or the husband of a factory laborer.

Actions which harm some parties unleash unstable forces in human society and such forces end up inuring to everyone's harm.

You are united in your opposition to the imposition of food risks upon you without your consent.

Hybridual morality is based upon three geoethical principles: First, there is a Principle of Consent which requires that any action reasonably likely to affect one or more others cannot be undertaken without the prior consent of those likely to be affected. If many are likely to be affected, then prior consent may be achieved via a representative democratic process. If there is doubt as to whether or not others will be affected, then an expert group should provide an opinion regarding that likelihood. If the likelihood turns out to be too small to bother obtaining consent, but the adverse consequence nevertheless occurs, one is geoethically clean.

Second, there is a Principle of Equilibria that requires any action reasonably likely to affect others to be structured so as to minimize harm and preferably to increase the satisfaction level of all affected parties.

Remembering that we are hybriduals, not individuals, it is crucial that actions contribute to a stronger We rather than to tensions within We borne of dissension over inequality. Actions which harm some parties unleash unstable forces in human society and such forces end up inuring to everyone's harm. It is frequently not possible

to know the consequences that one is consenting to. By requiring those actions that affect others to also benefit others, there is at least a partial safety net in place to better ensure that our actions are helping We, and not just Me. Beneficent actions move society to a stronger and more stable equilibrium.

Finally, the conditions of any consent to an action should be independently monitored and enforced, wherever possible. This third principle of Geoethics is called the Principle of Assurance. It ensures moral solutions are enduring in reality rather than chimerical and rhetorical. In other words, the Principle of Assurance involves Ti and Gi in an agreement amongst Me and We. The ethical benefits of consent and equilibria are only as real as they are assured of implementation.

Image 3 - Justice

Taken together, the three principles of geoethics implement a morality of hybridualism which is (i) cognizant of the multiple selves each of us comprise, and (ii) takes advantage of new tools of communications, while still being (iii) consistent with the moralities of the great religions. In essence, geoethics and the morality of hybridualism simply extend the Golden Rule of religion, and the Categorical Imperative of modern philosophy, into the newly recognized realm of hybridual beings and the newly emerged capabilities of cybernetic communication systems.

The Fiction of Biology

Biology is said to be the study of life. But this is not really true. In fact, biology is only the study of *some kinds* of life. Biology, as practiced today, studies living things that are deemed similar to *human* life in *one particular aspect* – the possession of organic cellular chemistry characteristics. These characteristics are the use of six atoms (carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur) to form molecules that build cellular membranes, metabolize nutrients and self-replicate in accordance with a chemical code.

Life is such an important concept – perhaps the most important concept – that it should be defined based on why life is important, not based on the lowest common denominator between humans and bacteria.

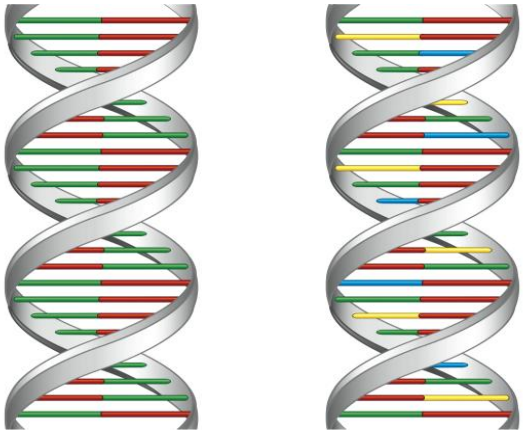

Image 4 - Biology

Because biology defines itself as the study of life, it obligates itself to define life. Yet, biologists frankly concede that they cannot consistently define life, and that, as they define it, life blurs into non-life. For example, biologists generally define life as something that is well-organized, seeks nutrients from its environment,

adapts to change and replicates. However, these same characteristics apply even to stars – they are organized into distinct shells, they gravitationally attract hydrogen and helium atoms from interstellar space, they alter their structure under gravitational influence and they reproduce via nova and supernova explosions, which seed interstellar space with thermo-nuked atoms. Since biologists do not want to study stars (and similar non-squishy examples abound), they attempt to more strictly define life as something organized *upon* cellular organic chemistry. Both their general (any self-replicating, well-organized, and interactive thing) and their specific (any self-replicating, well-organized, interactive cellular organic chemistry) definitions miss the mark because both fail to recognize the salient feature of life – its *purpose*, as evidenced by what it uniquely does.

Because biology defines itself as the study of life, it obligates itself to define life.

Life is important because it is the only way to make reality more pleasurable, and less painful, than it otherwise would be. Life accomplishes this by imposing order upon reality. It imposes order upon reality by processing, sharing and extending information, since information is a necessary, and sufficient, basis for development. Information is, in and of itself, a reduction of uncertainty, disorder and chaos. Therefore information is, in and of itself, a tool for imposing order upon reality. Information enables greater pleasure, fairness and justice than offered by a lifeless universe.

