

# **THE NEARNESS OF GRACE**

**A PERSONAL SCIENCE OF SPIRITUAL TRANSFORMATION**

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## Table of Contents

Acknowledgements .....	3
Chapter 1: In Search of the Miraculous .....	4
Chapter 2: Doesn't Everybody .....	22
Chapter 3: Transformations Of Energies .....	42
Chapter 4: Sensual In-Between Entropies .....	64
Chapter 5: Some Entheogenic Entropies .....	87
Chapter 6: Pentecostal Phase Transitions .....	122
Chapter 7: Amphetamine Roll-Up And Splitting .....	144
Chapter 8: Faith And Rationality .....	168

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The book is dedicated to my constitutionally curious and clear-headed young daughter Buna, and to my intellectual and creative companion, Dr. Karen Selz, whose deep and lovely mind and spiritual consciousness helped create much this book.

## **CHAPTER 1:**

### **IN SEARCH OF THE MIRACULOUS**

I have been led into many laboratories by more than a half-century of persistent, driven searching for a biophysics of mind and personal spirituality that might yield some understanding of healing transformation. The motive force may have been genetic. My father said that we were descended from several generations of Jewish mystics, few of them able to attain the status of a salaried rabbi or cantor. These ecstatic men lived lives of peripatetic eccentricity, visiting and stirring congregations with provocative insights and uncomfortably personal inquiry, but only for a little while. Often they were asked to leave the synagogue, and sometimes even pushed out of their Eastern European Jewish townships, called shtetels.

My father's generation was the first in our family without one of these out-of-work Hebraic scholars. He lived as a businessman-musician, who, in the early mornings, studied Talmudic commentaries. He taught me that most interpretations of the book by the rational, physician, lawyer, philosopher, Moses Maimonides, called *Guide for the Perplexed*, erroneously assumed that man *cannot* understand God's nature. He took issue with the opinion that the union of a person's intellect and Spirit with God was not possible as long as a person was living. My father disagreed with Ibn Tibbon, Maimonides' best-known early translator and interpreter who relegated the cognitive, analytical, physical and alchemical transformational

sciences to the earthly, not spiritual realm. My father espoused the work of the 13<sup>th</sup> Century proponent of a school of Jewish ecstatic mysticism, Abraham Abulafia, who taught that the human mind, *if transformed into a “state of active intellect,”* could become one with Spirit. This position is obvious in Abilafia’s interpretation of the *Guide* and in his *Commentary on the Secrets*. He believed that the Spirit could realize the Kingdom of God in rational yet mystical experience, in a state excited with ideas and images. The active intellect consciousness captures deep knowledge of both the “upper” and “lower” realms of “reality,” spontaneously and directly. He said that without spiritual transformation, this kind of knowing is not possible.

Abulafia’s lesson was that the mundane intellect of man has the potential for metamorphosis into another kind of mind through a spiritualization of thought. This occurs in a series of developmental stages that begin with exercises of the intellect and imagination and culminate in what he called prophetic emanations. The exercises leading to this transformation are to be strongly willed and practiced regularly. This work results in ascension to an ecstatic state accompanied by greater intuitive powers, which Abulafia called “prophesy.” Ibn Adret, the Chief Rabbi of Spain at the end of the Thirteenth Century, banished Abulafia from that country, a century before the Spanish Inquisition ousted all Jews.

Readying myself for the practice of *Kabbala*, a 13<sup>th</sup> Century tradition of esoteric and mystical interpretations of the Scriptures, I learned the secret meanings of each of the twenty-two letters of the Hebrew alphabet. Much like the Platonic view of mathematics, that mathematics existed before the physical

universe, these symbols and their equivalences were believed to be eternal in the transcendental realm. One of the rare written accounts of this oral tradition is in the thirteenth-century Hebrew *Book of Splendor*, called the *Zohar*, which describes the Hebrew alphabet as the heavenly code of the cosmos.

I learned the Hebrew unspeakable name for God in its four letters, the *Tetragrammaton*, yod-hei-vav-hei. The repeated letter *hei*, being fifth in the Hebrew alphabet, also represents the number five. In the Kabbalistic tradition, *hei* implicates the functional five-part partition of the human inner self or soul. The five parts are: *nefesh*, instinctual drives; *ruach*, mood, affect and emotions; *neshamah*, cognitive activities of the mind; *chayah*, efforts to understand and attain transcendence; *yechidah*, experiencing the world as a cosmic unity. Later in life as a psychoanalytical neuroscientist with a computational preoccupation, binary partitions divided the thoughtful, forewarning forebrain from the automatic and stereotyped hind brain; the signal analyzing thalamocortical from the emotional and impulsive brain stem-limbic systems; the symbolically logical left from the intuitively geometric right hemispheres. We divide the neurotransmitter moods of dopamine aggression from the transcendently erotic serotonin and the organized dynamical states of periodicity and quasi (multi)periodicity from the real world complexity of chaos. I practiced the comfort of dividing an unknown whole into two or more unknowable parts.

My fears of death emerged around sleep-time at age four, when the implications of my father's malignant melanoma and the surgical loss of his left eye became clear. Death could be near. It was there as I fell asleep. It was not until age

ten when the Jewish guru and Hebraic tutor of my childhood, Rabbi Isadore Kliegfeld, could smile when I told him about my recent loss of nighttime panics with repeated Hebrew letter meditation. He said that I had been graced with personal evidence that these powerful symbols could call forth the transformational powers of God. The Rabbi said that I had been given a blessing, a *nachas*. Maybe the excitement of panic is not that far from the ground for the transcendence of an *activated mind*.

It was the same tenth summer, in a hot back bedroom behind a closed door, first by accidental touch and then by more systematic chaffing, that I evoked a pleurably urgent and yawning feeling that began in the lower part of my abdomen and back. The thought-emptying fullness resolved in the spasms of my first memorable orgasm. It was followed by an hour or so of inexplicable sadness.

I had been struggling to understand my father's well worn copy of William James's *Varieties of Religious Experience* and wondered if I had been visited by one of the altered states James described. Was this what he meant by a transformative experience? A few months later, a similar late night meditation produced physical evidence, a thick, sticky, salty sweet stuff that by morning stuck my sheets together. Later that year, in my father's library, I found a translation of the 1500 BCE *Egyptian Book of the Dead*. It contained a creation myth of two Gods in which "rubbing with my fist, my heart came into my mouth and I spat forth Shu and Tefnut." Psalm 23, read rather regularly in Sunday school, began to make me wonder about the meanings of "...rod and staff that comforts...", and what was meant by "...my cup runneth over."

Among the ten regions of the *Zohar*, connecting the inner world of man to the upper world, is the tree of ten *sefirot*, the Tree of Life, in which *Yesod*, the phallus, occupies a central place. Now we know that G-spot stimulation of the para-urethral glands in the female and male can result in augmented spurts as well as cups that runneth over.

A similar disappearance of time and loss of self-awareness overtook me while doing the theorem and proof work of high school geometry. Axioms and the rule-bound processes of deduction created unobvious journeys from that which was given to that which could be found. Rocking back and forth in a desk chair for hours, chewing on fingernails, cuticles and pencil ends, time evaporated in a self-less state of work-a-day well-being. Sri Aurobindo's commentaries on the *Bhagadvad Gita* described this state as one of the rewards of *karma yoga* practice. Abulafia's Kabbalistic School emphasized the importance of *hitbodedut*, detachment and seclusion in concentrated thought, as a technique for the attainment of *spiritual intensification*. Stacks of lined yellow paper piled up full of blind alleys as I lived in humbling ignorance. One of my teachers of mathematics described this passage as the working mathematician's dark night of the soul. A breakthrough to a route from premises to proof brought an expansive rush.

The struggle to fuse two differing contextual worlds may be transporting. Geometric visions can be used to do imageless algebra in a brain state that feels like intuition.<sup>1</sup> It was Abulafia's kabbalistic belief that symbolic (algebraic),

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<sup>1</sup> The brain can do something like this: Let the number of a sequence of unit squares, each side of measuring 0 to 1, be the denominator of a series of fractions, say fifths. Now put five of these boxes in a row. Then the sequence of all possible fifths,  $0/5$ ,  $1/5$ ,  $2/5$ ...  $5/5$ , is inscribed by cutting the vertical sides of the five sequential squares with a diagonal from the

operations in (geometric) spaces can unify the “upper” and “lower” worlds in the eternal tensions between the body and soul, the inner world and the external cosmos, such conflicts making the global system both sensitive and stable.

The geometric-topological approach to modern dynamical system’s theory describes a convolution of the expansive motions (as in the upper world) and contractive motions (as in the lower world) embedded naturally in the curved time and space geometries of what are called *hyperbolic spaces*.<sup>2</sup> Loss of countervailing *hyperbolic dynamical stability* results in global system transformations called *bifurcations* and/or *phase transitions*.

Transformation requiring loss of the central stability of self is a theme of a recent poetic translation of portions of the *Zohar* by David Rosenberg. In his book, *Dreams of Being Eaten Alive*, he writes that at some time in the difficult journey through the often-incomprehensible *Zohar*, in order to gain entrance to the kabbalistic cosmos, one must accept what he called *heartbreak*. “No matter how much intellectual study is involved, the reader cannot understand the text unless he or she has offered his heart to be broken on the altar of poetry ...and prayer.” Surrender may be part of the “Aha!”, the triumphant feeling of worked through ignorance or noncomprehension.

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lower left of the first one to the upper right corner of the last. This line cuts each sequential square’s front boundary with vertical lengths, 0.0, 0.2, 0.4...1.0 in a series of decimal fractions equivalent to the sequence of all possible fifths, the proper fractions 1/5, 2/5...5/5.

<sup>2</sup> Each point in this space can be visualized as a little saddle, on which orbital flows from pommel and back flow down to the seat, bringing points together in contracting motion, and flows away from seat down along the sides are expanding the distance between nearby points. In the middle of the saddle, simultaneously expansive and contracting orbits demonstrate *hyperbolic stability* composed of intersecting destabilizing and stabilizing influences.

My mother, once a conservatory teaching assistant in piano, sat beside me while I practiced almost daily, weekends included, from the age of two until my midteens. Her quiet analytic counter-point sounded mathematical, “You can hear that this harmonic progression goes through intervals of fourths of dominant seventh chords.” I felt the persistent lack of harmonic resolution as growing tension in my groin. “If you transform each of the 12 notes in a chromatic scale, multiplying it by five (in what mathematicians call) *mod 12* (the numbering system goes from one to twelve, not ten, before it repeats), one can recover the circle of fourths, the commonest harmonic chord progression in music.” Though her computational talk supported rational thought, in my adolescent heat, the addition of Charley Parker’s flatted fifth and ninth to the dominant seventh chord led suddenly somewhere else, and she knew it. Hearing my arrangement of a Beethoven piano piece become a mix of classical and modern jazz themes that I called “How High the Moonlight Sonata,” she laughed lasciviously, tickled by this violation of musical canon. A boogie-woogie Bach two and three-part invention brought more excited disapproval.

Mysterious are the contrasting conditions of attentive (preoccupied) disappearing time and none attentive (fugued out) disappearing time. I found the latter when improvising on the piano, continually shuffling a small set of notes within the melodic field of the tonal center in an unchanging tonic chord. This is in contrast with most melodies and their chords that leave the tonal center and return to it in harmonic and melodic progression. We can call these leaving and returning conventional tonal centers *unstable fixed points*. They are *attractive repellers* of melodic and harmonic excursions and homecoming expectation. It has been

mathematically proven that these components of *hyperbolic systems* are globally stable.

On the other hand, a melody that stays put in its tonic chord, a purely contracting *stable fixed point*, is technically a *chant*. Paradoxically, it can be shown that this kind of fixed point can be globally unstable. Rigid things can fracture more easily. The rich, altered states of consciousness that emerge while hearing the beat of Tibetan monks meditating, the Sufi chant-dances of Rumi and the John Coltrane and McCoy Tyner's endless, single chord, tenor/piano dialogues exemplify the conditions for a bifurcation to hallucinatory new stuff that arises spontaneously from the experience of unchanging repetition. Constant repetition of the conditioned (expected) stimulus drove Pavlov's dogs, especially those with "nervous temperaments," into frozen, catatonic states. Abulafia's 1280 book on ecstatic techniques, *Hayyei Ha'Olam HaBa*, recommended the recitative rearranging of a small set of Hebrew letters, frontward and backward, many times, using prayer melodies, until "...the heart will suddenly become aware of the intellectual, divine and prophetic..." and *hitbodedut* will rest upon him. Albulafia's instructions were "...combine letters (and associated musical notes)... reversing and rolling them around rapidly until one's heart begins to feel warm."

It was in my freshman year at Stanford University when I met Michael Murphy, later to co-found Esalon, the California center for mystical pursuits, hallucinogens and naked mud bathing. He is the author of *Golf in the Magic Kingdom*, and with George Leonard, *Integral Transformative Practice*. I watched him go through what looked like a dramatic personal transformation after

participating in Professor of Asian Studies, Frederick Spiegelberg's seminar (with meditation lab) about Sri Arubindo's interpretation of the Hindu Bible, the Bhagavad-Gita. Shortly after the semester, he climbed into an abandoned tower on campus to continue his meditation. He remained there for several months, refusing to come down even after the Stanford Student Health Service sent a medical school psychiatrist to investigate. I wanted to know how this Phi Gamma Delta frat boy had suddenly become a transcendent ascetic.

My girlfriend Mary and I promptly signed up for Spiegelberg's seminar on Indian Religions. He told us of his experience administering a Rorschach test to the Indian Saint, Swami Sivananda. He recounted discussions about God with the artists Paul Klee and Max Ernst, and with the philosophers Rudolph Otto, Paul Tillich, Martin Heidegger and Martin Buber. As homework, Mary and I practiced breathing awareness mediation twice a day. During the year, Spiegelberg sponsored a visit to our seminar by the aging but very lively Aldous Huxley. He also brought us Alan Watts and lecturers from the Jung Institute of San Francisco.

Shortly after hearing Huxley talk about the spiritual power of a particular exercise of will and loving thoughts, Mary and I began the daily practice of *karessa*, some call it *coitus reservatus*. I was eighteen and she was nineteen. We found that withholding an orgasm in order to achieve *nirvanic extinction of all desires and passions* was difficult. We spent hours in *karessa* meditation, trying to experience the detachment described in the Bhagadvad Gita. This biblical explication of *karma yoga* told how it was that the warrior, Ardjuna, instructed by Lord Krishna, in the

form of his charioteer, was able to detach sufficiently to do his assigned job, killing without emotional involvement.

Ken Wilbur is a modern *pandit*, an academically oriented articulator and intellectual justifier of the *dharma*, the spiritual work of Hindu and Buddhist practice. He contrasts the *nirvana* (literally “end”) composed of emptiness in time and space and *dharma Kaya* in which “...no objects are arising...” with the lessons of the Bhagavad-Gita. Wilbur calls attention to the scriptures’ apparently paradoxical messages, including realizing ones spiritual unfolding within the stream of real time and space, and finding emptiness in the world of form and experiencing inaction in a world of action.

We worked at karessa so ardently that there was barely enough time left to do our assignments in our other courses. In a darkened room, Mary and I lay legs locked, lying on our sides, moving slowly and rhythmically, humming *Om* and waiting for our ascension. We worked at making the journey through Sri Aurobindo’s soul planes of *higher mind*, *illuminated mind*, *infinite mind*, *over mind* and finally, the *supermind* of *infinitely empty no mind*. This unusual method of study for a three credit course in Asian Studies grew naturally out of the central message of Spiegelberg’s seminar that whereas “...deriving a universal theology is not possible, having the *universal experience* is required for an understanding of any of the world’s theologies.” The controversial Bishop of the Episcopal Diocese of Newark, John Shelby Spong, D.D., teaches that Christian forms continue to evolve. He says, “...every biblical word represents an attempt on the part of our ancestors in faith to make sense out of a God experience *relevant to their time and place*. *The*

*experience ...is eternal and real. Their specific explanations will never be eternal and real. They will last only as long as the (cultural) mind-set that created them."*

Mary got an A+, topping Spiegelberg's class with a final exam essay, which, in literary detail, described her episodes of *samadhi*, yoga's state of unity with the creator. Her 25 page blue book contained accounts of walking fugues, spontaneous strong genital sensations, changes in tastes and smells, sudden feelings of rising spinal-abdominal kundalini and middle of the night dreams of oceanic orgasmic fusion with God. She did not mention that these were her usual pre-menstrual state transitions.

During the metaphysical struggles of my college years, I learned about two Isaac Newtons. The first I met at elementary physics lectures. The unit was about how things worked, called *mechanics*. Logically and computationally consistent, but taken on faith, I learned about an invisible *field force* between masses called *gravity*. Gravity decays in strength like the inverse of the square of the distance separating the objects, and operated in my intuitive world like an electromagnetic spirit. Less occult were the expressions of *gravitational fields as contact forces*, computed for the tension in the string of a pendulum or the pressure of the floor on a weight resting upon it. Exercises in visualizing physical objects and manipulating self-consistent algebraic symbols embodied faith. I learned about experiments attesting to the "reality" of these ghostly fields (that now include electric, magnetic and strong and weak nuclear forces), and yet it was the physicists that already believed in them who designed the machines to demonstrate them. It was Gregory

Bateson, Margaret Mead's lover, photographer and social anthropologist, who said, "Newton didn't discover gravity, he invented it."

One college summer I found a second Isaac Newton, perhaps not so estranged from the first. He appeared in the form of a marble bust in the chapel of Trinity College at Cambridge University, holding a prism like a talisman. He had used it to explore the polychromatic properties of light. In his essay called *Newton, the Man*, the early 20<sup>th</sup> Century Cambridge Don and economic theorist, John Maynard Keynes, said that the Newton of the chapel followed "...certain mystic clues which God had laid about the world to allow a sort of philosopher's treasure hunt to the esoteric brotherhood." Michael White's biography, *Newton the Last Sorcerer*, described his work as an attempt to integrate the magic of the Old World with the science of the New Age. Newton's awe over what he saw as the wonders of the universe maintained him in private theological study throughout his life. Arthur Waite's *Alchemists Through the Ages* describes how Newton's alchemical orientation toward the earth's fundamental substances such as fire, air, wind and water, their powers and potential for transformation, was joined imperceptibly with his physics. In his hands, experimental observations involving gravitation, celestial mechanics and optics, though motivated by esoteric alchemical theories, generated experimentally accessible phenomena and physically testable ideas.

The French mathematician, Jacque Hadamard, in his *The Psychology of Invention in the Mathematical Field*, said that mystical preoccupations were never far from the minds of most of the 18<sup>th</sup> and 19<sup>th</sup> Centuries' English and European mathematicians and physicists. This orientation may have allowed them to pay

attention to the almost imperceptible whispers of their emergent thoughts. E.T. Bell, the historian of mathematics and mathematicians said that even Descartes, the essential Enlightenment rationalist, was responsive to his "...call of the Spirit...". Napier the inventor of logarithms wrote an exegetical commentary on the Book of Revelations. The mathematician and physicist, Blaise Pascal, believing that contact with a religious relic had cured his terminally ill sister, wrote long tracks about whether or not the Devil could work miracles. The great mathematician, Augustin Cauchy, was known for his persistent efforts to convert fellow mathematicians to Roman Catholicism. Carl Gauss, who was not particularly religious, said that a difficult to prove theorem did not result from hard work but "...the grace of God." In letters between Gottfried von Leibniz, who invented the calculus separately from Issac Newton, and John Bernoulli, a member of a family of great mathematicians, used scriptural quotations and biblical diagrams as part of their correspondence about mathematical theory. Perhaps the greatest mathematician of the 18<sup>th</sup> Century (or ever), Leonhard Euler, in his *Letters to a German Princess*, discussed the functional characteristics of spirits and the connections between body and soul. Bell said Euler "...never discarded a particle of his Calvinist faith."

Ernst Mach attributed the beginning of the separation of physical mechanics from formal theology to the working out of a law of mechanics called *the principle of least action*. Here a physical miracle could be encoded by mathematical operations and quantifiably tested. The flavor of this change is captured in his 1893 *The Science of Mechanics*. This book stimulated Bridgeman's more formal 1936 philosophical analyses of physical theory developed from a position that came to be

called operationalism: the restriction of physical concepts and their mathematical representations to those definable in terms of a mathematical proof, computational simulation or experimental operations required to demonstrate and thus prove them. Australian physicist Earnst Mach said that operationalism marked the movement of formal metaphysical thinking about mechanics toward the physical sciences and away from the personal and private realm of belief and meaning.

Maupertuis, an eccentric friend of Frederick the Great and president of the Berlin Academy, proposed the *principle of least action* as evidence of the infinite wisdom of the Creator. A bit like an early psychopharmacologist, Maupertuis recommended the use of opium to facilitate creative thought. Voltaire famously parodied him for doing so. In Voltaire's 1752 story *Histoire du docteur Akakia et du natif de Saint-Malo*, Maupertuis is portrayed as the naïvely foolish Dr. Akakia.

The *law of least action* belongs to a set of mathematical physics ideas that are called *variational analysis*. They involve the natural (only apparently miraculous) selection of maxima or minima in quantifiable physical processes. Of all possible two-dimensional shapes with the same perimeter, the circle contains the greatest area; in three dimensions, it is the sphere. In his *Principia*, Newton reports his work determining the optimal shape of round solids, with circles of revolution having the same effective cross section, in order to minimize surface dependent frictional resistance to gravity in a medium. The *principle of least action* predicts that imparting energy; say by a kick, to a physical body, e.g. a ball, on a rigid two-dimensional surface like that of the earth, results in it taking the shortest route possible from its initial to its final position.

The related 1650 Fermat's *principle of least time* is about light. As Feynman explains in his 1962 *Lectures in Physics*, "...out of all possible paths that light might take from one point another, light takes the path that requires the shortest time." Feynman, using elementary relations from high school geometry, proved that the *least time principle* could lead directly to Snell's law of the refraction of light at the interface of two different conducting media, such as the interface of air and water. Comparing the principal of least action to the least time principal, he made an analogy with the optimal choice of the path to take in order to rescue his lady love drowning in the ocean. Whereas the shortest distance to the rescue leads directly into the water, faster running along the beach to the point that minimizes the distance required for the intrinsically slower rate of swimming increases the distance traveled but reduces the time required to reach her.

Euler attributed the optimization principle to an expression of the meaning and purpose of a loving God. Infused with this spirit, he developed mathematical methods describing smooth variations in position of an object in motion, the Euler differential equation, in which differential coefficients are varied to prove the principle of least action for mechanical motion. He gave the law Maupertuis's name, concluding, "As the construction of the universe is the most perfect possible, being the handiwork of an all-wise Maker, nothing can be met with in the world in which some maximal or minimal property is not displayed." Such faith based mathematical formalisms were rejected by Joseph Lagrange, an early 19<sup>th</sup> Century mathematician, who, among many other things, proved that every natural number could be expressed as the sum of at most four squared numbers. It was his strongly

held opinion that metaphysical speculation was both foreign and inimical to the conduct of mathematics and science. Lagrange's work in the *calculus of variations* led to the development of a system of algebraic manipulations seeking the value of constants, *Lagrange multipliers*, in place of solving Euler's differential equations. It makes it possible to immediately write down a computable expression for the maximum and minimum of a mathematical function of several variables if relations between the variables are known. The technique is now taught routinely to high school students, with no mention of the role the perfection of God in its history.

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I was a fortunate freshman medical student. After a visit to his office and an amazing discussion about the correspondences between the ideas of psychoanalysis and neurobiology, a conflict with which my late adolescent mind was struggling, Robert Heath, Tulane Medical School's Gary-Cooper-like charismatic psychiatry department chairman, offered me a place in his animal and human neurophysiological laboratory and \$200 a month from a Commonwealth Foundation grant. Between classes, in the evenings and on weekends, I used a Horsely-Clarke apparatus, one of the world's first stereotaxic devices. It allowed the precise placement of electrodes into functionally specific regions of a cat's brain. The electrodes were cemented to the skull in place and their wires connected to a device by which the frequency, amplitude and wave shape of the electrical stimulation could be oscilloscopically monitored and electronically controlled as the

conscious cat walked around the room. I spent hours observing and recording changes in spontaneous behavior that followed small electrical current activation of various nuclei in the cat's brain.

Deep in the part of brain that resides in the upper neck, called the lower *brain stem* is a region thought to regulate breathing, heart rate, blood pressure, gastrointestinal motility and global states of consciousness such, as wakefulness and sleep. There I found stimulus sites on both sides of the central region that, after 15 seconds of electrical activation, led to several minutes of hissing and nonspecific rage. One cat attacked an empty chair. Another, a nearby table leg. Stimulation also raised the cat's blood pressure. These brain regions when activated also inhibited spinal reflexes, such as the knee jerk of the standard neurological examination. Similar phenomena were already known in the late 1930's. W.R. Hess and later John Flynn, had found what they called *hypothalamic rage* following electrical stimulation of cats in the lateral hypothalamus. In the late 1940's and 1950's, work by Paul MacLean, at the National Institutes of Mental Health, attributed these rage attacks to the actions of parts of the emotional *limbic brain*, particularly the temporal lobe's *amygdaloid nucleus*. Modern imaging studies in man have shown that this source of emotional coloring is activated by new information, even before the more rational parts of the neocortical brain can find out about it. How we feel about something new arises before we think about it. These survival-oriented states of fight or flight are known to be biologically universal and demonstrable in even single cell organisms.

My brain metaphysics was further enriched by my observations that after seconds of stimulating brain stem sites in the more central regions, the cats became alert but quiet, staring into space for several minutes. Then, they circled slowly and curled up on the ground. This was followed by extended periods of grooming and loud purring. Difficult to handle cats became transiently tame, some coming close for petting. I found that these same sites also increased the amplitude and reduced the threshold for the cat's knee jerk reflex, as well as decreasing their blood pressure.

