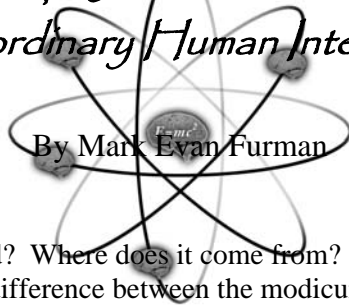


The Matrix of Genius: *Cognitive Neurophysics and the Development of Extraordinary Human Intelligence*



Prologue

What is genius—can it be defined? Where does it come from? Does genius develop from content or process? What is the difference between the modicum of human beings that history has venerated for their extraordinary intelligence and creativity, and the rest of humanity? How can genius be modeled? Where can the tools and rules for modeling genius be found? Will nature reveal her cryptotropic matrix for developing geniuses? Is genius learnable or are human beings randomly endowed with this genetic propensity at the roll of nature’s dice? Can it be explicitly taught? If we find this template can we truly influence our *own* design? Is it really possible to consciously guide the hand that weaves the fabric of human destiny? These are just a few of the questions that instigated the fifteen years of research and development, which have resulted in the interdisciplinary branch of science known as *cognitive neurophysics*.

The purpose of this paper is to advance an extension of *The Standard Theory of Pattern-Entropy Dynamics* that may endow humanity, if understood and seriously applied, with the “Rosetta stone” of mind—the template for the development of extraordinary human intelligence we call *genius*. The exploration of this area of human excellence has confounded human intellect for millennia, for even geniuses themselves seem to be unable to develop genius in those around them or even pinpoint the genesis of their own fortuitous endowment.

In this paper, we will be exploring this most elusive and respected of the human proclivities from the interdisciplinary vantage point of cognitive neurophysics. The answers to these questions do not come from psychology or neuroscience, biology or education science. Instead, we find such answers only by forming an integrated picture of what a human being is by weaving together all of the disparate disciplines that have attempted to understand the whole, by studying its parts. Then, to this picture we must add the laws of physics—our inseparable relationship with the physical world. Nature’s laws have illimitable dominion over *all* organizations of matter and energy great and small—human beings and human brains are *no* exception.

Where do we start looking for clues that will lead us to the matrix of genius? *The Standard Theory of Pattern-Entropy Dynamics* (Furman and Gallo, 2000), provides us with the essential foundation. To capture the essence of a gift of mentation as elusive as genius, we must begin at the most fundamental “building-block” possible. Physics tells us that the most fundamental building-blocks of universe are not building-blocks at all – they are *processes*. The long-held belief that atoms would contain the fundamental building-blocks of universe was firmly obliterated following the advent of high-energy particle physics.

As physicists increased the velocity of colliding particles in their particle accelerators and measured their results in bubble chambers, some of the strangest and most unexpected behaviors in nature emerged. Strangest of all was that new particles of “matter” could be made to emerge

from so-called “elementary” particles simply by selecting different velocities for experimental particle collisions—change the velocity, discover a “new” particle. The shocking realization that nature had no fundamental “building-blocks” to reveal, left physicists dumbfounded for decades. At the most fundamental level of the physical world, we find events, *not* things—the events from which ephemeral “structure” is born. If we can fully and completely understand this implication, we then know to look for genius not in content, but in process—not in *what* we know but *how* we learn it.

Morphogenesis: Pattern and Structure Arises from States of Motion

The Standard Theory of Pattern-Entropy Dynamics clearly shows that the most fundamental level of description available to us for understanding the physical world lies in *pattern*. The theory posits that pattern itself, is the universal language of nature. When a pattern-integrity arises, it arises from a “state of motion”. Different states of motion within our physical world both permit and constrain the development of certain patterns. A *pattern-integrity* can be defined as a set of *relationships* that defines the “pattern of displacement” of matter and energy of an encoding medium or coordinate space. This pattern of displacement emerges from a particular state of motion and is preserved as it propagates through an encoding medium.

Such a phenomenon is easily recognized in water. If we throw a handful of rocks into a still pond the rocks act as *force vectors* with direction and magnitude that will displace water molecules in such a way that a recognizable pattern-integrity emerges. Each impact will result in a pattern of concentric rings propagating outward at nearly a 90 degree angle to the direction of impact. Each set of concentric rings will vary in amplitude by the magnitude of impact (the *mass* of the rock times its *velocity*) such that rocks that are heavier and faster will create ripples (displacement of water molecules) having greater amplitudes (larger wave patterns). It is the “pattern-integrity” that propagates through the medium we call water, *not* the water molecules. The only thing that travels is the “pattern of disturbance”—the particular set of angular relationships and accelerations of the displaced matter and energy we refer to as *information*.

Waves that we see traveling from deep water to the shore of an ocean are also pattern-integrities—patterns of displacement that have amplitude, velocity and shape (angular relationships). Here again the molecules themselves are not traveling to the shore, only the pattern-integrity is. The water molecules themselves are simply moving in spiral patterns at approximately 90 degree angles relative to the direction the pattern-integrity is propagating. Keep in mind that if we can *see* the wave, that the pattern-integrity is not only propagating through the *water*, but also through the visual system of *our brain*, thus simultaneously displacing the matter and energy of our biophysical encoding mediums via the electro-magnetic displacement of atoms and molecules within our retina and higher-level visual pathways.

As we look up into the sky on a partly cloudy day, we notice cloud formations. These cloud formations are pattern-integrities that emerge out of the state of motion of the particular layer of the atmosphere in which they form. If you look carefully at a partly cloudy sky, you will notice that different layers of the atmosphere do, in fact, contain different cloud shapes. You will also notice that within the same layer of the atmosphere, while clouds may differ significantly in size, they maintain the same pattern-integrity— they are *fractal* (multi-scale self-similarity) structures, emerging from recursive processes in our atmosphere. From day to day, these pattern-integrities called clouds emerge with new forms. The matrix from which they emerge is a state of motion which permits their development, while at the same time constraining the type of development of the cloud forms we had seen yesterday.

The Construction of Brain and Mind: Content vs. Process

Nature reveals on all its levels that different states of motion give rise to different pattern-integrities and pattern-integrities in certain cases, become structures. What physical law tells us is that “content” arises from “processes” and the emergence of different “contents” are permitted, and at the same time constrained by the dominating “process” within a given system. In spite of this understanding, American school systems, as well as many others throughout the world, continue to operate from the assumption that intelligence emerges from the assimilation of “content”. The close examination of the physical world on every level proves this assertion to be false.

Pattern and *structure* are ephemeral and transient but if the *matrix* (hidden process template) from which they emerged is in place, these patterns and structures will emerge once more. The cloud patterns that we see on Tuesday are certainly not the “same” clouds that will be seen on Sunday. Yet, they will bear a striking resemblance since they emerged from the near-same state of motion in the atmosphere. Although for four consecutive days a qualitatively different cloud pattern might have prevailed, when the matrix returns those structures that naturally emerge from the matrix return. Pattern and structure are ephemeral and transient. When we force a child in school to assimilate content without process rather than to allow the content to emerge as a result of a process, we mistakenly assume that we have imparted knowledge. Evidence suggests that we have not. Year after year teachers are perplexed by a phenomenon called “forgetting”—this strange thing that occurs when content is assimilated without process and then measured by a test.

The classic scenario finds children studying “for” a history exam on Monday, by blindly “memorizing” names, dates, places and events to be regurgitated during the test on Friday. Even if the children had initially scored well, tragically, if the teacher dare challenge the laws of nature by giving a pop quiz on the *same* material the following Wednesday, they are dumbfounded by the mountain of failing scores. Nature is relentless. Her laws have illimitable dominion over all physical organizations of matter and energy from biospheres to brains. And, just as we can expect new states of motion in the atmosphere to give rise to different cloud patterns while “forgetting” the previous ones, we can also expect the pattern-encoding mediums of the brain to give birth to new forms while “forgetting”, at least temporarily, the previous ones. Only if the isotropic matrix is present, can we expect these familiar forms to re-emerge once again.

Recipe for a Brain: From Chocolate Cake to Bioarchitecture

A simple way to envision the significant differences between content and process is to liken it to a “recipe”. If I were to invite you to a dinner party where I served a mouth-watering chocolate cake, after tasting it, you may have a strong desire to replicate it at home. To do this, you would ask for my recipe and that recipe would consist of two things – a set of “contents” that we call ingredients and a “process” – an order and sequence for combining those ingredients. Let us assume that I sent you home with simply content – a list of 15 ingredients. If you did not understand the process of cake-making, what are the chances that you will combine the 15 ingredients in the right order and sequence, cook them at the correct temperature and for the correct length of time? Realistically, even with only 15 ingredients, the odds are stacked heavily against you. You could potentially *not* replicate my chocolate cake in hundreds of different ways. Without the process to guide you, *entropy* (the tendency toward disorder) will always have the upper hand.

Now let's imagine that you have both the content and the process for making the cake. If you follow the process exactly, the chances of you baking the cake and then erroneously adding the eggs to the top when it's done, would be quite slim. With both content and process in hand, your ability to replicate the same type and quality of cake is significantly improved. In fact, once you have learned the process, some of the ingredients may be changed to allow you to create many different varieties of cake. In the same regard, once the *brain* has learned a process for *learning* or for the development of genius, it can and will use it over and over again regardless of the content encountered. A thorough investigation of human genius throughout history clearly reveals that a genius is master of many "contents". Whether we are talking about human brains or chocolate cake, from the standpoint of physics, the relationship between content and process is the same.

With regard to education, we refer to the content that we wish the human brain to assimilate, as *information*. And, as you may recall from previous papers (Furman, Nov. 1999, April 2000, May 2000), information and pattern are one and the same. Unfortunately, today's educational systems attempt to develop mature brains and a high degree of intelligence simply by shoveling large quantities of content into a student's brain through their unconditioned sensory systems in the hopes that the information will "know" what to do when it gets in there. This process is no different than asking someone who has never baked before, to replicate my chocolate cake with only a listing of ingredients. The chances of the assimilated information organizing itself in any useful way, within the brain of a student, is next to zero. It is no wonder that we so ardently venerate the modicum of geniuses that we stumble across in our lifetime.

Considering the fact that educators attempt to impart thousands of disparate "content" morsels per semester, instead of a mere 15 in our chocolate cake example, the chances of producing extraordinary intelligence via this method seems little more probable than a collection of ingredients assembling themselves into a chocolate cake under the direction of a breeze from a nearby window. So now that we have established the importance of process over content, let's take it one step further and elucidate their relationship to one another. If we *isomorphically* (equal structure) and *isotropically* (equal influence) compare the forms around us from atoms to galaxies, we come to the conclusion that "content" itself, arises *from* "process". The two are recursively enumerated in nature giving birth to an ever-widening range of different contents that vary in complexity. Process gives rise to content, which in turn is acted upon by the very process that gave rise to it.