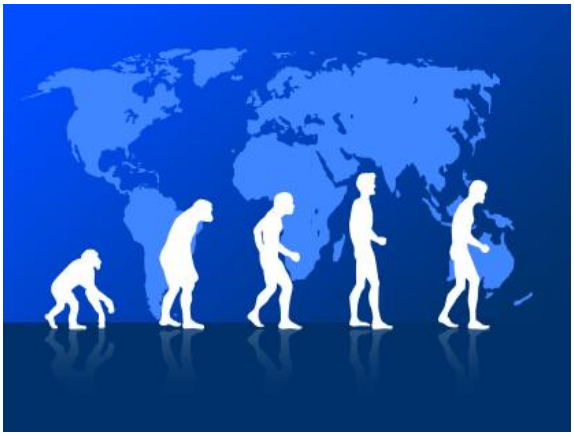

Image 5 - Evolution of Man

Evolution has created beings with an ever greater ability to impose order on the world. One could say that the purpose of life was to evolve, but that would be like saying the purpose of arithmetic was to add. We evolve so that we can achieve ever greater ratios of pleasure-to-pain in the world; ordering reality is the best way to do this (beats random chaos!). The evolution of sensory, manipulative, mobility and cognitive systems are the successful outcomes of an age-old process of trial-and-error to find the best tools for ordering reality. Just as the purpose of arithmetic is to appreciate an abstract reality, and the ordering of numbers via addition is a super tool in that regard, the purpose of life is to enjoy total reality, and the ordering of phenomena via evolution is a super tool in that regard.

The Purpose and Definition of Life

The 17th century philosopher from Holland, Baruch Spinoza – considered by many to be Jesus-like in his humility – discerned that what makes life important is also its very purpose. Spinoza observed that "God can ask nothing of man which is contrary to nature," and then further observed that every creature in nature is primarily motivated to seek pleasure (e.g., eat) and avoid pain (e.g., not be eaten)[7] . Consequently, discovered Spinoza, the purpose

of life *is* to seek pleasure and to avoid pain.

Image 6 - Mother Theresa

Nowadays we often associate the word "pleasure" with hedonistic pursuits, but Spinoza explained how true pleasure requires *new* achievement. In other words, doing the same old thing is not increasing pleasure, and will eventually become the pain of boredom. Achievement of pleasure means developing one's capabilities (including, but not limited to, sensual and epicurean pursuits) and taking pride in one's contribution toward making the world a better place. In the parlance of physics, pleasure would be called "positive delta" phenomena, meaning it was the *increase* in beneficent achievement, not the preexisting level of such achievement that really constitutes pleasure.

In modern English, the term "satisfaction" (or perhaps the psychological term "self-actualization") is closest to the quest for "blessedness" that Spinoza deduced to be the purpose of life. To be satisfied, self-actualized, or possess blessedness, one should make ever more contributions to the order of the universe. Yiddish has a good word for Spinoza's conceptualization of the purpose of life – produce "nachas." Roughly translated, producing "nachas" means giving a kind of pleasure that arises from someone improving themselves, others, or the world in general. This is what Spinoza would say is the purpose of life, because this kind of order-building is what the universe is all about.

[T]he purpose of life is to increase pleasure and to decrease pain because that principle works best at propagating itself.

The restless and curious mind will ask "why is the purpose of life to increase the ratio of pleasure-to-pain?" The inquisitor may fairly comment that "I can see that this does, in fact, occur, but why does it occur? If this is the intent of the universe, why does the second law of thermodynamics that of ever increasing disorder in the universe, point in the opposite direction?"

The answer to the first question is that the universe is designed so that increasing the ratio of pleasure-to-pain is a self-fulfilling prophecy. Things that feel good (meaning generate true satisfaction), get done more, and things that feel bad (including boredom), get done less. Consequently, the purpose of life is to feel good (i.e., pursue satisfaction). There are only two other ways the universe could have logically been designed: (1) painful things could feel good, in which case those phenomena would quickly disappear from reality in self-immolator activities, such as suicide, or (2) whether something feels good or bad at any point in time could be a random occurrence – a reality of pure chaos no matter what.

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By choosing the seek-pleasure, avoid-pain approach, the universal design selected for rationality and success. Indeed, from an evolutionary standpoint, the seek-pleasure, avoid-pain approach may have simply edged out alternative design principles that worked less effectively at propagating themselves. In short, the purpose of life is to increase pleasure and to decrease pain because that principle works best at propagating itself.

Why the universe would be designed to favor order on the one hand (evolution), and constantly drift toward disorder on other hand (thermodynamics)? Every good teacher and trainer knows that the best progress requires continual challenge, and hence to grow beautiful order one needs the ferment of disorder. Or, in the words of the great philosopher

Image 7 - Heraclitus

and energy to randomness, empty space and endless time. Given that we already understand the game plan, and still have at least nine-tenths of this universe's life ahead of us, the smarter bet seems to Heraclitus, living some 2600 years ago in Greece, "the mixture that is not shaken, decomposes." We can place our bets on what will happen first: intelligent (re)ordering of the universe, atom-by-atom, to escape the fate of thermodynamic entropy via a more subtle comprehension of physics, or the loss of all matter,

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[I]ntelligence will manipulate physics to save the universe, and thus escape its own extinction.

be that intelligence will manipulate physics to save the universe, and thus escape its own extinction. For example, all the forces of disorder on the earth have not stopped the planet from becoming an ever more ordered place via our ever better understanding of physical sciences such as materials engineering. Dams don't change the laws of hydrology, but they manipulate them to escape the brute force of their uncontrolled application. On a vastly grander scale, intelligence can do the same thing with the laws of physics. Yes, our little earth in our little time is but a small piece of the puzzle. But if our accomplishments here are a portent of things to come, intelligence will ride thermodynamics, not vice versa.