Generally, reflex responsiveness decreased with rage-inducing stimuli and increased with calm-inducing stimuli. Particularly interesting was the finding that electrical induction of this purring state could immediately stop on-going stimulation-induced episodes of hissing rage. I referred to these experiments with my friends as brain studies of lateral Old Testament vengeance and medial region New Testament forgiveness. I imagined that the hissing rage state was consonant with the hypertensive, eye for an eye, tooth for a tooth, *talon principle* of the Old Testament and Koran. New Testament forgiveness would yield low blood pressure health and Jesus was certainly a healer.

It was about this time in the early 1950's that Northwestern University social psychologist, Jim Olds, found that rats could be trained to push levers to obtain current delivery via electrodes in various parts of their brains. Shortly after, Joseph Brady, then of the Walter Reed Army Institute of Research, showed that squirrel monkeys would do the same. With electrodes sunk deep into their brains and attached by wires to a miniaturized electronics box on their belts, some of Robert

Heath's schizophrenic patients spent apparently blissful, beaming hours pressing their own switches.

It was after several months of cat experiments that Professor Heath suggested that I join them in the human neurophysiology laboratory. We visited a hospitalized, chronically ill female patient, Donna, as she was being interviewed before and during the time she was being studied with recording and stimulating depth electrodes. I interviewed her before the experimental session. Donna, bony thin in a loose fitting green hospital gown and sandals, had dark red toenails, blonde hair and eyes shadowed darkly. In her mid-thirties, she had never married and, when she could, worked as a beautician. She told me that since her menarche at 13, she had increasingly frequent episodes of spontaneous ecstatic rushes accompanied by sudden visions of strong white light. She attributed these experiences to visitations of "...an unseen Christ." She showed me a stack of notebooks filled with hand written accounts of her religious experiences interspersed with biblical quotations and difficult to follow discussions of what she called the Christian ideals underlying the Civil War. She read parts of it to me. One of her memorable stories was about being invited to a Children's Crusade that had begun in Georgia, led by a great grandson of Stonewall Jackson. "We were trying to find the Lord to see if He would part the waters and open up an escape route from General Sherman's march to the sea."

From a relatively poor family of Southern Baptists in rural Louisiana, she had lived in a state psychiatric hospital for almost three years. Her diagnoses ranged from *borderline schizophrenia* to *temporal lobe epilepsy*. The collateral interviews

with her mother from several years before had been placed in the hospital chart. They recounted that in the patient's middle to late teens she had become suddenly promiscuous, frequently approaching strange men in city parks. Obsessed with fellatio and swallowing sperm, she told her mother that she was receiving a holy sacrament. More recently, the increasing incidence of ecstatic episodes and compulsive note taking coincided with a complete loss of interest in sexuality in any form. Her talk was now full of moralizing lists of shoulds and should-nots of daily living. She referred to herself as a non-Catholic nun who was married to Christ. The brain waves recorded from electrodes deep in her brain demonstrated transient episodes of spiking in a midline limbic structure called the *septum* and in the right *hippocampus*, deep in the *temporal lobe*. Paul MacLean and others since have shown that electrical stimulation of these and related brain regions could produce pleasure and grooming reactions in cats and prolonged penile erections in squirrel monkeys.

Many years later, I spoke about Donna when visiting the Harvard professor of neurology, Norman Geschwind. He took me to his twice a week epilepsy clinic in an effort to demonstrate what is now known as the *Geschwind Syndromes* of between-seizure, *inter-ictal personality changes* in patients with temporal lobe epilepsy. He stood in front of the patients' waiting room, and in a loud voice, he asked that all people keeping diaries and personal notebooks please stand up. Several did, some displaying their notebooks in outstretched hands. The pages that I saw were filled mostly with interpretations of scripture, biblical quotations and many exclamation points. Gathering the positive responders together in a corner of

the waiting room, he asked them in turn what religion they were. Several answered the question with the question, "When?" Many spoke of having multiple experiences of religious conversion. Geschwind called them "Jamesian Episodes" after William James' descriptions in *Varieties of Religious Experience*. He then asked when they had last engaged in sexual activity. For most of them, including those that were married, it had been years. Though the men said they were not physically impotent, for example, many spoke of experiencing early morning, waking erections, they claimed a complete loss of interest in sex. However, they reported having warmly affectionate feelings toward most people. Consistent with the descriptions of the Geschwind *Syndromes*, the patients were emotionally intense and unstoppably loquacious, needing to speak at length about their moral philosophies. They followed us around the clinic waiting room, several speaking at once. In his lectures and papers, Geschwind called this last feature, end-of-the-visit difficulty in separation, *interpersonal stickiness*. First reported by the French electroencephalographer, Henri Gastaut, a history of multiple ecstatic religious experiences, increasing emotional intensity and lability, hyposexuality (not impotence), moralizing religiosity, compulsive and often poetic writing and tendency to cling to authority figures is, as noted, now called the *Geschwind Syndromes* secondary to *temporal lobe epilepsy*. Some say it is relevant to the lives and behavior of Apostle Paul, Mother Teresa and Joan of Arc.

The evening came when I was to join Dr. Heath and a crowd of human brain scientists behind a two-way mirror to watch an interview with Donna while electrical current was being put through her recording electrodes for the first time. We all

watched and listened as the assigned departmental psychiatrist interviewed her. When I arrived, the patient was speaking about her childhood. Unseen by the patient, a neurophysiologist, with us behind the mirror, was intermittently pushing a button stimulating her brain with very low current applied to the *anterior septal nuclei*, a brain region under the frontal lobes. Dr. Heath told me to listen for subtle changes and discontinuities in the emotional flow of the on-going conversation that he said might reflect alterations in her thoughts and feelings.

“One time, when we took a break from Sunday school for the church service, while hearing the choir and the pipe organ, I was suddenly filled with such strong feelings of happiness that I hoped would last forever. My Sunday school teacher told us how much Jesus loved us and that’s what the music made me feel like. For the first time in my life I felt completely loved, forgiven and safe.” Though the two way mirror I watched the psychiatrist nod silently. “It was then when I learned about the real meaning of Christmas and Easter. It was scary and beautiful.”

The neurophysiologist behind the mirror, unseen by the patient or her interviewing physician, pushed the switch on the stimulus generator. Donna stopped talking. After she had been silent for a while, her interviewer encouraged her to continue,

“You were talking about how beautiful the meaning of the holidays was. Tell me in what ways?”

“I don’t want to talk about that anymore.” She blushed and looked very uncomfortable. The neurophysiologist’s hand remained on the switch.

“I have to ask you a favor and I don’t know why I’m asking. I hope you don’t get upset. The thought won’t leave me alone.” Her face reflected embarrassment even as her body relaxed against the back of the chair, almost languorously.

“Of course not, Donna. You know that here you can say anything.”

Her face reddened further. She stuttered something unintelligibly and then got silent.

“Pardon me, Donna, I didn’t hear what you said.”

“Would you mind if I rested my legs on your shoulders?”

### **Further Readings for In Search Of The Miraculous**

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## CHAPTER 2:

### DOESN'T EVERYBODY

The varieties of religious experience and the potential they bring for change are at least partially constrained by our individual personalities. The *obsessive compulsive personality* may more easily accept the restrictions of Fundamentalism and find the unpredictability and emotionality of mystical experience more difficult. Although, certainly, members of many fundamentalist denominations, such as the Assemblies of God, routinely show physical evidence for transcendent experiences such a *praying in tongues* and *dying in the Lord*. The *hysterical personality* may find experiential evidence for the Holy Ghost more accessible and the rigidity of fundamentalism more alien. Both religious orientations may be possible for those with double-jointed, multiplicity in intense personal styles and quick transitions between them that characterize what is sometime called the *borderline personality*. People with this dynamically ambiguous life pattern may, in one life time, experience several religions. How can we think about the existence and dynamics of personality and character patterns and their transformations? We explore some examples from several points of view.

A skinny, knobby kneed, small breasted, mousy haired, bright-eyed psychotherapy patient of mine at UCLA's Neuropsychiatric Institute Outpatient

Clinic was among the high priced Santa Monica call girls serving Beverly Hills. Answering my unaskable question about her thousand-dollar fee, she explained that she was living proof that, in her profession, what was more important than physical beauty was *griv sense*. She explained that by her middle twenties, she discovered that she had the ability to quickly discern many aspects of the client's personality and then anticipate their most highly valued but often embarrassing-to-say longing for a particular sexual act without being asked. She told me that she had to "empty out my own sex manual" to feel the cravings of her clients. Who the *john* was and what he most wanted appeared suddenly in her mind in the form of a cartoon. A university criminologist later suggested that her word "griv" was probably derived from what pick pockets call *grift sense*, the ability to intuit who was likely to have enough money in their billfold to justify the risk, even if they appeared in the worn clothes and dated cars of old money.

In his 1913 Dernieres Penses, Henri Poincare', France's seminal theorist in nonlinear dynamical systems theory, described intuition as a mental faculty which allows us to "...immediately see the end from afar..." In the context of mathematical epistemology, the instantaneous images of a geometer contrast with the labored sequential logic of the mathematical analyst. Poincare' claimed that inclinations toward one or the other of these two cognitive styles and their associated mathematical tools arise from different kinds of minds. He contrasted the 19<sup>th</sup> Century German mathematicians, Weierstrass, who he said reduced his general theory of functions to "...a prolongation of arithmetic...without a single (pictorial) figure in any of his books..." with Riemann who called geometry to his aid in

describing functions. He created "...an image that no one can forget... once he understood it." It's not a far reach from these contrasting ways of thinking to the scholarly study versus the inspired insight of transformative religious experience.

Experiencing the behavior of others, we create a set of anticipations about whom and how they are that align with parts of ourselves. Becoming aware of one aspect of a person, we imagine the others. With a small amount of initial information, we connect the dots, fitting features we have seen and heard to personality configurations stored by informal category in our brain files. Our conclusions about them "being one of those" can both facilitate and bias our perceptions. Eastern metaphysicians, Western mystical religionists, socially liberal secular humanists, Shannon information theorists and today's students of dynamical systems in brain and behavior can, in different ways, make the case that the content of these stereotypes reflect a pattern of constraints, our personal limitations resulting from the rutted roads of worldly experiences. Baba Muktananda, the Hindu Saint from the Indian village of Ganeshpuri, taught me to call them *samsara*. These scars limit the formlessness of anticipation that underlies sensibility. Our *samsara* reduces the uncertainty that could serve as grounds for new perceptions and compassionate understanding of others. Pre-emptive distortions reduce the bandwidth available for new information and experience. They impair the range of empathic relations with others as well as ourselves. These restrictions in possibilities and choices are expressed in enduring patterns of behavior, thinking and feeling that mental health practitioners call *personality* and *character*. When confronted with these constrictions, the self justifying and

diagnostically revealing thought about a feature of one's personality is, "...doesn't everybody? " This none insightful pride in our shape contrasts with the teachings about emptiness of one of Baba's favorite Indian holy men, Zipruanna, who sat all day, loin clothed naked in a garbage dump, instructing his students and followers about knowing and being nothing.

We quantitate deficiencies in formlessness using statistical measures of *entropy*. This number characterizes the system's behavior as a distance from the state of *highest entropy* also known as *maximal randomness*. Professor Karen Selz of Emory University did a study in which her human subjects, after taking a battery of personality inventories, were asked to remove as many dots as possible from a computer screen full of them in three minutes. They were to do so by left clicking on each of them with the mouse key. Two seconds after a dot was removed, it reappeared and became subject to removal again. As they went about the dot removal task and unbeknown to the subjects, the orbit inscribed by their dot removing mouse travels was recorded for later graphic representation and quantification. Most subjects with the usual broad mixture of personality traits inscribed a wide variety of mouse movement orbital styles: little wiggles, big wiggles, large and small loops, little smooth slides and big and little jumps. The counter-intuitive coupling of stylistic rigidity and whole system instability (as in non-hyperbolic fixed points described in Footnote #2 and below) was in evidence at the extremems of personality and graphical patterns of her subject group.

A fastidious, rigidly organized, severely *obsessive-compulsive* subject repeatedly removes the same dot, only occasionally moving to a neighboring one to

do more repetitious left key mouse clicking. Very little of the large computer screen of possible mouse travels is occupied. All the action is centered on a small set of points. When such a *minimal entropy* person is injured and feeling helpless, their stuckness can grow bizarre. Ruminative fixation in self-critical and persecutory ideas extend into poisoned food anorexia, circular pacing, weight loss and middle-of-the-night, worried insomnia. Suffused with sin, they ask forgiveness for soiling the chair by their sitting in it or smelling up the room with their body odor.

At the *high entropic* extreme, the mouse orbits of the seductively dramatic, new reality-creating *hysteric* includes big jumps, disorganized whorls and large and small restless and short attention span scribbles that tend to fill up the entire screen. The fragility of fixation at this end manifests itself in breakdown into impulsively out-of-control and floridly dramatic displays. Their decrease in contact with reality precipitates social chaos around them. The Montreal behavioral neurologist, Pierre Flor-Henry, using electroencephalographic and psychological test data, described the difference between these two extreme forms of personality expressions as the overly dominant expressions of one or another of the *left obsessional* or *right hysteric hemispheric emotional styles*. As examples, Flor-Henry said that a left half brain depression feels like hopeless and agitated indecision. The depression of the right brain is an experience of emptiness like homesickness. Left-brain happiness is being exactly correct and right brain joy rushes like being especially chosen.

The church going obsessional resonates with the sermon of the punitive priest who invokes the tension and relief of sin and salvation. The practice can result in a life long addiction to the relief and transient high of this temporary

forgiveness. In other churches, the hysterical character gets spiritual respite in disassociative visitations of the Holy Ghost and attendant *signs and wonders*. At Wednesday night healing services, new hope arises from personal surrender in a floor hitting, backward collapse called *dying in the Lord*. Both of these antipodal personalities contrast with the more receptive state of *in-between entropy* (with enough uncommitted entropy available to send and receive adaptive messages) which predicts more flexibility and higher potential for undistorted information processing. Relatively style-less and ego-less people are more open to hearing a variety of Gods in themselves and others. High alertness without presupposition, ecstatically aware and selfless, it is God's gift realized, a joyfully awake and nonjudgmental empty state of transcendence. As we sit, we work at feeling this projection from the brain of the enigmatically smiling stone Buddha.

The externally inactive state of high internal activity, the Bhagavad-Gita's formlessness in the world of form, inaction in the world of action, has a natural mathematical representation in the simultaneously expanding and contracting motions of previously described *hyperbolic dynamics* and its associated entropic descriptors. How can this kind of formlessness equip us for almost instantaneous knowing? In a resting state of *uniform hyperbolicity* that only looks like randomness, accurate impressions of others can arise quickly and from only a few data points of observation. In the late 1960's, University of California mathematician, Rufus Bowen, proved the now famous *shadow theorem*. This says that in dynamical states of *hyperbolicity*, directly observable on the screen in computer simulations, the first few points of the on-going wild dynamical dance that appears to jump randomly

from here to there on the computer screen, counter-intuitively will quickly outline the entire skeleton of its future global shape though more time of observation is required to realize this structure in full detail. The contracting motions on the stable surface of action, called a *manifold*, iron down all the points onto the sheet of the *unstable manifold* that, in turn, spreads out points along the sheet and serves to outline the shape of the *attractor* of all starting points. In such a system, observations of just the first few points outline the whole. Intuition, anticipatory knowing and that which some call *prophesy*, may be expressions of the hyperbolic brain's mind doing *dynamical shadowing*. We know the shape of the dog from the pattern inscribed by its fur.<sup>3</sup>

The intuitive reason *shadowing* works is built into these natural countervailing tendencies of *hyperbolic dynamics*, which on one hand tends to spread out nearby initial points and brings disparate others together. The latter inclination is the one

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<sup>3</sup> To review briefly, *hyperbolic (brain) flow* is made up of three decomposable components: (1) The apparently predictable one along the main road of the action, going straight ahead and round and round on a throughway called the *center manifold*—analogous perhaps to what might be a sequentially logical development; (2) Intersecting the center manifold transversally is a field of influence moving the action away from the center manifold with out-of-the-box motion, exploring side paths of unpredictably new, creative possibility called the *unstable manifold*, we might think about inspired risk-taking, impulsive associations in thought; (3) Another transversally intersecting field of influence, which conservatively, rationally, “irons down” the expansive flow back onto the road, the entire constrictive field called the *stable manifold*. This influence herds points into *shadowing* the main road of the dynamics, like the hair of the dog that stay close to the real body of the animal in motion. It is in this way that just a few often slightly off the mark points nonetheless shadow the real (called *fiduciary*) orbits of the attractor, outlining its global geometry with just a little information.

that smoothes down the escaping points onto surfaces of actions that mathematicians call *manifolds*. However, the details of the orbital paths don't look that orderly due to the *mixing* of the sequence of points in *hyperbolic motion* (see Footnotes #2 and #3). The mixing process on manifolds has been analogized to that of the bundled pink loops of the stretching (expanding) and folding (contracting) taffy puller at the carnival candy stand. The process gets sequences of small particles of candy out of sequential order while maintaining the taffy's overall geometrically ovoid shape. *Disorder is local* with the entropy being generated by the repeatedly *shuffling* of the line up of the original orbital sequence. This results in the impossibility of any point-to-point prediction for more than a few points even though the over all shape is maintained. Exactly what minute a habitually late sleeper awakes can't be predicted. On the other hand, the skeletal manifold of the global structure is entirely in evidence from almost the beginning. Late risers remain late risers even without a precise, minute-to-minute, predictable schedule.

It is also interesting that a uniformly hyperbolic dynamical system, unlike the *fixed-point attractors* of stylistic fixation, resist perturbation-induced changes in global dynamical form. In an apparent paradox worthy of metaphysical allusion, the dynamically hyperbolic kind of formlessness has *structural stability*. The global geometric predictability of this point-to-point, completely unpredictable system can be both the subject and object of Zen frustration and thoughtful meditation.

During weekly professorial rounds at Los Angeles's Neuropsychiatric Institute, I assigned a standard exercise for psychiatric residents on clinical rounds, which involved limiting their contact with a patient to five minutes. This was followed

by detailed discussion of everything we'd seen and heard. I'd ask them to predict what we'd find in the many pages of personal interviews and nurses observations in the clinic chart. The student psychiatrists with the most street smarts, called *emotional intelligence* by Daniel Goleman, were particularly quick at *shadowing* and thus predicting the patient's global dynamical pattern.

Are their fundamental elements underlying specific personality patterns? Evidence from biometric studies of the hereditary aspects of personality style in animals and humans suggest that relatively few global component properties underlie a variety of complicated-looking manifestations of behavioral style. Primary colors are the source of all hues. Harvard psychologist, Jerome Hagen, has reviewed the history of this idea in his book, Galen's Prophecy. While there are differences among personality research programs, almost all rating scale and questionnaire-based studies result in clusters of traits that reflect statistically associated properties which when taken together are called *temperament*. This idea is close to what we mean by personality. These relatively few response clusters are given descriptive names such as *introversion*, *extroversion*, *neuroticism*, *impulsivity*, *sociability*, *task persistence* and *tolerance of ambiguity*. As defined by psychological inventories, studies of families show that these styles are heritable in the range of 60%.

Hans Eysenck, in over four decades of work and more than 5000 published papers from London's Maudsley Hospital, derived common global factors of personality using questionnaires. The best known was called the Eysenck Personality Inventory. His studies resulted in evidence for only a few fundamental

behavioral axes, behavioral manifolds, which describe the extremes of personality dimensions analogous to stable and unstable manifolds: *introversion-extroversion*, *shyness-sociability*, *low and high activity level* and *emotional constriction versus impulsivity*.

To make the issue of personality as dynamical system a little more realistically complex, we can call on some examples from the rich history of behavioral genetic studies using animals such as the mouse. They can be selectively bred for underlying personality factors, such as dominance, fear, aggression or exploratory courage. Not surprisingly, social interactions, as configured by the mouse's own personality style, contributed significantly to their behavioral patterns. As an example, the C57BL strain of laboratory mouse has strong tendencies toward impulsively wild behavior. To be anthropocentric and using Hagen and Eysenck-like behavioral dimensions, we could describe the C57BL mouse as exhibiting high *psychoticism*, *P*, energetic sociability as high *energy*, *E*, and low emotionality as low *neuroticism*, *N*. The C57BL also loves alcohol and will dominate the low *E*, shy, low *P*, retiring, alcohol avoidant, high *N*, emotional, anxious, frequently defecating albino BALB strain of mouse when they are placed together for a limited time in a novel situation during the daylight hours. Over a more extended time, however, the BALB mouse comes to dominate the C57BL, beginning with attacks in the dark and finally as the persistent and patient survivor over days of aggressive fighting. BALB's low *E*, social fear eventually turns into rage and aggression. The C57BL is quick to mate and ejaculate but very slow to recover sexually, so that the less post-orgasmically refractory BALB also wins in

long term sexual competition in a cage full of fecund females. Modern social psychological approaches to human personality are beginning to approach the interactions of genetic brain proclivities and collective social dynamics in this way.

Employing Eysenck categories of personality characteristics, similar results about style as influenced by genetic selection can be seen in humans. The correlations between factor scores based on the California Personality Inventory in twins demonstrated as much as threefold higher correlations among identical twins for *extroversion (E)* and *neuroticism (N)* factors compared with matched fraternal twins. The primacy of some of the in-born biological roots of these personality styles is suggested by other findings of higher correlations between identical as compared to fraternal twins when studied at the age of two months. The similarities in personality and temperament measures included *activity level, regularity, approach-withdrawal, intensity, persistence, distractibility* and *adaptability*.

More recent familial studies of the heritability of personality characteristics included *childhood shyness, neuroticism, depressive symptoms, aggressiveness, behavioral inhibition and anxiety, behavioral flexibility, narcissism, deviant motor activity levels, novelty seeking, harm avoidance* and *reward dependence*. These studies indicated familial congruity of these characteristics among first and second degree relatives in the range of 40-50%. This level of heritability in genetically unrelated family members was found to be less than 20%.

Low entropy fixations of personality can also evolve developmentally. Experiments in young animals have shown that stress-induced high levels of adrenal hormones exaggerate the normal developmental process of trimming back

unused neural connections, called *pruning*, the normally complexly over-grown *sprouting* pathways. The pruning actions of the *pituitary-adrenal stress hormones* come to dominate sprouting actions of *neural growth factors* and their protection of neuronal axonal branching and connections during development. The research program of Bruce McEwan of Rockefeller University and others document nerve cell loss resulting from the neurohormonal concomitants of stress. This reduction in neuronal connectivity and neuronal cell content has been conjectured to contribute to the *pathological simplification* of neuronal projections and neural network complexity, reducing information processing capabilities. The still intact machinery underlying the global patterns of neurological activity, such as those that underlie personality styles, is arranged around these pruned, unoccupiable holes of lost from brain connection possibilities. If this range of potential behavior is extremely reduced, the behavioral syndrome is often called a *personality disorder*. Those that have one are the predictable Johnny one notes of response to perturbation: thrash out, lie without reason, get drunk, binge on promiscuity, steal unneeded things from department stores, or withdraw into interpersonal isolation. <sup>4</sup>

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<sup>4</sup> A more abstract and quantifiable way of representing the pathological simplification-induced emergence of low entropy, stereotypical personality style is inscribed on the head stone of the post-suicidal grave of Ludwig Boltzmann. This father of modern statistical physics expressed the idea in the form of a transformation: the (maximal) entropy,  $S$ , of a system is the *logarithm of the number,  $\Omega$ , of its available ways of being*, (i.e.,  $S = \log \Omega$ ). That is, one way a reduction in the dynamical entropy of a system can occur is by reducing the number of its available states. As the repertoire of ways of personal responding,  $\log \Omega$ , is reduced, so is the brain system's entropy,  $S$ .

Reality constrained patterns of behavior, as in successfully adaptive personalities, lie in some optimal in-between place between the maximal and minimum measures of entropy. The dynamical state that is postulated to yield *in-between-valued entropies* is called *nonuniform hyperbolicity*.<sup>5</sup> The labored logic and inscrutably compact mathematical formalisms of the Nobel Prize winning physicist, Ilya Prigogine, and his Belgian school, explain the thermodynamics of these long lasting niches of restricted variation in our personal style as energy requiring *dissipative structures*. Compulsive nail biting, driven promiscuity, readiness to be suspicious are seen as a persistence of deviations from the maximum entropy of formless, flexible, receptive end states. The system is trapped in possibility reduced, *energy requiring, samsaric niches* of what Prigogine called *minimal entropy generation*. We unique and oddly shaped and entropy leaking balloons maintain our characteristic distortions through energy-requiring, persistent efforts at insufflation. The maintenance of neurotic defenses and eccentric habits can be fatiguing.

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<sup>5</sup> This is best seen when the values of the experimental observations are plotted in a two dimensional *phase space* with each point represented by two values: along the *x-axis* is plotted the value observed, along the *y-axis* is graphed the *change* in the value from the last observation. The signatory motions of these observations plotted in *phase space* are irregularly varying in rate of expansion (near by initial values are separating in time) and contraction (greatly differing initial values are coming together in time). Values are not fixed, rhythmically varying nor in random motion. These *nonuniformly hyperbolic motions* are seen in speeded up, talking head videos showing bursts of hand gestures and in normal neuronal activity. Silences have widely varying lengths and bursts of hand movements and neuronal discharges are irregular in duration and character. The statistical pattern of neuronal inter-burst intervals is not the convergent Gaussian distribution of I.Q. or heights but the nonconvergent, long tailed, Levy distribution of flood incidences and, according to Mandelbrot, stock market crashes.

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The children at Kids in Distress Residential and Day Care Center in Southeast Florida, called KIDS, tended to be small for their ages. As a psychiatric consultant to the Center, I often summarized an evaluation of both their physical and intellectual development as “delayed.” Looking like almost completely formed adult-like personalities, however, they were developmentally “advanced.” I heard in a child analytic seminar at the Psychoanalytic Institute of Southern California that traumatized children often hurry through the dangerous developmental ambiguity of openness and flexibility to the predictable, fixed attitudes and behavior of adults. It was common to find prematurely wise children serving as parents to the younger children in chaotically dysfunctional families. In residence at the Center, set free from their pathogenic homes by social workers and family law judges, these premature caregivers lost sleep worrying about who was taking up their obligations to the sisters and brothers left behind.