The Matrix of Genius: The Five Behaviors of Pattern

Knowing that process is the critical missing element for the development of genius and extraordinary human intelligence, is by itself, quite useless. We still need to define precisely *what* processes or "states of motion" form the matrix from which genius comes forth. To accomplish this, we must search for the most fundamental influences responsible for the initial assembly and dynamical arrangement of human brains from the level of atoms to the fractal folding patterns of the neocortex.

The Standard Theory of Pattern-Entropy Dynamics defines these fundamental states of motion as the *five behaviors of pattern*. Once we understand that pattern is the universal language of nature, we can liken the five behaviors of pattern to a "grammar" which imposes rules and constraints upon pattern behavior. Since the theory clearly establishes how the physical world produces all its forms, including brains, via these five behaviors, we will bypass this discussion due to limited space and proceed to utilize the model to explicate the matrix of genius.

We defer those readers who are interested in a more detailed discussion to *The Neurophysics of Human Behavior: Explorations at the Interface of Brain, Mind, Behavior and Information* (Furman and Gallo, 2000).

The five behaviors of pattern are formally known as *incorporation*, *replication*, *cleaving*, *recombination* and *transmission*. These are the five self-referent grammars of nature's language—pattern. As we will shortly see the “collective” interaction of these five behaviors seem to be governed by a property that emerges from, and is ubiquitous to all five, called *recursion* (Hofstadter, 1980). Recursion is a term used for describing the way in which each of the processes act upon each other as well as themselves to produce patterns of ever-increasing complexity and diversity. Together these states of motion erect and destroy all the ephemeral forms of universe from mind to matter. During the course of this paper, we will be defining these states of motion (processes) in greater detail in order to show exactly how extraordinary human intelligence is born from this matrix and destroyed by disregarding it. We will be defining and exploring these pattern behaviors first in groups of two and then collectively as we discover how ever-increasingly complex forms and processes can emerge from the recursive enumeration of these five fundamental behaviors of pattern.

Incorporation

If we redefine the human brain in terms of a neurocognitive system of pattern-encoding mediums, *incorporation* then can be described as the *displacement* of a pattern-integrity from outside the system to someplace within the system's coordinate space or encoding mediums—the assimilation of an aggregate of elements, processes or configurations of displacement of matter and energy, whereby the “relationships” between the elements, processes or displacements are preserved (an “isomorphic” displacement). The critical distinction that separates incorporation from *transmission*, which we will discuss later, is that the *pattern-integrity* is not only displaced in coordinate space, but also “crosses” a system's semi-permeable boundary or barrier which separates the incorporating system from its environment. Nature is rife with examples of this pattern behavior.

There is a wonderful illustration proffered by physicist Erwin Schrodinger (1944) that we can use as an example. Let us say that we have two biological organisms named A and B. If “A” *incorporates* “B” and “B” dies we call this *eating*. If instead “A” dies we call it *infection*, and if they both live and continue to co-exist “nested” inside one another we call it *symbiosis*. A close survey of the physical world from the microscopic to the macroscopic will also reveal the ubiquity of this pattern behavior. For example, when the nucleus of one atom is incorporated by the nucleus of another atom we call the process *nucleosynthesis*. This is nature's way of manufacturing all of the atoms heavier than hydrogen, which are needed to assemble human beings and the physical world in which we exist. On a grander spatial scale we can find the process of incorporation at work as we watch one galaxy engulf another through the forces of mass attraction acting *precessionally* (at other than 180 deg. angles), only to become one enormous *elliptical galaxy*.

In order to understand how to properly apply this ever-present pattern behavior to the development of brain, mind and extraordinary human intelligence, we must explore it in conjunction with the second behavior of pattern—*replication*.

Replication

Replication is the copying or “reactivation” of a set of aggregates, elements or displacements of matter and energy defining a pattern-integrity. Due to almost infinite variances in type and stability of encoding/replicating mediums the “copy” is not always isomorphic (from the Greek root meaning “equal structure”) thus allowing for mutation and diversity to arise spontaneously. Replication can be found occurring ubiquitously throughout nature from DNA, viruses and cells to atoms and stars. *Incorporation* and *replication* must be considered together so that their relevance to human intelligence may be deeply understood and educational design correctly applied. Considered together, incorporation and replication constitute what we loosely define as “memory”—and having a good one intimately depends upon the interaction of both processes.

For example, if an incorporating medium is too “unstable” a pattern-integrity will be lost over time, as when we put a drop of red food coloring in a glass of water and watch it disintegrate over time. If the incorporating medium is too “stable” the pattern-integrity could be distorted, or parts of it may be deleted upon incorporation as when we put a drop of food coloring on ice. If the incorporating medium is very stable in relation to the pattern-integrity it may resist incorporation all together as when we put a drop of red food coloring on a piece of glass. Naturally, all variances in the *incorporating* medium will effect the accuracy of *replication* of a pattern-integrity in some way. This fact of nature in part, accounts for the enormous odds stacked against large numbers of human beings *spontaneously* developing genius.

Measuring Intelligence: Incorporation, Replication and Time

An arduous survey of today’s educational “testing” and “measuring” systems reveals a cryptomorphic (hidden structure) relationship notwithstanding the educational “content” we are testing for. When you or your children go to school and take a test on a certain subject matter, do you get all the time you want to answer the questions? Absolutely not. All tests are *timed*. Have you ever learned something and tried to remember it under pressure to no avail, yet an hour later it came to you spontaneously? Does this mean you are not intelligent? If you had been taking a test it would.

The hidden structure ubiquitous to all systems extant today for measuring human intelligence is a “time limit”. This has important implications for the intentional development of mind, brain and genius. Since these properties do not exist in isolation they are a function of how we choose to measure them. And as the physicist Heisenberg warned us, that which you measure you will also change by the very act of measuring it. In order to score a perfect 100% on a standard spelling, vocabulary or math test given to us with the purpose of measuring our understanding of the “content” taught, we must *incorporate* and *replicate* the patterns shoveled in through our sensory systems with near 100% accuracy *within* the time limit chosen by the teacher. If you arbitrarily change the time limit you will change the scores. What would the scores be if we cut the time available by 20%? What about 25% or even 35%?

We can conclude from this cryptomorph in the standard educational testing design, which happens to be ubiquitous throughout our educational system, that our intelligence is being measured not only as a function of *what* we know but how “*fast*” we know it. The testing design commonly used by our educational system actually reveals how “energy-efficiently” we are able to *incorporate* “and” *replicate* a pattern-integrity, since energy-efficiency profoundly influences the *speed* at which a pattern can be replicated (called *phase velocity*). Understanding the implications of this testing design affords us an enormous advantage with regard to the intentional

development of extraordinary human intelligence. It also begs the question—what is involved in packaging and delivering a pattern-integrity to the human brain as energy-efficiently as possible?

Responsiveness of the Incorporating Medium

The first thing we must ascertain is how well the incorporating mediums of a given human brain are functioning. This necessitates that we carefully test sensory acuity before attempting to impart information. Naturally, the finer the distinctions we can make with a given sensory system, the better the chances of accurate incorporation of the pattern-integrity. Eye tests and hearing tests are critical in this regard, because to the degree that our information incorporating pathways are occluded, our ability to incorporate a pattern-integrity without distortion or deletion is affected. If a pattern-integrity is incorporated with aberrations it will obviously be impossible to later replicate it with 100% accuracy. Naturally, since all of our sensory organs contribute to the construction of “mind”, we must test the functional efficacy of every sensory organ we intend to package information for. It goes without saying that children with uncorrected vision problems or inner ear/middle ear fluid build-up due to recurrent ear infections, are at a grave disadvantage, as their information incorporating mediums are compromised and therefore less responsive. This is certain to result in deletion and distortion of information.

The importance of physiologically sound organs of incorporation is really no secret yet its far-reaching implications appear to elude educators, especially those who work with children having speech development problems. It does not appear obvious to many of them that a child’s ability to produce clear speech sounds (replication), stems from their inability to *incorporate* the sound patterns with a high degree of accuracy. Many speech impaired children also have a history of recurrent ear infections and produce speech that sounds as if they are under water, yet it sounds perfect to *them* because that is exactly the way they hear *us* prior to the excess lymph fluid being drained from their ears. During the early stages of constructing mind, we can only expect to replicate a pattern-integrity as accurately as we have originally incorporated it and not one bit more. In the later stages however other pattern behaviors assist the neurocognitive system in enhancing some types of degraded and distorted sensory representations.

Even if our sensory organs are sound, deletion and distortion of information can also be caused *internally after* incorporation, by *competition* between previously incorporated information patterns within the brain (Furman and Gallo, 2000). Both, NeuroPrint and an ancient meditation system called Zen, have been effective at eliminating this type of information distortion. In the same regard, new incoming sensory information can become deleted or distorted *during* incorporation by *internal* information competing for the same encoding mediums of the brain. This is why information incorporation must be carefully timed with the opening and closing of attention cycle windows (Furman, May 2000).

Once it has been firmly established that we do possess a properly functioning set of sensory organs and processing pathways, from a physiological standpoint, the answer to the question of energy-efficient “structure” development within mind and brain comes from recognizing an isomorphic relationship between phobias, video games, and cardboard boxes.

Spontaneous Pattern Stabilization: And the Tensegrity of Phobias, Video Games, and Cardboard Boxes

Experience tells us that not all pattern-integrities result in stable replicatable structures within the brain and mind. What then turns an incorporated pattern-integrity into a replicatable structure? The answer is the ability to *self-stabilize*. The pattern’s energy vectors must be configured in a

way that they *inter-stabilize* each other—a property called *tensegrity*. The term tensegrity was coined by R. Buckminster Fuller in his magnum opus, *Synergetics: Explorations in the Geometry of Thought* (1975). It means that a set of elements have a tensional integrity that restricts their degrees of freedom and therefore stabilizes their form.

Imagine joining two toothpicks together at one end. Each toothpick represents an energy vector and they are joined by a single bond. This gives them a lot of flexibility of motion to change shape (by angular relationship) but little stability. If we add a third toothpick and join each of its ends to the free ends of the other two toothpicks we have a triangle—the minimal two-dimensional, self-stabilizing structure. It is the tensegrity of the energy vectors that maintains each of the angular relationships of the pattern integrity – “triangle”. In order to build the minimal three-dimensional, self-stabilizing, structural system of universe, we would need four such toothpick triangles, forming three sides and a base—that means six energy vectors forming four angles or vertexes. The three-dimensional geometric figure that emerges from this relationship is known as a *tetrahedral* – a solid geometrical figure with four triangular bases. The tetrahedral has not only been shown by Buckminster Fuller to be the prime structural system of universe, but also the very shape of energy itself.

Cardboard Boxes and Tensegrity

Tensegrity can be illustrated in another way. Let us say that you have a cardboard box and you want to fill it with some things that you will be carrying to a friend’s house. Once you have filled the box, you attempt to seal it only to find that you don’t have tape or staples or anything else that would work. If you leave the flaps unsecured and the box turns over, everything will fall out. By themselves, the flaps on the top have no stability. Then an idea pops in your mind to take each of the flaps and put it under the next until finally the last flap is put under the first. The four, overlapping/*under*-lapping flaps produce a tensional integrity that gives the top of the box structural stability. The structural stability comes from the fact that each of the flaps (vectors) are inter-stabilizing one another, and thus maintaining their angular relationship to one another. Tensegrity is the matrix from which structure emerges from pattern. Such tensegrity is ever-present in nature since no two lines of force (energy vectors) can occupy the same point in space..