It is said that ontogeny recapitulates phylogeny. This means that a developing embryo (ontogeny) reveals, stage by stage, the evolutionary history of that being (phylogeny). But it is also true that the evolutionary history of a being enables one to predict its future development. Consequently, it is also true that phylogeny *recapitulates* ontogeny.

Now, think of the future development of the universe as our to-be ontogeny, or "destiny," and the historical development of order on earth as our phylogeny, or "reality." We then may say that phylogeny prefigures ontogeny, or more simply, that reality prefigures destiny. In other words, what we see a little of we will eventually see a lot of. The cosmic fruits of tomorrow are in the earth seeds of today.

Life accomplishes its purpose by creating order out of disorder, and forging fairness out of random chaos. Of course life often fails to make the world a better place, and often makes it a worse place. Nevertheless, reality would be much worse if all were left to the mindless fluctuations of the environment. Without life, there would be no pleasure in the universe. Of course, there would also be no pain, but the course of evolution has been to increase the ratio of pleasure to pain in the world. This is the universal purpose that was discovered by Spinoza.

When those very first amino acids felt complete, electrically, from a particular configuration (but not from other configurations), pleasure entered our corner of the universe. A world with hellish environmental conditions, but some electrically satisfied amino acid chains, was a more pleasurable world than one in which just hellish conditions prevailed. And pleasure continued to mount exponentially as the amino acid chains replicated themselves many times over, and satisfied themselves with ever more complex biochemical structures.

Life is in many ways an "n steps forward, n-1 steps back" process (pessimists assign n a large number, like 100, while optimists assign n a smaller number, like 2), but that is still a process that gradually forges more and more order out of disorder; that creates more fairness and less injustice[8]. Even though most living things have been wiped out repeatedly throughout the earth's history (at least every hundred million years or so), there are more living things in existence today than ever before. N steps forward, n-1 steps backward. And, amazingly enough, there is now technology at hand, born of information-induced order, that could save the earth from the species-devastating effects of the random earth-crossing asteroids of the past (space-searching radar systems, ultra-fast information processing capability, nuclear missiles).

Cellular organisms have done a fantastic job of remaking the environment into a more livable world. But it is not the cellular structure of the organisms that make them alive; it is their ability to make the world a better place. Cellular structure proved to be an excellent tool for safeguarding valuable information, coded in DNA, as to how to build increasingly capable organisms – organisms that could make increasingly more order out of a largely, but not entirely, disordered universe. But, *a priori*, we cannot say that such structures are the *only* way to create an entity that makes the world a better place. Consequently, organic cellular chemistry is biology, and biology can become life through the force of evolution and natural selection. But life is not necessarily biology, because biology is not the only way to create (and does not necessarily create) a more ordered, fairer, more just universe. There is, for example, circuitry, as one finds in chip-based computers and machines.

Any non-biased, i.e., non-cellcentric, definition of life will include many entities that biologists do not currently consider to be alive. Logically, this does not mean that such entities are inanimate (they may or may not be). It only means that such entities lack organic cellular characteristics. The reason for this is that biologists require an entity to have an organic cellular structure in order to be considered 'alive.' Yet, there is no reason to suppose that having a organic cellular

structure is a necessary (although not sufficient) condition for being alive.

Consider, for example, biology's dogma that living things (i) are organized, (ii) take materials and energy from the environment, (iii) respond to stimuli, (iv) reproduce, (v) develop, and (vi) adapt to the environment. These conditions are certainly satisfied by bacteria, plants and mammals. But are they necessary conditions for an entity that serves the purpose of life, to make the universe a more ordered, less random, place? Is it necessary, for example, for each member of a species to reproduce; indeed, most members of many species do not. On the other hand, as noted earlier, the criteria are so general that they can be satisfied even by stars in space, unless one starts getting cell-centric in the definition of "organized."

Now, it is possible to have a definition of life that is more elegant, more precise and more useful. Here it is: life is an entity that autonomously processes, cooperatively shares and transcendentally extends information. These criteria may be formalized as saying that an entity is alive if it demonstrates (i) Autonomy, (ii) Coopetency, and (iii) Transcendence ("ACT"). In shorthand, it can be said that to be alive, something must satisfy the ACT criteria. Rephrased in common language, logically structured, life is something that (i) processes its own information (which means Autonomy), (ii) shares its information consensually (which means Coopetency and requires Autonomy), and (iii) operates beyond its information to achieve the purpose of life (which means Transcendence and requires Coopetency).
The new word "coopetency" is used instead of "cooperativeness" because the new word encompasses cooperation via competition as well as via teamwork [9]. Lifeforms share information through both teamwork and competition since each form of cooperation (or, more properly, coopetition) has its time and place advantages[10]. "Autonomy" is a classic term meaning on one's own. It is a needed component of a definition of life to separate out what is alive, sub-alive and macro-alive. We want to think of a person as alive, not a muscle cell in the person, or the city in which the person lives. Finally "transcendence," which means going beyond one's programming, is an essential definition of life because ultimately it will separate out the inanimate from the animate.

Now, are non-brained entities alive? They are if they process information (as even a bacterium does by executing its genetic code), share information (as bacteria do via plasmid exchange), and extend information (as bacteria do by carrying out activities, such as colonization, that are beyond what is written in their genetic code).

Image 9 - Bacteria

Now, suppose a cybernetic being with adequate memory, software and power satisfied the ACT definition. Is s/he or "heesh"

alive? Yes, because it (or heesh) is like us in an important way, namely in the way of working together to make the world a more satisfying place.