Trauma-induced possibility pruning was often obvious in the young refugees at Kids in Distress. Having been soaked in alcohol containing, nutritionally deficient, crack-laced amniotic fluid, young babies were then left in dirty cribs behind locked doors to cry themselves into exhausted despair. Their mothers were working the streets for drugs. The children that survived often demonstrate personality styles that are reduced in variety. They came to use a few, individualized, and stereotyped techniques for survival. Some children’s insulated detachment was hollowly

disguised as interpersonal caring. Others used driven and rigid compulsion to maintain the appearance of conscientious good citizenship. For some children, paranoid thoughts were realistic expectations. .

Arriving at the Center I heard “Dr. Arnold! Dr. Arnold!” in high-pitched screams. Several children ran up to me at once, demanding to be held. Some leaped into my arms for a hug. Trying to get and hold their visual gaze was another matter. Their eyes darted back and forth across my face, not stopping at my eyes, as though checking for danger. It felt like a strange mix of physical clinging and interpersonal distantiating. Many articles in the International University Press’s Psychoanalytic Studies of the Child book series, described these prematurely formed child personality types: the paranoid scouts, the detached *as if* children pretending to feel, the desperate to please obsessionals, the charismatically seductive hysterics and the unconscionable psychopaths.

Experiments simulating trauma and neglect in young animals also demonstrate acceleration in biobehavioral development. Possibilities, the number of available states,  $\Omega$ , brain entropies as  $S = \log \Omega$  (Footnote #4), become casualties of traumatic and neglected early life. Like one trick ponies, these abused and abandoned children take up singular patterns of behavior that seem to work and stick to them. One doesn’t anticipate seeing such narrowly fixated personality patterns until late adolescence or adulthood. They appear at ages too young to qualify for the character pathology coding of the Diagnostic and Statistical Manual IV. Yet the labels of adult personality disorder seem inescapable when one sees a

four-year-old child trapped in a compulsive hand washing ritual or a panty flashing five-year-old girl with a seductive gait.

Four-year-old Alicia rubbed the lumps in my right hip pocket containing caramel candies. Her blue eyes twinkled. Her long blonde hair was in bangs and her lips in a pout. She kept a hand on her hip and tilted her pelvis as she spoke. Listening to children's stories, she straddled the reader's thigh and rocked. Alicia had a history of sexual abuse in a home that was a hang out for drug dealers. There were rumors that she talked to strange men late at night on the phone. On admission to the Center, she was found to have genital herpes. Both of her parents had been in and out of prison for drug-related crimes. The Center's staff spoke of Alicia's seductive smiles, incessant demands, irritable complaints and tantrums. With the back of her hand held against her forehead, she said that it was too hot to pick up the toys she had scattered around the fenced yard. Ordered to comply, Alicia took three steps into Florida's summer heat and fainted. Each morning, she spent the better part of an hour in front of the mirror, trying on all four of her dresses and their scarf and belt accessories before choosing one for her appearance at the breakfast table.

Five-year-old Grace was a suspicious and dictatorial presence in the Center's kindergarten class. Articulate and righteous, she confronted children and staff alike with evidence for the unfairness she found everywhere. In legalistic defense of her rights and sometimes those of her peers, she used her strong wide face, penetrating look and quick and observant mind aggressively. Her somewhat intimidated childcare worker maintained Grace's cornrowed hair with care. Sensitive

to criticism and quick to anger, she competed with her teacher for control of the class. Her drug abusing young mother had escaped from her own mother's authoritarian house, leaving six-month-old Grace in the care of her commanding grandmother, a matronly church elder. Recent studies by David Reiss and associates at George Washington University assessed psychosocial dynamics in genetically varied families. They found that genetic similarities amplified the expression of individual characteristics of interpersonal relating through what might be called *personality resonance*. Relatives often commented that Grace and her grandmother, being alike, deserved one another. Shortly after her fourth birthday Grace was removed from her grandmother's home while the circumstances surrounding the accidental scalding of the bottom half of her body in an overheated bath were being investigated. She began her first conversation with me with "Hey doctor baldy, why are your bottom teeth so crooked?"

Damon was darkly handsome, with teasing eyes and a gleaming smile. Talking to his legal guardian on the pay phone in the afternoon of his second day at KIDS, he was heard to be making charges of mistreatment by the staff. He asked his guardian, loud enough to be heard throughout the day room, "What does it take to get someone fired around here?" Six years old and abandoned by his mother at the age of three, Damon came to KIDS with a history of provoking administrative conflicts at several children's shelters. His record showed that once he successfully used accusations of beatings to get a staff member fired employing charges that were later shown to have been fabricated. He argued persuasively, manufacturing events and quoting imaginary conversations with smooth confidence. He could

change stories midstream without apparent loss of continuity or confidence. He learned the power of a claim of abuse, and used the threat of it to control his environment. Damon talked other children out of their candy allotments, cheated at games and stole clothes from other children's lockers.

Debbie, age eight, was the eldest of four children. Her mother was a street prostitute with an expensive drug habit. Debbie was thin, restless and worried. A self-appointed mother from the age of four, Debbie felt responsible for the care and feeding of her brother and two sisters. With a history of physical and sexual abuse by a series of her mother's boyfriend-pimps, Debbie spent most of her time cleaning and recleaning their small apartment and worrying about obtaining enough food for her brothers and sisters. Her mother was often gone for one or two days at a time, and food supplies were not dependable. On several occasions, Debbie was caught stealing food from all night grocers. The investigative social worker reported that Debbie had learned to sell oral sex to the men who loitered behind a neighborhood bar. She used the money to buy food. For several days after admission to the crisis home, Debbie was anxious and sleepless. She worried endlessly about the welfare of her sisters and brother despite reassurances that they were in caring foster homes. She checked on them as frequently as allowed by phone. In a playroom therapy session, wielding a rubber knife, she pointed to a scar on her left forearm and told a story about the time that she cut herself with a kitchen knife and fed her blood to her infant sister when there wasn't any food in the house. Debbie kept her room very tidy, did all her chores and sometimes those of other children. Even after

several months in residence, always-busy Debbie didn't have even one close relationship with any of the other children or members of the staff.

Despite the superficial differences, there are subtle and pervasive similarities among the personality styles of Alicia, Grace, Damon and Debbie. Like overgrown and tasteless cabbages, pale and four feet across, growing from seeds over-treated with gibberellin or auxin plant hormones, the inner lives of these prematurely big little people are relatively empty of stable interpersonal objects. The pantheon of indwelling companions are either malignant, absent or both. There is a deficiency of internalized significant others with qualities we more healthy neurotics paste onto new faces which we then love and hate. Instead, every interpersonal arrangement is new, suspect and run on a cash-and-carry basis. We are made to feel like there are no seats for us inside of them. Even Debbie, with her history of selfless motherly devotion to her "children," felt like an empty husk, encased in the exoskeletal armor of compulsive correctness. With their inner life unpeopled, the best we on the outside can hope for is to be valuable to them as tools, like forks and chairs.

In new and potentially therapeutic settings, for example a genuinely loving foster family, these children manipulate, testing for the feared loss and abuse that first generated their detachment. They provoke the very mistrust they fear. The sexually exploited child is seductive. The physically abused child provokes attack. Personality constellations which can be adaptive, when narrowed and fixated, become impediments to new and reparative experience. It is in this way that personality disorders are self-maintaining.

An irony is that these interpersonally empty and rigid patterns in personality tend to occur in the most constitutionally robust of the abused and neglected children. They are those who have escaped early death from failure to thrive, severe neuropsychological impairment, chronic depression, severe social withdrawal or the pediatric psychotic disorders. The children with sufficient flexibility to adapt quickly and survive often settle into empty-centered rigid caricatures of adult personality styles.

Of course, well-defined and characteristic personality patterns do not require abandonment and abuse or the pathological simplification of traumatic deforestation of neuronal connectivities in order to emerge. Demanding social selection of particular personality proclivities that are competitively advantageous for highly sought positions also results in the appearance of well-defined personality styles. Common examples are the technical types, “techies,” “nerds,” whose work require long hours alone to master and execute, as in doing mathematical proofs, solving problems in theoretical physics, unraveling computer programming problems or writing highly technical tracks. These activities can be aided by the personality inclinations of shyness and distantiation, the experience of discomfort in social occasions along with a rich private fantasy life. Diagnostically oriented mental health professionals (and lonely mates) may label these interpersonally distant, engineering rocket science people, “high functioning” sufferers of *Asperger’s autistic spectrum disorder*. Things going on inside get most of the attention, having more impelling importance than those on the outside involving other people. A recent study by Cambridge University’s Autism Research Center compares the

*empathizing (E)* versus *systemizing (S)* ability of normal controls and adults with Asperger Syndrome and find the quasi-autistic adults are *deficient in E* and *superior in S*. They call it the *E-S theory of autistic spectrum diseases*. Psychotherapists of these *autistic spectrum* personality types, patients who characteristically do not seek therapy but are forced into the office by marital or family conflict, speak of their long, patient and mighty struggles to make intimate contact with these clients. A more philosophical question involves issues of what are acceptable individual differences and why it is that these high functioning, highly paid and successful professionals have any diagnosis at all.

It is not surprising that the highest paid members of corporations producing technical products and services such as IBM and Oracle are those rare individuals in technical sales that are able to combine the skills and insights of introverted scientists and technicians with those of gregarious, successful salespersons. In business schools such a blend is seen in people who combine talents in both marketing and finance. In architecture this combination might take the form of a graphic-design artist with computational mechanical engineering skills. Recruiters know that it is difficult to find people for what is called engineering sales.

From all over the United States, professional instrumental musicians that began to experience severe technical difficulties that defied their teachers as well as more extended practice time came to see Chicago's music guru, Carl Boardstadt. He was a nationally known consultant to classical and jazz professionals in the 1920's and 30's. His particular specialty involved those who had "hit the wall," those whose progress toward advanced musical mastery and accession into the higher

echelons of the profession had been cut short. His recommendations were often eccentric indeed. For the wind musician with breadth control problems, it might be blowing uniform bubbles through a long tube held at increasing depths of a filled bathtub or feeling the seductively diaphragmatically oscillating belly of a taxi dancer. Pianists with speed problems worked at specially constructed up-side-down keyboards with the rationale being that finger lifting was more rate limiting than finger placing. He said that his most hopeless cases were those whose personalities didn't fit their choices of instrument, too often made by what position remained open in the high school band rather than following a personal interview. He claimed that trombonists should be sensually languorous; clarinetists, nervously impatient; double reed instrument players, obsessional and withdrawn; brass players, athletic and exhibitionistic.

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As one of the team physicians of the San Diego Chargers in the years 1971-1975, I spent several days a week in their summer training camps, on the team plane to and from games, in the locker room and on the sidelines during games. I was involved particularly in player drafts. Unbeknown to candidate players and other teams, we used a system of what social scientists call *unobtrusive measures* of their personalities as part of their evaluations. College football players are sent questionnaires each year by professional teams asking about a variety of life events and attitudes including their goals for the future. Filled out by hand, they served as

*repeated measure, handwriting samples.* Twenty years of them were available in the Charger's record room. Using 30 standard signs from the French graphology literature and three trained raters, we evaluated the hand writing characteristics of players, National Football League wide, who obtained and retained playing, not reserve, positions in the League for at least three years.

After studying handwriting profiles from close to a thousand established NFL players, and hundreds of hours of individual interviews of members of many teams, it became clear that, athletic abilities being equal, success was more likely when the player's personality type fit his football position. What amounts to a series of selective filters are operated by coaches, scouts and managers throughout the playing careers of these players in grammar schools, high schools, universities and, ultimately, the NFL draft. Choices obviously involved more than height, weight, time in the 40-yard dash and performance in motor coordination tasks. The players behavior, carefully studied on the field, in multiple camera angle game films, direct and collateral interviews and observations under game conditions constituted a high level of selective pressure that brought with it the emergence of characteristic personality types. Tens to hundreds of thousands of candidates are winnowed down to several hundred highly paid players in this selective process.

Distinctive personality patterns accompany success at particular positions. Structure loving, politically more conservative, choreographed in detail and repeatedly rehearsed, offensive players keep their lockers more organized and tidy. More rebellious, resentful of structure, politically more libertarian, thematically instructed but principally opportunistic, defensive players, particularly linemen and

linebacker's, had messy lockers. Defensive team players were most often in trouble with the law. Offensive lineman including centers, guards, tackles and some tight ends tend to be patiently enduring and tenacious, their aggression taking the form of stubbornness. This contrasts with the temperamental explosiveness of the defensive line and linebackers. We could speak of the volubility of centers, the loyal and caring kindness of offensive tackles, the narcissistic exhibitionism of wide receivers, the murderous rage of the defensive end, the sullen and paranoid depressiveness of the defensive back, the joyfully impulsive unpredictability of broken field running backs and the good citizenship egolessness of the blocking fullback. Some quarterbacks lead and play fearlessly in a religious state of grace, some are members of the Fellowship of Christian Athletes. Others lead as fearlessly, but in the style of an unconscionably calm, psychopathic, bank robbing professional.

Influenced by our findings, the San Diego Chargers drafted the Hall of Fame quarterback and one time ABC Monday Night Football commentator, Dan Fouts. Skinny and hurt several times during his college years as a quarterback in Oregon, he was passed over in the NFL draft until the third round. The scouts "knock" on him was that they thought that he lacked psychological and physical toughness; the ability to get up after a hit and to ignore the on coming tons of defensive linemen while calmly and quickly surveying the routes of several potential receivers. The pattern found in his handwriting features, however, resembled those of Johnnie Unitas, the Hall of Fame quarterback of the Baltimore (then) Colts who, in spite of his small size, played with great courage and physical toughness. In chronic and

severe back pain, he played regularly until retirement in his early 40's. Fouts drafted in the third round with a small five-figure bonus, proved to be a great bargain for the Charger franchise.

Given the theoretically infinite number of ways that a personality can be, it is remarkable that the latest Diagnostic and Statistical Manual of the American Psychiatric Association, DMS-IV, describes only eight types, which form three subsets of exaggerated expressions of stable personality styles called *personality disorders*. All eight personality disorders can be grouped into: (1) *Cluster A - Odd and eccentric types*, whose anxiety is related to the felt threat of disintegration and annihilation of the self and whose style is dominated by mistrustful paranoia, a schizoid, detached and emotionally flat pattern or the isolated strange eccentricism of *schizotypal characters*; (2) *Cluster B - Unstable and impulsive types* whose anxiety is related to loss of the stable self and whose style is dominated by irresponsible antisocial behavior, chronic instability with high amplitude fluctuations in behavior called *borderline*, or patterns of excessive emotionality and dramatic display associated with *histrionic characters*; and (3) *Cluster C - Fearful types* whose anxiety is related to hypersensitivity to criticism, guilt and feelings of inadequacy or loss of control, and whose style is dominated by interpersonal avoidance, clinging dependency, or rigid lock up into obsessive-compulsive efforts to do the right thing and avoid disapproval. This remarkably small array of stylistically consistent global behaviors selected from a practically infinite number of imaginable possibilities establishes a small set of invariants of some, perhaps

abstract, properties. These characteristic patterns inspire our search for the implied brain and behavioral conservation laws that may underlie them.

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## **CHAPTER 3:**

### **TRANSFORMATIONS OF ENERGY**

After several of months of running, 12 miles most days, I felt an energetically calm, self-containment and a growing loss of interest in sensual things. My increasingly sexually impoverished fantasy life led my training psychoanalyst to suggest that I was running away from the critical issues involving females issues in my psychoanalysis. He said I was becoming more emotionally out of reach as I became more superficially pleasant. This was decades before Prozac, Paxil and other serotonin reuptake inhibitors were inducing similar hyposexual, insulated states of cordiality in millions of Americans. Recall that Norman Geschwind, the Harvard neurologist, reported similar conditions of high energy, sexual disinterest and general friendliness in patients with right temporal lobe epilepsy. For reasons other than the threats of loss of church property rights and the dangers of the spread of syphilis to the clergy, it felt like I was being readied for Pope Gregory VII's Eleventh Century celibacy reforms for abbots and clerics of the Catholic Church.

It was true that my feelings of dependence on my analyst for understanding and approval grew less as I ran into more emotional detachment. I thought I was becoming a more rationally objective observer of others and myself. It wasn't the first time that over-ardent practice led to this warning. Once, after I had been in

residence at his Ashram for a couple of weeks, Baba Muktanada, my Hindu guru, told me to reduce my daily sitting time of meditation. He said my spacey social smile belied a loss of compassion in a growing disinterest in the welfare of others. I was getting hooked on the hard training, psychologically distanced, high of not being there for other people.

Several articles in *Runner's World* concluded that many, in this kind of running program became addicted. It's true that in over fifteen years I missed less than 10 days of running in any year. I ran in driving rain, sweltering heat and dangerous places. In New York's Central Park after dark, I followed a freshly strewn trail of torn woman's garments that ended in shredded panties and a bra on the Park's bridle path. In Oklahoma City at 104°, I was chased and bitten by a terrier. In Munich at 4:30 AM, before delivering a morning lecture, the black uniformed police stopped me for a shakedown. In Ann Arbor, I shuffled along in two feet of snow. By the Seine, at 14°, paranoid barge hounds barked in big dog baritones. I ran on the Hebrew University track a block away from a loud Palestinian bomb left in a refrigerator near a busy street corner. Breathless at nine thousand feet in Aspen, gagging on the strong manure smell of Sacramento Valley farms, in the hot wetness of Houston and dry heat of Palm Springs. I wore out three to four pairs of Nike running shoes per year. What I did not tell my training analyst was that this felt like prayer, my chase after God. As in most spiritual practice, His transformational visions and messages could emerge quite suddenly.

Even after stretching, it was painful to begin and that was my daily sacrifice. I was readying myself to follow the God of the Hebrews and make the "three days

journey into the desert” as in Exodus and Paul’s recommended presentation of my body “as a living sacrifice, holy and well pleasing to God.” After three miles of running, the hip pain, back stiffness and leg heaviness lifted, difficult breathing became easier. A burst of new energy appeared suddenly. The first pop usually took the form of assertive feelings fueled by new personal power, an undoing of the lethargy and depression of the helpless. New and big, I felt like I could create or repair almost anything. Up bubbled an aggressive speech to the Dean about his refusal of our recent request for an increase in departmental research space. As for the National Institute of Health’s recent return of one of our grant proposals, it was now clear that the reviewers were wrong. I would resubmit but this time ask for twice the amount of money. I rehearsed a new list of necessary but routine laboratory chores for my most rebellious post-doctoral student. I would tell my teenage son that he must wait another year for his own car.

In an article in *Runners World*, I labeled my run’s first *global brain state transition*, the *first second wind*. It energized me with the cool firmness but ready-to-be angry righteousness of modern religious orthodoxy: Orthodox Jews gunning down Hamas terrorists as retribution for bus bombing children which was itself part of an endless chain of retribution; Muslim suicide bombing as vengeance for cultural contamination; Catholic Bishops refusing the Eucharist to pro-choice politicians; Charismatic Christians gay bashing defense of the sanctity of marriage; Mohammed’s early Sufi-like poetry of love turning into territorial aggression and Jew killing in his later years.

Once in while, unpredictably, past the first hour of running and after the first second wind was followed by the return of fatigue, a second burst of energy appeared. I called this *second global brain state transition* the *second second wind*. It was a much softer, smoother and loving energy. Colors became intense, clouds breathed and my body lightened. Running once again became easy. I was flooded with empathic and compassionate thoughts. I suddenly understood that the Dean was faced with too many space demands to satisfy; I realized that the grant reviewers' criticisms of the budget were meant to be constructive. I recalled that strong minded, rebellious post-doctoral students often made the most creative contributions to science. I realized that my son's urgent desire for his own car was a proposal in the direction of the independence that would be required of him the following year when he was going to be hundreds of miles away at a university. Filled with benign optimism, I felt the compassionate perspective afforded those with energy but without irritation, envy, anger or fear. William James, in *Varieties of Religious Experience*, A.C. Underwood's book, *Conversion, Christian and Non-Christian* and Gobi Krishna's *The Awakening of the Kundalini*, among many others before and since, describe the sudden appearance of lasting states of optimistic energy and loving empathy that can emerge after episodes of suffering, especially following periods of privation of spiritual meaning and the loss of a previously strong faith. These painful episodes were chronicled by St. John of the Cross in his *Dark Night of the Soul*.

In the long distance running model of spiritual transformations, the first energy appears suddenly in the middle of painful fatigue and feels like a vigorous

implementation of righteous Halachic commands or Canon Law. The second burst of energy emerges from readiness for personal resignation and ends in humane comprehension and compassion. In some Christian monastic practice, a transition similar to the latter is represented in the ritual of *Tenebrae* (or *Darkness*). Fifteen lit, unbleached candles are extinguished, one by one over the night, while reading the Psalms. The practice is said to represent the desertion of Christ by his disciples, as the church grows darker over the night. After the singing of the *Benedictus*, the one remaining light is quenched, plunging the church into total darkness. In *Myth and Ritual in Christianity*, Alan Watts suggests that the loss of the last light of *Tenebrae* induces the realization that “I am nothing.” This reduction in egocentrism, along with a dark-piercing alertness is said to facilitate an invasion by a loving God that precipitates the fasting, sleep deprived and praying petitioners into long lasting, quiet, ecstatic states.

These uses of *energy* and its attendant characteristics are not physically specifiable but rather hermeneutic of a force. It is both a potential and a realization, observed and inferred. It is the “energy stuff” of Freud’s *libido*, Wilhelm Reich’s *orgone energy*, Pavlov’s *drive*, Rudolph Steiner’s *etheric formative force*, the *arousal* and *attention* of brain wave and consciousness research, the *Ch’i* of Chinese medicine, the Hindu divine energy of *Shakti*, the Hebraic *ruach*, the Cabalist’s *Yesod*, the Sufi’s *Baraka*, the Christian *Holy Spirit*, the Yogic breath energy, *prana*, Mesmer’s *animal magnetism*, Galvani’s *life force*, Goethe’s *Gestaltung*, Madam Blavatsky’s *astral light*, Georg Groddeck’s *it*, Henri Bergson’s *elan vitale*, Schroedinger’s *entropy*, Abraham Maslow, Ruth Benedict and

Buckminster Fuller's *synergy*, Bertalanffy's *anamorphosis*, Colin Wilson's *x factor* and George De la Warr's *biomagnetism*. Of course, by nationality, culture and field of study, there are many more examples, each locally defined by its particular context and haunting with its feeling of universality.<sup>6</sup>

The abstract and formal idea of energy in physics first arose in mechanics and was generalized to electrostatics and electrodynamics. If one idealizes these systems, eliminating real world factors such as friction, temperature gradients, temperature dependence of the properties of materials, viscosity, hysteresis and other nonlinear behavior, then the energy conservation law says that in an *isolated and interacting* set of systems, the sum of the energies of the several systems remains constant. If, on the other hand, a system interacts with its surroundings, *not isolated and interacting*, then the increase in the energy of the index system is equal to the *work done* on the system by its surrounds. Like pre-

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<sup>6</sup> *Energy* in the context of mathematical physics is intuitional, abstract and relational. It is not created or destroyed, but rather transformed. Consistent with his deceptively simple style of physical intuition training of the young, Feynman's discussion of *thermodynamic energy* and its *conservation* in *Lectures in Physics* begins with the premise that it is a numerical quantity that does not change when one or many alterations in the system occurs. His heurism for energy and its conservation involves the premise that Dennis the Menace has 28 indivisible blocks, a number which his parents find constant at the end of every day of play. If one day a count yielded 27, an investigation would reveal that a block could be found elsewhere, say under the rug. If at the end of the day, the count was 29, the extra one had to come from somewhere else, perhaps Dennis's playmate Bruce. If Dennis locked some of his blocks in the toy box and threw some into a bathtub of dirty water and (1) A block weighed three ounces; (2) The box alone weighed 16 ounces; and (3) Each block raised the water level of 6 inches by one fourth of an inch, then this metaphoric energy relation can be expressed:

$$(\text{blocks seen}) + \frac{(\text{weight of box})-16 \text{ ounces}}{3 \text{ ounces}} + \frac{(\text{height of water})-\text{six inches}}{1/4 \text{ inch}} = \text{constant (28)}$$

Feynman notes that this representation of an energy relation, computed as a number of blocks, will always remain the same. If there were no blocks in sight, and one used this *energy conservation relation* with blocks as units of energy, we find no blocks as such in the expression at all.

Enron bookkeeping of corporate cash flow and balancing ones personal checking account, energy, like money, does not disappear; it is only changed in expression. As in the context of currency equivalent value, energy can represent a very general quantity applicable to a wide array of specific objects and activities. The results of the early studies by Professor Seymore Kety of Harvard and Dr. Harold Himwich of the Thudicum Laboratory in Galesberg, Illinois, using measures of *whole brain oxygen and glucose utilization* as indices of energy generation and utilization by the brain, surprised many of us. They indicated that energy use by the *whole brain* was relatively constant when states of relaxed awakesness, mathematical cognition and deep sleep were compared. Of course, modern studies have indicated that relative *regional* brain energy utilization is state dependent and may vary quite widely among brain areas.

More spiritual aspects of energies and their transformations were made clearer during several month visits to Baba Muktananda's, now Gurumayi Chidvilasananda's, Sidha Yoga Ashrams. Baba Muktananda loved and worshipped his Hindu Guru, Bhagawan Nityananda. Baba had been a restlessly wandering, guru-hunting, young man. Nityananda said he had "wheels for feet." After many years of devoted meditation, chanting and service, *sadhanna*, all the while being prohibited from eating mangos, his favorite food, his passive, taciturn, ecstatic guru, Nityananda, presented voluble, energetic, joyful Baba with the guru's rather aromatic and worn sandals. This symbolically acknowledged Baba's successful absorption of the guru's transforming spiritual energy, *shaktipat*, the power of his enlightenment.