Triangles in the Brain: the Shape of Energy

Both two-dimensional and three-dimensional minimal structural systems can be found forming in the brain due to the property of tensegrity. Neuroscientist, William H. Calvin (1996), uncovered such a phenomenon acting on nerve cells in the human brain. He discovered that when two nerve cells approximately 0.5 mm apart, fire simultaneously, they tend to recruit a third nerve cell equidistant from the other two on the *surface* of the neocortex that was not originally stimulated by sensory information. The energy pattern formed by the simultaneous activation of the three nerve cells forms an equilateral triangle with naturally occurring tensegrity.

He further discovered that these triangular energy patterns form two-dimensional hexagons along the surface of the neocortex and concluded that the minimal structural array necessary to replicate a complex pattern-integrity within the brain, were two hexagons composed of six triangles each. If we combine the conclusions of both Buckminster Fuller and Calvin, we can infer that since brain tissue is three-dimensional, so are the triangular patterns of energy that are formed within them. It follows then that those energy vectors within the brain that achieve tetrahedral tensegrity, form self-stabilizing structures. There is in fact, much evidence to support this (Furman, Nov 1999; April 2000).

Not only do tetrahedral arrangements of energy exist at the level of nerve cells 0.5 mm apart, but Buckminster Fuller believed that stable “thought patterns” themselves were arranged tetrahedrally. This assumption can, and has been verified, by employing the use of *NeuroPrint* to model the structure of compulsive thoughts (Furman and Gallo, 2000). Mounting evidence suggests that the tetrahedral arrangement of energy vectors exists on all scales of nature from atomic particles to galaxies – recursively nested within one another, they are responsible for the existence of structure within a universe that Einstein himself, has proven is only energy.

The famous formula $E=mc^2$ is the essence of the interconvertability of matter and energy. It implies that only energy (states of motion) exists, not matter. Buckminster Fuller (1975), tells us that the only reason matter even exists ephemerally is that energy arranges itself in recursively nested tetrahedral tensegrities with different bonding tendencies (variously involving one to four vertexes). So what bearing does this have on the development of brain, mind and extraordinary human intelligence? Simply this, that if we want to package information such that its pattern-integrity, once incorporated within the brain, becomes a spontaneously, self-stabilizing structure we must package it with recursive tetrahedral tensegrity in mind. The simplest way to accomplish this is by packaging information so that a minimum of four to six of the brain’s incorporating systems/mediums undergo matter/energy displacement simultaneously. While this sounds complicated, it is really rather simple. It means that, if we want to package information that is easily replicatable and energy-efficient, we must *simultaneously* stimulate a minimum of four sensory systems, whether they be internal or external. Since energy interacts with *itself* precessionally (in other than 180 deg. angles), tensegrity is a natural property of energy interaction. Simply provide four to six energy vectors to the brain’s sensory organs simultaneously and the rest happens automatically.

Video Games, Phobias and the Tensegrity of Simultaneous Sensory Stimuli

Why do children learn video games so easily and enjoy them so much? Because of the principle of tetrahedral tensegrity. The addictive video game offers a *visual* stimulus, an *auditory* stimulus, a *motor* stimulus, *proprioceptive* and *tactile* stimuli, all simultaneously while at the same time producing an intense, pleasurable neuroendocrine/*somatosensory* system response we call “emotion”. It is no wonder why video games are more addictive and more easily learned than mathematics.

There is an interesting relationship that emerges from this perspective between psychotherapeutic intervention and education. In a strange way, they are mirror-image compliments of each other. From the vantage point of cognitive neurophysics, *psychotherapy* can be viewed as the attempt to *destabilize* unwanted self-stabilizing, biophysical and neurocognitive energy structures that arise spontaneously. *Education* can be viewed as the intentional attempt to *create* useful self-stabilizing, biophysical and neurocognitive energy structures. With the enormous number of people today seeking psychotherapeutic intervention and the equally staggering number of students being poorly educated it appears quite paradoxically that nature does a better job teaching “remembering” than our educational system and our educational system does a better job teaching “forgetting” than our psychotherapeutic systems. Paradoxically, both industries are plagued with the same phenomenon—self-stabilizing energy patterns. Educators want to create them and psychotherapists disrupt them.

Phobias and traumatic memories are examples of “one-time” learning—if only calculus could be that easy. Why is this so? The answer again is tensegrity. Traumatic memories and

phobias both form from the simultaneous incorporation of sensorial information in at least four to six biophysical/neurocognitive encoding mediums (Furman Nov,1999; April 2000).

If we deeply understand the implications of tetrahedral tensegrity and self-stabilizing structural energy systems then we can fully appreciate why it might take untold numbers of repetitions to force a student to remember even 80% of the information simply incorporated from a uni-modal information source like a textbook or a lecture at school. This single-modality, non-simultaneous energy vector method of creating replicatable pattern is little more effective than trying to get two toothpicks to stand up together in a teepee shape with no other support than to lean them against each other at two *different* times.

Music and the Matrix of Genius

Music was the first human language. It was also the first *formal system* developed by humanity that possessed natural tensegrity. Unlike mathematics and other formal systems that we have developed since, music involves the tightly correlated multi-modal processing of pattern-integrities. As a human brain “sight reads” a musical score, pictographic groupings of spatial dot patterns incorporated by the eyes tightly correspond to rhythms, pitches, melodies and harmonies that are incorporated by the ear during the performance of that score. These pattern-integrities of the *visual* and *auditory* systems in turn tightly correspond with those incorporated and replicated by the *motoric*, *proprioceptive*, and *tactile* systems when the music is “performed” by transforming the dot patterns on the page into the skilled movements of the musicians hands. These tight correlations result in the inter-stabilization *of* each of the sensory patterns *by* each of the sensory patterns. Such inter-stabilization produces a morphogenetic information field capable of regenerating itself from any part *of* itself after it has been disturbed or disrupted.

When the proprioceptive pattern-integrities of the performance displace matter and energy within the auditory system causing “sound”, they also produce a neuroendocrine response. Our intricate “*emotional*” responses to music are due to the corresponding displacement of matter and energy within our neuroendocrine and somatosensory systems in response to the sound patterns heard by our ears and felt by our skin. Six different incorporating/replicating systems are *simultaneously* displaced by intricate pattern-integrities in response to this deceptively simple human act of “making music”.

What is quite interesting is that while most of us who are untrained in the formal system of music need to *hear* the sound patterns in order to *feel* an emotional response, a trained “sight reader” and composer will have this emotional response as well as a motoric response, simply by “reading” the written score. The matter and energy of their neuroendocrine system in this case, is precisely *displaced* in direct response to the visual pattern-integrity alone. This phenomenon, which is sometimes referred to as *synesthesia*, has its physical basis in tensegrity.

The very act of learning how to transform a written score into its corresponding auditory and motoric pattern-integrities causes the brain’s neural circuitry to weave together in highly complex ways resulting in the formation of a labyrinth of information processing pathways that will be used over and over again for the study of other formal systems like mathematics, language and science. This is why there is such an outstanding correlation between children who study music seriously and “straight A” report cards (Furman, Sept.1997). This transformation of visual pattern-integrities performed by the brain results in the *simultaneous* meeting of *six* energy vectors within the multi-modal encoding mediums of the brain—significantly more than what is necessary to produce the minimal conditions for self-stabilizing structure to arise.

As we will see shortly, music not only possesses natural tensesgrity but it is so flexible as a formal system that it is considered one of the prime systems for the intentional development of the matrix of genius. While in principle it is possible to develop genius through the rigorous study of other formal systems such as mathematics, logic, philosophy, rhetoric and science when properly taught, few of these can be commenced by the age of three when the brain is in its critical stages of development and only one can establish the neurocognitive pathways that *all* the others will depend upon in the future—music.

In Through the Out Door:

Reducing Recursive Transitions for Energy Efficiency

Before we move on to the next pair of pattern behaviors we need to introduce one more principle to guide the proper use of the incorporation/replication, mind-constructing process. Always incorporate a pattern-integrity as a “whole” if possible and incorporate it within the *same* system you will need to replicate it in. If you are going to be in a spelling bee where you are required to respond *verbally*, incorporating the words *visually* and then *writing* (motor) them down for practice will cost you priceless energy and time in attempts at spontaneous verbal replication—not to mention the increase rate of mistakes made when trying to transmit the word pattern from one incorporating/replicating medium (visual/motoric) to another under (linguistic/motoric) pressure. Instead, practice by incorporating the word patterns visually and then replicating them both visually and auditory, while gradually increasing your speed of replication. For a more detailed discussion of this see *Intelligent Learning Systems* (Furman, Dec 1998).

Content and Process Revisited

We established before, the fact that process is far more important in the development of genius than content but this does not mean that content is unimportant. *Content* provides the raw material for the *processes* of incorporation, replication, cleaving, recombination, transmission and recursion to act on.

What do you think you get when incorporated mental patterns of violence, sex and drugs from multi-media sources of energy tensesgrity like TV and video games, are replicated? Massacres like the ones which have recently occurred in Littleton, Colorado and Michigan. How does a six-year-old first grader *learn how* to murder another student in cold blood with a pistol for spitting on a desk before he even *learns how* to read or multiply? The answer again is the simultaneous, multi-modal incorporation of pattern-integrities—tensesgrity.

What do you think might be *replicated* instead when a human mind is developed by the systematic *incorporation* of the life works of Einstein, Aristotle, Plato, Socrates, Mozart, Bach, Darwin, Leonardo da Vinci, Rembrandt, Pavlov, Nikola Tesla, Shakespeare and other intellectual giants throughout world history. Which building-blocks would you prefer your children to start with when they apply the additional process of cleaving, recombination, transmission and recursion to the patterns that they have previously incorporated?

Precise, energy-efficient, incorporation and replication of the right pattern-integrities can certainly get you “straight A’s”. It is also the essential *foundation* for the development of genius in that it provides the brain and mind with the raw materials from which we will draw in order to construct new ideas that will influence the physical world. But by itself it can never be considered *the matrix* of genius. As we will shortly see, profound genius, requires the development of three more essential *processes* and one emergent property ubiquitous to all five

that governs their collective interaction, but none the less, all the rest depend on the functional efficacy of these first two.

Minimal Conditions for the Development of Genius

Now that we have discussed in great detail the role of incorporation and replication in providing the brain with the raw materials needed for the development of extraordinary human intelligence, we must begin to explicate how these raw materials must be acted upon for such a phenomenon, as genius, to occur. What would a human being be like if the living architecture of their brain was only assembled from the minimal pattern behaviors of incorporation and replication? The answer is simple. That human being would behave like a machine. Unable to have an original thought, or to perform the act of thinking as we know it, that human being would simply be able to regurgitate anything that we put in. One might hazard a guess as to just how limiting and possibly dangerous this type of brain development could potentially be. In fact, one might want to ponder for a moment the pernicious effect of the unmodified incorporation and replication of the following things: child abuse, peers experimenting with drugs, the massacre at Littleton, Colorado, gangs, television crimes such as theft, rape and murder, childhood pregnancy and cult conversion.