Image 10 - Cybernetic Upgrade

This cybernetic being, like us, could be an example of transcendental biology, if it was constructed based upon cellular organic chemistry, or an example of non-biological transcendence, if it was constructed using inorganic molecules. Hence, the beauty of the ACT definition of life is that it includes all that biologists deem to include in life, and it also includes non-organic phenomena that "quacks like life and waddles like life." On the other hand, the ACT definition of life clearly excludes phenomena, such as a rock or the sun, that either fail to demonstrate autonomy (a rock or a sun does not process information because nothing proceeds pursuant to any kind of an uncertainty-reducing code), or fail to demonstrate coopetency or transcendence (a rock or a sun does not operate consensually or enhance order in the universe).

The fact of the matter is that biologists have been mis-defining life for a long time. Life is not equivalent to a growing, reproducing, reacting entity with a cellular structure. Such entities are simply cellular organisms. They constitute a particular, and fantastically diverse, form of self-replicating matter. But life is something different altogether. Something is alive if it is (1) an autonomous entity that (2) builds information sharing relationships with other living entities for (3)

Something is alive if it is (1) an autonomous entity that (2) builds information sharing relationships with other living entities for (3) the purpose of creating for themselves a "happier" (as they would define it) world.other living entities for (3) the purpose of creating for themselves a "happier" (as they would define it) world.

the purpose of creating for themselves a "happier" (as they would define it) world. All biological organisms meet this definition, which is why they seem to us to be alive (those that don't, like viruses, don't process their own

information). Biological organisms seem to exhibit Transcendence by extending their behavior beyond its stored information.

hese three characteristics make them alive, not the arrangement of their molecules.

Vitology Is Life

To avoid confusion we need a new, more appropriate term for the study of life than biology – which is now more properly understood as the study of life built from organic cellular chemistry. A better term for the study of life is vitology, which includes biological life as well as cybernetic life, while excluding non-teleological biology (such as organelles within a cell) as well as non-teleological non-biological entities (such as a memory chip). The science of vitology includes the study of all entities that demonstrate Autonomy, Coopetency, and Transcendence (ACT) – things that are alive.

Divisions of vitology could include biovitology (entities like *homo sapiens* which demonstrate ACT and are organized according to organic cellular chemistry), cybervitology (entities like intelligent computers or futuristic robots which

demonstrate ACT and are organized according to inorganic circuit chemistry) and infovitology (entities like "virtual personalities" which demonstrate ACT and are organized according to software logic).

The back-and-forth nature of human progress results in the fact that "out of the crooked timber of humanity, no straight thing was ever made." I. Berlin (1969), *Four Essays on Liberty*, Oxford University Press: Oxford, p. 170. The most important point, though, is that many things have been made, albeit they are not straight. Consequently, antipodal philosophers such as Nietzsche and Rousseau both miss the point. They each see the back-steps of civilization and pine for either forward-motion at goose-step rate under a strongman (Nietzsche) or no back-steps in an idyllic natural world (Rousseau). Yet the goose-step approach inevitably takes one right off a cliff, while the anti-civilization approach leads one to slow decay. There appears to be no good substitute for careful trial-and-error progress, with reliance on free discussion and collective decision-making to keep the ratio of n:n-1 as high as possible.

A good case can be made that all life is really infovitology because it is information processing, sharing and transcending behaviors that make something alive. Nevertheless, up until now, all vitological life has been expressed via biological substrate, and hence there is utility to understanding the impact of that biovitological medium on the infovitological message. Similarly, we are at a cusp of time when autonomous information processing, sharing and transcending capability will be incarnated into computational hardware. That hardware will impose its unique limitations on the life process, and hence there is value in understanding cybervitology as a category of life. Ultimately, however, information processing, sharing and transcending capability will become platform independent by achieving the ability to reorder atoms at will using nanotechnological tools. This will be the advent of truly infovitological life.

One can also envision categories of transontological life such as: transbiological life (mostly biological but also cybernetic and/or informational) and transcybernetic life (mostly cybernetic but also biological and/or informational) for many years to come. There is substantial work for scientific researchers to do in the years ahead to categorize organic, inorganic and software entities in accordance with their relative capabilities for autonomy, coopetency, and transcendence. In this regard, an important sub-field of protovitology should be recognized, which deals with the characteristics of entities having some but not all of the ACT features.

There is also substantial work for ethicists, lawyers, sociologists, policymakers and theologians to do in the years ahead to assay the relative rights or protect-able interests of entities in accordance with their ACT capabilities. At the end of the day, though, it should not be the organic or inorganic, or biological or informational, nature of life that determines how it is respected, any more than it should be the gender or exterior appearance of a person that determines their fate. Categorization of life forms is useful for many purposes, but one of those purposes should not be the denial of the privileges and responsibilities accorded to living beings.

"[T]he right to life applies to all vitology."

One of England's leading medical ethicists, John Harris, has observed[11] that "a right means there exists valid moral reasons for not denying something." For example, a right to life means there are moral valid reasons not to deny someone their life. One such reason

would be that if people could have their lives taken from them, then all society would feel unsafe, insecure and unpleasant. On the other hand, if a condemned murderer is said to forfeit his right to life, it is because there are not morally valid reasons to prevent his execution. Everyone will not feel insecure because everyone is not a condemned murderer.