At Nityananda death, Baba, using world tours, spiritual fellowship meetings, *satsangs* (public conversations) and spiritual training sessions called intensives, organized Ashrams in West Coast sites such as Oakland and Venice, and on the East Coast, in South Fallsburg, New York, where he bought several old residence hotels in the Borscht Belt. Baba was introduced to America by one of his first advance men, the author of *Be Here Now* and more recently, *I'm Still Here*, Baba Ram Das, Timothy Leary's co-investigator in the Harvard Student LSD project when his name was Richard Alpert. It is interesting to note that the leader of what would become *EST*, Werner Erhard was another of Baba's early coterie.

Baba disciplined and disciplined a sister and brother who, when 18 and 11 respectively, were sent to live in his Ashram in Ganeshpuri India by their parents. The girl was known as Malti when she served as a translator for Baba and Gurumayi Chidvilasananda after receiving the energy of her enlightenment. The younger brother was given the name of Baba's guru, Nityananda. When Baba took the pre-announced guru's ecstatic death, *Samadhi*, both Gurumayi and young Nityananda became co-gurus. Following three years of, perhaps Baba anticipated as necessary, spiritual struggle, Gurumayi took over the guru lineage of Siddha Yoga. Her lively brother's worldly preoccupations with jazz drumming and confessions of promiscuity led to his giving up of the orange robe of the denunciate, *sanyasi*, for the blue robe of worldliness, exchanging one kind of energy for another.

Brad Gooch who visited Gurumayi's Ashram in Ganeshpuri, India, wrote in his recent book, *Godtalk*, that she looks like a "synthesis of Indira Gandhi and Bianca Jagger." In what reads like a Hunter Thompson episode in an unwritten book

that I would have called *Fear and Loathing Along the Guru Trail*, Godtalk's explication of Siddha Yoga was dominated by yellow journalistic rumors such as the one about Baba's use of a gynecologist's table with stirrups for non-ejaculatory *Tantric practice* with some female followers. This unconfirmed claim remains, as Gooch says, in the realm of "...he said, she said." Gooch's exploration almost ignores the deeper meanings of *Kashmir Shavism*, *Buddhism* and *Kundalini Yoga* that compose the philosophical foundations of Siddha Yoga. The importance of knowing, loving and becoming one with the God within trivializes all but ungenerous or hurtful interpersonal behavior. Even the tougher version of the Ten Commandments in Leviticus 19 would not necessarily be in disagreement.

Baba's Karma yogic orientation toward both making unimportant yet effectively managing the material world is exemplified by the incident in which a Los Angeles Times reporter tried to chide Baba about being driven about in a Mercedes sedan. Baba explained that a very wealthy Indian merchant had given it to him and "...I have to put my behind somewhere." Similarly, why would Gooch's account of Baba's Tantric practice, even if true, ruin the imago of him in my mind unless I had already surrendered to the pantheon of good and evil absolutes of Judeo-Christian-Muslim taboo? My awareness of the non-materialistic meaning of apparent materialism was reinforced by tales of one of the favorite finds of Baba's youthful days of guru hunting: Zipruanna, who, wearing only a loincloth spent all day, every day, on a stool in the middle of a garbage dump. Remarkable changes occurred in the people who spent time there in his presence. Baba said the identity of guru was established by the results experienced by those that spent time in his presence. It

could not be defined by the physical features or ritual conduct of the interaction. People became spiritually energized and changed in Zipruanna's smelly, garbage-filled presence. I keep a picture of him in that setting on my desk.

Gooch, in his implicitly and superficially righteous preoccupation with what he considered disenfranchising human vulnerability, in the context of discussing Baba's orange robed renunciates, recalls how the medieval church used the difficult to impossible vow of chastity for political control of their priesthood. He seemed to have missed Baba's lessons about the remarkably simple sounding practices for mobilizing the energy of the God-receptive state. Once in this new state, the rest of the metaphysical work almost takes care of itself. I, like many others, adopted Baba's mantra, *Om Namah Shivaya*, "I worship the God within me (and you)" that he was given by his guru. The inner chant of this mantra brings me to an internal quiet in which things gain perspective, becoming clearer. Meditation, chanting and service to the guru was motivated by his promise that my egoistic concerns ranging from the number of publications on my *curriculum vitae*, to the size and adroitness of my penis, would *disappear autonomously in the Baba state of bliss*. This sounds very much like the role of the transition to an *active intellect* in Abraham Abulafia's 13<sup>th</sup> Century *Commentary on the Secrets*. Arduous study of the spiritually dense writings of Sri Aurobindo during the days with Professor Spiegelberg at Stanford gave me a peak into the elementary but difficult to execute idea of "simply" becoming the transcendently comprehending state of *existence-consciousness-bliss*.

Whereas Baba would occasionally lapse into terse Sanskrit verse and its multiplicity of potential meanings, Gurumayi keeps things simple. Sitting silently and immobile at *satsang* for hours, she radiates transformational energy, *shakti*, that makes ruminations about everyday human affairs unimportant. The work is about getting the self obsessed, head noise of ones preoccupations sufficiently out of the way to allow the emergence of the discovery of the God Who has been waiting patiently within. A fellow ashramite gave me a photograph of my first audience with Gurumayi. It showed me on my knees in front of her. She appears to be dismissing me with a baleful, almost disdainful look as my introducer, gesturing broadly, was, unasked, reciting a list of my professional bona fides. The picture caught her waving me off with a long, peacock-feathered stick. Obviously unimpressed, she is sending me back to my all night, every night, tent cleaning labors at the Ashram. Rich Indian businessmen, whose large donations were a major source of support of the Ashrams, fared little better. They seldom received a personal audience or favorable seating at *Darshan*, the evening public time of question and answers with the guru. In contrast with the relatively easy public availability, mischievous play, provocative humor and worldly sophistication of Baba, the ambience of Gurumayi is more private, simple, serious and subtle. It is as powerful, but in another way.

In response to Gurumayi's ascension to Siddha Yoga's singular guru, I imagined hearing Baba saying that God energy was at least androgynous, if the dimension of sexual identity was relevant at all. Baba taught that *divine energy*, by necessity, is expressed through a wide variety of particular personalities and cultures and should not be confused with the details of its manifestations. This

included the sexual identity of the chosen Vehicle. Gurumayi's central theme, as I understand it, concerns the simple, quiet and pervasive powers of love and faith. Some say Baba took the path, *marga*, of selfless action, *karma-marga*, whereas Gurumayi took the *bhakti-marga*, the road of loving devotion and faith. The third *marga* is *jnana-marga*, my inclination, the road of intellectual study and knowledge. Aldous Huxley related the choice among these three categories of *yoga* practice, to the physical and personality types of William Sheldon's 1954 *Atlas of Man*. *Karma yoga* corresponded to the *mesomorphic* body type and the assertive boldness, high energy, and interpersonal relative disinterest of the *somatotonic* personality. *Bhakti Yoga* was the characteristic choice of *endomorph*ic body types with the *viscerotonic* personality traits of sociability, good will, tolerance and love. Huxley associated *Jnana Yoga* with *ectomorph*ic body type and the *cerebrotonic* characteristic of shyness, sensitivity and intellectuality.

My summers with Baba at his temporary Ashram in Venice, California and the permanent American Ashram in South Fallsburg, New York, were spent in daily, very early morning, chanting of the *gurugita* after most of the night spent taking down, cleaning and putting up large tarpaulin meeting tents. I was assigned this simple, arduously manual, all night work after being interviewed and found out to be a professor and chairperson of a medical school department. Baba instructed his assignment committee that many if not all professorial egos would benefit from what Andrew Carnegie famously called the dignity of real work. Spicy one dish vegetarian meals, twice a day meditation and brief stolen naps consumed the rest of the day. I found myself meditating for longer and longer times, chasing the promised *Blue*

*Pearl* that Baba said appeared behind the eyes near the supreme meditative end point.

Beside care with the titration of meditation-induced interpersonal disconnection, *detachment with love* is the desired end point of most Hindu and Buddhist meditative practice, another set of “side effects” of the energy arising early in the course of too much meditation is called *kriyas*, spontaneous episodes of involuntary behaviors and postures of the body such as unprovoked chanting and writhing and stereotyped hand positions called *mudras*. Baba told us one of his *kriyas* took the form of spontaneous erections that occurred during his first experiences with deep meditative states. I recall a woman physician and fellow ashramite in Los Angeles telling me that her panties often got so soaked during meditation that she worried about being stuck to her cushion. Beyond these initial somatic overflows of Divine Energy, *shakti*, emerges a vision of the *Blue Pearl, bindu*, Baba’s “gift from the Goddess Kundalini.” As he entered this stage, he said that his mind filled with “joyous contentment.” Jewish mysticism of the 1300’s acknowledged these, what mathematical topologists would call, neighborhood relations of Eros and the Sacred.

More formal and scientific uses of the word, *energy*, like all objects of thought embeddable in a mathematical context, are abstract and relational. In his book, *Mathematics-The Music of Reason*, Jean Dieudonne treats *mathematical objects as objects of thought*. Dieudonne’s book documents the 19<sup>th</sup> Century transition from concrete, visualizable, classical mathematics to abstract, nonvisualizable relational ideas. The conceptual transition to abstract, relational thought-objects that are no

longer representable by pictures or accessible to our senses, characteristics of mathematics and physics, is yet to reach the concrete DNA-causal religionists of modern molecular biology. In 20<sup>th</sup> Century mathematics, Dieudonne' observes that "...the primary role in theory is played by the *relations* between mathematical objects concerned *rather than the nature of the objects themselves*...these relations are often the same for objects which appear to be very different and therefore they must be expressed in ways which do not take these appearances into account...and can then be specialized at will..." DNA sequences are, as MIT molecular biologist, Eric Lander observed, nothing more than an elemental "...list of parts..." In fact, since about 1% of the nucleotides are relevant to functional genes, one might say that the important members of this list of parts are distributed very thinly among many more with unknown function. The next frontier is certainly an understanding of the dynamics of the interactions among individual elements and in more abstract laws about molecular biological relations; a focus on the dynamics that regulate and control gene expression, not simply their structural parts, .

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I made a pilgrimage to spend eighteen months within Rene' Thom's penumbra, living among mathematicians in his "ashram" in Bures sur Y'vette, France. Thom was one of the founders of the *Institute des Hautes D'Etudes, IHES, Institute for Advanced Scientific Studies*, created to help slow the flow of high-level scientific talent away from France after the Second World War. It is in Bures sur Y'vette, deep in a green forested valley, 50 or so miles South of Paris, in a building

packed with small, thin walled, big windows-on-the-woods offices. Each office contained a single hard chair, an old office desk, two walls of blackboards and a box of white only chalk. The use of colored chalk was felt to be without mathematical rigor because its use substitutes colors as dimensional descriptors for more demanding abstract and formal representations. Color was cheating. Meditation in this ashram was practiced by hours of staring, pacing, scribbling, and humming, mumbling, belching and farting through the Institute's thin office walls. The building, though almost completely occupied, was otherwise silent. The Institute was populated by such world-class mathematicians and theoretical physicists that once inside that building, I felt so intimidated that I almost never spoke above a whisper. Listening to the brilliant mathematician, William Thurston's casual use of a tiled bathroom floor to motivate a unique partition of a topological space, I experienced the time-arresting awe of an early morning visit to an almost empty Notre Dame Cathedral in Paris or standing in front of Michelangelo's radiant marble statue of Mary and Jesus the Infant in the Vatican. Though the environment was one of tranquil academic scholarship, I lived charged with anticipated performance anxiety about the seminars on *the brain as a dynamical system* I was scheduled to present. I feared what I imagined to be psychiatrist-disdainful pure mathematicians and theoretical physicists

My dorm-style sleeping room at *IHES* was, in winter, painfully cold and drafty; the narrow iron bed's thin mattress contained lumps of persistently disturbing dreams, the small scratched table for work shim-irreparably wobbled. A faded poster of Van Gogh's garden was tacked crookedly on the door facing the toilet in

the dank, dimly lit small bathroom. A dwelling for distracted young mathematicians. A retired but still famous Parisian chef cooked many course, elegant meals every afternoon. The food was accompanied by so many liters of unlabeled red wine and peer pressure to be French and socially drink it that it became a choice between dulled, blunted,. sleepy post-prandial afternoons or living on bread, many cheeses, apples and Perrier water, alone in my room. I chose the latter.

Thom's gifts to us theoretically oriented non-mathematicians were diagrammatic, easy-to-visualize pictures that allow the intuitive capture of counter-intuitive discontinuities in functions. How we might imagine that smooth, small, continuous changes in causes can lead to big, discontinuous changes in the results. His system of topological (shape not size) diagrams was useful when considering up to four causes and one to two effects in predicting how things might behave.

For an important real life example, in modern clinical pharmacology, the smooth *dose-response curve* consistent with the physician's intuition that if a little drug didn't work, a little more may do so, should become an up and down search for the dose-range for the desired effect. Sometimes, drug treatment may require *smaller* amounts than a previously ineffective drug dose. The therapeutic effect may occur in the middle of a narrow dose range with too much or no effect occurring out of this span. In many physical systems, sudden and global transitions in state, from incoherent light rays to coherent lasing and from laminar flow of fluids to turbulence, emerge unexpectedly when a causal influence is moved into what some call the *critical region of the values of control parameters*. Outside this region, cause and effect were behaving linearly and smoothly whereas within this *critical region* we

observe global and dramatic changes in what Thom called a *catastrophe* and others use related words such as *bifurcation* or *phase transition*. The transitions from painful fatigue to running rage and then to ecstatic transcendence feels like the gifts from two kinds of Gods, the first, bearing the righteous lawfulness of the Old Testament, the second bringing the empathic forgiveness of the New Testament. Catastrophe and bifurcation theories predict and keep track of these transitions using mathematically describable changes in global characteristics of the “motion” using technical terms such as *eigenvalues*, *germs* and *jets*.

Thom taught me my first catastrophe, called the *cusp*, in words during our late afternoon walks along a shadowed green wooded path on the grounds of the Institute des Hautes Etudes, outside of Paris. My homework consisted of trying to visualize his verbal descriptions. It was not until weeks later that he drew the geometric object being discussed on the blackboard. With eyes twinkling and in his provocatively playful style, he said,

“Imagine an empty rectangular box with the front edge of its roof buckled into an ‘S’ and the back edge, an unfolded, left-to-right gradually rising simple smooth curve. If one moves the causal force from low to high, from left to right along the back of the box, the changing effect (represented by height) would be smooth; moving from left to right in the front encounters a sudden drop off at the S shaped buckling, a discontinuity in roof height indicating a discontinuity in effect. The energy equivalent height of the roof graphically indicates the amount of result.”<sup>7</sup>

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<sup>7</sup> The roof is the *manifold* upon which the result of causal change is portrayed. The two dimensional floor of the box represents a graph of the two causal parameters, the increasing amount of *normal factor* going left to right along the “x” dimension, the increasing

He gave me some examples of systems that showed cataclysmic changes in effect from smooth changes of *normal* and *splitting factors*. About the onset of a war: “At the back of the top surface of the box, the manifold, the *normal factor* increasing from left to right is the amount of the perceived threat. The *splitting factor* decreasing from front to back is the cost (and ability to pay) for war. Without the financial capacity to make war, threat goes from left to right smoothly at the back of the box as tension gradually increases without the onset of armed conflict. When effective fighting capacity is cheap and/or already well funded, the country well armed, the increases in threat go from left to right at the front edge of the box and encounter the cliff of catastrophe and war is declared. Cost of, or ability to wage war varies from the front to back, and serves as the *splitting factor*. Considering prison riots, social tension is the *normal factor* and alienation (degree of identification with prison authority) is the *splitting factor*.” Using facial expressions of dogs sketched by the Konrad Lorenz, Christopher Zeeman then of Warwick Mathematics Institute in England, considered countenances reflecting increasing rage as the normal factor, the amount of fear was the splitting factor. Increasing rage at high fear increased smoothly at the back of the box; at low fear, increasing rage falls off the cliff to an animal attack at the front of the box.

Rene Thom walking along with me as he talked, occasionally looking over to see if I was following him, he continued,

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amount of *splitting factor* (taking one from the back to the front to the region of the buckling) going back to front along the “y” dimension.

“A light above the box casts a shadow from the roof to the floor, outlining the gradually widening fold created by the transition from the smoothly rising back of the roof to its ‘S-shaped’ front. This projected triangular shadow on the x-y causal floor is the region in which the discontinuity in the result surface can be seen and is called the *bifurcation set*. An increasing amount of the causal ‘normal factor’ is represented from left to right along the ‘x’ dimension, the results of which change smoothly at the back of the roof but encounter a discontinuous jump up or fall down crossing the inaccessible crevice in the ‘S’ fold at the front of the roof. Again, the triangular shadow on the floor made by the fold indicates the causal value region in which discontinuous changes in the result surface occur. The reason the parameter that determines the front to back location of the left to right movement of the ‘normal factor’ is called the ‘splitting factor’ becomes obvious. Its value determines whether the results induced by increasing amounts of ‘normal factor’ will be smoothly changing or generate a discontinuous jump. The entire visualizable object is called a *cusp catastrophe* and it along with higher dimensional parameter region-inspired shapes such as the *swallowtail* and *butterfly* buys back the intuition lost with unexpected discontinuous changes in results.”

He grinned mischievously as he asked, “Can you see it?”

Thom’s catastrophes serve as accessible and powerful theoretical settings for the use of *energy as a generalizable, one dimensional, dependent, resulting effect*, influenced by one or several, sometimes conflicting, independent, causal, variables. For more examples: the weight of a ship (smaller to greater, left to right, along the x, *normal dimension*) and the position of center of gravity (smaller to

greater, front to back, along the *y* *splitting dimension*) are causal with a jump in roof-height *energy* from stability to capsizing, a discontinuity emerging from initially smooth changes in stability. As above, gradually increasing tension (the left to right *normal factor*) and alienation (the back to front (*splitting factor*) in inmates generate a sudden increment in *energy*, from subtly increasing tension in relative quiet to the sudden outbreak in a riot in the prison population. Embryological *notochord somitogenesis*, (that which become the vertebrate of the spinal column) has a smooth (left to right) causal influence that Chris Zeeman named a *normal factor*. It is the smooth growth of the material wave of mesodermal (to become muscle, connective tissue and bone) tissue. Zeeman called the front to back dimensional gradient of influence, the secondary wave of adhesiveness, the *splitting factor*. The value of this secondary wave co-determined a critical-valued interaction between these causal parameters leading to a discontinuous change in the “energy” equivalent continuity of developmental growth and vertebral column segmentation.<sup>8</sup>

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<sup>8</sup> A little more technically: Thom’s basic mathematical contributions were in *differential topology* and *analysis* with particular emphasis on what is called *structural stability* of surfaces representing and supporting actions called *manifolds*. For example, in a graph of a function, say  $F(x)$ , such that a change in cause  $x$  determines what happens to the result  $y = F(x)$ , the stability question involves what happens when one perturbs  $F(x)$  with a little  $\delta$ , i.e.  $\delta + F(x)$ . Do the *topological properties of the surface representing the potential range of actions of the system* (such as nearness of an originally close point set, continuity and connectedness of the surface, its dimensionality, its compactness as a generalization of finiteness) remain the same after perturbation? Note that the inter-data point metric distances are not considered. If they do, the two dynamical objects being compared are *topologically equivalent*. The test of this equivalence requires the mapping one set onto the other with, at most, smooth distortions of either or both surfaces. In the context of catastrophe-related *bifurcation theory*, if a  $\delta$  converts a steady valued *fixed point* to an oscillating *cycle* on a manifold of potential actions, also called a *state space*, then the fixed point system was *not structurally stable*. In phase space, this is seen as a change-in-causal-parameter induced transformation of a dot to a circle. If the one frequency circle is perturbed to a manifold of the system’s actions consisting of two independent frequencies, the circle takes the topological form of the crust of a doughnut, one frequency graphed spiral winding around the doughnut, the other winding along the doughnut around its orifice,

The seductive possibility, one which Thom realized so successfully, was that in the language of distance-independent differential topological forms, there would exist a small, finite set of shapes categorically describing the causes and result parameter spaces from which, even without specific quantities, universal qualitative (including discontinuous) behavior could be described and sometimes predicted. A formal yet general categorical system within which a small set of universal *discontinuous changes in global qualities* could be rationalized seemed seductively applicable to the enlightenment transitions, *spiritual transformations*, appearing suddenly after months and years of disciplined spiritual practice. The Platonic view is that the universal forms of discontinuous change existed before they could be about anything specific, before the universe was born.

In this era of nonlinear dynamics and dynamical system, common dynamical scenarios give accounts of smooth changes in causes leading to discontinuous changes in results. The Nobel Prize winning solid-state physicist, Phillip Anderson, in a short but memorable piece in *Science* in the 1970's said it tersely, "More is different." This general, qualitative mathematical theory of discontinuous change models nicely the sudden delivery of the *first* and *second second winds* from gradually and continuously increasing running distances as well as the abrupt transmission of the guru's "energy", *shaktipat*, from smoothly increasing amounts of chanting, meditation, guru service and Baba love. Gradually changing forces

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the circle is not structurally stable. If  $\delta$  distorts the frequency-amplitude relations on a surface such that the manifold of possible actions is distorted from a doughnut to a tea cup, both topological manifolds being one holed surfaces and therefore *topologically equivalent*, the system is *structurally stable*. Perturbed systems that maintain the sequence of points in time in sequential order (though the distances between the points may be different), are generally structurally stable.

leading to sudden changes in an energy-equivalent result are found in most rigorous form in Rene' Thom's *singularity-bifurcation-catastrophe theory* applied to *rational mechanics* and *geometric optics*. Here the existence of already solvable computational formalisms makes this more qualitative approach superfluous. On the other hand, the power of this both basic and applied mathematical orientation and method lies in its approach to the qualitative understanding of variously induced global and sudden changes in an energy-equivalent observable in biological, psychological, spiritual and social systems, fields of study in which little abstract and formal lawfulness presently exists. Oxford's Chris Zeeman's more accessible applications of Thom's deeper, more generally ramifying, almost mystical (due to their apparent wide generality) results, include approaches to real world problems such those above as well as the sudden change in excitable membrane potential accompanying the generation of the heart beat and neuronal discharge; mechanisms of opinion change, stock market crashes and, as noted above, the social science of riots. Whereas Thom's *On Structural Stability and Morphogenesis* can be said to be scriptural, Zeeman's *Selected Papers, 1972-1977* constitute the Book of Common Prayer of the Catastrophe Church.

To review and place *catastrophe* and *bifurcation theories* in the context of the differential equations of mathematical physics and biology, causal determinism implied by differential equations conventionally requires continuity and smoothness in behavior to be credible. Our intuitions as well as the formal conditions for the generic differential equations of mathematics and physics imply that smoothly increasing amounts of cause lead to smoothly increasing results and yield at least

local predictability: a little more leads to a little more, a little less leads to a little less. This smoothness-dependent intuition of determinism breaks down in nonlinear equations as well as in a wide variety of the machines of experimental physics, from the sudden coherent lasing of previously incoherent light to the vortices and turbulence in suitably bounded rotating or flowing fluid. It took me a while for these topological still shots and movies of the head to become real. Nevertheless, the enrichment of intuition was well worth it. Of course one could smoothly increase the *normal factor* weight of a ship until it gradually sank, but if one moved the center of gravity *splitting factor* to an eccentric position in the ship in the *parameter region of the bifurcation set*, a sudden global capsizing before weight-induced gradual sinking made sense. I could see it. Indeed, increasing *normal factor* tension in a prison population that was identified, not alienated, from the officials and mores of the penal institution, would increase social symptomatology gradually. However, increasing the *splitting factor* of social and institutional alienation results in the cataclysmic change of a riot with increasing tension. I could see it. The same kind of analyses could be made about world wide Muslim alienated youth and the probability of terrorist bombings. It is self-organizing without a central authority being necessary.

Do we need to know the causal equations to anticipate instability and discontinuity in our lives? Zeeman making Thom's thoughts accessible to the rest of us answered not necessarily. He suggested that we could use *several diagnostic phenomenological signs* to make a good guess about whether we are *near or within the bifurcation set*. Depending upon the route that the causal variables take through

the shadow of the bifurcation set, we may see *very large fluctuations* in our observable. The Dow or S&P stock indices in the neighborhood of a sudden large change is often presaged, sometimes for weeks, by a marked increase in volatility, fluctuations between extreme values. Theorists call the statistical properties of a time series of values behaving this way *anomalous variance*. For several months, I did psychotherapy with a genuinely spiritual Catholic priest who only some Sundays served the Eucharist, the corporal presence of our Lord at Communion, wearing no trousers or underpants beneath his robes. A sudden change in a stock index in response to the “shock” of a terrorist attack takes much *longer to settle down* if a cataclysmically bigger change is in the neighborhood. This extension of the system’s usual *relaxation time* is sometimes called *critical slowing*. In the bifurcation regime of a schizophrenic break down, *critical slowing* can be both global and literal as the patient freezes in catatonic postures.

In the neighborhood of the *bifurcation set*, big jumps in the stock index, up or down, are possible under almost the same surrounding conditions. This stock analyst-humbling phenomenon is called *bimodality*. Jimmy Swaggert’s Saturdays were often spent watching the show at naked dance parlors and buying videos at the pornography shops of Metairie Highway near Schwegmann’s Grocery outside New Orleans. Sundays found him on national television engaged with infectiously real, transcendent experiences in the public arena of the pulpit. The ecstatic congregation was deeply moved by his eloquent and tearful sermons about sin and salvation. Counter to most suspicions, this is less conscious fakery than the

genuinely felt alternating states intrinsic to the *bimodality* in neighborhoods of *spiritually unstable, born again transitions*.