These few examples should make it blatantly obvious how important it is that we be able to act upon the patterns which the mediums of our brain have incorporated. There are at least five minimal conditions necessary for extraordinary human intelligence to develop out of the modest beginnings afforded by the behaviors of incorporation and replication. They are as follows: the ability of patterns of the brain to *self-organize*, *self-stabilize*, *self-replicate*, *self-reference or self-mirror* and *self-modify*. Without these abilities, the brain is simply a medium for the mindless replication of incorporated patterns—a biological machine unable to think *about* its patterns, but only replicate them. Such a state of brain is referred to by computer scientist, Douglas Hofstadter, as M-mode (machine mode)—a state in which a system may only carry out its programs or instructions, unable to release itself from shackles of its own system.

Let us briefly define each of these conditions. The ability of patterns in nature to *self-organize* is one of the most fundamental, and is the very reason why patterns occur in the first place. Patterns self-organize due to the physical phenomenon of attraction and repulsion caused by the four fundamental forces of nature—namely the strong force, the weak force, the electromagnetic force and gravity. Since these are covered in great detail in *The Standard Theory of Pattern-Entropy Dynamics* (Furman and Gallo, 2000), this brief mention should suffice.

As mentioned earlier, the ability of ephemeral patterns to *self-stabilize* and become enduring structures that are replicatable, is the very bedrock of memory. As we alluded to earlier, the ability of a pattern to *self-stabilize* is in large part due to the physical property of tensegrity (recall the examples of phobias, video games and cardboard boxes). *Self-stabilization* is also dependent upon a system's ability to regulate the flow of energy and information across its boundaries either moving in or out. This means that *self-stabilizing* patterns can be disrupted if there is an *excess* or an *absence* of new information propagating through the system. This can occur if too much information is forced in beyond a person's attention span or when information flows too slowly as in the examples given in the paper entitled *Super-Learners in a Slow Motion World* (Furman, May 2000). Existing patterns within the brain can also be disrupted if they exist in an environment with other conflicting patterns, such as when a person attempts to maintain two conflicting ideas, desires, beliefs or traditions. The regulation of information flow across the brain's barriers and boundaries not only affects the individual patterns but also the state and

health of the entire brain and its connected systems. The excess and absence of pattern/information as well as the existence of conflicting pattern/information, is responsible for the myriad of mental diseases extant today. This area is also covered in great detail in *The Standard Theory of Pattern-Entropy Dynamics*.

Once pattern-integrities within the brain are able to *self-organize* and *self-stabilize*, they must then be able to *self-replicate*. The ability of patterns within the brain to self-replicate allows multiple copies of a piece of information to exist in various places at once within the encoding medium, thus protecting it from damage in the event of trauma to the brain such as that which occurs as the result of a stroke or seizure. Self-replication also allows for “copies” of patterns to be modified while the “original” pattern-integrity remains unchanged. This condition is essential for our maintenance of the distinction between reality and fantasy. Have you ever been asked how to spell a word and at the same time been offered the incorrect spelling of that word by the person who asked you to spell it? This is a quick way to disrupt your own memory of how to spell even a simple word. I can remember a time in school being asked “Do you know how to spell the word ‘of’, is it ‘uv’?” This can be an unbelievably disorienting experience, especially if we were not able to maintain the stability of the original pattern-integrity (the correct spelling) which had been previously incorporated.

A more serious example of this occurs when a memory of an actual experience is unwittingly modified by the pernicious questioning techniques of a well-meaning psychotherapist who believes that the child being questioned might have been the victim of abuse, when in fact that is not really the case. This phenomenon is widely known throughout psychotherapeutic circles as “false memory” (Ofshe and Watters, 1994). The most extreme examples of a blurred line between reality and fantasy occur in schizophrenia. These are just a few of the reasons why it is necessary for patterns to be able to self-replicate. Although the pattern behavior of *replication* is considered one of the five fundamental behaviors of pattern, it is a bit more complex than incorporation, cleaving, recombining and transmission and many times will require two or more of these acting in concert in order to occur (we will see this shortly when we discuss the replication of DNA).

The next critical condition for the development of genius is the ability of a pattern-integrity to be *self-referencing* or *self-mirroring* (self-reflecting). A simple example of this can be seen when a camera is pointed directly at its monitor. Within the monitor you will see a picture of the monitor and within that picture, another picture of the monitor, and then within that picture, another picture of the monitor, nested within each other, ad infinitum. When a pattern becomes self-referencing or self-reflecting, the emergent phenomenon of *recursion* appears. Another example of a self-referencing pattern occurs when a baby first realizes that the image she is seeing in the mirror is not another baby but in fact, “herself”. If you, as a parent, are present when *that* moment transpires, it can be a spine-tingling experience. For self-reference to occur within the medium of the brain, neural circuits must loop back upon themselves—a phenomenon of neural anatomy referred to as *reentrant circuitry*. Reentrant circuitry is what makes it possible for us to be consciously self-aware (Edelman, 1987; Harth, 1993; Hofstadter, 1980; 1999; Kandel, et al. 1991). It is the very keystone of consciousness.

The ability of pattern within the brain to self-reference or self-mirror, develops by degrees over time and only if properly encouraged. Prior to this phenomenon hitting “critical mass”, thought, as we know it, is not possible. The ability to think *about* a pattern, rather than just mindlessly replicating it, requires self-reference. There are those who learn the “operations”

of multiplication and division and there are those who develop number theory. The difference can be found in part, in the degree to which incorporated patterns within *their* brain are self-referent. Have you ever watched a young child knock over a full glass of milk and not realize that *they* were responsible for it? This is just one of many examples of a lack of self-reference. An extreme example of lack of self-reference occurs when a human being is afflicted with leprosy, a rare disease where among other things, a person is unable to realize when their own body parts are being damaged. This is due in part to the fact that pain messages are unable to reenter the motoric circuits that are responsible for the retraction of limbs in the face of an aversive stimuli. Thus, it is possible under these extreme conditions to cut off your own finger without being informed of it by your somatosensory system, only to be recognized later by your visual system.

The most important thing to understand about self-reference is this: the more self-referentially rich are the patterns of the brain which we incorporate, the more conscious we are of the “self” to which it gives rise to (Hofstadter, 1999). Thus, the more complex and recursive our thought, the more profound our intelligence and the closer we move to the phenomenon called genius. As we will see shortly, the attainment of self-reference or self-mirroring requires the five behaviors of pattern, incorporation, replication, cleaving, recombination and transmission, to all act in concert.

The last of the five critical conditions for the development of genius is *self-modification*. Self-modification is a natural outgrowth of self-referencing and self-reflection. Once a circuit of the brain’s encoding mediums is reentrant or an incorporated pattern of the brain is self-referent, it is able to modify itself. This means that the pattern not only “sees” itself, but it also changes itself. This is the point in the developing mind and brain that is marked by a change in dominance from outside control to inside control.

The Brain Develops a Mind: Outside vs. Inside Control

As trajectories of information flow, twist and turn within the brain, and finally loop back upon themselves, they simultaneously develop the ability to “see” (self-reflection) themselves and to “change” themselves (self-modification). At this stage, patterns of the brain have the potential for the first time to modify themselves in significant ways and to protect themselves from the effect of pernicious stimuli from the outside. To the degree that the brain forms these intricate *information loops*, both “consciousness” and “mind” develop. Prior to this point, the developing brain is helplessly assaulted by any information/pattern that its mediums can incorporate and replicate—the developing brain and the mind’s range of thought are dominated by the influences of the external information field. The matter and energy of the brain are simply deployed by the forces of that field to incorporate and replicate the patterns that are present—mercilessly denying the “user” access to all other incorporated information. Some examples of this phenomenon are memory lapses, “going blank” on a test, forgetting a name, and state-dependent memory such as the inability to remember “positive” things when we are depressed or angry. In order for the developing brain to cross the critical threshold where “mind” is born, at least two additional behaviors of pattern are necessary. As we alluded to before, these two behaviors are *cleaving* and *recombination*.

The Genesis of Mind: Cleaving and Recombination

Cleaving is the propensity of a pattern to “separate” or “dismember” into smaller patterns while *recombination* is the propensity of patterns to aggregate or agglomerate into new, complex patterns. Both of these behaviors individually allow an enormous range of new and unique

patterns/information to form, but when the two of them work together recursively, acting upon each other, the range and scope of “original” pattern formation seems limitless. Here lie the two most fundamental pattern behaviors responsible for not only the development of mind but also several properties of mind which we variously refer to as *creativity, innovation, analysis, comparison, inductive and deductive thought, problem solving, logic and genius*.

As with the previously mentioned behaviors of pattern, incorporation and replication, cleaving and recombination can be found operating at every level of nature. For example, *atomic fission* is a process whereby the nucleus of an atom splits into two or more parts, while releasing energy. Conversely, *atomic fusion* is a process whereby nuclei fuse together in order to make one heavier nucleus, also releasing energy as they do so. At the atomic level of pattern, fission is the *cleaving* of a pattern while fusion is the *recombination* of a pattern.

In the slightly larger biological world, the replication of DNA involves the “unzipping” (*cleaving*) of the double-helix as well as the enzyme-assisted *recombination* of nucleotides. Replication on a cellular level is accomplished by a process known as cell division (meiosis), which involves genetic-level *recombination* as well as the *cleaving* of a cell into daughter cells. Both of these complex multi-level processes underly growth and healing in larger organisms (a process called mitosis). Two other elegant examples of recombination in the biological world come from the mixing of genes from two parents (approximately half from each parent) in order to make one baby and the activity of *variable B-cell “jumping genes”* within the immune system.

Jumping up another biophysical level, we can find cleaving and recombination actively working together in order to propagate information patterns from one nerve cell to another and from one nerve cell to an adjoining cellular system such as muscles and glands. In order for certain types of information patterns to propagate between nerve cells, the nerve cell must “fire”. In order for this to occur, the nerve cell must become polarized and then quickly depolarized. This process of polarization and depolarization of a nerve cell is facilitated by the pattern behaviors of cleaving and recombination.

The fluid in and around a nerve cell contains ions having both positive and negative charges. When these positive and negative charges are well-mixed, we say that they are close to an equilibrium state. A nerve cell will not fire in such a state. So, in order to cause an instability or disequilibrium necessary for a nerve cell to fire, nature had to find a way to be able to cleave and recombine this well-mixed, random pattern of positive and negative ions. The mechanism that performs this cleaving and recombination of ion pattern is a “membrane channel protein”. This membrane channel acts like a gate or a camera shutter. Instead of letting in light, it selectively allows the passage of certain ions, resulting in ions of the same charge all lining up on the same side. The pattern of ions has at that point effectively been cleaved resulting in a change in the nerve cell membrane’s potential. Only now is it “ready” to fire—poised like a cat ready to pounce on a ball of yarn.