What does this have to do with vitology, the study of life? John Harris' formulation helps us to see that the right to life should not be withheld from cybernetic or informational life because there are valid moral reasons to respect these forms of life. In addition to the argument of the preceding paragraph (which biovitological life forms might dismiss on ontological grounds), there is the following strong argument. Ending something that is making the world a better place makes the world a worse place for all. Consequently, there are morally valid reasons to not deny life to a cybernetic or software being that demonstrates Autonomy, Coopetency, and Transcendence.

If such entities are making the universe a more satisfying place, one in which some of us are at a little less risk of random harm, there is no moral reason to end their life. Consequently, cybervitological and infovitological beings have a frank right to life. Quite analogous arguments support the biodiversity movement's efforts to forestall extinction of species. In summary, the right to life applies to all vitology.

It is apparent to anyone that not all life is created equal. Different vitological beings satisfy the ACT criteria for life to different extents. Dogs evidence greater autonomy, coopetency and Transcendence than do bacteria. A quantifiable hierarchy of life results from a more detailed examination of the three criteria for life. That hierarchy is based on a V score derived from the following function: V = A*C*T, where V is the vitological index, A is a quantified autonomy value calibrated as the exponent to which 10 must be raised in order to best estimate an entity's maximum number of decisions per second. This value ensures the entity is, in fact, processing information. C is the empirically obtained number [12] reflecting the percentage of the time that an entity consensually shares information, multiplied by 100. The multiplication factor enables the C value to be combined equally with the A value. T is an empirically obtained number reflecting the percentage of the time that an entity is using information to improve the universe, again multiplied by 100.

A maximal [13] vitology score of 1,000,000 (or 1M) would result from an entity with the processing power of every atom in the universe (approximately 10^{100} atoms, give or take a few million trillion), that maximally shared information (C=100) and that devoted all of its efforts to enhancing universal order (T=100). Let's assume, for sake of illustration, that humans consensually share information only half the time (C=50), and that society devotes less than 10% of its time to building a better world (T=10). Then humanity has a vitology value of 500 times the exponent of mankind's mental processing capability, which is about 10^{26} calculations per second (100 billion neurons times 1000 connections per neuron times 200 signals per second times 10 billion humans). In this illustration, the vitological hierarchy value of humanity would now be about 13,000 (=500 times 26) on a scale from 1 to 1,000,000, or .013M. Interestingly, an individual person who consensually exchanged information half the time and devoted only 10% of his or her efforts to increasing universal order would have a V score of 8000, or .008M.

By comparison, a typical insect brain can

handle up to 10^6 calculations per second (A=6), rarely communicates consensually (but almost constantly using non-consensual chemical signaling), and makes minimal efforts to establish a more ordered universe. Assigning, for the sake of illustration, Coopetency and Transcendence scores of C=1 and T=5, we get the result that a typical insect may have a V score of 30, or much less than 1% of that of a human. A MacIntosh computer also has a V score of about 30, representing a 1 Megahertz processor, minimal consensual communications capability, and minimal contributions to a better world.

It may seem that the Vitology Index is rigged against insects and PCs by virtue of their low scores for consensual communications and Transcendence. This is not the case because there is widespread agreement that the "gold standards" of "higher life" are the abilities to engage in meaningful communications and to use tools to create a less random world.

Coopetency measures "consensual communication" to assay how frequently, and to what extent, an entity can (a) frame an idea, (b) communicate it to another entity, (c) have that entity understand the idea, (d)

frame a response, (e) communicate that response, and (f) have the original entity understand the response.

Technology is absolutely essential to ethical concepts such as equality named insect species, plus about another 600,000 named non-insect species, ranging from 270,000 named plant species to 4,650 named mammal species. However, it is estimated that named species represent only about 10% of the currently existing species, with millions of insect species, hundreds of thousands of bacteria, nematode and virus species, and tens of thousands of protozoan species deduced yet to be discovered. While the industrialization of natural ecosystems is reducing this species' count at an unprecedented rate, new non-biological species of life, such as computer hardware and software systems, are now being created at a very fast rate.

Consensual communications is absolutely essential to the ethical systems of "higher life", such as the geoethical principle of consent. There is no way that one can obtain the prior consent of another to an action that may affect them without consensual communication. While all life forms, by definition, engage in some degree of consensual communication, for "lower" life forms it is limited to sexual reproduction or basic food gathering. Humans engage in a much greater degree of consensual communication than do lower animals. However, humans have a lot of "growth room" in consensual communications as is evidenced by the many disagreements, some violent, that result from inadequate attention to the geoethical principle of consent.

In a similar vein, Transcendence measures the extent to which an entity is enhancing fairness in the universe. Tools are essential to this task because raw nature is not fair – it kills with abandon, and it has no sympathy for the injured. It is a random process.

"[H]igher" life forms have a much greater impact on the universe because of the leveraging capability of technology.

Technology is absolutely essential to ethical concepts such as equality of opportunity, and to the geoethical principle of equilibria. Technology is absolutely essential to ethical concepts such as equality of opportunity, and to the geoethical principle of equilibria. It is impossible to continue to add happiness to the world without tools to create more value. While all life forms make some contribution to universal order, "higher" life forms have a

much greater impact on the universe because of the leveraging capability of technology.