Similarly, beginning with nearly the same initial values near the boundary of the *bifurcation set*, very similar motions lead to dramatically different results. This counter-intuitive behavior has been called *divergence*. At UCLA's Neuropsychiatric Institute, I interviewed a pair of lively teenage, genetically identical male twins raised by a loving family in Los Angeles's Valley. One was president of his high school class, a Sunday school nursery school volunteer and a Saturday soup server to the poor. The other twin sold pot and cocaine to support his habit. Deep and potentially dark mysteries live in these spiritual bifurcation sets. They leave us pondering child sexual abuse by deeply religious clergy and the massacre by mass suicide of a New Christian congregation by James Jones. We wonder why it is that fundamentalists (Jewish, Christian and Muslim) have the most ecstatic and direct validating experiences of God and do the most shooting and bombing of other people. In Burt Lancaster's portrayal of bifurcation set dweller, Elmer Gantry, charismatic believer and exploitative psychopath, were simultaneous and both credibly real.

Another feature of the occupancy of this bifurcation region in control space is that the values producing a sudden jump that occur passing through going one way along the "normal" dimension usually jump back much further along when moving the other way. Theorists call this characteristic sign of bifurcation land, *hysteresis*. It is generally known that sudden healing changes of the first born again experience can arrive magically fast whereas trying to return to the blessed state a second

time, a return to another born again transition after the loss of the first one, comes, if at all, with much more delay, effort and difficulty. Members of Alcoholic's Anonymous know that getting on the AA wagon the first time may be quick, joyful and easy. Getting back on this wagon after a fall is much more painfully slow and demanding, analogous to the Carmelite monk; St. John's lost faith engendered suffering of the *Dark Night of the Soul*.

Viewing the instabilities and extremes near the boundary of a bifurcation brings inquiries and advice about why a rational compromise, some form of disciplined moderation, would not be more desirable. It turns out that in this parameter regime, the in-between state is intrinsically *inaccessible*. The pocket in the *S shaped fold* of the upper manifold cannot be attained, at least for very long, by varying the values of the two parameters. However, if one increases the number of controls, it might be possible to stabilize a small island in a parametric sea of instabilities. In an application of this strategy, Smith College and Harvard Professors James Callahan and Jerome Sashin used a geometric representation of the difficult to stabilize region of normal weight maintenance on a *double cusp* manifold representing the behaviors of patients with eating disorders typified by both anorexia nervosa and bulimia. They varied *five controls* to stabilize a very small result area representing normal eating by varying the control values for ability to *verbalize feelings*, to *imagine solutions*, to defend against anxiety with unconscious forgetting called *repression*, to make contact with *realistic rationality* and to *modulate feelings* with say exercise, meditative practice or psychopharmaceuticals.

My experiences with the so-called *borderline personality*, with the tendency toward sudden and global personality change, from Sunday school teacher to Harlot in what seems like the space of a breath, has been both sexually exciting and personally ruinous for me in my life. I could feel the instabilities in these dwellers of the bifurcation pockets and my heart raced at the promise of mutually unconsidered impulses, the blurring of official identities, the experiments with sexual roles and modes and the incipency of collapse into regressive mud play. Most of all, I anticipated that their screaming orgasms, potentiated by a natural inclination to bifurcate, would be so messianic as to carry me along to a transcendently erotic new place. Unfortunately, paranoid rages, bursts of promiscuity and hopeless inconsistency of goals and efforts dominated the remainder of our living days.

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## CHAPTER 4:

### SENSUAL IN-BETWEEN ENTROPIES

Since the early teens, I've been beguiled by girls and women that have what might be regarded as *exquisite sensibility*, perhaps more precisely, *exquisite self aware sensibility*. These inhabitants of the near transformational neighborhoods of *bifurcation sets*, are perceptive and responsive receivers of emotionally significant information arising from their insides and the world. They are the canaries in the deep mines of human experience. Not the usual one lively-eye, one sober-eye, binocular difference of most of us, both their eyes sparkle, their feeling antennae await a happening and each is regarded as novel. I spot these brains in a crowd within minutes and am compulsively drawn to know them better, to become part of them, to vicariously experience and serve them. They experience little dampening control of even weak sensory information on its way to their strong, global feelings. Near ecstasy and excruciating pain are near. They feel anticipation with their whole bodies, down to their painted toes. Their sensibility always brings me lower abdominal warmth.

At sixteen, in my Dad-purchased second hand Ford convertible, I was parked with my new girl friend on Sarasota's Lido Beach, hearing and seeing the dark shadows of the Gulf of Mexico's waves hit white sand against the night sky. I took her flat party shoes off to message her feet. When I kissed her left foot and sucked

gently on her toes, she gasped and became faint. She told me that a strong electric shock had run up her back. The passionate licking and sucking of her musky, moist, pink labial lips brought what she said were explosions of pink and blue lights. She had several ecstatic multicolored crises in a row, sometimes without pause. She begged me to stop. I was as pleased as a sexually inexperienced young man in love could have possibly been.

Bowled over by what seemed to be the uniquely sensual properties of her brain, I began to wonder if her sensitivity was more general when she asked me to keep the windows open or top down, even in the cool of a Florida January, because the exhaust smell in my car was suffocating, though I couldn't smell it. The car had been checked and registered negative for abnormal fumes and leaks by Anderson Ford. She asked me never to wear any kind of after-shave lotion because it choked her. Jazz music on the car radio had to be played quietly. On-coming headlights gave her headaches. Her mother, sometimes desperate, called me to help distract her during her daughter's episodes of premenstrual emotionality and early menstrual discomfort. During these times, we would drive together for hours as she explained the many different colors of lower abdominal pain and how one in particular yawned darkly before it cramped. It was more purple than any of the others. I tried to explain what I intuited but didn't understand to her mother about her gift of unfiltered information coming through her nerve endings, her ever readiness for surprise and her brain's unwillingness or inability dampen or ignore what it didn't like. She saw things in art, heard things in music that I only saw, and heard after her telling. She had tearful smiles listening to Debussy's *Afternoon of a*

Fawn. The flatted fifths of Charley Parker and the laconic riffs of Miles Davis made her anxious.

Since then and for all these many years, the same sensually susceptible brains showed up in my life carrying a variety of woman's names and I never lost my fascination for them. I learned that their heightened awareness extended to the spiritual realm with unusually strong metaphysical inclinations and readiness for transcendent experience. They seemed to live closer to the direct experience of God. Attending Assembly of God and other Pentecostal midweek service, I found that praying in tongues and dying in the Lord came as easily and dramatically to them as their orgasmic experiences. At the same time, distant bad news could suddenly become immediate and loud in a litany of threatening thoughts that hooked and persisted through sleepless nights. They taught me to see genuinely the delicate beauty of flowers and to know in my stomach that some forms of sadness felt hollow like homesickness. In medical school I found that that some of them were the clinic patients, women and men, with unusual sensitivity to chemical odors, think Gulf War Syndrome, and fibromyalgia, which I heard as unusually sensitive awareness of sensory information about posture and position coming in from the bones and muscles of the body but experienced as pain. The background noise of odorific and somatic information is usually out of the awareness of most of us. Their medical charts contained detailed accounts about how each of their organs was feeling at the time, sensations that the textbooks say we are incapable of knowing consciously. Internists and psychiatrists often dismissed their accounts as signs of *somatoform disorder*, psychological conflicts expressed in the language

of body feelings. I tended to consider them to be talented super-normals.

In the psychophysiological laboratory, I learned these brains tended not to *habituate*. Each of a series of noises continued to elicit *startle responses* that could be picked up in brain wave recordings or in the running record of a psychophysiological, lie detector-like, machine. In psychoanalytic training, I learned that these brains remembered their dreams in more rich detail than the rest of us and that treatment with over twice a week analytic sessions was potentially dangerous. The psychoanalytical situation-engendered fantasies and feelings could get too strong and exaggerated, too real.

Professor Iris Bell of University of Arizona's Alternative Medicine Research Program has, studying these brains, found slower reaction times, defects in divided attention psychological tasks, longer latencies to the first dream, and unusual patterns of odor reception called *cacosmia* or *dysosmia*. Using brain wave and cardiac interbeat interval data as markers, Bell reports the increase in the amount of *alpha awake brain waves* and decreases in *cardiac interbeat interval variation* associated with increasing sensitivity, rather than habituation, with repeated exposure to a variety of smells over time.

In spite of these brains usually requiring what is known as high maintenance in relationships, I continue to be erotically spellbound, in love with them in all their forms. Questions about how to think about these exquisitely sensitive women, *Bell's Syndrome* exists but is rarer in men, continue to drive aspects of my scientific research. It has been variegated quest, which began with trying to find a general conceptual framework that would help my understanding of this unique capacity to

be aware and process large amounts of internal and external information that escape the awareness of most of us. As one might guess, this search led to fundamental ideas about *information* and its inverse, the *entropy* indicating the amount of *information transport capacity*, with respect to their characterization, quantification and measurement.

To get to the end from close to the beginning, we recall that it was Claude Shannon and his followers who both mathematically proved and experimentally verified that a receiver must have more *entropy*, less already fixed knowledge and more wondering, than the sending source, in order for the message to be sensitively and reliably received and encoded. Sensibility seems to have something to do with the readiness for information transmission afforded by the brain's high entropy, minimal fixed information states, in its resting dynamics. Their remarkable receptivity derives from a baseline brain state like the formless emptiness of the *bodhisattva's* "...no form, no sound, no feelings, no perceptions, no consciousness..." of transcendent Tibetan Buddhism as described in the *Heart Sutra of The Dalai Lama*.

In Chinese Medicine, *xu*, meaning *emptiness*, contrasts with *shi*, the word for *fullness*, both of these complementary opposites having multiple specific meanings. Most metaphysically relevant is the characterization of *xu* as the emptiness of the deepest reality of being and the highest state of human spirituality. Like that aspect of Lao-Tsu's ineffable *Dao*, *The Way* that is empty, *xu* indicates a mind devoid of desire, being lucid and serene. In the context of dynamical form, *xu* shares the structureless, non-imagery of maximal entropy systems and *shi* the lower dynamical

entropy of fixations on form, desires and beliefs. Shigehisa Kuriyama's *The Expressiveness of the Body*, elucidating historical and conceptual divergences of Greek and Chinese Medicine, notes that *xu* was the supreme end of self-cultivation and the secret to vigor and longevity. "...to achieve fullness of life one had to abide in empty nothingness, *xuwu*." In Lao-Tsu's *Tao-Te-Ching*, "...the Way is gained by daily loss, loss upon loss until...by letting go, it all gets done..."

William James, in *The Principles of Psychology*, tried to capture the subjective dynamics of the brain as an on-going preconscious stream of statistical wave processes. He envisioned autonomously increasing and decreasing coherence emerging spontaneously and from sensorial evoked thoughts via the confluence and disaggregation of statistical wave processes, "...wave crests and hollows..." that achieved temporary statistical stability by "...feelings of relation, consubstantial with our feelings or thoughts of the terms between which they (only temporarily) obtain." In the more receptive, higher entropy brain systems, fleeting forms change without continuity, jumping from one to another with "magical rapidity," *but being not already engaged, are available for use for self-organized structure evoked by new information*. Without ordered, low entropy, preconceived ideational defects in the resting random brain field, the full attentional statistical machine is available to sensitively respond in self-organized, quasi-stable states of *cognitive, conative and affective integration*. They then disappear; this brain relaxes quickly, ready for new experience. This contrasts with those brains that are dominated by islands of opinionated order, composed of personality fixations and rigid belief systems, *low entropy defects*, which interfere with sensorially responsive *new self-organization*.

As in most systems of authoritarian premises, precise definitions and logical continuity, as in discussions of Torah among Orthodox Jews and Canon Law by Catholic bishops, *classical equilibrium thermodynamic ideas* that are borrowed for use out of the context of their origins, risk the calumny of their physicist practitioners. We have probably already earned more than a little disdain from those quarters with our use of none-minimal or none-maximal but *in-between entropies*. This phrase cannot be found in the literature of physics or, as such, in the writings of *communication and information theory*. In the modern theory of nonlinear motion called *dynamical systems*, in-between entropies can be generated by *chaotic systems* that are non-uniform in their *rates of separation of near by points* and *convergence of far-away points* in dynamics that have been previously described as *nonuniformly hyperbolic*.

The energies and their transformations that fuel and support *karmic escape* from the personality fixations of *samsara* and accession to *unmanifest Divine Life* can occur without the loss of the richness and multiplicity of apparent reality. Big internal changes without external sign can occur in the arrangements of the ineffable and mysterious formless silence within which we have associated with states of *high, but not maximal, in-between entropy*. For examples, the Indian Saint, Sri Aurobindo, in the early 20<sup>th</sup> Century, the Catholic metaphysical anthropologist, Teilhard de Chardin and currently American pandits (spiritual seekers with intellectual and academic inclinations) such as Ken Wilber, among many others over the millennia, direct us toward the goal of Nirvanically changeless emptiness without the properties of space or time. At the same time, we maintain an astute

and effective yet distantiated appreciation for existential realities. The *non-dual enlightenment of Integral Being* or *Yoga* involves realizing emptiness through the world of form. There are ways of thinking about and even computing that “nothing within” and its changes.

As John R. Pierce suggested in the 1981 revision of his book that made the theorems of the father of *communication theory*, Claude Shannon, so accessible, “...if we want to understand information-related entropies, it is perhaps best to clear our minds of any (physical) ideas associated with the entropy of physics.” Nonetheless, historical comments about what the *classical thermodynamic term, entropy*, is and is not about are in order.

We recall that Richard Feynmann, in his well-known 1962 class notes, *Lectures on Physics*, said that the subject of thermodynamics is the study of relationships among the heat, energetic and organizational properties of materials, *without knowing their internal structure*. Historically, the relational formalisms of *equilibrium thermodynamics* emerged before our knowledge of the internal structure of matter. For examples, the pressure in an insulated container of gas is due to molecular bombardment of the container walls, which increases with heat or compression of its volume. Compression of its volume increases its temperature and expansion of its volume leads to cooling. Note that these relationships hold without specifying the constituents and the specifics of a particular gas or solid.

In his lectures, Feynman’s intuitively accessible examples of reversible thermodynamic properties are reminiscent of his on camera performance at the Senatorial hearings about the Challenger disaster. Recall that he dropped an O-ring

in a glass of iced water demonstrating cold-induced rigidification of the rubber ring, which he postulated to be the cause of the fuel leak and resulting explosion. In his *Lectures*, he said that if one holds a rubber band between ones lips as a crude thermometer, stretching a rubber band heats up the lips and relaxing it cools them. Working the same system in reverse, and *equilibrium thermodynamic systems are classically reversible*, we find that heating a rubber band makes it contract. These changes involve complicated alterations in the internal arrangements of the polymeric strands of rubber, their structural properties, the details of which, for the purpose of global thermodynamic characterization, need not be known. The *relationships between physical state, energy and temperature* in this material were predictable from *thermodynamic laws* even without specific knowledge of the complex internal structure and physical dynamics of rubber.

Thermodynamic theory, which makes deep conceptual connections between *quantitatively measurable primitives* such as *heat, hotness and work* and *the invisible* in the form of derived ideas such as *energy and entropy*, yielded an enormously rich and logically consistent intellectual framework from within which to characterize macroscopic behavior composed of unknown molecular mechanisms. Ideas about entropy grew out of William Thomson's (a.k.a Lord Kelvin) thermodynamic laws about *energy conservation* and its allowable transformations. Later Clausius decomposed the *energy* into that which was available for mechanical work, called *work-content*, and that which was not, called *transformation content*. He referred to the *transformation content*, a reflection of what changes in the

internal order properties of the system that occurred as a concomitant of changes in energy and heat, as the *entropy*.

Rudolph Clausius added the word entropy as a thermodynamic property to the conceptual armamentarium of theoretical physics in about 1865. This followed the earlier work of the French engineer, Nicolas Leonard Sadi Carnot, who was trying to develop a theoretical framework within which efficiencies in heat-generating engines might be understood.<sup>9</sup> The resulting losses in the form of *wasted energy* show up as increases in *molecular motion*, which could be *estimated from the increases in heat*. Wasted energy dissipated as heat increases the amount of random motion and volume occupied by the surrounding molecules in physical processes involving *heat, pressure, vaporization, condensation* and *work*; all elements of that era's dominant physical metaphor, the *steam engine*.

The highly developed, multifaceted, often quite abstract formal characteristics of the inferred property, entropy, prevent glib definitions and generalizations.<sup>10</sup> If one does allow some loose thinking about *heat-induced*

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<sup>9</sup> It implicated positive,  $> 0$ , changes,  $d$ , in *entropy*,  $S$ , with changes in time,  $t$ , i.e.  $\frac{dS}{dt} > 0$ , entropy is increasing in time, as a concomitant of the inevitable mechanical inefficiencies in an energy driven system.

<sup>10</sup> In the context of Kelvin-Clausius theory, the entropy of a closed system will remain the same if it is isolated from any matter or energy exchanges with the environment. If heating a system such that the change,  $d$ , in heat,  $Q$ , is positive, i.e.  $dQ > 0$ , it experiences a rearrangement in its microstructural motions, but the temperature is left unchanged. The (inferred) entropy,  $S$ , increases (i.e.,  $dS > 0$ ) as the ratio of change in added heat,  $dQ$ , over the unchanging, absolute temperature,  $T$ . Thus, one definition of entropy change is  $dS = dQ/T$ . In classical contexts,  $dS$  is expressed in *units of heat* called *Joules per degree of absolute temperature* in units Kelvin, the temperature in Centigrade plus 273.16°. The best-

*increases in the statistical randomness of molecular motion* in the machine that is associated with the loss of *useable* energy, the positive entropy change, is vaguely relatable to the kinds of *information entropies* to be discussed below. If a gas trapped in an insulated, physically *isolated*, closed cylinder is allowed to expand *infinitely slowly, reversibly, called adiabatically*, pushing up the piston that closed off its end, the gas will become cooler, energy having been expended doing the work of lifting the piston. Defined as an isolated system (of course no where in the real, non-laboratory, world can this condition of absent exchanges of energy or matter with the environment be found), it is a *reversible* process, because returning the energy of the work by, again, *infinitely slowly* pushing down on the piston and compressing the gas to its original volume, returns it to its former temperature-defined energy state. In this historically prominent thought-toy of physics, there has been a *reversible* change in energy but no changes in the entropy. The gas's *heat, temperature* (and *energy* and *volume*) can be completely restored in this metaphysically mythic classical thermodynamical tale of an entropy-conserving, reversible process.

While fixed entropy and independence of the specific path is the case for the abstract reversible cycle described in Footnote #10, in the real, irreversible orbits of

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known physical image involves the heat-energy transfer to and from heat baths called *reservoirs* as intermediate actions of the work of the heat driven engine executing what has come to be known as the *Carnot Cycle*. The same formulation emerges in this more concrete context: the heat,  $Q$ , transfer,  $dQ$ , at a particular absolute temperature,  $T$ ,  $dQ/T$ , has been used to define an entropy change,  $dS = dQ/T$  related to some not-need-to-know-about specific alteration(s) in a system's internal physical properties.

most physical and all biological systems, entropy increases. Walter Nernst's 1907 *heat theorem* yields a zero point from which to determine a difference measure in the postulated, real physical world of ever-increasing entropy. He showed that at an absolute temperature of zero, entropy is zero.<sup>11</sup>

Using another well-known thermodynamic thought toy, the original isolated, insulated body of gas in the cylinder is partitioned by a membrane into two chambers, one containing all the gas with its temperature, pressure and ability to do mechanical work and the other a vacuum without these properties. This equilibrium state is changed into another equilibrium state by suddenly removing the membrane, filling both chambers with gas and, while increasing its entropy *irreversibly*, removes at least some of the gas's ability to do piston raising work. In the context of classical thermodynamics, it is in this way that *irreversibility can be defined by its associated increase in entropy*. Though there has been no change in total energy in this insulated closed system, an increase in entropy means a decrease of the energy available for work. The *increased disorder* in the gas is associated with the loss of ability to convert heat, thermal energy, into mechanical energy. Historically important and still available elementary texts by Enrico Fermi (1936), Mark Zemansky (1957) and Herbert Callen (1985), among many others,

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<sup>11</sup> We can illustrate an approach to this singular state by placing a heated metal rod in ice water which would result in a decrease in the entropy of the rod's molecular motions by  $dQ/T_1 < 0$ , the cooling reducing the complexity of molecular motion in the metal bar and an increase in the entropy of the water by  $dQ/T_2 > 0$  indicating an increase in the amount and complexity of the surrounding water's molecular motions. Of course the heat moves from metal rod to the water as  $T_1 \rightarrow T_2$  making  $dQ > 0$  positive and the entropy change,  $dS = dQ/T_2 - dQ/T_1$ , also positive. In another simple example, producing friction by rubbing a surface generates heat,  $dQ > 0$ , at a temperature  $T$ . This induces a positive change in entropy,  $dQ/T > 0$ , in the form of increasing amount and complexity of the patterns of molecular motion in the air surrounding the rubbed surface.

explicate clearly the formal, but far from biologically relevant, classical theory of the *physical entropy of closed equilibrium thermodynamic systems*.

Growing in part out of the formal thermodynamics of physics, *statistical mechanics* offers yet another set of intuitions about the not-necessarily-known molecular details associated with changes in entropy. These ideas are closer to applicability in problems of making measures on the behavior of biological systems. Very generally, in the statistical mechanical context, an increase in entropy means a decrease in the order, which can be a quantitative observable reflecting a decrease in predictability and/or knowledge about the system. For example, we can locate the molecules of the gas more accurately when they are all on one side of the membrane-partitioned cylinder compared with the situation when the membrane is suddenly removed. This accompanying *increase in ambiguity and decrease in knowledge in locating a set of gas particles reflects a statistical mechanical view of increases in entropy*. Can anything general be said about the bounds on an increase in entropy? The statistical developments of the Yale mathematical physicist, Josiah Willard Gibbs (about 1875), consonant with the logical arguments of the Greek mathematician, Constantin Caratheodory (about 1910), conclude that *the entropy increase goes to the maximum allowed by the constraints imposed by or upon the system*. A change in likelihood as a *probability* is a characteristic way to quantify the *entropy change*, reflecting an alteration in knowledge or its reciprocal complement, *uncertainty*. The system's entropic uncertainty said more colloquially, and relevant to the *Bell Syndrome's* women of my life, is its *capacity for surprise*.

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A statistical mechanical approach to the total entropy of a bounded set of molecules in motion involves summing this property across all the participating molecules. We let  $N$  be the number of particles involved. As a problem in Newtonian mechanics, each of the  $N$  particles is represented in  $6N$  dimensional phase space. That means that each point represents one of the  $N$  molecules in the *three dimensions of location space plus three dimensions of motion space as its velocity*, more specifically, the product of *mass times velocity called momentum*. This adds up to 6 dimensions of measurement. This so called *phase space reconstruction* of the molecules of a gas as individual particles are a daunting task, though fast computers and new algorithms are making computations from first principles more generally attainable. Those based on the *first principles of short-range repulsion and long-range weak attraction among particles* and the bumper-car *collision* dynamics between them can now be implemented if the system of particles being simulated is sufficiently small and the computer simulation is for very short times.

To transform the entropy into something more statistical and global, we return to the theoretical work of Ludwig Boltzmann whose formalism was used previously to quantitate pathological developmental simplification. He assumed that given a set of constraints, say the closed volume,  $V$ , of a box,  $B$ , of a fixed size,  $V(B)$ , the orbit of each particle would eventually explore all the space in the box that was available to it. Boltzmann's entropy became a constraint dependent,  $n$ -dimensional volume measure, with the assumption that the entropy,  $S$ , equals the logarithm of this volume measure,  $S = \ln V(B)$ . To calculate a value for the entropy, compute the volume of the molecular motion as determined by the invariant

constraints of the system, such as the volume, temperature, pressure and/or its total number of molecules. We may *partition*, discretize, the volume up to some limit of resolution such that it is divided into  $\Omega$  small boxes, each containing the representation of a particular state.<sup>12</sup>

Leaving the framework of physical thermodynamic entropies entirely, the *entropy of information* was introduced in the context of *communication engineering* in electrical and electronic devices. The metaphorical machine for the current age of entropy, analogous to the role of heat and steam engines in classical thermodynamics, is the *computer*. Energy in this context is a relatively trivial property. Ammeters and other monitors of load are unable to discriminate between a computer actively engaged in encoding and computation or one simply maintaining its dynamic memory while resting in computational readiness. This situation is very analogous to the results of early work discussed previously on the metabolic rates and sources of the *whole* brain's energy, oxygen and glucose metabolism, by National Institutes of Mental Health's Seymore Kety and Louis Sokoloff and the State of Illinois Thudicum Laboratory's Harold Himwich. Using whole head arterial-venous, energy-in, energy-out, differences, they could not

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<sup>12</sup> Making the same assumptions of closed system, equilibrium thermodynamics, such a system is completely isolated from outside sources of matter and energy, it spends equal time in each of its  $\Omega$  available states. In such a case, the *characteristic occupancy time of any state is inverse to the number of states available*, e.g.  $1/\Omega$ , and the system's *entropy is maximal* for that set of states. Under these conditions,  $S = k \ln(\Omega)$ , where the  $k$  term is the Boltzmann constant that contributes to the numeric units of entropy, as above, in Joules of heat /degrees Kelvin of the temperature. If the system is in *contact with a heat bath*, but cannot exchange matter with its environment, it is called *diathermally isolated*. The distribution of times spent in the available states of a classical diathermally isolated system of gas molecules can be represented by what is called a *Boltzmann distribution of probabilities of state occupancies*,  $\rho$  (as a function of their energy level, more measurably,

demonstrate differences in rates of whole brain metabolism between states in which the human subjects were engaged in solving mathematical problems or deeply sleep. In today's brain imaging research, using a variety of physical reflections of the brain's metabolic activity, it is the *differences in regional distributions of metabolic activity* that are relatable to subjective and behavioral states, not differences in total amount of energy expended. In graphically coded representations of the regional metabolism of the brain in action, one or another or many areas "light up" and others "grow dark" in correlation with changes in thinking, feeling and action.