The second phase of this activity, depolarization, is the opposite process. In order for information (an impulse) to travel along the nerve cell’s axon, part of the axon’s membrane must depolarize, which means that the filtering proteins of the membrane allow the positive and negative ions to recombine resulting in a “closer to equilibrium state” in that particular section of the axon. This process repeats until the disturbance travels down the entire length of the nerve’s axon in the same manner as a wave travels along a whip that has just been cracked. It should be noted here that the process of polarization and depolarization is a complex one.

The pattern behaviors of cleaving and recombination do not act in isolation. In fact, they act in concert with the other pattern behaviors. If we look carefully at a lower level of the process, in this case a single membrane channel protein, its fundamental function is to *incorporate* the appropriate ion. When many of these membrane channels perform this incorporation in concert, only then does a cleaving and recombining of the random ionic pattern occur. The result of the whole process is a *disturbance*, or more appropriately a *pattern-integrity*, that propagates along the nerve axon. If this pattern-integrity propagation is considered in detail, we see that the lower level process of *incorporation* facilitates a higher level process of *cleaving* and *recombining* which then in turn, facilitates an even higher level process called a “nerve impulse” which is the *transmission* of a pattern-integrity (an information pattern) in coordinate space or through different encoding mediums separated by a boundary. Not only are cleaving and recombination essential processes of life itself, but they are also essential to the “quality” of the life and health of our minds

Thought, Meaning, Creativity and the Matrix of Genius

We can find cleaving and recombination working in highly complex ways at the inter-cellular, organ and system level within the human biophysical system. An emergent property of the brain’s activity we call *meaning* depends upon the continual cleaving and recombining of *cell connectivity patterns* (attractors) within the brain and its adjoining systems. Meaning is born out of the “relationship” between cell connectivity patterns which have been previously incorporated separately within the brain and are in turn *replicated* conjointly in response to forces from the information field. For example, we experience certain visceral patterns within our somatosensory system which we refer to as “emotions”. We also experience patterns within our visual and auditory sensory systems called “perceptions”. If you are self-aware and pay close attention, you will undoubtedly notice that different visual and auditory perceptions appear to “cause” predictable emotional responses; perhaps it’s the sight of a dozen red roses or the sound of someone screaming or the sight of blood or maybe the sound of a car skidding out of control. As the human brain and mind develops, perceptual patterns and emotional patterns are *combined* (by joint activation) to create meaning—both good and bad. Many psychotherapeutic practitioners unknowingly rely on the pattern behaviors of cleaving and recombining in order to change the meaning of a troubling or traumatic event (Furman, November 1999 and April 2000). A branch of psychotherapeutic intervention called logotherapy, developed by Viktor Frankl, depends almost exclusively upon the brain’s ability to perform these processes (1992).

Several times in his life, Albert Einstein had been asked to describe his thought processes so that to public may apprehend the quintessence of his genius. Einstein believed that most of his “thought” occurred visually. He was not aware of any auditory or linguistic patterns that influenced the development of his theories. He attributed his extraordinary creativity to the ability to “recombine replicatable forms” (Schilpp, 1995; White and Gribbin, 1994). If one were to study his detailed commentary on how his most popular theories were derived, both the cleaving and recombination of previously incorporated, replicatable patterns would be found to be essential ingredients. It is clear that when the behaviors of cleaving and recombining recursively act upon previously incorporated, replicatable patterns (content), original thoughts are born. The processes of cleaving and recombining when acting upon “content”, produce new replicatable and transmittable content. This phenomenon is sometimes referred to as “recombinant ideas” by the AI (artificial intelligence) community.

The processes of cleaving and recombining can also be found in the legendary work of mathematical genius, Kurt Godel. Among other things, Godel is famous for his development of the *incompleteness theorem*—the notion that no system however powerful, can ever be complete or reach perfection. In his lifetime, Godel developed a system whereby parts of formal systems can be cleaved and recombined and then isomorphically “mapped” into one another or into topographical number theory in order to study nested isomorphisms and explore the limits of a given formal system. His work in this area, referred to as “Godel numbering” is a profoundly elegant application of the fundamental behaviors of cleaving and recombination (Hofstadter 1980).

The work of Thomas Edison provides us with another elegant example of cleaving and recombination. When all but the most essential part of the light bulb—its filament—had been discovered in his laboratory, he repeatedly *cleaved* and *recombined* its internal structure with every known conducting material. Finally, after almost 10,000 trials he employed Tungsten with great success—the electric light bulb was born. What would have happened if Edison had never learned to cleave and recombine patterns but instead, only incorporated and replicated that which was already known during his lifetime?

Many children in school learn how to solve mathematical problems by simply incorporating and replicating the algorithms taught by teacher or book. Some children however, are able to find “shortcuts” by cleaving and recombining the number patterns as well as the combinatory rules themselves. These are the potential Einsteins, Edisons, and Godels of our world.

The use of analogy and metaphor in language are also elegant examples of cleaving and recombination at the level of nerve cell assemblies. When we create an analogy such as “the brain is a computer”, we cause nerve cell connectivity patterns previously incorporated by the brain to cleave and recombine the isomorphic elements of both mental representations, thus allowing for a new way to understand and converse about both “brain” and “computer” (Furman, Feb.1996). While the ability to cleave and recombine previously incorporated, replicatable patterns puts us firmly on the road that leads to genius, there are still two more critical processes involved—as mentioned before, they are *transmission* and *recursion*.

Transmission and Recursion

We now arrive at the two final processes involved in the development of extraordinary human intelligence—genius. The first is a pattern behavior referred to as *transmission* which we have alluded to before. The second, recursion, is an emergent property of all five of the pattern behaviors—*incorporation*, *replication*, *cleaving*, *recombination* and *transmission*, acting in concert. Let’s consider transmission first.

Transmission is simply the isomorphic “displacement” or “propagation” of a pattern-integrity (information) through coordinate-space or different encoding mediums separated by a boundary, where information is preserved or conserved. Transmission is the way in which information “travels” or gets “exchanged” through and between mediums such as cells, organisms, water, atmosphere, etc. This displacement or propagation of a pattern-integrity (transmission) can occur in many different ways and is responsible for the enormous flexibility and variation found in the world of pattern. Without it, the diversity and beauty of nature as we know it, would vanish. We will mention just some of the major ways in which this displacement can occur and then describe each in a little more detail.

Transmission can occur by *solition wave* (translation), *rotation*, *involution*, *exvolution*, *vibration*, *expansion*, *contraction* (in time or space, symmetrically or asymmetrically), *diffraction*, *refraction*, *three-dimensional to two-dimensional*, *inversion*, *mirror image*, *retrogradation*, *inside-outing*, *enfoldment*, and *unfoldment*. In each case of displacement of the pattern-integrity, information is preserved—simply shunted in space or time isomorphically. Let's explicate each of these types of pattern transmission and highlight their relevance to the development of mind, brain and genius.

Transmission by Solition Wave (Translation)

When transmission occurs by solition wave, also known as translation, the pattern-integrity is simply displaced in coordinate space or through and between encoding mediums in more or less a linear trajectory. This type of transmission can be readily observed when watching a wave travel along the surface of the ocean towards the shore. As alluded to earlier, the water molecules themselves do not actually travel with the wave, only the disturbance (the pattern-integrity) actually travels.

We can also see transmission by solition or translation when we look into the sky on a partly cloudy day. If you allow your eyes to follow a particular puffy cloud as it travels across the sky, the pattern (the cloud) simply changes in *position* from moment to moment, following what appears from the ground to be a linear trajectory. Of course from the perspective of space, we can look back at the earth and see that the cloud actually has angular, not linear, acceleration.

Messenger molecules within our body can also be seen traveling about from place to place by translation. This can be seen in the behavior of neurotransmitters as they jump from synapse to synapse between nerve cells. It can also be seen in the behavior of neuroendocrine molecules such as hormones as they travel to their target cell through the bloodstream. Transmission by solition or translation can also be seen occurring within brain and mind on a larger scale. This happens when we incorporate a particular image, such as the face of a loved one, and then close our eyes and move that image throughout our visual field from left to right, or top to bottom, without changing the image (the pattern-integrity).

Translational displacement is also a common element found in the music compositions of many great composers such as Beethoven, Mozart and Bach. Quite often while reading a particular score, you will notice a pattern of notes that is simply displaced upwards or downwards on the staff without the *relationship* of each note to each other note ever changing. The key that the pattern is played in changes while the melody (the pattern-integrity) remains the same.

Transmission by Rotation

Another type of transmission is transmission by rotation. This can be found ubiquitously at all levels of nature, big and small. The pattern-integrity called planet earth is one among an untold number of planets in our universe which spin on their axis, and return to the same position periodically. As a pattern-integrity rotates in coordinate-space, it appears to change only from a particular perspective but in fact, as it rotates all information is preserved. Of course, planets don't simply rotate. The motions of planets are products of collections of many different transmission types operating in concert. As the planet earth rotates, it also revolves around the sun tracing an angular trajectory around it. So, as it rotates it can never really come back to the exact same place in coordinate-space.

In the world of the very small, electrons are believed to travel around their atomic nuclei by the same translational and rotational displacements in coordinate-space. And, in the world of the colossal, entire galaxies travel translationally while the individual stars that make them up travel rotationally as well as translationally in an angular acceleration forming enormous spirals of light in the evening sky. Within the human mind and brain, rotational transmission is essential for many high and low level cognitive tasks. Sometimes we see someone in a crowd we think that we might know but we see them from an unfamiliar angle. In order to confirm our assumption, we take that incorporated image and mentally rotate it in the coordinate-space of working memory until we can make a positive identification of the face. Once we do, we feel confident in approaching that person and tapping them on the shoulder to say “hi”.

Many questions on IQ tests are designed to confirm whether or not the test taker has this cognitive ability. The most common form is a set of approximately six connected blocks drawn three-dimensionally. The test taker is given the reference pattern and then asked to match it against four or five other patterns which have been displaced rotationally. If the test taker matches the reference pattern with the correct pattern, he or she is considered intelligent. Yet, when broken down in terms of pattern behavior, the question simply determines whether or not the test taker has had prior practice in the process of rotating a pattern-integrity. You can test for whether or not you currently have this capability by starting very simply. Imagine a plate with a familiar design and on top of this plate a bright red apple. Rotate the plate clockwise in your mind while at the same time rotating the apple toward you end over end. Many people cannot do this. Yet, you can train the brain to perform this process simply by doing the process physically with real objects and letting your visual system incorporate not only the content (the apple in the plate) but also the process (the clockwise and the simultaneous end-over-end rotation). Both translational and rotational displacement of mental images (pattern-integrities) were essential to the thought experiments that led to the development of Einstein’s theory of relativity.