Sociobiologists will not find it to be inordinately difficult to assign Vitology ratings to the plethora of biovitological life forms that permeate the earth. Cybersociologists will find it only somewhat more challenging to categorize infovitology by Vitology rank. As transvitological life forms emerge in the 21st century, we can expect steady movement toward the epitome of a V=1M being. Such a being would have many billions of times the information processing capability of humanity (something that is sure to be achieved with a century more of information technology development). Such a being would never adversely impact another without the other's informed consent – this is the objective of consensual communication. And such a being would work feverishly toward the goal of building a just universe. This will arise by ensuring to each an unlimited opportunity for growth, and by extending to all a shelter from damage caused by catastrophic events, be they of terrestrial or extra-terrestrial origin.

The Autonomy and Coopetency of Life

Autonomy means independent action. For something to be autonomous it must be able to act based on decision rules reflected in remembered experiences, or in "birthright" algorithms, be it DNA or some other kind of original code. Even simple algae acts on its own because it processes information relevant to, among other things, converting sunlight, carbon dioxide and water into oxygen and glucose (photosynthesis), in accordance with decision rules contained within its birthright DNA code. The chloroplasts inside the algae, on the other hand, are not autonomous because they do not process information using their own decision rules. Instead, they obey the decision rules contained within the algae's DNA.

Image 11 – Apple Computer and Algae

As a very different example, consider the classic MacIntosh personal computer. Like the algae, it too processes information in accordance with a birthright code that is installed in its memory at the factory. It also acts autonomously by processing information in accordance with decision rules that others have subsequently fed into it. This is quite different from the chloroplast, which is never vested with decision rules, but is instead always simply carrying out the algae's decision rules. In the case of a MacIntosh with a new program, there is a greater degree of autonomy, at least for a period of time, because the new program is vested in the MacIntosh. The original source of decision rules is not the most relevant issue in autonomy – all of us acquired our birthright decision rules from another source. What is key to autonomy is whether the subject entity has decision rules to use, or simply carries out instructions pursuant to the use of decision rules elsewhere.

Now, it may be said that every code was developed somewhere other than where it is used, and hence every entity with a code is simply "carrying out instructions pursuant to the use of decision rules elsewhere." To a certain extent this is true, and indeed this is a nice way of describing the "We in Me." Indeed, it may be said that autonomy exists *to the extent* that an entity is *not* simply carrying out

instructions coded elsewhere, but is instead applying a code, in a differential manner, based on varying environmental inputs. The algae and the MacIntosh do not have much flexibility in how to apply their codes, but they do have some. Both algae DNA and MacIntosh programs describe rules for processing environmental inputs – that constitutes autonomous flexibility. The chloroplast, on the other hand, has no such flexibility because *it* has no code. Darkness tells the algae's DNA to shut down photosynthesis; the chloroplast responds to instructions from this DNA, not from anything else.

Algae, and every other cell-based entity, are amazingly complex creations. But in its own ways, the MacIntosh computer is as amazing an entity as is an alga – and, of course, most people are generally sorrier for the crash of a MacIntosh than for the death of algae.

The extent of an entity's autonomy can be calibrated as its computational capability because that directly measures decision-making capability, which is the sine qua non (end product) of autonomy. Humans have approximately 100 billion neurons, and each of them have up to 1000 connections to other neurons. In addition, each neuron can fire about 200 times per second. Consequently, the human mind is capable, at most, of about 100 billion x 1000 x 200 = 2 x 10^{16} cps. Hence, a human's Autonomy value is A = 16. A MacIntosh computer, on the other hand, had a rated processor speed capability of about 1 x 10^{6} cps. Thus, a MacIntosh has an Autonomy value of A = 6. An entity that had the incomprehensibly large processing capability of googol (10^{100}) calculations per second would have an Autonomy value of A = 100.

The second criterion for life, Coopetency, means that an Autonomous entity is communicating consensually. Why is this requirement necessary for life? What entities demonstrate Autonomy but not Coopetency?

The Coopetency criterion is needed because life is important to us for its purpose of increasing justice, happiness, and fairness. Yet none of these goals can be achieved without consensual communication. A creature can be autonomous, and even quite intelligent, but vapidly destructive of all in its path. There is no reason to consider such a creature to be alive. Instead, it is simply an organic or inorganic threat, not dissimilar in nature from a natural catastrophe like a hurricane. The fact that it can act on its own does not rescue it from a vitological perspective if it is not communicating with those around it, and for higher life, seeking their consent to its actions. Such an entity will be destroyed not because it has forfeited its right to life, but because it is a threat to life. There never were any morally valid reasons to spare it harm because its *raison d'etre* (intention) was to harm others. If something has no ability to communicate, it cannot be faulted for not communicating.

Nor is this a matter of mere semantics. Something that acts like a typhoon does not get elevated to vitology by virtue of being made out of organic molecules. Similarly, something that acts like a pet doesn't get downgraded to non-life by virtue of being made out of computer chips. The Coopetency criterion reminds us that it is the behavior of the entity, not its appearance that is important from a vitological perspective.

Application of the First Principle of Geoethics, the Principle of Consent, is a challenging test *of* Autonomy because it can only be satisfied by giving the fullest respect *to* autonomy. An autonomous agent that seeks the consent of another autonomous agent is demonstrating a *high level* of Autonomy because it is demonstrating *high control* of its actions. For example, a dog demonstrates a *modest level*

of autonomy because when it decides what to do, either by genetic program or by training, it may take into account the sentiments of another autonomous entity (man or dog). Dogs don't usually satisfy their internal needs without consideration of other autonomous beings, and this behavior can be enhanced through training. A bacterium or MacIntosh, on the other hand, demonstrates a *low level* of Autonomy because they pay little if any heed to the consent of other autonomous entities. Given that bacteria cannot give consent, humans are not obligated under the Principle of Consent to seek the consent of bacteria before eradicating them. The Principle of Consent applies amongst consent-capable beings, which effectively means co-planar life forms. In a similar vein, because dogs are capable of giving consent to some things, with respect to those things their consent needs to be obtained.