The *entropy* first developed by Claude Shannon was formalized for use in 1948 in what was then called *communication theory* and now *information theory*. It represented a measure of the *ambiguity* and *uncertainty* that had the potential for being resolved by new knowledge. In this context, *entropy and information were obviously complementary descriptors*. A message that informs us about which of ten possibilities should be chosen contains less information than one that informs us about the proper choice to be made from among a thousand possibilities. The entropy of communication theory is a measure that is computed on uncertainty. The *information reception capacity* of a system is dependent upon the *amount of uncertainty in the receiver that pre-existed the receipt of the message*.<sup>13</sup>

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their responsiveness, *susceptibility*, to heat). Here the *characteristic time* of the system spent in each state varies as the particular state's *probability*.

<sup>13</sup> In the binary coding scheme of digital electronic operations, the unit of information is the *bit*, a choice made between 0 or 1 in the resolution of a two state ambiguity at each place of some power of two number of places. Our relatively common computers these days have 32 or 64 bit processors. If these 0,1 choices are made in a random sequence in which each step is independent of the previous one, the sequential probabilities  $\sim 0.5, 0.5,$  are

The dot-dash choices of Morse code machines, the go, no-go gates of transistors, the open versus closed ion channel-mediated neuronal membrane discharge and the left, right spins of the single electrons of today's quantum computers lead naturally to an information encoding of multiplicative sequences as the sum of logarithms in base (equal to the number of available states) two, each  $p=0.5$  choice called,  $\log_2(0.5) = 1$ , a *bit*. Shannon's 1938 master's thesis mapped George Boole's algebraic scheme for doing yes-no, either-or computation onto current switching devices such that circuit closed was "true" and circuit open was "false." Using Boole's laws such as "Not(A and B)" always equals "(Not A) or (Not B)" led to schemes for circuit routing through electronic gates which also serve for information storage in gadgets ranging from cell phone directories to computer hard disks.<sup>14</sup>

If a system's behavior is *distributed equally among its possible states*, the *Shannon entropy is maximal and equal to the logarithm of the number of defined*

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multiplicative: e.g. the probability of getting two 1's (heads in a fair coin) in a row are the product of each 0.5 probability:  $p_1 = 0.5 \times 0.5 = p_1 p_2 = 0.25$ . Using the common base ten system of logarithms to demonstrate the algebraic fact that *multiplicative probabilities are logarithmically additive* (and ignoring the minus sign that comes with making logarithms of the decimal fractions of probability), we notice that  $\log_{10}(0.5) = 0.693147$  and  $\log_{10}(0.25) = 1.386294$  and that  $0.693147 + 0.693147 = 1.386294$ .

<sup>14</sup> Following Claude Shannon, each logarithmically additive entropy term is expressed as the sums,  $\sum_i$  of its probability,  $p_i$  times the probability's logarithm,  $\sum_i (0.5 \times \log_2) (p_i)$  in base two). A *logarithm is an exponent of its relevant base* such that, for example, the logarithm, base two, of  $2 \times 2 \times 2$ ,  $2^3$ , = 3 and 3 bits can encode eight binary (0,1) numbers: (000, 001, 010, 011, 100, 101, 110, and 111). Shannon used a hill-like, called *convex, entropy function*  $S(p) = -\sum(p \ln(p))$ . *The amount of information required to gain knowledge of an event is dependent upon the probability of its occurrence.*  $\log_2(0.5) = 1$  is the maximal entropy when modeling the equilibrium entropy of an independent random 0,1, (heads or tails) series of informational states as might result from flipping a fair coin a large number of times. This value would be maximal when the coin was fair,  $p(\text{heads, tails}) = 0.5$ , and the entropy would be  $2(\text{number of allowed states}) \times 0.5(\text{probability of occupying each state}) \times \log_{10}(0.5) = 0.693147\dots$  or in *bits*,  $\log_2(0.5) = 1$ .

states, for example,  $\log_2(2) = 1$ . Shannon's classical equation about information content says the amount of information,  $I = -\rho \log_2 \rho$ , measured in bits. The minus sign in this reciprocal relation indicates that the information content of data,  $I$ , goes up as the probability of occurrence of the observed data,  $\rho$ , goes down. Since soon we will be talking about brains and their various styles of information encoded content as well as its transmission, we note the other famous Shannon theorem dealing with limits on the channel capacity,  $C$ , for information transport is  $C = W \log_2(1+S/N)$  where  $W$  is bandwidth, the range of frequencies available for information transport,  $S$  is the strength of the signal and  $N$  is the strength of the noise. Recall that the  $\log_2(1) = 0$  so only the signal-to-noise ratio,  $S/N$  contributes to the value of the product of the multiplication by bandwidth,  $W$ . Transparent clinical examples come from studies of the perceptual and cognitive decline in normal geriatric patients in which the range of aural frequencies ( $W$ ) heard without augmentation decreases with age as does the frequency range ( $W$ ) observed in their resting brain waves. The inattentiveness of the obsessively worried ruminator can be used as an example of brain channel capacity being reduced by the amount of on going head noise, an increase  $N$ , which, of course, reduces the value of  $S/N$  and therefore  $C$ .

Measures of the *informational complexity of systems in motion*, in contrast with the *information content of a static equilibrium state*, are of *dynamical entropy*. Dynamical entropy is often called  $H$ , in contrast with thermodynamic and/or informational entropy,  $S$ . One can begin with a representational image of the location, velocity and directional tendency of every point generated by a dynamical

system by an arrow on the surface of action, the *manifold*, of a dynamical system. This field of arrows indicating directional and strength of motional tendencies is called a *vector field*. A vector represents its location at the base of the arrow, its velocity by the length of the arrow (called the *modulus*) and the direction of the motion by the direction of the arrow. If we regard all moduli as equal to one, every vector on the surface has the same length. The resulting graphs are called *direction fields*. Looking at a stop-action photograph of any point on this surface, its associated vector informs about where the system would take it over the next unit of time. The whole surface can be marked by initial points, which the dynamical systems move as they generate patterns of orbits of moving arrows in time. The following two brain and behavioral experimental circumstances make this depiction and its relevance to dynamical entropy more concrete.

We review in more detail the concrete and visualizable findings from experiments requiring the quantification of characteristic patterns of motion in animals and man. They can be embedded into a similar surface-like setting, which might be called a *behavioral manifold*. For examples, my students from the past, Martin Paulus and Mark Geyer, now Professors at the Medical School of the La Jolla branch of the University of California studied the effects of psychotropic drugs on the patterns made on the floor by rats of various genetic strains while they wandered about, in *exploratory behavior* in a bounded space. Monitored by a video camera placed above the ceiling less cages, the patterns made by the paths taken by the rats over time were reconstructed as *vectorial orbits on a behavioral manifold*. This manifold was then repeatedly *partitioned, covered* with, from just a

few large, in graded progression, to many smaller boxes, each partition composed of rectangular lattices of a particular size. Units of time were also partitioned into range of units from larger to smaller durations of observation. Differences in the rat's *genetic strain* as well as injections of *stimulants*, *antidepressants* or *antipsychotic drugs* resulted in characteristic and discriminable path geometries mapped onto the behavioral manifold as orbital patterns. Each path was encoded as a sequence of size-dependent numbered boxes that were entered and occupied or left. The new information being generated by the pattern of spatial orbits took the form of sequences of numbers or symbols representing the sequence of labeled boxes. The complexity of these numeric or symbol sequences was then quantified in a variety of ways including the use of *two fundamental measures of dynamical entropy*.

One measure reflects how many new, previously unexplored boxes were entered by the rat per unit of time. This rate represents a percent of the *possible*. The second measure reflects how much of the time did the rat in each box visited as a distribution of the *probable*. The *rate of expansion of the possible* and the *relative time in occupancy of these possibles, the probables*, form the bases for the computation of these *two kinds of entropies*. For example, the work of Paulus and Geyer showed that the administration of a very small amount of stimulant drug, compared with a salt water control, led to an increase in the first measure of the number of new, previously unexplored, boxes entered per unit time. With respect to the second measure, the stimulant drug augmented exploratory activity was also more uniformly distributed over the possible boxes, making for more uniform

probability. Administration of higher doses of stimulant drugs, at a critical dose, led suddenly to more spatially and temporally restricted and stereotyped patterns of motion of the rats, compulsive circling alternating with frozen sniffing. Both contributed to a *decrease in the possible and nonuniformity in the distribution of the probabilities*. In man, low doses of amphetamine tend to increase the rate and creativity of thought streams and high doses generate fixed ideas and paranoid delusions. In the statistical approach to nonlinear dynamical systems, time-dependent *generation of new possibilities* is called *topological entropy*,  $H_T$  and the entropy associated with the *distribution of probabilities* is called the *metric entropy*,  $H_M$ . These kinds of entropies have also been used to quantitate characteristic patterns of in human behavior as well.

We have previously mentioned these measures as used in human experiments by Karen Selz, a Research Professor of Psychiatry at Emory University in Atlanta. Recall that she devised a set of experiments leading to unobtrusive measures made on human subjects by asking them to remove, as many as they could, the dots in a lattice, one by one, from the computer screen, by clicking on each point with a mouse. In more detail, some experiments, after removal, the dot reappeared in fifty milliseconds, in the “fast return condition”, or after one-second delay in the “slow return condition.” Unbeknown to the subject, the path made by the motions of their mouse on the computer screen over time while removing dots were reconstructed as a path on a fine to coarse grained box-partitioned behavioral manifold. Entropic indices of the rate of expansion of the possible, number of new boxes entered, reflecting  $H_T$ , and the relative occupancy of the partition of the

possible, reflecting  $H_M$ , the distribution of probabilities with respect to the boxes, could then be computed. As noted previously, Selz found that the spatial and temporal patterns of computer mouse motions made in this dot search and destroy task correlated highly with the subjects' age, sex and personality types as defined by profiles from the Minnesota Multiphasic Personality Inventory, MMPI, and the Structured Clinical Interview, SCI, associated with the standard Diagnostic and Statistical Manual, DSM IV. She found that subjects whose personalities were like my high self-sensibility girlfriends demonstrated high indices of both  $H_T$  and  $H_M$ .

The actions of not symbolically solvable nonlinear differential equations, i.e. not solvable by the usual techniques of integration, can be transformed into graphical images by plotting their orbits in abstract *phase spaces* with the three physically measurable coordinates of *location*  $x$  (or some other temporarily fixed *value*), *velocity*  $y$  (the rate of change in the location or measured value) and *acceleration* (the rate of change of the rate of change in location or value) in  $x, y, z$  space. Graphical representations of the system in action *in phase space* can serve in place of analytic solutions to the equations. This idea was one of Henri Poincare's major contributions to mathematics and physics, and has come to be the centerpiece of the *qualitative theory of differential equations*. The often point-to-point unpredictable but globally and qualitatively characteristic geometric shapes of the orbital patterns in abstract *phase space* are the objects of interest. There are visualizable representations such as cycles as circles and statistical measures made on these objects such as the  $H_T$  and  $H_M$  entropies and the *in-betweenness* (neither maximal nor minimal) of their difference.

A global statistical context for these qualitative differential systems was inspired by the Russian mathematician, Andrei Nikolaevic Kolmogorov. In his now famous foundational talk about the stability of *classical mechanical systems* in the final session of the 1954 International Congress of Mathematics, he gave public birth to, among other ideas, what has come to be called the *ergodic or statistical or measure theory of dynamical systems*. Here, *ergodic* means the existence of an *invariant statistical measure* on the phase space attractor of the system that can be obtained using a variety of equivalent methods and beginning the count at any of its points. Two phase space objects generated by a dynamical system may look different in phase space but their statistical measures may all be the same, i.e. *invariant*. These qualitative orbits in a box-partitioned space can be visualized as Paulus and Geyer's rats exploring a space and Selz's path sequences of computer screen dot quenches produced by clicking on them with a computer mouse.

A precursor of Kolmogorov's use of the term, *ergodicity*, was the earlier use of the term by Ludwig Boltzmann. This describes a *suitably partitioned* system such that *equivalent values* come from quantitating the behavior of *one single orbit* exploring the space of the lattice of boxes over very long times time as those obtained from a single aggregate photograph of *all orbits run from all possible starting places simultaneously*. The ergodicity of gas-like molecular randomness implicates systems being in one of only two possible equilibrium (the same forever) statistical states: *measure zero* (at most occupying a single point, zero, *minimal entropy*) or its "complement," *full measure one* (occupying all available space in a state of *maximal entropy*). Joseph Goldstein, a well known teacher of meditation,

giving advice recorded in Daniel Goleman's 1977 book on the subject said that all methods of nirvana directed meditation amounted to "...simple mathematics ...all systems aiming for One or Zero—union with God or emptiness." In place of the maximal or minimal values for the  $H_T$  and  $H_M$  entropies of these states of transcendence, we in the material world of *samsara* are stuck in states of *in-between entropy* which *invariant statistical measures* made on *phase space shapes* help quantify.

To generalize measures made on rat and computer mouse paths to more general and idealized systems, after plotting an *orbital path* in a *phase space*, we may *partition* the space of values taken by the journey of the orbital action generated by the equation over time with rectangular grids of increasing fineness. The result is an *equipartition* of phase space such that there is at most one orbital point in each rectangle of the grid, with, of course, many rectangles in the finer grids being empty. This final grid partition is called a *generating partition*. The proportion of the available boxes of the partition occupied by points is called its *area* or *volume measure*. This measure has been given a variety of names including *Liouville*, *Haar* and *Lesbague measures*. If every box is occupied, it has *measure one*. If at most one box, it has *measure zero*. If we allow partitions to be non-uniform and/or not fine enough to be generating and apply probability weightings for how many points fall into each particular box of the grid, the method is called the *Sinai-Ruelle-Bowen* or *SRB* measure after Kolmogorov's students and followers, the Russian, Ya Sinai, the Belgian Frenchmen, David Ruelle and the American, Rufus Bowen.

Similar to the *SRB measure*, the distribution of box occupancy probabilities multiplied by their logarithms and summed over all cells of the partition yields a statistical measure that is close to the *informational entropy* of Claude Shannon as described above. It is called the *metric entropy*.<sup>15</sup> It was the above noted Russian father of modern dynamical systems, Kolmogorov, who in 1956 proved that the *Shannon metric entropy is a quantifiable invariant of systems even in very complicated motion*. Stanford University's Donald Ornstein won a Field's Medal (the under forty year old mathematician's Nobel Prize) for his late 1960's work proving that the Shannon *metric entropy*,  $H_M$ , was the only invariant for a large class of appropriately defined, *expansive* (near by points separating in time) dynamical systems. Recall that we refer to *metric entropy* reflecting the relative occupancy as *probability* among the *possible* boxes (or states) as  $H_M$ .  $H_M$  is maximal when the percentage occupancy of all occupied boxes is uniform.

IBM's Roy Adler in New York and Brian Marcus in California, Hebrew University's Benjamin Weiss, Warwick University's English mathematicians, William Parry, Peter Walters, Mark Pollicott and others developed and proved the relevance of a related measure of the rapidity of dynamical expansion, the generation of new information seen as the rate of entering new boxes of the partition, a logarithmic rate of expansion of the *possible*. Counting the number of previously unoccupied squares entered by the dynamical systems orbit per unit time over the generating partition, for instance, yields an estimate of entropy that, as in the rat and computer mouse examples above, is called the *topological entropy*,  $H_T$ .  $H_T$  is about how

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<sup>15</sup> Metric entropy defined here ( $H_M = -\sum(\rho_i \ln(\rho_i))$ ), where  $H$  means entropy and  $\rho_i$  is the proportion of the total observations that occupy cell  $i$  of the state space partition.

much new information is being generated by the system per unit time. Theorems have been proven that  $H_T$  is a maximal estimate of the global dynamical entropy with  $H_M$  proven to be a minimum estimate. Monitoring single or aggregate molecular motion in a system with the maximum randomness of a space filling gas, we find that, on the average, every box is entered and occupied uniformly such that  $H_T = H_M$  or said another way,  $H_T - H_M = 0$ .

As evidenced by the above described experiments in rats and people, the same entropic relations (but usually not with maximal or minimal measure) can be found in biological systems. We have previously described the manifold geometry of a generic (typical, idealized) nonlinear dynamical systems as *hyperbolic* (Footnotes #1 and #2) defined by the presence of simultaneous but decomposable components of the motion including the straight ahead and round and round actions on the center *manifold*, the new possibility generating, expansive, away from the center manifold motions along *unstable manifolds* and the back to the center manifold, contracting motions, along the *stable manifolds*. Uniform expansive and contractive influences in the flow leads to *mixing of the order of the initial sequence* of the values inscribed by the orbits. This results in maximization of the entropies and satisfaction of a concomitant of the uniformly hyperbolic condition,  $H_T - H_M = 0$ .

These clean and mathematically proven findings do not hold for the quassiness that is human neuropsychobiology. Enmeshed as most of us are in only *intermittently random* or *nonuniformly hyperbolic* systems with the *in-between entropies* of the only apparently real world of *maya*,  $H_T - H_M \neq 0$ . How the  $H_T - H_M = 0$  of uniform hyperbolicity fails,  $H_T - H_M \neq 0$ , and along with it the dispassionate

detachment of entropic emptiness and fullness, becomes a problem not unrelated to the existence and quantitative qualities of personality styles and their dissolution with return toward but not reaching the maximally entropic openness, flexibility and naïve credulousness of the in Jesus and Holy Ghost occupying transcendent dynamical states. We are all stuck somewhere in the range of measures indicating *in-between entropies*.

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## CHAPTER 5:

### SOME ENTHEOGENIC ENTROPIES

In the spring of 1968, members of my laboratory team were looking for new brain metabolic pathways of the essential amino acid *tryptophan*, the dietary precursor of the human mood, sleep, libido and ecstasy neurotransmitter, *serotonin*. After struggling for several months to identify an apparently new compound, which turned out not to be new but only new in the brain, we collected evidence for a mammalian brain enzyme that could catalyze the production of an LSD-like hallucinogen, *dimethyltryptamine*, DMT. Tracing its metabolic origins, we found that DMT was derived from tryptamine, a common metabolite of the essential and omnipresent amino acid, tryptophan. This enzyme and its metabolic product were located in highest concentrations in the rat brain stem systems that influence the neural regulation of the heart, blood pressure, temperature, breathing, vomiting and primitive approach-avoidance behavior. It was also found in limbic brain nuclei thought to modulate the emotional coloring of perception and thought. Richard Wyatt, working at the National Institutes of Mental Health also found DMT in the urine of a human population that live in an mind altered state, schizophrenic patients. He also showed that blood and urine levels of DMT increased significantly if tryptamine's normal pathway for degradation was blocked by *monoamine oxidase*

*inhibitors*, such as Nardil, Marplan, Eutonyl, Parnate and others of a then commonly used, pre-SSRI, family of antidepressant drugs.

The presence of a DMT-generating enzyme in mammalian brain was particularly exciting because we knew from the work of Harvard botanist, Richard Shultes and others, that DMT and the monoamine oxidase inhibitor, *beta carboline*, are combined in a mixture of the leaves of a shrub and the bark of a vine, both Amazonian plants, used together by the *shaman* of Peru, Colombia and Ecuador for thousands of years to evoke mystical experiences in themselves. In their state of chemically-facilitated, spiritual transformation, they were better able to engage in healing and divination. More recently this and other similarly acting biochemicals have been called *entheogenic*, “promoting connection to the sacred within.”

Consistent with our neurochemical findings in mammalian brain, the shamanic concoction, called by many names including *ayahuasca* and *yage*, combined the DMT containing plant, *Psychotria viridis*, with an extract of a vine with the powerful monoamine oxidase inhibitor properties of the *beta carbolines* found in *Banisteriospsis caapi*. In 1975, working with a graduate student, Louise Hsu, now a professor of pharmacology at a research institute in Taiwan, we found that the mammalian brain could also synthesize *beta carbolines*. This family of compounds from the vine protects the tryptamine substrate as well as DMT from metabolic degradation such that it could circulate in the blood long enough after oral ingestion to diffuse what is called the blood brain barrier to induced prolonged and dramatic alterations in perceptions, feelings and thoughts. In addition, the *carbolines* of the *Banisteriospsis* component extended the time of action of DMT beyond the 15-30

minutes of effect of DMT when injected alone in human subjects. We found it fascinating that the mammalian brain made combinations of DMT and *beta carbolines* similar to the blend that indigenous shamanic chemists discovered as an entheogenic from plant sources.

Ralph Metzner, in the introduction to his 1999 collection of papers called *Ayahuasca* concluded that "...it is widely recognized by anthropologists as being...the most powerful and most widespread of the shamanic hallucinogens." William Burrough in a 1953 City Lights published book written with Allen Ginsberg, *The Yage Letters*, said that *yage* "...gave entrance to a city where all human potential is spread out in a silent market..." It was generally believed that with adequate spiritual preparation, *ayahuasca* could generate transcendent states that allowed access to ones inner being and the beings of other worlds that could serve as sources of mystical knowledge and healing. The *Shams dervish* of the 13<sup>th</sup> Century, wandering the Turkish portion of the Silk Road, used the word *sohbet* to describe the inner land of *mystical conversations about mystical subjects* that their *turning meditation*, whirling, and the shaman's entheogenic compounds, such as DMT, give entrance.

The questions became whether our finding of DMT and its brain enzyme in rats was a laboratory artifact and, if not, was it applicable to humans. Members of my neurochemical research teams at the University of California Medical Schools in Irvine and La Jolla, notably Dr. Lee Poth, now a professor of pediatric endocrinology at the Uniform Services Medical School in Washington D.C., demonstrated that the DMT synthesizing enzyme existed in the brains of recent automobile accident

victims that, as far as we were able to learn from their family and social histories, had been completely psychologically normal. More than a little bit excited by this finding and worried about making a sensational scientific mistake, we repeated the experiments with a variety of controls with the same findings. Though our original estimates of the human brain enzyme concentration were on the high side, we confirmed the finding and published them in *Science* in 1969 and *Nature* in 1970. Our carboline work was published in the *Journal of Neurochemistry* in 1975. A year or so after our *Nature* paper was published, the Nobel Prize winning neuropharmacologist at the National Institutes of Mental Health, Julius Axelrod, confirmed the presence of the DMT biosynthetic enzyme that converted the tryptophan product, tryptamine, to DMT in mammalian brain tissue. We were both delighted and relieved.

We speculate, perhaps too grandly, that this finding, along with the *beta carboline* human brain synthesizing capacity, supplies one of many possible neurobiological and neurochemical mechanisms underlying claims of the *cross-cultural universality of mystical experience*. We human all had brains with these enzymes. The idea that the phenomena accompanying primary religious experience were common to all cultures was a major theme of the life's work of the philosopher-psychologist, William James, and was studied using fieldwork by anthropologists such as Bronislaw Malinowki as described in his classic book, *Magic, Science and Religion*. Was this neurochemical-behavioral organization an evolutionarily adaptive mechanism selected so that some gifted individuals, self-selected from a severely stressed population, could spiritually escape and then lead the rest of us out of an

unhappy material sense world that had become intolerable? Could this be an antidote for the hopeless, who were without worldly solutions and trapped in an intellectually “sophisticated” state of spiritual nihilism? Was this a brain chemical transcendent spiritual escape system for the suprapyschological survival of those in dire need? As the 13<sup>th</sup> Century Islamic mystic, Jelaluddin Rumi, has written, “If a tree could fly off, it wouldn’t suffer the saw...” and more specifically, “...if you can’t go somewhere, move into the passageways of the self...” a spiritual escape via an entheogenic road to the God-space within.

What followed were a few years of occasional exploration of an “inside out” understanding of the mystical states evoked by the entheogenic family of chemicals. There were varieties of settings for these personal experiments. I found myself LSD-lost, circling endlessly in the tall silence of a Northern California redwood forest. I tried on Hunter Thompson’s *mescaline* lenses for the experience of Las Vegas unfiltered. I was expertly mentored in these quests by a distinguished collection of guides: Cultural anthropologist Michael Harner who taught me about the *yage* and *datura* use among the shaman of the *Jivaro*; Social anthropologist, Barbara Meyerhoff introduced me to the personal renewal rituals of the *peyote cactus*-using *Huichol Indians* of the Southwestern Sonora Desert; Neurochemically sophisticated Sidney Cohen, founding director of the National Institutes of Health’s Institute on Drug Abuse, told me stories of his involvement with Aldous Huxley and Barbara Brown in the Los Angeles covey of early American LSD explorers; organic chemist Albert Hoffman, Sandoz’s designer of a series of ergot alkaloids including LSD, told me stories of his accidental post-sniff hallucinations while returning home

on a bicycle; An anonymous group of us conducted personal experiments with Sacha Shulgin, the University of California at Berkeley professor who first synthesized and tested the mescaline-derived, *Ecstasy* series of compounds; We did some work with the dissociated anesthetics (producing wide awake but not there states) having consulted with John Lilly, a brain scientist who used these agents as a courageous self-medicating explorer of sensory isolation tanks; I met several native shamanic practitioners including the Huichol Indian that was the model for Don Juan in Carlos Castaneda's five volumes of pseudoethnography written up in my essay "Is Don Juan Alive and Well?" republished in the book, *The Pushcart Prize of 1977*. Issues of culture and brain chemistry came together in several accounts about entheogenic, mescaline-containing peyote use among the Huichol Indians in a book edited by Kathleen Berrin and Thomas Seligman of the San Francisco Art Museum called *Art of the Huichol Indians*.