Transmission By Involution and Exvolution

Transmission by involution or exvolution are similar to transmission by rotation. This can be easily imagined by visualizing a doughnut. If a doughnut was symmetrically rotating toward its own hole, such that the part of it that was outside is now inside, and the part that was originally inside is now outside, we call this involution. If the process of transmission occurs the opposite way, such as if we were to run a film of what just happened backwards, we would call this exvolution. In a sense, there are several types of transmission occurring simultaneously in this example. There is rotation of a pattern, as well as retrogradation of the same pattern, during instances where there is a switch from involution to exvolution. This particular pair of pattern transmissions happens to be one way in which we can create an “inside-outing” of a pattern, which we will discuss a little later. One structure which has the capacity to involute and exvolute is called a Taurus, a pattern which occurs often in the modeling of non-linear dynamic system.

As in all other pattern behaviors, involution and exvolution appear to be ubiquitous in universe. This behavior can be found in many lower level single cellular organisms that ingest their food by the process of *engulfment*. Black holes in space also exhibit what might be thought of as involution of the matter and energy that come too close to its event horizon. And of course, there are those select children throughout the ages who at their parents chagrin persist in turning their eyelids inside-out to entertain their friends and siblings.

Transmission By Expansion, Contraction and Vibration

Transmission by expansion and contraction are much more fundamental types of pattern behavior than those such as involusion and exvolusion. And again, such behaviors of expansion and contraction can be found ubiquitously throughout the living and nonliving world. We can see both expansion and contraction occurring in the subatomic world in the behaviors of atoms. When atoms are excited by the absorption (*incorporation*) of photons, their electrons move from their ground state within the inner shells of the atom to their excited state where their electrons can be found orbiting the nucleus for a trice in their outer shells. This can be considered a transformation by *expansion* of the pattern where information (the structure of the atom) is preserved. As these electrons emit (*transmit*) the photons that they have previously absorbed (incorporated), they immediately return to their ground state—orbiting again within their inner shells. This can be considered a *contraction* of the pattern-integrity called “atom”. When expansion and contraction occur in close succession, we refer to this as *vibration*.

Vibration can also be seen on a slightly larger scale when atoms temporarily join together by sharing electrons. This coupling between two or more atoms is a loose one involving enough play where together as a single pattern-integrity, the atoms can expand slightly away from each other and subsequently contract toward each other periodically as they also rotate around a common axis. A behavior quite similar to this can be seen when looking up at the heavens. On a scale many magnitudes of order larger than the last example, *pulsars* vibrate and revolve with such regular pattern that we can almost use them as clocks. A pulsar can be formed out of two neutron stars or “white dwarfs” as they enter each other’s field of gravitational influence. When this happens, the two stars interact *precessionally* (at other than 180 degree angles), expanding and contracting their orbits around a common axis.

We can also see expansion and contraction of pattern-integrities throughout all parts of the biological world. As a young child hops down a flight of stairs on the balls of his feet, the closely packed molecules of liquid and gas that make up his multifarious tissues contract upon impact and then expand upon release creating a vibration that is transmitted throughout his entire body to such an extent that if he does it hard enough, or continues it long enough, he will end up with a headache.

Pattern-integrities can not only expand in dimension of space but also in time. Musical forms such as fugues and canons employ this type of pattern transformation yielding enormous variation that results in the listener’s unending pleasure. This type of musical form was created by taking a small pattern of notes (a melody) and expanding them in time by playing them twice as slow in a different instrument voice than the first pattern is played. At the same time, another voice is assigned to play the same melody (pattern-integrity) contracted in time. In this case, it would be played twice as fast as the original melody. The type of auditory complexity that results is called *recursion*. Recursion is a nesting of self-similar patterns which we will be discussion shortly. It is interesting to note that in a case of music-making, the pattern-integrity which expands and contracts, does so in many modalities. Auditorily, we can hear the expansion and contraction of the melody which gives us listening pleasure. Visually, as we circumspect the score, we can see the expansion and contraction of a pattern-integrity as it imbues the paper it is written on with a phantasmagoria of visual textures. At the same time, as a listener, we can feel the expansion and contraction of the pattern-integrity through the quickening and slowing of our heartbeat and respiration as it is phase-locked in forced resonance with the vibrations of the music. And finally, the performer can also feel the expansion and contraction of the pattern-integrity through their tactile and proprioceptive sensory pathways as their fingers perform the written score.

Normal organismic growth is also a good example of transmission by expansion. As the heart, lungs and other vital organs of a human being grow in size, information (the pattern-integrity) and thus proper function, is preserved or conserved.

Another example of expansion and contraction of a pattern-integrity can be found in the boiling of a cup of water in a pot. As we boil the cup of water the resulting kinetic motion will make the pattern-integrity called “water” *expand* in space. It will first become steam and form a large cloud above the pot, then it will continue to expand, becoming a diffuse water vapor that fills the room as it seems to disappear. *Contraction* occurs when steam condenses and becomes water.

The ability to expand and contract pattern-integrities that were originally incorporated into our mind and brain is vital for problem-solving, decision-making, creativity and the development of extraordinary intelligence. For example, it was common dogma for nearly 2,000 years since the inception of Euclidian geometry, that the sum of all angles of a triangle invariably equal 180 degrees in all cases. Albeit a modicum of experimental evidence, this was somewhat of an a priori conclusion. Numerous theorists throughout the years questioned this dogma when new evidence was found suggesting that the earth was round, not flat, as originally assumed. It was a priori theorized that a triangle, *expanded* enough so that it was drawn over a significantly large spherical surface of the earth, would clearly exhibit a sum of angles far in excess of 180 degrees. The increase in the sum of the angles would vary in direct proportion to the curvature of the earth that the triangle was drawn upon. This critical discovery spearheaded a paradigm shift in science that shook the very foundations upon which society had been built. The implications of this discovery have only begun to unfold themselves in the practice of present day science and technology. Had the human mind not had the fundamental ability to expand the pattern-integrity, this discovery would never have been made.

Expansion and contraction comes in many different forms. As we have just seen, expansion and contraction of pattern-integrities can occur in both space and time. They can also occur both *symmetrically* and *asymmetrically*.

Transmission By Diffraction and Refraction

Transmission by diffraction and refraction bear many similarities to the pattern behaviors previously discussed. *Diffraction* is a change in direction and intensities of a group of waves after passing by an obstacle or through an aperture. Most young children have seen this phenomenon demonstrated by nature when rushing water in a stream attempts to pass between two large rocks positioned very close to one another. Diffraction and refraction are very closely related phenomena recursively built up from more fundamental pattern behaviors. As we take the pattern-integrity called a light wave, or white light, and we direct it through a prism, diffraction and refraction cause the white light to *cleave* into several discrete waves of different wave-length revealing all the colors of the visible electro-magnetic spectrum. For those readers who have never seen this demonstrated in a school classroom, fear not. The next time you look up into the sky and see a beautiful rainbow, you can rest assured you have seen the combined behavior of diffraction and refraction at work.

Refraction is the spreading, slowing, bending of a wave due to passage from one medium or another. In both diffraction and refraction, we can witness a bending of a pattern-integrity called a wave. This is referred to as a change in direction which tends to also result in a

spreading or expansion of a pattern as is seen when white light is passed from air through a prism, producing a spectrum. The same phenomenon can also be seen occurring in sound waves, as well as waves in other mediums such as water. The slowing of a wave during refraction, means that the wave or pattern-integrity has changed velocity (light travels at different velocities through different mediums such as air, water and glass). This slowing can simply be understood as an *expansion* of a pattern-integrity in “time”. As you can see, diffraction and refraction are complex pattern behaviors which are assembled from simpler ones on one level and result in both simpler and more complex pattern behaviors on other levels. The ability to represent such patterns as these in mind was critical in the development of Einstein’s theory of special relativity, as well as his theory of general relativity. The mental representation of these pattern behaviors are also critical for engineers involved in acoustics technology. This is the type of technology that might be employed to make sure that every listener in a concert hall has an equally pleasurable experience no matter where they are sitting. The engineering genius, R. Buckminster Fuller, employed the mental representation of this, as well as many others pattern behaviors, in order to develop the theory of *synergetics* which has become indispensable knowledge in the field of engineering.

Transmission Between Dimensions

Transmission of a pattern-integrity can also occur between dimensions such as the second and third dimensions of space. A simple example of this comes from our ability to recognize a close friend or relative from a photograph. If you look at a 3x5 photograph, and have this feeling of instantaneous recognition, it is really quite a remarkable achievement since the pattern-integrity you call “your friend” has not only been significantly *contracted* in space, but has also been transmitted from three dimensions to two dimensions, while at the same time conserving enough information for you to recognize this new transformation as “your friend”.

A much more complex example of dimensional transmission is employed by nature in the opposite direction (from 2D to 3D) during the manufacturing of proteins from DNA. Both DNA, as well as the *primary structure* of a protein (a string of articulated amino acids), can be thought of as structures having only one or two dimensions (depending how small a measurement you use). As a protein folds itself, this two dimensional string of articulated amino acids rapidly becomes a three dimensional molecular machine able to perform complex tasks throughout living organisms. This three dimensional folding pattern is said to be the protein’s *tertiary structure*.

With practice, human minds and brains can also be taught to transmit information isomorphically between the second and third dimensions. In the human brain, the cerebral hemisphere is divided into two parts that we refer to as the left and right hemispheres. The visual pathways in the right hemisphere of right-handed people are equipped with special cells which are able to represent previously incorporated images in 3D. These visual pathways are referred to as *magnocellular* pathways (Davidson and Hugdahl, 1995; Gazzaniga, 1995; Kandel, et al., 1991). To use these pathways for image representation, a normally organized right-handed person would move the image to their left visual field in working memory (Furman, Nov. 1996; Dec. 1996). This is considered a transmission by solition or translation. The visual pathways in the left hemisphere have a greater preponderance of *parvocellular* representation medium. Unlike magnocellular pathways, which are made up of large, overlapping cells, parvocellular pathways are made up of relatively smaller, non-overlapping cells. This cellular matrix does not allow for the representation of visual information in three dimensions. Instead, we see the same image represented in two dimensions. You can experiment with this by visualizing a familiar room in your home, including all its contents using your left visual field. Then, simply slide the

image over to your right visual field and you will notice it will become flat. Thus, the transmission of visual information from magnocellular to parvocellular pathways allows a pattern-integrity to be represented variously in three dimensions or two dimensions. Another interesting fact about parvocellular pathways is that since they form a non-overlapping, cellular matrix, a visual image held in working memory in the right visual field, can much more easily be *cleaved* into parts and the *recombined* in new ways (Furman, Nov. 1996; Dec. 1996; Jan. 1997) allowing for greater creativity and problem-solving skills.

Transmission By Inversion and Retrogradation

Transmission by inversion and retrogradation are closely related pattern behaviors found ubiquitously in mind and nature. A simple form of *inversion* can be visualized if we go back to our example of the photograph of your friend. In addition to contracting your friend and transmitting him or her from three dimensions to two, you can also invert the pattern-integrity simply by turning the photograph upside down. This is the simplest form of inversion. Notice that you can still recognize your friend and pick his or her photograph out of a collection of many others with relatively little difficulty.