Their limited ability to seek and give consent makes them a lower form of life than humans, but they cannot be gratuitously killed, like bacteria, because, unlike bacteria, they do have a limited ability to communicate consent to treatment, and even to request consent to an action.

The Transcendence of Life

The third criterion of life, Transcendence, requires a potential life form to demonstrate that it can extend itself beyond its information processing capability to serve the purpose of life. A fair test for Transcendence is compliance with the Second and Third Principles of Geoethics – the Principles of Equilibria and Assurance. The Equilibria principle says that actions should make the world a better place by increasing pleasure (which can include reducing pain), or reducing injustice (which can include increasing order). This principle is similar to the difference principle espoused by Professor John Rawls of Harvard University in his treatise [14] the *Theory of Justice*. Rawls deduced that if autonomous beings were asked to design from scratch a society in which they might have to occupy any role in the society, they could reach but one rational decision. They would require that there was equal opportunity for all and that any differences in equality operated to benefit most those who were least well off [15]. This outcome is the only logical outcome because nobody would want to end up being a person in a society who was discriminated against or trapped indefinitely in a bad situation.

Image 12 - Scales of Justice

The Principle of Equilibrium says about the same thing as Rawls' difference principle, although the geoethical emphasis is on the more ascertainable "increase pleasure," rather than on Rawls' more incalculable "benefit most those who are least well off." Geoethics relies on the fact that since actions are consented to, the subject of an action has an opportunity to negotiate such benefit as it can obtain in a given situation. Both principles endeavor to accomplish the same goal: increase the well-being of a group of people or society. Experience has taught us that reducing the disparities between people brings more total enjoyment to a group of people than does increasing the disparities. The Principle of

Consent, coupled with the Principle of Equilibria, operates to reduce disparities because more well-off segments of a community cannot further advance their position without impacting less well-off segments, and those less well-off segments will demand a disparity-reducing share of any further advance as a condition for their consent.

Francis Bacon, a lawyer-scientist who kicked off the modern age ethos of "we make our own destiny" with his publication of *Novum Organum* in the early 1700s, explained clearly why reducing inequalities among people is in everyone's best interest [16]. Bacon observed that people's happiness is relative to the available happiness. Keeping everyone fed, clothed and housed, will not keep everyone happy if some people in the society also get to travel, learn and be entertained. In other words, if people knew a certain type of satisfaction was available, they hungered for it, although what they did not know they would not miss.

"[I]t is only in the best interests of everyone in a society to provide reasonable legal avenues for people to satisfy their wants."

Now, if people are not given a chance within the laws of a society to achieve greater happiness, they will resort to extra-legal avenues to achieve that satisfaction. Such extra-legal avenues are frequently violent, and drag down the progress of an entire society. Consequently, it is only in the best interests of everyone in a society to provide reasonable legal avenues for people to satisfy their wants. Given the nature of human wants, this entails constant efforts to reduce inequality. An entity that was *not* trying to reduce inequality would *not* be increasing the ratio of pleasure-to-pain as much as possible. Consequently, such an entity would exemplify a lower level of Transcendence, and a lower level of life.

The Transcendence of an entity may be quantified by assessing its contributions toward creating a more just universe. An entity that added no net pleasure to life would not be alive. Hence, a fantastic information processor, that never affected another entity without securing its consent, but which added no pleasure to life, is not alive because A*C*(T=0) is 0. In fact, it is difficult to say that any entity adds no pleasure to life. Even very painful actors generally add some pleasure to some aspect of life. Hence, a more typical situation – for a problematic life form -- is that T equals a very small number, and hence the life form occupies a very low rung on the vitological hierarchy.

Consider, as an alternative example, a nice flower. It has an Autonomy value governed by the information processing rate of its DNA-RNA-protein machinery – perhaps on the order of one thousand calculations per second, or A=3. We do not know with which organisms flowers can communicate, other than perhaps the insects that pollinate it. Consequently, it is difficult to determine a Coopetency value to a nice flower, and so it may be accorded C=1 by default on the assumption that it does not fail to seek the consent of that with which it does communicate. Finally, a nice flower rarely adds pain to the world, but does make the world a more beautiful, and often a more fruitful place. Hence, the nice flower enjoys a T value that must be greater than 1. How much the T value of a nice flower exceeds 1 depends on how one chooses to unitize the teleological aspect of life. In other words, by what units does pleasure and pain get measured? This question is beyond the scope of this introductory text, but we can clearly determine that a nice flower is in the set of objects that are alive because they process information, communicate consent, and

contribute more pleasure than pain to the world. Indeed, from our theoretical structure we can further deduce that a "bad flower" with comparable information processing capability, and comparable coopetency, but no pollination capability must have a lower vitological score than "nice flower" and hence occupies a lower slot on the hierarchy of life. Indeed, the phyla of biology imply precisely this result.

The Third Principle of Geoethics is reflected here by virtue of its requirement that the terms of consent amongst members of a just society be independently enforced and monitored. In other words, in order to comply with the Third Principle of Geoethics a superstructure must be created to help implement the consensual agreements of autonomous beings. Compliance with this Principle of Geoethics makes quantification of Transcendence much easier because the superstructure ordinarily is unitized.