Over these years I collected many nauseating, upper and lower bowel wrenching and ecstatically transcendent and exhausting day-long episodes of the angular geometries of visual pattern-generating DMT, the animistic breathing of bush and flower breathing peyote cactus, the darkly forbidding shadows of the psilocybin-containing mushrooms, the irreversible rocket launches into the electrically buzzing, kaleidoscopic circus of LSD-containing vials from Sandoz and the optimistic, trust engendering, expansively warm rush of six of Sacha Shulgin's gregarious, rave dancing, chlorinated, methoxylated and ethoxylated phenylethylamines which he had, years before, synthesized for "an undisclosed purpose" for the Dow Chemical Corporation under contract with the U.S. Army

Chemical Corps. The best known of the latter group remains part of the *rave culture* as *Ecstasy*.

These agent's peaks are flooded with exaggerated, caricaturizing images of people's faces and a belief in the *mindedness* of animals and even the *embodiment* of inanimate things. Evoked are simultaneous and diametrically conflicting interpretations of the same social context, *heteromodal sensory fusion* called *synesthesia* so that sound bespoke color and smells induced music, habitual thoughts rearranged as new ideas in what is experienced as exciting new insights, and, most of all, that which Louis Lewin, Berlin's early 20<sup>th</sup> Century Freud of psychotropic drugs in his book *Fantastica*, called *gladness of the soul*. Timothy Leary wrote of entheogenic escape from the habitual human brain's *mental-manipulative* and *socio-sexual circuits* gaining access to the rapture and ecstasy brain pathways on the way to the *new planet within*.

What is seldom written about is the aftermath of chemical entheogenic agents. After the several hours of fireworks, all of these entheogenic agents, some more than others, gifted me with weeks to months of more self-sufficient, emotional fullness and ease in the conduct of living that was less contaminated by narcissistic preoccupation or defensive distantiation. I was left with increased interpersonal sensitivity and a noticeable repair of my deficiencies in aesthetic sensibility, particularly for the visual arts and landscapes. What were once two dimensional, trivial, beside-the-point, scattered copses of trees and apparently casual arrays of plant life in the Boboli Gardens behind the Palazzo Pitti in Florence, became the grandly structured, botanical wonder of increased dimension, communicating awe

filled new perceptions of its previously unseen beauty. For the first time, I found myself walking slowly and stopping for several minutes, wordless, spellbound, in front of the modern art pieces of New York's Guggenheim Museum. Lost in the experience, I found myself exclaiming to no one in particular, "I can see!"

The delicacy and deliciousness of post-entheogenic agent's new and beautiful everything made me tiptoe watchfully so as not to injure an ant. Feelings of omnipersonal kindness and generous compassion were without prideful self-reflection. This state of grace felt like an invasion of a shimmering presence that made contact with my other, generally unknown to me, life. It brought new perceptions, feelings and ideas for which I was moved to give thanks. I began to think I understood a little bit about what was meant by *living in the Spirit* and *merging with God*. Mircea Eliade, the French, University of Chicago Professor of the History of Religions, in his classic *The Sacred and Profane*, calls the revelation of the sacred in ordinary objects, people and events an *hierophany*. In the state that this requires, "...all nature is capable of revealing itself as cosmic sacrality...." The entire world can become a hierophany with what Abraham Abulafia called an *activated mind*, the Jewish soul of emergent properties called the *Nefesh*.

This entirely new world, Rudolf Otto in his 1917 *Das Heilige (The Sacred)* called it *ganz andere*, (wholly other, something else), seemed to emerge spontaneously along with an instantaneous knowing-how-it-is-with-you-and-I-and-all-of-us that made even vicious killers appear sympathetic. Is this what the Charismatic New Testament Book Churches mean by redemption through forgiveness of others, requiring the genuine sincerity of this thought before

qualifying for Communion? Is this Christ's undemanding gift of grace as in *Romans 4*: where Paul observed that all of us fall short of the full glory of God unless justified freely by His grace. Was this the New Testament's spiritual technological advance from the Old Testament's and Koran's eye-for-an-eye? Did this chemically triggered transcendent experience differ significantly from the supernatural transformation of individuals by the Holy Spirit of Christian revivalist teachings? Martin Marty, University of Chicago's Professor of Modern Church History, dates the institutionalization of this personal transformation in the United States to the post-Civil War period. Did this mean that the mysteriously selfless love of Christian agape and the altruism of E.O. Wilson's sociobiology lay waiting in the brain and could appear spontaneously, by grace, without lawful directive, repetitive recitation or the discipline of catechism?

As one might have suspected, the urgency of my inner and outer search for a new spiritual ecology of mind was driven by more personal needs. My spiritual hunger was made acute a couple of years before our laboratory's DMT discovery when as a 30 year old Assistant Professor of Psychiatry and Neuroscience at UCLA in West Los Angeles, I was living in a small, heavily mortgaged house in Brentwood with my graduate student wife and two young sons. A testicular lump was an accidental discovery made while showering. After surgical biopsy and radical lymph node dissection, the professor of urology gave me a diagnosis of right testicular choriocarcinoma. All by itself, my testicle had given birth to a mass containing all the embryological tissues of a fetus, and had thrown in some maternal placental cells as lagniappe. Unlike now, when the group of testicular neoplasms are treated

successfully with a high survival rate (think Lance Armstrong), at that time, follow up research of this young man's disease by the Army Medical Corps promised a five-year survival rate of only 5% to 10%. The news filled me with fear and the ensuing hopeless resignation detached me from life with a dread broken up only by episodes of rageful envy of everyone else in the world that had been spared. My wife escaped into an alcoholic flirtation with her major professor; my sons grew increasingly ensconced in the generous and kind neighborhood homes of their playmates. I metered as many hours as possible in equity growing, long lonely days in a small, dark, couch filled, university office, listening to Beverly Hills, Brentwood and West Los Angeles citizens as they psychoanalyzed their mysterious lack of emotional fulfillment from materialistic fulfillment. Legend has it that Gautama's sudden insight about the universality of this sated, bored condition occurred in 528 B.C. after 49 days of sitting in the lotus position under the bodhi tree, now called *ficus religiosa*. In contrast with Buddha's illumination, my psychoanalytic training-induced, Freudian-Darwinian instinctual conflict, driven by fears of starvation and castration, drew me tighter into the world of meaningless, coin flip probabilities.

Our house was a block away from a West Los Angeles synagogue and we knew the Rabbi and his family well. Our sons played together frequently. The Rabbi tried to bring comfort to me on my death watch, with hours of discussions about trans-individual, ethnic belonging and a deeper foray into philosophical humanism. Both felt completely irrelevant to my condition. As an intern tending to those dying at night in Ochsner Foundation Hospital in New Orleans, it seemed to me that Jews tended to die more noisily than Catholics. For my personal escape from low-lying

dread, I needed the metrically linear time of *chronos* to become the metric-free, topological, *continuous surface* of the *twisted circular ribbon of a Mobius loop*, with the view from each moment a *kairos*, a stretchable infinity of each moment's internal multiplicity of times.

The ruthlessly reasonable Hebraic historicity, configured by the tooth-for-a-tooth, Mosaic and Roman *talion law*, the reciprocal, economic, exchange-calculating brains of Barkow, Cosmide and Tooby's *The Adapted Mind* (1992) and the terrifying stories of the *Five Books of Moses*, made the hopelessness of this sinner's plight inevitable. It felt like my dichotomous choice of God-type was between One of merciless fairness and the He and She of unconditionally forgiving generosity. The mind set of logical problem solving applied to the question about which of these two represented the true character of God lead to a momentarily distracting, metaphoric ecclesial exercise: *what were the minimal number of four magical cards need we turn over with preconditions or results on the upsides and downsides if what was showing was*: (1) Beatifically good; (2) Cursed with extraordinarily bad luck; (3) Not dependent upon personal virtue; (4) Inordinately fortunate in all of life's trials. The pay-as-you-go God people would need to pick up (1) and find fortunate life and (2) to find the fate of the non-believer to establish that God was coldheartedly true and fair with the results of flipping (3) and (4) being none contributory. The grace-to-all-sinners God people need to turn over card (3) to find good life and (4) to find sometime sinners nonetheless fortunate to confirm their belief in the unconditionally of the loving generosity of God and making finding out about the underside of cards (1) and (2) unnecessary. This liturgical discussion and gamble with God's cards,

perhaps a caricature of the Talmudic, rational discussions with the rabbi, felt irrelevant to my spiritual needs.

Missing was mysticism's promise of the disappearance of I into a union with the divine, the *Heart Sutra's* eternal *emptiness of form* and the *eternal form of emptiness* that gifts with spiritual perspective and not-necessarily-logical intuition about unseen *Absolute Reality*. Forced either-or, binary, card-turning cognition in the search for God's logic is unrewarding. As the Dalai Lama, in his *Heart of Wisdom Teaching*, says, "...all phenomena are emptiness, without defining characteristics, they are not born, they do not cease..." In trying to penetrate the mystery and promise of this emptiness, it was difficult to surrender my internal parody of what sounded like that day's Southern California New Age stuff about global nonaggression, sexual politics, Beadles music, distressed jeans and pot. In the synagogue of my neighborhood, experience with a deeply felt, never-you-mind-about-anything God of detachment with love, was not on the menus of Friday night or Saturday morning services. All I could feel was a faithless and nonnegotiable fear.

In the work of many mysticism-positive scholars, a classic being Evelyn Underhill's *Mysticism, 1961*, it has been speculated that this ineffable state as a union with a powerful unknown, transcending description in language, becomes more socially prominent during times of cultural efflorescence. She pointed to the flowering of mysticism in epochs of the high cultural achievements at the close of the Classical Period in the Third Century, the Medieval Period in the Fourteenth Century, the Renaissance in the Seventeenth Century and, now, as we know, in the

Western World toward the end of the Twentieth Century. An increase in general acceptance of talk, writing and practice focused on mystical experience is said by many to accompany historical high points in intellectual, literary and political achievement. One might include as a component of our growing cultural richness, the new science about chemical dialogues with the brain. Although no central nervous system agents were ever allowed in the ashrams of Baba Muktananda, it was common during some evening sessions of questioning, called *satsangs*, for him to acknowledge that one or a few experiences with entheogenic agents can open many recalcitrant folks to the existence of the God within. This, in turn, led them to the drug free spiritual exercises, *sadhana*, of *love*, *self-truth*, and *spontaneity* (each according to their nature) as well as *abstinent discipline*, *meditation*, *chanting* and *yoga* to maintain the knowledge. We might speak of participating in the creation and maintenance of the spiritual ecology of ones inner and outer being. Underhill said that the cultural richness of an efflorescent epoch is *taken inward* and accompanies personal and societal mutations into states and institutions involving higher spiritual consciousness.

In addition to an increase in the common outward manifestations of having had a mystical experience, such as an increase in compassion, forgiveness and more respectful and reverential attitudes toward the Earth and all its creatures (currently taking the forms of *deep ecology*, *ecofeminism*, *herbal medicine*, *organic farming* and the like), these times bring more public consideration of the nature of reality itself, apart from its material manifestations. The theme of the life's work of the Dominican priest, Thomas Aquinas, made master of theology by papal

dispensation in 1259, involved the existential recognition of this dichotomy of existence, *esse*, and *essence*, nature and grace, the material world and God. William James wrote famously about mystical experience penetrating the *thin veil* between these two worlds. Those with a mystical orientation attribute reality to inner experience in relationship to a transcendental, supernatural world. Whereas everyday events are subject to perceptual ambiguity and its attendant variety of interpretations, mystical union is claimed to bring the existence and meaning of *Absolute Reality* into direct experience. This kind of knowing is more akin to the *Platonic view of mathematics*, that theorems have been everlastingly existent, from before our physical world, then it is to the here and now, physically based, finite computations involving the experimental machines of physics.

The philosopher-mathematician father of *phenomenology*, Edmund Husserl, criticized the physics-want-to-be orientation of the 1860 empirical, objective measure psychologies of Fechner and Wundt. He understood the best of their findings as simply correlations between subjective and observable events. Using mathematical discoveries as examples, Husserl spent his life arguing for the possibility of abstract truths relevant to mind being more reliable and valid if grasped via direct experience. Knowing by what the popular mid-twentieth century writer of science fiction, Robert Heinlein, called *grocking it*. This is antithetical to the attitudes of today's human *cognitive and brain sciences* which disallow such knowing as deeply suspect unless accompanied by objectively definable observables such as changes in *electrical or imaging indices of brain activity* in one neural region or other. The modern psycholinguistics of brain mechanics can be called

*neolocationism*. Using modern technology to measure *regional blood flow, energy metabolism and/or electrovoltage or magnetic field activity*, stories of function are spun that closely resemble those imagined more than a century ago by the first *locationists*, such as Ramon Cajal. These neuroanatomists spent thousands of hours looking at cell clusters and their connections in stained slides of human brain tissue using microscopes and imagined their singular and integrated function.

Today, Lewis Judd, long time chairperson of the Department of Psychiatry at UCSD in La Jolla, carries a full sized, polymeric, three-dimensional model of the human brain when teaching his students about human subjective experience and interpersonal behavior. In his weekly grand rounds, he explains that day's psychiatric patient's problems pointing here and there at regions in this plastic surrogate for our electrical jellied brain. Few, if any, of the psychiatry students in his class was inclined to ask the foundational question: how it is that a finger point and a name of a brain place can describe, much less explain in the language of physical or physiological mechanism, a patient's illogical thoughts, feelings of hopelessness, irrational rage or prayerful gratitude. There remains a wide gap between ideas about the mechanisms of human symbolic processing and those involving the structures and functions of neuronal components and their connectivities in the brain, particularly when perceived as regionally segmented meat. Yet this report of Professor Judd's finger-pointing plastic brain ritual should not elicit surprise since iconic manipulation is certainly not new to the practices of priesthood.

In contrast with neuropsychiatry's behavioral attributions to brain parts as an explanatory pantheon of mysterious doers, absent of mechanical specifics, the

fields of physics turn to more abstract and general mathematical and statistical, so-called *phenomenological laws*, such as those of *thermodynamics* and *statistical mechanics*. The accounts of Feynman's abstract and general thermodynamic development of *conservation of energy* as well as *equilibrium thermodynamics* discussed previously serve as relevant examples. These abstract models have been found to capture the behavior common to diverse physical systems involving (often still unknown) differing physical mechanisms. Consistency of description, *reliability*, weighs in before predictive *validity*, which, with maturation of the research area, gradually becomes detailed mechanistic understanding with the eventual goal being derivation from the *first principles* of physics. The painful truth is that that in spite of evocative claims made to the contrary in the 1990-2000 *Decade of the Brain*, this level of understanding at the interface of neurobiological hardware and software remains unbreached. Some recent attempts are interesting.

One of the current research themes about real single neurons in real brains (in contrast with the silicon chip modules used in *neural network computer simulations*), involve widely distributed neurons that discharge in *temporal synchrony*. These phenomena have been described by Max Planck's Wolf Singer, Christoff Koch of California Institute of Technology and Florida Atlantic University's Steven Bressler and others with words such as *synchronization*, *phase locking*, *coherence* and *binding*. *Binding* is an intuitively seductive word that premises that two, even widely spatially separated, brain regions that manifest neuronal signals of activation locked together in time are assumed to be functionally integrated. Another time-dependent neuronal characteristic of current interest involve neurons or

neuronal clusters that beat with almost strict periodicity, the *oscillatory pacemakers*. For example, the program of research by Professor Al Selverston at University of California at San Diego, among others, has elucidated the role of these *rhythmic pattern generators*, both autonomous and those emerging from particular patterns of network connections. A wide variety of functional links involving *neuronal pacemakers* has been demonstrated. They range from the *oscillatory transport of calcium* through *membrane channels* in neurons and heart muscle, *smooth muscle oscillations* of the pylorus muscle of the stomach, the neuronal ganglion driven chewing motions of the jaws of invertebrates and the retina-to-brain *hypothalamic cells* gating *human circadian rhythms* coupling our body's *hormonal clocks* to *light cycles*.

Though *regular rhythmicity in neuronal discharges* is an intuitively attractive idea and relatively easy to quantitate using simple *sine wave trigonometric transformations*, in the real brain it is statistically rare. The commonest neuronal discharge pattern observed is that of *intermittent bursting, clusters of neuronal discharges in time* in which the *inter-discharge intervals* *irregularly stretch and contract* like the bellow pleats of a syncopated accordion. Bursts of repeated firing of some unpredictable length followed by silences of equally mysterious durations. Their behavior can be represented as statistical measures using non-normal, *long tailed distributions* and *in-between entropies* described previously. For a whole human example, although the rhythm of *manic depression* is commonly thought to involve *periodic cycles*, careful study using *motility patterns* of the timing through life of these episodes of extreme mood states by Professor Allan Gottschalk at the

University of Pennsylvania and others have demonstrated an irregularly *intermittent bursting pattern* in manic-depressive episodes, getting more frequent with age. Neuronal inter-discharge intervals seldom demonstrate what is called a *regression to the mean* like the *normal distribution* of heights, as one increases the number of people measured, the tighter the distribution around the mean. Neurons, much like our own irregular pattern of doing things (in spite of our plans), the statistical distributions of neuronal interspike intervals have increasingly *long tails*. Contrary to the behavior of a *normally distributed observable*, the larger the series of neuronal spike observed, the more likely that a longer interspike interval than had been seen before will occur. Counter-intuitively, long intervals tend to be followed by more long intervals as more shorts follow short intervals. Manic attacks cluster in time as does a number of other brain and body diseases. Maybe it is intuitively obvious that bad stuff tends to cause more bad stuff and good stuff is self-propagating. Having suffered recently does not mean fate owes you one. The brain's syncopated segmentations of time can be translated into a creatively arrhythmic dance.

What makes *neurologizing conversations* like these about subtle human experience possible are the human subjective scenarios we have agreed to short hand with names of brain parts and neurochemicals. The *how* is *where* conceptual connection is filled with post 19<sup>th</sup> Century Spanish microscopic neuroanatomist, Santiago Ramon y Cajal-like, intuitions about the functional role of brain structures: we think motor automaticity and pacing when hearing the brain place names such as *caudate*, *putamen* and *cerebellum*; we think *limbic lobe* when musing about sexuality, rage and depression; we short hand *left versus right hemispheric places*

for *verbal and sequential versus intuitive and geometric shape cognition*; we point to the *frontal lobe* for the future work of *executive control, anticipation and paranoia*; the *hypothalamus* for primitively expressed *appetites* and to the *brain stem* for our *vital functions* such as *breathing* and *blood pressure*. With respect to the brain juices, we say *dopamine* for *aggressive activity*, *norepinephrine* for *attention and sensory discrimination* and *serotonin* for *hunger, mood and sexual inclination*. No matter how avant garde our experimental techniques such as monitoring local functional blood supply by *fMRI*, *regional brain glucose utilization maps*, time-dependent changes in skull surface voltage using a cap studded with electroencephalographic, EEG, leads, monitoring these voltage field via their transverse magnetic fields by the frozen helmets of *magnetoencephalography*, *MEG*, we conclude our work by calling forth named but still enigmatic brain parts and their juices as mysteriously powerful little men and women executing remarkably complex and subtle tasks, sometimes even when called upon.

Current neurochemical research using molecular biological tools such as mice knockouts (the ablation of specific proteins though interference with their nucleotide-mediated protein biosynthesis), for example, the production of animals missing a subunit of their *hippocampal glutamate receptors* associated with the loss of some memory functions, conclude the memorial mechanism to be a specific cellular region, such as *hippocampal CA3 cells*. Technology advances but continues to support a primitive philosophic animism of named brain parts which pop science icons like the late Francis Crick called “The Amazing Hypothesis.” He and his fellow brain philosophers implicate brain mechanisms such as the *amygdaloidal nucleus*

*man* who can *emotionally color* even affectually neutral information that is transported through him. Imaging data showing *amygdala man* lighting up is used to tell us that circulating sensory information through the differentially behaving *amygdaloid nucleus* is used for *fight or flight* interpretive significance. Emotionally expressive human faces light up *inferior parietal cortex*. The Iowa University Professors, the husband and wife Damasio, have located even the criminal psychopath man in specific locations in the brain. As we have argued, perhaps *ad nauseam*, using multimillion-dollar imaging and molecular biological technology and no new thoughts that weren't around during the era of the 19th Century's neuroanatomists, specific brain regions continue to gain implicative properties like the task-specialized gods of the Roman and Greek pantheons. Crick implied that God is a brain part.

At the same time, those of us that have been in the brain business for a while, recall skyscraper window washers, standing steady, high up on rope lashed planks, suffering from congenital absence of the *cerebellum*, the supposed *sine qua non* brain part supporting motor coordination and balance in humans. More generally, there is much evidence that if young enough and willing to work, many of the functions of missing parts of the brain can be taken on remarkably well by other brain parts thought not to be involved in these functions at all. In addition, since evidence of neuronal responding to loud noise or bright light perturbation can be found almost everywhere in the hyper-connected human brain, because anticipation and brain time inversions make *before* and *after* indicate little about human neuropsychological causality, and *inhibitory on or off* and *activating on or off* are a

*priori* functionally equivalent with respect to the logic gates of information encoding, transport or storage, the modern study of brain mechanisms in emotion, cognition and behavior remains almost as mysterious as ever.

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The only human mind-brain observations that are doubted consistently, and treated as unpublishable by the editors of the journals of science, are those that result from direct human experience using subjective reports from within. They are called unscientific. Often ignored are logically consistent mathematical and computational contexts, which, as abstract and general tools of thinking and imagining, have the capacity to frame, rigorously define and describe thinking about both the subjective and objective aspects of brain-generated phenomena. These mathematically configured metaphors can lead to consistencies in description, *this is behaving like that*, in what are called *equivalence relations* expressed both as intuitive imagery; for a concrete example, a one holed bagel and one handled tea cup are *topologically equivalent* because, sculpting in clay, they can be smoothly transformed into each other. We have seen that *invariant measures* in computable statistical flows can come out of a mess of data. Professor Paul Rapp of the University of Pennsylvania has been able to mathematically encode the verbal content of the patient's free associations and the therapist's responses, using tape recordings of hours of psychoanalytical treatment. Examples of quantifiable qualities found useful in this regard involve a variety of characteristic statistical patterns in

what are called *entropies* and *information* as well as various measures of what with a wide range of definitions is called *complexity*. These quantifiable properties, *measures*, can help in the struggle with the intrinsic tension of Absolute Reality between the “eternal emptiness of form and the eternal form of emptiness.” We resort to measures of *entropy*, *information* and *complexity* when confronted with our ignorance, “emptiness,” great or little, with respect to either cause or result, about what exactly is going on. *Entropy* in its forms relevant to information quantifies our ignorance, the emptiness and its mystery. Computations of the entropy of systems in motion convert questions and answers concerning the detailed workings of the leg’s neuromuscular machinery to global statistical descriptions of more abstract thematic motifs, *forms*, expressed in the dance. Patterns of behavior of these properties can suggest intuitive ideas and imagery about global mechanisms, *approach/avoid*, *smooth/discrete*, *wild/tame*, as well as correlated and objective physical observables.

To learn more about this abstract, topology tinged (none numeric) style of model building, we can go to school on a long studied physical example. It connects a simple and well understood *real world observable* with *abstract statistical patterns* resulting from motions using the *one-to-one correspondence* (the *equivalence relation* called *isomorphism*) between their *entropies*. As we have discussed, the Stanford mathematician and Field’s Medal Winner, Donald Ornstein, proved that in statistical studies of even *point-to-point unpredictable, chaotic systems*, *entropy is the only isomorphism*. The *hardware* of this physical example is what the statistical physicists call a dilute gas of some fixed number,  $n$ , of uniform hard spheres,

*moving scatterers*, that, absent of *dissipative friction*, wander continuously around, changing their directions when bumping into each other. In a two dimensional bounded arena of randomly rolling balls, this game has been called *Sinai's billiards*. It was named for previously mentioned Ya Sinai, an eminent Russian mathematician He is now at Princeton and was previously a student of Andrei Nikolaevic Kolmogorov, the Russian guru of many of the Twentieth Century's world-class Russian mathematicians. Kolmogorov axiomatized the field of probability and, more relevantly, initiated the theory of *statistical descriptions*, the *ergodic theory*, of *nonlinear dynamical systems*. In the language of *statistical physics*, we will see that the same system produced by high number of elements executing Newton's deterministic laws can be generated by a so-called random system such as that resulting from flipping a suitably biased coin. Our example can also serve as a metaphor, used extensively in the mathematical biology of the late Professor Art Winfree, for the *temporal features of life on a topological circle*: the natural irregularities of the recurrent beat of the heart, the in and out breathing of lungs, the up and down voltage of brain waves, the pendulum swings of our blood hormone levels, the cyclic procession of our days, months and years and at large scale, our body's journey from dust to dust.

The angular deviation theta,  $\theta$  from the initial reference direction of a single moving sphere, gets rotated to a new angle theta,  $\theta \rightarrow \theta'$  by a collision with another sphere. It has been shown that the new angle  $\theta'$  is the previous angle  $\theta$  times twice the average distance traveled between collisions called *the mean free path*, here symbolized by delta,  $\delta$ , divided by the diameter,  $D$ , of the sphere. Algebraically,

$\theta' = \frac{2\delta}{D}\theta$ . the new angle is equal to twice the *mean free path* divided by the diameter of the spheres times the original directional angle of the sphere's motion. If we symbolize the time between collisions with tau,  $\tau$ , after an elapsed time of experimental observation,  $t$ , we can say that the deviations from the initial direction of the sphere changes like  $(\frac{2\delta}{D})^{t/\tau}$ . The exponent,  $t/\tau$ , represents the time of the experimental observation divided by the average time between collisions of the spheres, i.e. the time we've been watching,  $t$ , is expressed as units of inter-collision interval,  $\tau$ . Of course, the circular deviation in the angle from the initial direction rotates repeatedly around a circle as the number of collisions increase. If a point on a circle marks the angular change resulting from each collision and the system runs long enough, it has been shown that the circle will eventually be completely covered by points.