Many speed-reading courses make use of inversion by having participants turn their reading materials upside down and asking them to read them. This helps them gain the mental flexibility to learn how to process the same code in very different ways. It is interesting to note that the images contained on *this* page which you are currently reading, are automatically inverted as they pass through the convex side of your ocular lenses and are subsequently represented by your retinal sheet upside-down. Through many stages of processing, these images are finally seen by you in their original orientation.

A more complicated form of inversion is employed in music when a composer takes a core pattern-integrity (a melody) and inverts it by making the high notes low and the low notes high, by the same intervals. Such a simple transformation has created a myriad of beautiful compositions by composing geniuses such as Bach, Beethoven, Chopin and Mozart. It is also useful to note that from certain frames of reference, *rotation* and *inversion* can appear to be one-in-the-same.

Transmission by *retrogradation* can be thought of as another form of inversion with the only difference that this inversion does not just occur in space but also in time. Retrogradation simply defined is backward motion. If we get in our car and drive a few yards and then shift into reverse and exactly retrace our trajectory, we have employed retrograde motion or the retrogradation of a pattern-integrity. Many speed-reading courses also employ retrogradation by having the reader read line 1 of a passage from left to right and then rather than wasting the saccadic motion necessary to return the eyes to the beginning of line 2, the course instructor will have the reader actually read line 2 backwards; thus doubling the speed of the reader.

Retrogradation is also very often employed by composers who increase the complexity and beauty of their compositions by assigning counterpunctal melodies to two different instrument voices such as piano and violin. These interwoven melodies are actually the same melody except for the fact that one of the voices plays the melody backwards.

In the world of molecular biology, we can also see retrogradation at work in the behavior of ribosomes. Ribosomes are large proteins that read mRNA and in turn assemble proteins out of the correct amino acids specified by the mRNA. Ribosomes have the capability of reading

mRNA in either direction (in forward or retrograde motion) in order to produce the proteins used by living organisms.

Retrogradation is one of the keystone pattern behaviors employed by the field of NLP in the construction of the now-famous V/K Disassociation method for eradicating long-standing phobias and traumas. For those who are not familiar, the method works like this. The subject is asked to make a representation of the traumatic event in the form of a movie. The subject is then asked to watch the movie from beginning to end in a disassociated fashion as if they are in a movie theatre watching themselves, watching the movie of themselves, from the perspective of the projection room (sometimes referred to as double disassociation). What this first step does is simply *contract* the pattern-integrity called “traumatic event” in space such that when the subject thinks about it in working memory, it takes up a relatively insignificant amount of the visual field compared to the way the subject normally represents the event to themselves. This contraction of the pattern-integrity in visual working memory also corresponds to a contraction of the neural network or number of neurons needed to represent the traumatic event. This is called *population coding* (Furman, May 1996). This pattern transmission by *contraction* of the number of neurons which transmit the traumatic event, results in an attenuation of the emotional pain normally experienced by the subject.

The second part of the technique requires the subject to view the movie backwards from the end to the beginning several times very rapidly. This part of the technique employs transmission by *retrogradation* as well as a *contraction* of the original pattern-integrity in time since the subject is viewing it much faster than it is normally represented. The combination of retrogradation and both types of contraction (space and time) employed by the technique is what imbues it with its tremendous power to eradicate traumas and phobias. The original pattern-integrity is irreparably disrupted by these competing pattern behaviors resulting in an increase in entropy within the neurocognitive system—opening a doorway to positive change (Furman and Gallo, 2000).

Transmission By Mirror-Image

The isomorphic transmission of information by *mirror-image* is quite interesting indeed. In a way we can think of this as a form of inversion since things appear to be reversed by their mirror images. If you look at yourself in a mirror, or at your reflection in the water, and you raise your *right* arm, it appears that the pattern-integrity looking back at you, called “the mirror-image reversed you”, is raising their *left* arm. Had this image been an actual person staring back at you, that would be the case.

Transmission by mirror-image was employed by the scientific geniuses who discovered how DNA was able to copy itself. DNA in human beings consists of two strands of nucleotides approximately 3 billion in length. The nucleotides are strung together like beads and this string of beads has only a four letter alphabet, T, A, G, C. T and A are known to bind only to each other. And, G and C form a similar partnership. It was found that the two strands of DNA are in a sense mirror-images of each other. If a T exists on the first strand, an A exists in the same position on the second strand. In the same regard, if a G exists on the first strand, its partner C, occupies the same position on the second strand. In this way, the complex codes incorporated within this string of 3 billion nucleotides can be *replicated* by the mirror-image strand. This amazing feat is performed by employing enzymes that break the bonds between partners and “unzip” the double helix into two separate templates. The process of unzipping can be understood as the pattern behavior of *cleaving*. Once unzipped, specialized enzymes *recombine*

the nucleotides on each template with their corresponding partners but in this case, their corresponding partners are selected from free-floating nucleotides. When this process of *recombination* is complete, DNA has effectively *replicated* itself by employing a *mirror-image* template for its construction of two identical double helixes. As you can see, DNA replication is a highly complex process employing many of the pattern behaviors previously discussed.

It is important to note here that nature had been employing mirror-image pattern-integrity transmission for quite some time before the human mind discovered how it was done. However, in order to make this discovery, the human mind first had to learn how to transmit pattern-integrities in mirror-image reverse in order to form the testable hypothesis that determined the correct experimental design, which in turn, led to the discovery of how DNA replication worked.

Transmission By Enfoldment and Unfoldment

Transmission by enfoldment and unfoldment in its simplest form can be understood by taking a piece of paper, drawing a picture on it, folding it in half and then in half once again. If the picture that we drew represented a pattern-integrity, the folding of the piece of paper into four equal parts and thus the enfoldment of the pattern-integrity, resulted in a transformation of that pattern-integrity such that it disappeared from sight. Yet, even though it disappeared from sight, information was conserved since we can simply unfold it and the resulting pattern-integrity stands as clear evidence. Had we folded the paper in the opposite direction, such that part of the pattern-integrity could be seen from the outside instead of being completely hidden as in the first example, we would have ended up with a pattern significantly different than the one we started with. In the same regard, if we simply unfold that which was enfolded, we would see that the pattern-integrity—the original picture we drew—remains the same.

Some pattern-integrities when enfolded enough, can not so easily be unfolded; such as when we scramble an egg or blend the ingredients of a cake mix, yet the information is conserved. The pattern behaviors of enfoldment and unfoldment were used as a model by the physicist David Bohm, to explain how subatomic particles such as electrons can “appear” to move in coordinate space when in fact, they may not be moving at all, but simply appearing in rapid succession as a result of the enfolding of one particle which makes it seem to disappear and the corresponding unfolding of nearby particle which makes it seem to appear out of thin air. If the enfolding and unfolding of the corresponding particles happens quickly enough, it creates an “apparent motion”(Bohm,1995). This type of visual illusion is often seen when the individual lights on a commercial sign or Christmas tree are turned on and off in close succession.

Transmission By Inside-Outing

Probably the most complex and interesting of all of the pattern behaviors found in nature is the isomorphic transmission of a pattern-integrity (information) by *inside-outing*. The simplest way to envision inside-outing and its far-reaching implications is to imagine a rubber glove, the type of rubber glove that you might use for house cleaning will do fine for this thought experiment. Imagine that we are holding in our hand a yellow-colored, right-handed rubber glove. Now imagine placing your right hand inside the glove. Incidentally, the inside of the glove is colored green. Once your right hand has slipped into the rubber glove, you can easily verify that it is a right-handed glove since it fits perfectly over your right hand. Now imagine grabbing the edge of the rubber glove while simultaneously holding your fingers tightly together so that in one quick motion, you can turn the glove completely inside-out. The resulting transformation of information is profound. First you will notice that as you were pulling the glove inside-out, you were employing the pattern behavior of *involution* and *exvolution*. Once the glove has been

turned completely inside-out, you will notice that its pattern-integrity has been *inverted*. Since the fingers of the glove are now pointing toward your fingers, and the end that you slip your hand into is pointing away from you—the pattern-integrity is completely upside-down. Upon closer inspection, you will notice that the inversion that occurred is no simple inversion. You are actually looking at what could be a *mirror-image* of the original glove. If you now perform one additional transformation, this time a transformation by counter-clockwise *rotation*, you will notice immediately that you no longer have in your hand a yellow, *right*-handed glove. Instead, you are now the proud owner of a green, *left*-handed glove. The right-handed glove has disappeared from sight. Simply by slipping the glove over your left hand, you can confirm that it is in fact, a left-handed glove.

This may not seem so miraculous to you, as you have probably done this before at some time in your life. But, for a moment let's imagine that you were not privy to the transformations that were made. Let's instead imagine that you were originally given a yellow, right-handed glove as a gift from a friend. You open the box in front of your friend, try on the glove and confirm that it is in fact, a yellow, right-handed glove. You then proceed to close the box up with glove inside, and set it on the counter. When you awake the next morning, you decide to use your new, yellow, right-handed glove for some spring cleaning. You open the box, and to your surprise, you instead find a green, left-handed glove. Try as you may, it does not fit your right hand. Imagine how shocked you would be if you were unaware that nature had the power to perform this information-preserved transformation.

This is probably the exact same feeling many scientists had when the engineering genius, Buckminster Fuller, suggested that subatomic particles previously believed to be able to disappear in thin air, don't actually do so. He suggested instead, that they simply turn inside-out and become their mirror-image reverse. From the outside, scientists who are unaware of nature's ability to transform a pattern-integrity in this way, would assume they are seeing two *different* particles, when in fact they are just seeing *one* particle radically displaced in coordinate space by an inside-outing transmission. In the future, this may explain how it is possible that an electron and its anti-particle, the positron, can “annihilate” each other and become two photons as well as how two photons can annihilate each other to become an electron and positron pair (Feynman, 1985). It may also explain what happens when a star implodes and becomes a black hole, two of the most profound enigmas left in the field of physics.

Recursion, Nested Loops and the Genesis of Self-Reference

Up until now, we have discussed each of the processes that make up the matrix of genius in somewhat of an isolated fashion, in order to define them. Although they had to be defined separately, it would be a grave mistake to think that they exist separately in nature. They do not. All the behaviors of pattern interact with one another. The principle that appears to govern their interaction is called *recursion*.

Recursion is somewhat slippery and difficult to define but it can be thought of as the *incorporation* by a pattern-integrity (structure or process) of exact or modified copies of itself or more commonly, isomorphic transformations of itself, where information has been preserved. Recursion is sort of a “nesting” of copies of a pattern, structure or process yielding a self-similarity on multiple levels. Every complex structure and process experienced in nature develops out of the recursive interaction of the five behaviors of pattern (*incorporation, replication, cleaving, recombining* and *transmission*). The result of recursion on these five behaviors is the birth of complexity, diversity, adaptation, beauty, nested information loops,

fractals and self-reference to name just a few (Hofstadter, 1980; 1999; Mandelbrot, 1977; Margulis and Sagan, 1986; Loewenstein, 1999).