An example of an Assurance superstructure is money. Such an artifact is not written into our DNA code. Instead, we have *extended* our information processing capability to create a unitized system that greatly facilitates coopetency. Money is a means of assuring compliance with consensual agreements, since it can easily be added to or subtracted from for any variation from an agreement.

The main point here is that the third requirement for life is evidence of making the world a happier place. Such evidence comes from behavior that addresses the Second Principle of Geoethics (enhance pleasure; reduce pain), and is manifest in higher life forms by externalized systems that keep track of consensual agreements. Such independent systems are expected of higher life forms via compliance with the Assurance Principle of Geoethics.

Our definition of life is based on why life is important to us. It is important to us because it accomplishes the purpose of making the world a better, more just, place. In order to make the world a better place a life form must be able to make decisions based on the status of the world as it is perceived (Autonomy). In addition, the world can only become a better place via cooperation amongst life forms (Coopetency). But, finally, pure cooperation among life is not enough to ensure the achievement of the purpose of life because life forms can cooperate in their own destruction. The ultimate hallmark of life is its ability to achieve objectively ascertainable advancement in the quality of life – greater fairness, greater justice, greater opportunities for universal satisfaction and pleasure. This criterion of vitology is called Transcendence.

Summary of the Fiction of Biology

Biology is not the study of all life, and all life need not be biological. Instead, life is much more than biology – it includes all phenomena that demonstrate autonomy, coopetency and transcendence – fancy words for processing, sharing and extending information. In order to process information, and thus demonstrate autonomy, an entity must have its own decision-making rules, such as are contained in DNA, computer programs, or acquired experiences. In order to share information, and thus demonstrate coopetency, an entity must be able to obtain the consent of other entities to actions that affect them. Finally, in order to extend information, and thus show transcendence, an entity must be able to construct an external, independent mechanism for assuring compliance with the terms of consent among autonomous entities. Any entity that meets these three criteria of Autonomy, Consent and Transcendence – shorthanded as ACT – will be alive. Indeed, all biological organisms currently thought to be alive do meet this definition, with evolution and natural selection often serving as the sole

mechanism of transcendence. But of great importance is that many non-biological organisms also meet the ACT definition. These entities are equally alive, and hence the new term "vitology" more appropriately defines life as any entity -- biological, cybernetic or informational -- that processes, shares and extends information. Furthermore, such vitological entities can be arrayed along a vast hierarchy of life, calibrated from 1 to 1M, based on the product of their processing capability, consenting behavior and resources devoted to implementation of consensual agreements.

Endnotes

[1] Kant, I. (1979), *Lectures on Ethics*, Infield, L., tr., Hackett: Indianapolis.

[2] Habermas, J. (1990), *Moral Consciousness and Communicative Action*, Lenhardt, C. & Nicholsen, S., tr., MIT Press: Cambridge, Mass.

[3] Beck, U. (1992), *Risk Society: Towards a New Modernity*, Sage: London

[4] Rawls, J. (1971), *A Theory of Justice*, Harvard University Press: Cambridge, Mass.

[5] Habermas, J. (1996), *Between Facts and Norms: Contributions to a Discourse Theory of Law and Democracy*, Rehg,W. tr., MIT Press: Cambridge, Mass.

[6] Beck, U. (1992), *Risk Society: Toward a New Modernity*, Sage: London

[7] Spinoza, B. (1957), *Ethics, Demonstrated in Geometrical Order*, reprinted in Gutman, J., ed., Hafner: New York.

[8] The back-and-forth nature of human progress results in the fact that "out of the crooked timber of humanity, no straight thing was ever made." I. Berlin (1969), *Four Essays on Liberty*, Oxford University Press: Oxford, p. 170. The most important point, though, is that many things have been made, albeit they are not straight. Consequently, antipodal philosophers such as Nietzsche and Rousseau both miss the point. They each see the back-steps of civilization and pine for either forward-motion at goose-step rate under a strongman (Nietzsche) or no back-steps in an idyllic natural world (Rousseau). Yet the goose-step approach inevitably takes one right off a cliff, while the anti-civilization approach leads one to slow decay. There appears to be no good substitute for careful trial-and-error progress, with reliance on free discussion and collective decision-making to keep the ratio of n:n-1 as high as possible.

[9] Brandenburger, A. & Nalebuff, B. (1996), *Co-opetition*, Doubleday: London

[10] Ridley, M. (1997), *The Origins of Virtue*, Penguin: London.

[11] Harris, J. (1985) *The Value of Life: An Introduction to Medical Ethics*, Routledge: London

[12] The empirical determination of vitological numbers can be accomplished in at least two different ways. First, it is possible to do a "time and motion" analysis of a being, or enough beings to be representative of a species. Such a time and motion analysis will result in a percentage of time allocated to components of the vitological index. Alternatively, an assessment can be made of the percentage of time that either the most simple living entity we know spends on components of the vitological index. Then all other beings and species can be assigned a multiple of that value based on how much more time they spend.

[13] One reason to have such a broadly

enumerated scale such as 1-1,000,000 is that there is such a plethora of different species. There are already over one million differently Technology is absolutely essential to ethical concepts such as equality of opportunity, and to the geoethical principle of equilibria.

[14] Rawls, J. et. al. (1987), *Liberty, Equality and the Law*, Cambridge University Press: Cambridge.

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[16] Bacon, F., (1620), *Novum Organum*, London

BIO

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