One way to think about recursion is simply to imagine the nesting of stories inside stories, movies within movies, paintings within paintings, parenthetical comments inside parenthetical comments, Russian dolls inside Russian dolls, Chinese boxes within Chinese boxes, subroutines within computer programs or processes within processes (Hofstadter, 1980; 1999). This is the world we live in, the world of mind, brain and nature, where patterns incorporate other patterns and processes incorporate other processes, in order to build the universe around us and within us. Even a casual glance at a head of broccoli reveals the self-similarity on multiple levels—a contraction of a pattern-integrity in space that is ever-diminishing as we move our eyes from bottom to top. You can separate the smallest branch of a head of broccoli near the very top and when you hold the branch that you separated under a magnifying glass, you might be startled to find that it looks just like the head of broccoli that you separated it from. Recursive processes yield *fractal* structures. This is the stuff that lungs, brains, vascular systems, coast lines, and clouds are made of.

If you've ever pointed a T.V. camera at its own monitor, for a short time you can witness the nested pattern of televisions within televisions ad infinitum. The resulting image appears like a long hallway of T.V. monitors ever decreasing in size—one nested inside the other. To create such a complex and compound pattern, the pattern must loop back upon itself over and over again, allowing for self-mirroring or self-reflection. In the same regard, the neural matrix of our brains is capable of modeling the world around us. Since approximately one half our brain interfaces with the outside world of sensory stimuli (the external information field), and the other half of our brain connects with itself, thus interfacing with the internal information field, our neural architecture loops back upon itself in ever-increasing complexity. These nested information loops in the neural matrix are what make it possible to make models of the world and in turn be consciously aware of the models that we make. As certain neural networks within our brain incorporate and represent visual, auditory, tactile, olfactory and gustatory information from the outside world, other neural networks mirror those neural networks and then finally mirror themselves, making possible conscious awareness of what we are currently experiencing.

As alluded to in many of the previous examples used to describe pattern behaviors, complex behaviors such as DNA replication do not involve replication alone but instead, the complex, recursive enumeration of all of the behaviors of pattern occurring simultaneously on multiple levels of scale. We see such properties as these emerging in the activity of our immune systems, in the activity of individual cells and even in the behavior of stars in galaxies.

Recursive enumeration is a process by which new things emerge from old things by fixed rules such as the energy shunting processes of incorporation, replication, cleaving, recombination and transmission, and the symbol shunting processes of topographical number theory and music. Recursion produces surprises—unexpected results from the interaction of elements governed by a set of fixed symbol shunting or energy shunting rules. Suitably, complicated, recursive systems such as human brains, or even subsystems of a single human brain, are strong enough to break out of any predetermined patterns of behavior that seem initially to be imposed by these fixed rules. It is this phenomenon that is one of the most important, defining properties of genius—the development of extraordinary human intelligence.

AI pioneer, Douglas Hofstadter, has made an elegant distinction between those systems possessing the capacity for “true thought” and those that do not (1980; 1999). Those that are capable of the type of thought that result from complex, recursive processes are said to be operating in I-mode. If a system is operating in I-mode (intelligence mode), it continually breaks out of predetermined, predictable patterns of behavior even though it is operating from a collection of simple, fixed rules (symbol shunting or energy shunting rules). If a system is operating in M-mode (machine mode), the system has not developed enough recursive complexity (self-referential, information loops) to perform any behavior other than what it was programmed to perform. Here is the difference. If two children are both given sets of numbers along with their combinatory rules, such as addition, subtraction, multiplication and division, to be performed in a certain order and sequence, the child operating in M-mode will be able to follow the combinatory rules and produce the correct answer. This child need only have incorporated and replicated the numbers and their combinatory rules. The child operating in I-mode, however, cannot only perform the behaviors dictated by the combinatory rules and get the correct answer, but can also think “about” the rules, thereby creating short-cuts, and developing new formulas and algorithms for symbol shunting. Such children are capable of applying meta-mathematics.

As we mentioned before, the *incorporation* and *replication* of patterns which are the quintessence of M-mode system operations, are sufficient for getting A’s in school math courses. But, there is a world beyond the classroom that stubbornly chooses not to obey such conventions and pays rather handsome rewards to those who can create and innovate. In order to work out his theory of relativity, Albert Einstein, had to break out of M-mode and think *about* the “rules” of mathematics as well as the “laws” of physics extant in his time, when he finally realized that the “accepted” use of those rules and laws would be insufficient to accurately model the real world. Many great scientists before him, found the necessity to develop new mathematical systems—new symbol shunting rules in order to describe the portion of reality of interest to them. For example, calculus had to be developed in order to fully describe laws of motion and non-linear differential mathematics had to be developed in order to describe the behavior of systems over time. Such developments could never have been made by blindly following the current dogma. Rather, each genius in his time had to prolong an apostasy in order to show that the development of new rules and laws would increase our ability to describe reality thus advancing our understanding and appreciation of nature.

Multiply embedded states of motion are ubiquitous throughout nature. Cells, organs and organ systems incorporate, replicate, cleave, recombine, and transmit patterns (information) in order to sustain life—a delicate balancing act between the opposing tendencies of pattern and entropy. The matrix of genius is subserved by both the pattern behaviors of our cellular information encoding mediums as well as the behaviors of information itself. The patterns and processes which we incorporate throughout life, forcibly deploy our pattern encoding bioarchitecture, resulting in the dynamical development of our information encoding mediums, both neurophysical and biophysical. Information *shapes* the encoding medium that it passes through—it *in-forms* that medium, imbuing it with new functions. This is why both “content” and “process” are critical elements of early educational training. When the human mind learns a new process, the human brain learns to connect a new way. The degree of recursion that can be found within our brain tissue, determines the degree of recursion, ergo genius, that can be produced by mind. Nowhere in our educational mediums are these properties of pattern more thoroughly exploited than in high-level mathematics, music and art.

Recursion in Music

Composers of the Baroque and Classical eras are notorious for their recursive employment of incorporation, replication, cleaving, recombination and transmission. Although we have briefly discussed some of these examples earlier, it is important to note that the *structure* of these musical forms bear a great influence on the minds of composers, performers and listeners alike since their action literally shape the brain tissue and biophysical systems that process these pattern-integrities. Cannons and fugues, two musical forms developed during the Baroque era, make use of the sheer elegance and complexity of recursive pattern-integrities.

Many times a single piece of music will start off as nothing more than a short pattern of note sequences (a melody). This melody will be considered the core or the tonic for the piece. The rules by which the piece expands to full length, are in essence, the pattern shunting behaviors of incorporation, replication, cleaving, recombination and transmission, and it is done so recursively—one isomorphic transformation of the core pattern nested inside another. For example, the core pattern may consist of just eight notes. Then the eight notes are *replicated* so that they appear several times throughout the piece. *Incorporated* within this *replication* might be a contraction in time, of the core pattern which means that it is played twice as fast. The contracted pattern would then be assigned to another instrument voice. In another part of the score, the reverse may take place. The core pattern would be expanded in time and played only half as fast. To develop the cannon or fugue further, the core melody may be played several times throughout the piece in *retrograde* (backwards). This too, would be assigned to a different instrument voice to increase the beauty of the piece. The next section of the musical score may change in texture completely as it might contain an *inversion* of everything that was done so far. It is also very common to *cleave* the core pattern into pieces such that when the first part of the pattern is played, it creates a tension in the listener which lasts until the last part of the *cleaved* part is played. This *cleaved* core pattern could be separated by many other isomorphic transformations of the core pattern. If you would like to be able to experience just what such a piece of music sounds like, I would suggest to the reader a collection by Johan Sebastian Bach called the Musical Offering. The Musical Offering is a mirror of nature's most fundamental processes for the creation of beauty and complexity from a set of simple rules.

Epilogue

What is genius? Genius is the ability to produce new things of great complexity from a set of fixed simple shunting or energy shunting rules. Genius is the ability to step outside those rules and think about them, question them, modify them, in order to produce that which has never been produced. Where does genius come from? Genius comes from nature—and her five behaviors of pattern. Genius comes from the recursive enumeration of these pattern behaviors in mind and brain. What is the difference between those who have extraordinary human intelligence and creativity and those who do not? The difference is that as a result of incorporating and utilizing the five behaviors of pattern recursively, the mind of a genius can more closely model reality. The mind of a genius can step outside a set of fixed rules and create new rules. Where can the tools and rules for modeling genius be found? They can be found in nature's patterns. Is genius learnable? By now the answer to that question should be self-evident. Can genius be explicitly taught? Absolutely! It can be explicitly taught when designers of educational materials take into account the critical need for fusing process and content together. Recursive enumeration of the five behaviors of pattern can be taught explicitly, content notwithstanding. Such processes can be taught in mathematics, English and science as easily as it can be taught in music and art. The term for such an educational system that employs all of what has been previously discussed within this paper is an *Intelligent Learning System* (ILS).

Genius is not an all-or-nothing phenomenon. It is not something we *have* or do not have. It is instead something that we *develop* by *degree* as a direct result of the patterns that we *choose* to incorporate as well as *how* we learn to incorporate those patterns and use them once we can replicate them. To the degree that our life experiences—our changing information field—imbues our neural matrix with the essential ingredients; the *contents* and *processes* that we have previously discussed in this paper, we will exhibit the characteristics so commonly defined by humanity as genius. The matrix of genius is a process template—a blueprint for designing a mind and brain capable of great acts of erudition far beyond that which is made possible by the haphazard incorporation of “content”—a template with which we can consciously influence our own design if we so choose.

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Mr. Furman is an internationally respected scientist, author and lecturer. By the age of 37 he and his pioneering work became the subject of historical, biographical record, reported within the pages of the 17th Edition of *Marquis' Who's Who in the World*, *Marquis' Who's Who in Medicine and Health Care* and the 5th Edition of *Marquis' Who's Who in Science and Engineering*. He is recognized world-wide for his significant contributions to the fields Cognitive-Neurophysics and Education Neuroscience, his prolific published works and international public speaking. He is the developer of *Human Performance Modeling and Engineering*, *Intelligent Learning Systems (ILS)* and *NeuroPrint*—the first mind-imaging technology.

Furman has recently completed his second book entitled ***The Neurophysics of Human Behavior: Explorations at the Interface of Brain, Mind, Behavior and Information***, which was released in June of 2000. He has lectured both in the U.S. and Europe and his pioneering work in the field of neuroscience has been published in 42 countries. Furman is certified by The Society of NLP as a practitioner, he is also a member of The New York Academy of Sciences, The Cognitive Science Society, The American Society for Training and Development (ASTD), and The American Association for the Advancement of Science (AAAS). Mr. Furman has been a featured guest on several radio talk shows and his work has been the subject of a numerous feature interviews and articles appearing in national business journals. Mr. Furman is an affiliate member of the International Society for the Study of Peace, Conflict & Violence, Division 48, American Psychological Association, Washington, D.C. **He may be reached via e-mail at: neurosci@gate.net**