An *estimate of the entropy*,  $S$ , being generated by each sphere labeled with some index  $i$ ,  $S_i$ , is positive because the recurrent motion is deviating continuously from the initial direction. It can be computed for each sphere as the *logarithm of the intercollision time-averaged deviation from the initial direction*,  $S_i = \frac{1}{\tau} \log(\frac{2\delta}{D})$  and the *entropy* of the whole  $n$  hard sphere system is the sum of the  $n$  entropies, which can be expressed as  $n \times S_i$ . If we keep books by registering the points when each sphere's  $\theta'$  makes a stop on the top half of the sphere's circle as 1 and the bottom half as 0 (and we must arbitrarily decide between 0 and 1 if it falls exactly on the division between top and bottom and do so in a consistent way), then we can keep

score with a random looking binary series such as 11001001010.... that describes the sequence of rotations. The advantage that accrues by doing so is that this *coin flip counting* eliminates details in favor of a *computable over all measure* and supports several forms of *entropy calculations* for its use in deciding if *this system is behaving like that system*, an *equivalence relation*. One can imagine a series of coin flips with 1 being heads and 0 being tails such that the statistics of a characteristic series is determined by the *fairness* of the coin. As noted above, Donald Ornstein's famous theorem says that the entropy of these kinds of hardware and software systems is the only general basis for finding correspondence between characterizations of two such *irregularly behaving systems*. The important idea here is that a series of 1's and 0's may not be identical but the two systems can be *isomorphically equivalent with respect to their entropy*.

Notice again that the physical process of hard spheres bouncing off each other on a flat surface has been captured by an abstract representation in *binary numbers* that, like a series of coin flips, can be quantified as entropies (which would be maximal for an ideal, fair coin). After describing the process of real number representation by the binary code, we will show *how entropies can be computed for these binary series*. We remind ourselves that we are struggling to obtain some kind of knowing in a representative system manifesting the *tension and mystery between emptiness and form*. We can translate all finite real numbers into this language, making them accessible to standard entropy computations.<sup>16</sup>

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<sup>16</sup> The following discussion of the process of *transforming numbers into binary series* is in the spirit of the famous number theory theorem that every *natural number* (the *positive integers* such as 1, 2, 3, 4...) can be expressed as the sum of at most four squared numbers. Encoding any number by a series of 0's or 1's in what is called a *binary*

It was the co-inventor (with Isaac Newton) of the calculus, Gottfried Wilhelm Leibniz, in about 1665, who fully developed the *binary representation of all decimal numbers*. In a state of wonderment about the simplicity, power and completeness of this 1 and 0 encoding, he is said to have the beliefs that 0 symbolized the emptiness of the universe's beginnings, 1 represented the complete fullness of God and that this transformation served as metaphoric evidence consistent with God's creation of the universe out of nothing.

The simplicity of binary expressions as in the dynamics of hard spheres or rotations on the circle as well as the transformations such as  $729 = 1011011001$  make them propitious for exemplifying the methods for computing the *entropies of the growth rate of the possible, called the topological entropy,  $H_T$* , and the *probable, the metric entropy,  $H_M$* , which was introduced in a previous chapter called "Sensual In-Between Entropies." We exemplify the computations of measures of *topological and metric entropies,  $H_T$  and  $H_M$* , another computable idea called *algorithmic*

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*transformation*, begins with its separation, called *partition*, into a sum of powers of 2, for example,  $100 = 64 (2^6) + 32 (2^5) + 4 (2^2)$ . A short hand description of this sum begins with a form indicating the presence or absence of each successive power by a 1 or 0 coming before the relevant power of two; i.e.  $100 = 1 \times 2^6 + 1 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0$  (in which the last term, arbitrarily, is  $2^0 = 1$ , since anything to the power 0 = 1). This can be written even more simply as a series of 0's or 1's, their presence indicating whether the power represented by each place in the left to right descending sequence of powers of two participates in the sum of the partition. It is in this way that in binary numbers,  $100 = 110010$ . As another example, if we similarly partition the decimal number  $729 = 512 (2^9) + 128 (2^7) + 64 (2^6) + 16 (2^4) + 8 (2^3) + 1(2^0)$ , we find that its binary transformation results in  $729 = 1011011001$ , the 0's representing the descending powers of two that are absent in the powers of two partition. One can compute the binary representations of lower valued numbers immediately; for example,  $4 = 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0$  so that there is a 1 in the multiply-the-power-of- two column and 0 the power 1 and power 0 columns so in binary representation,  $4 = 100$ . Similarly,  $6 = 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$  making the binary transformation of  $6 = 110$ .

complexity, AC and finally, the well known (to statisticians) *standard run score*, *src*. Their descriptions *have* as their purpose a demonstration for the reader that these apparently abstract, perhaps nebulous sounding, words can be transformed into well-defined, concrete, quantitative and computable form of reality. <sup>17</sup>

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<sup>17</sup> The computations of  $H_T$  and  $H_M$  begins with keeping track of how many  $0 \rightarrow 1$  and  $1 \rightarrow 0$  transitions are found going from left to right in the binary series. For example, in the binary expression of 729, 1011011001, one starts counting with a  $1 \rightarrow 0$  transition followed by a  $0 \rightarrow 1$  transition and then a  $1 \rightarrow 1$  transition and so on. A useful way to record the count is via entries into a  $2 \times 2$  matrix for score keeping in which the horizontal rows are labeled 0 on top and 1 below and the vertical columns are labeled 0 on the left and 1 on the right. The number of each kind of transitions (from the vertical label to the horizontal label) are counted and summed in the appropriate box of the two box by two box matrix; for examples: for a  $0 \rightarrow 0$  transition, a tally mark is entered in the upper left corner of the matrix; for a  $0 \rightarrow 1$  transition, a tally mark is entered in the upper right corner; a  $1 \rightarrow 0$  tally goes in the left lower corner and a  $1 \rightarrow 1$  is tallied in the right lower corner. The resulting transition incidence counting matrix,  $M_t$  for the 729 binary transformation series looks like  $M_t$

$$= \begin{matrix} 1 & 3 \\ 3 & 2 \end{matrix} \text{ indicating one } 0 \rightarrow 0, \text{ three } 0 \rightarrow 1, \text{ three } 1 \rightarrow 0, \text{ and two } 1 \rightarrow 1 \text{ transitions have}$$

been tallied. Although this series alone is too short for computing reliable statistical measures, if we assume that the pattern of transitions observed in this short series is stationary, that is its transition behavior will remain the same if the binary series continued on to be infinite in length, the *assumption being that the dynamics of now will be the same as always*, 729 will stay 729, then we can use two forms of this transition matrix in the computation of the *topological entropy* reflecting the *growth rate of the possible*,  $H_T$ , and the *metric entropy* from the *statistical weights of allowed choices among them*, the *probable*,  $H_M$ .

To obtain the entropy representing the *growth rate over time of the new possibles*, the computation of  $H_T$ , the *topological entropy*, involves first transforming  $M_t$  into an *transition incidence matrix*,  $M_{t,i}$  a 0 or 1 matrix indicating whether each box has been entered at all (or not). Since in the binary representation of 729, all four boxes of  $M_t$  are

occupied, the  $M_{t,i} = \begin{matrix} 1 & 1 \\ 1 & 1 \end{matrix}$  indicates that all four kinds of transitions are possible. Since we

remain in the context of a 0,1, two state system, the growth rate of the possible equals the logarithm, base two, of the sum of the entries in the boxes of the left-top-row to right-bottom-row diagonal called the *trace* and  $H_T = \log_2 (1 + 1) = \log_2(2) = 1$ . Consistent with intuition, since every transition is possible, the topological entropy of  $M_t$  as indicated in its  $M_{t,i}$  is maximal (= 1). Another expression equal to the *sum of the trace* (the sum of the upper left to lower right diagonal) in a square matrix, is its leading *eigenvalue*, most often symbolized with a lambda,  $\lambda_1$ . *The logarithm of the leading eigenvalue of the transition incidence matrix is equal to its topological entropy*. Symbolically,  $H_T(M_{t,i}) = \log_2 (\lambda_1) = \log_2 (\lambda) = 1$ . Standard elementary linear algebra texts describe how to compute eigenvalues, these relations and related operations as well as their foundational theorems.

Before computing the entropy of the distribution of probabilities among the possibles as the *metric entropy*,  $H_M$ , let us notice again that the occupancies in the four entry boxes of the transition matrix  $M_t$  are not uniform,  $M_t = \begin{matrix} 1 & 3 \\ 3 & 2 \end{matrix}$ . This leads naturally to the intuition that

for this series of binary transitions,  $H_M$ , in contrast with  $H_T$ , will not be maximal, i.e. not equal to 1 and the nonuniformity of  $H_T$  and  $H_M$  is a computational expression of what we mean by a state of *in-between entropy*. These entropies are identical and their difference = 0 for transitions reflecting maximal entropy, as might be realized in a very long series of fair coin flips in which the entropies = 1. Entropy will be minimal when flipping a two headed coin, here the entropies = 0. More compactly, the *non-uniform probabilistic, metric entropy, differing from the maximal topological entropy* indicates that the system is in a dynamical state of *in-between entropy*, written as  $H_T - H_M \neq 0$ .

In the computation of the metric entropy,  $H_M$ , the  $M_t$  is transformed into a transition probability matrix,  $M_{t,p}$ , called a *Markov matrix* named for one of the two great Russian mathematicians, both students of Pafnuti Lvovich Chebyshev, the Markov brothers. The entries of each row in the  $M_t$  are transformed into transition probabilities, so that the sum of the decimal fraction parts of all the boxes in each horizontal row add up to 100%, or as a real number, 1.00. Recall that in the example we've been using, the binary expansion of the natural number 729, the transition incidence matrix is  $M_t = \begin{matrix} 1 & 3 \\ 3 & 2 \end{matrix}$  and its Markov matrix is

top row, 1/4, 3/4 and bottom row 3/5, 2/5, i.e.  $M_{t,p} = \begin{matrix} 0.25 & 0.75 \\ 0.60 & 0.40 \end{matrix}$ . *Matrix multiplication* of  $M_{t,p}$

by itself repeatedly is equivalent to tracking the temporal evolution of the transition matrix's probabilities until the resulting matrices move toward, *converge onto*, a steady state; each self matrix multiplication step represents what results from the passage of one unit of time. The convergence to equilibrium values is continuous and gradual. When the steady state is reached, *both rows become identical*. For this example,  $M_{t,p} \times M_{t,p}$  or

$$M_{t,p}^2 = \begin{matrix} 0.5125 & 0.4875 \\ 0.3900 & 0.6100 \end{matrix}; M_{t,p}^4 = \begin{matrix} 0.4527 & 0.5472 \\ 0.4377 & 0.5622 \end{matrix}; M_{t,p}^8 = \begin{matrix} 0.4445 & 0.5554 \\ 0.4443 & 0.5556 \end{matrix};$$

$$M_{t,p}^{16} = \begin{matrix} 0.4444 & 0.5555 \\ 0.4444 & 0.5555 \end{matrix} \text{ which for the first four decimal places remain the same for}$$

additional times of self multiplication. Note the convergence of the top and bottom rows to the same asymptotic values. Books discussing the multiplicative and other behavior of these *nonnegative matrices* are numerous and frequently appear in matrix algebra texts under the rubric of the *Frobenius-Perron theorems*.

Using the entropy formalism of Claude Shannon as developed previously,  $H_M$  is computed as the sum across either of the identical rows of each probability times its logarithm,  $\sum p_i \times \log(p_i)$ , remembering from above that we are working in base 2 logarithms and to change the minus sign (resulting from taking the logarithms of decimal fractions) to plus:  $H_M(M_{t,p}) = .4444 \times \log(.4444) + .5555 \times \log(.5555) = .9911$  The *nonuniformity* of the box occupancy probabilities is reflected in *the difference between the topological (maximal estimate) and metric (minimal estimate) entropies* and is therefore quantifiable and computable:  $H_T - H_M \neq 0 = 1.00 - 0.9911 = 0.0089$ . If the maximal and minimal estimates of the entropy were equal and all the probabilities boxes in each row

*Complexity* is a more general and variously defined descriptive expression than that of the topological and metric entropies and as such brings with it many kinds of definitions and computational approaches. One choice that's intuitively appealing assumes that the relative complexity of an expression representing, say an outcome of an observation or experiment, is reflected in the *minimum length of the most compressed program (algorithm)* from which, given a suitable *dictionary of symbolic equivalencies*, one can reconstitute the original expression. Increases in what some have called *algorithmic complexity, AC*, are reflected in the growth of this minimally descriptive symbol series length. Karen Selz's approach to compression and AC, similar to one proposed by University of Pennsylvania's Paul Rapp, involves the identification and symbolic representation of repeated blocks of symbols called *words*. For example, given an arbitrary, exemplifying binary series: 011011101010001010101001001010011, we first find the longest repeated word [1010100] and represent it with the symbol, *a*, yielding a shortening in the original series, 011011a010a1010011. The next longest repeated word is [011] is replaced with *b*, yielding a further compression, *bba010a1010b*. The next remaining binary word is of length equal to the previous one, [010], which, when replaced by *c* results in the series *bbaca1cb*. This can be further compressed to the final representation with four symbols and for the sequentially repeated *b*, one exponent of degree two, *b<sup>2</sup>aca1cb*. From this representation and a dictionary of letter equivalent words, the original binary expression can be recovered. For a quantitative index of the

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asymptotically contained the same probabilities as in  $M_t = \begin{matrix} 0.5 & 0.5 \\ 0.5 & 0.5 \end{matrix}$ , it would retain these values across an infinite number of self multiplications such that  $H_M = .5 \times \log(.5) + .5 \times$

*algorithmic complexity, AC*, of the compression, Selz computes the sum of the number of distinct symbols plus the sum of the natural logarithms of the exponents:  $4 + \log(2) = 4.6931$ . The binary representation of 729, 1011011001, discussed above, is compressed by making two [101]'s =  $a$  and two 0's =  $b$  resulting in  $a^2b^21$ . Having three distinct symbols,  $a, b$ , and 1, and two exponents of two, its algorithmic complexity is equal to,  $AC = 3 + 2 \times \log(2) = 4.38$ .

In addition to  $H_T$ ,  $H_M$  and  $AC$ , if computable in a meaningful way, the *deviation of the binary series under study from the idealized random behavior of a fair coin* could serve as another index of complexity. Common descriptions of the amount of randomness in a series are indices of *run length*. If a *run length* is defined by number of elements in a series of the same symbol before it stops, counting the *number of run boundaries* by reading along the binary series and counting the *number of switches* from  $0 \rightarrow 1$  or  $1 \rightarrow 0$ , then the binary expression of 729, 1011011001, has six runs. The great analytic probabilist, William Feller, among many others, including the distinguished 18<sup>th</sup> Century Swiss family of mathematicians, the Bernoulli's, proved that computing a *standard run score, srs*, involves three terms, the theoretical expectation,  $E$ , of the number of runs,  $r$ , that is  $E(r)$ , the number of runs actually observed,  $Obs(r)$  and the variance of the expectation of the number of runs,  $Var(E(r))$ . If the *srs is less than zero, then the binary series is more random than that resulting from the flipping of a fair coin*. Interestingly, when a normal group of subjects are instructed to simulate what they think of as a random coin flip determined series of 0's and 1's, their *srs* tends to be

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$\log(.5) = 1$  and  $H_T - H_M = 1.00 - 1.00 = 0.0$ .

lower than zero, over-estimating the degree of irregularity that randomness represents. Long runs occur by chance far more often than intuition would dictate. If  $srs$  is more than zero, than the binary, coin-flip series is *more ordered than random*. If  $srs$  equal to zero, the binary series is not discriminable from fair coin flipping randomness.

The expected number of runs,  $E(r)$ , can be estimated by a fraction formed by twice the product of the number of heads times tails divided by the sum of the heads and tails to which is added one. That is,  $E(r) = \frac{2 \times 6 \times 4}{6 + 4} + 1 = 5.8$ . The average

variation around this expectation called the *variance*,  $Var$ , of the expectation,  $Var(E(r))$ , is estimated by a fraction formed by (take a breath) twice the product of the number of heads times tails  $\times$  twice the product of the number of heads times tails minus the number of heads and minus the number of tails, all over the product of the sum of the heads and tails squared, times the sum of the number of heads

and tails minus one. That is,  $Var(E(r)) = \frac{(2 \times 6 \times 4)(2 \times 6 \times 4 - 6 - 4)}{(6 + 4)^2 \times (6 + 4 - 1)} = 2.03$ . From these

three terms, we compute  $srs = \frac{E(r) - Obs(r)}{\sqrt{Var(E(r))}} = \frac{5.8 - 6,0}{\sqrt{2.03}} = -0.140$ . We conclude that

the *standard run score* of the binary series is less than zero and therefore more random than the expected random behavior of a fair coin.

Recall from the last chapter that Karen Selz, Martin Paulus and others have shown that various personality types and psychiatric diagnoses are associated with characteristic deviations of  $srs$  from zero. When the winners of the 2002 Annual World Rock, Paper Scissors Championships held in Montreal Canada were

interviewed, they said that sensing their opponent's characteristic style of deviations from randomness in what we would call the continuum from maximal to minimal entropy determined their successes. We characteristically use all of these measures to estimate quantitate the deviation from randomness *standard run score, srs, algorithmic complexity, AC*, as well as  $H_T$  and  $H_M$ , the *topological and metric entropies*.

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The encounter with mystical Absolute Reality, though sought by arduous contemplative and other practice, emerges spontaneously, most often during times of apparent mental emptiness, detachment, a state in which rationally instructive thought and the choral background of brain voiced, emotion-laden, commentary have disappeared into the entropic soup of formless silence. It is this indescribable, ineffable, stillness that we think serves as the psychophysiological anlage of mystical experience. The mathematical systems yielding quantitative metaphors, descriptive ideas about dynamical entropic statistical emptiness and form, inspire the use of mathematical structures in place of neural nuclei or regions, localized lumps in brain meat, used as personalized icons of doing.

Our wedding of well-defined mathematical objects to metaphoric elements of more general nonverbal intuition has a long tradition. Rene Thom's 1990 book, *Semiophysics*, discusses mathematical mechanisms and their representations in mind and the real world, analogizing mathematical objects and the intuitions they

generate to *mechanical tools*. Similar ideas are found among the *four liberal arts of the ancients: Number, Geometry, Music and Cosmology*. The epistemologies of all four require, then and now, the intuitive use of mathematical objects, conscious or unconscious. Examples can be found in conceptual issues of Geometry and Number with implications for relationships between man's physical and psychological worlds. One set of articulations were attributed to the *shapes of Platonic solids* found among the Neolithic stone circles in Aberdeenshire, Scotland, 2000 years before Plato. Each symbolized particular physical and psychological themes. All manifested equal edges and every face of each solid was the same perfect polygon. The solid with four equilateral triangles manifesting four vertices and faces, the *tetrahedron*, represented the physical element, *Fire*, and the personal psychological climate of a choleric, fiery nature. A Platonic solid composed of eight equilateral triangular faces, two tetrahedrons annealed, the *octahedron*, signified *Air* in physical composition and optimistic hopefulness in psychological disposition. Six square faces together making a *cube*, evoked the elemental physical component, *Earth*, and its human expression as a phlegmatic, apathetic personal style. Twenty faces, all equilateral triangles, constitute an *icosahedron* indicating *Water* and a dominant feeling state of melancholic sadness. Like onomatopoeic words and pictorial script, the three dimensional geometry of *these Platonic solids feel like what they came to symbolize*.

The personality styles symbolized and evoked by the Platonic solids continue to be used to this day. For example, they compose the basic elements of the constitutional categories of remedy in homeopathic medicine as introduced over

200 years ago by Dr. Samuel Hahnemann in his classical *Organon of the Medical Art*. The assignment of clinical remedy in homeopathic treatment combines consideration of the presenting physical symptoms and signs, the *what*, with intuitive discernment of the patient's constitutional type, the *who*. To the homeopathic physician, *tetrahedral fire* is suggested by the traits of personal magnetism, courage and inspiration as well as egotism, strong desire and rage. *Octahedral Air* people intellectualize objectively in confident and insensitive aloofness. Those symbolized by *cubic Earth* are realistic and practical, a what-you-see-is-what-there-is belief along with rigid, materialistic ways. *Icosahedral Water* types experience emotions strongly and are sensitive, intuitive, nurturing and can be overly sensitive and dependent.

What intuitions and observations relevant to self, subjective and objective, emanate from the stylistic properties of feelings as derived from a time series of observations of their associated actions suggested by their statistical measures,  $H_T$ ,  $H_M$ ,  $AC$  and  $srs$ ? The yield is rich and unexpected. We find an enjoining of values of these measures, characteristic and invariant for each person, with the brain and behavioral actions of entheogenic agents and Zen meditation in contrast with worldlier focused attitude adjusting experiences and drugs. The range of their potential values helps rationalize a person's inclinations along the continuum of *attachment* and *detachment*. This quantifiable dimension augers positively and negatively with respect to the requirements for mystical experience as poetically described by the ambivalent warrior prince, Ardjuna, in conversations with Lord Krishna in the *Bhagavad-Gita*, the most famous and influential component of the

*Mahabharata* of Hindu scripture, A similar theme relevant to the occupancy of a propitious range of values for the measures,  $H_T$ ,  $H_M$ ,  $AC$  and  $srs$ , is found in what is often called the *Second Nobel Truth* as explained by the Buddha, Siddhartha Gautama, in lectures recorded in a deer park near Benares.

In the following, we begin with the results of some behavioral and drug experiments and end with suggestions about the intuitive relevance of the conceptual content of the  $H_T$ ,  $H_M$ ,  $AC$  and  $srs$  measures to some universals of mystical experience and to elements of spiritual transformation.

As previously noted, the brain and behavioral process of *habituation* is characterized by a decrease in the strength of an observable response to the repetition of an evocative stimulus. Imagine the decrease in our startle responding when a once unexpected loud noise occurs repeatedly. Sir Charles Sherrington, the early Twentieth Century British pioneer in neurophysiology showed that animals and humans gradually stopped the withdrawal of a limb when stimulation of its skin was repeated several times. Columbia University's Nobelist in the brain sciences, Eric Kandel studied the neural mechanisms of *habituation* as a primitive, accessible and fundamental example of *learning*, the association of a nonresponse to a usually evocative stimulus, in *Aplysia californica*. The *sea snails* learned not to respond to a local irritation with a *gill-withdrawal response* when exposed to it many times. They learned to stop paying attention to the perturbation. For most people, the background noise of a shopping mall tends to disappear out of consciousness after a little time of exposure. Though Kandel's exploration of synaptic mechanisms involved the neural circuit of the gill-withdrawal reflex in the marine snail, its

generality and human relevance has been well established. Hundreds of published papers report the results of studies of habituation in normal humans under all kinds of circumstances as well as in psychopathological conditions.

That characteristics of habituation are both fundamental and persistent is suggested by studies in children by one of Kandel's students, Michael Lewis. He found that the *rate of habituation of a startle response* to a bright light in one-year-old human infants predicted success in many kinds of learning and other cognitive functions when the children were tested again at the age of four. Pavlov's experiments studied habituation of the classically conditioned salivary response to meat powder-coupled bell sounds in dogs in which the bell was followed by nothing, not only led to inhibition of the salivary response with unreinforced trial repetition but generalization of the inhibitory state such that dogs were observed to freeze in motionless catatonic states for hours. In the language of our statistical measures of complexity, the fixation of the dog's behavior would manifest minimal entropy in the form of  $H_T = H_M = 0$  and the lowest complexity values for *AC* and *srs*. Entheogenic agents like *LSD* or *mescaline* inhibit the process of habituation and fixation, maximizing the entropy of behavioral measures,  $H_T, H_M \rightarrow 1$  and high complexity values for *AC* and *srs*.

Mark Geyer and David Braff, Professors at the University of California in La Jolla and Michael Davis, a Professor at Yale's School of Medicine, found that entheogenic agents, such as mescaline and LSD, as well as DMT, which we found occurs in normal human brains, *prevented habituation of startle responding* in mammals. Each sound repetition was treated as though it were new. *The baby is*

*Buddha* is an Eastern philosophical aphorism that captures the fresh spiritual state of each moment's openness and readiness, the state of *in-between entropies* ready for the surprise of something new. Geyer and Martin Paulus found that entheogenic agents such as *Ecstasy* also increased the *complexity* of the patterns of *spontaneous motor movement* made by rats exploring a bounded space. Recall that they partitioned the floor to document the exploratory motion in the context of a sequence of location transitions, readying the data for the computation of some of the measures previously described. Following the administration of entheogenic agents, computable entropic and complexity measures such as  $H_T$ ,  $H_M$ ,  $AC$  and  $srs$  on symbol sequences were increased following the partitioning of the space that the animals were exploring into a lattice of discrete boxes and encoding of each square with a symbol. In contrast, the administration of amphetamine-like stimulants led to a very different kind of behavioral activation than that induced by entheogenic agents. The measures of  $H_T$ ,  $H_M$ ,  $AC$  and  $srs$  reflected decreases in entropy and complexity. As University of California's David Segal and others documented in the 1960's, high doses of amphetamine drove animals into a minimal entropic state, they were frozen in stereotyped rocking, nodding and circling motions. High dose amphetamine-treated humans develop rigid fixation of ideas, low  $H_T$ ,  $H_M$ ,  $AC$  and  $srs$ , this is seen as inescapable obsession and paranoid delusion. There is considerable medical evidence that Hitler took large doses of amphetamine (Benzedrine) daily for the last 20 years of his life.

The entheogenic drug-induced phenomena of naïve openness and absence of fixed ideas, states of high entropy and complexity that are reflected in behavior

generating measures tending toward maximal values of  $H_T$ ,  $H_M$ ,  $AC$  and  $srs$ , are observed in the results of personal experiments by University of Chicago's Heinrich Klüver, described in *Mescal and Mechanisms of Hallucinations* (1966). Observing himself after the self administration of a crude preparation of *peyote cactus*, he said that it led to *glad feelings of unfamiliarity* and a *marked reduction in his tendency for boredom (habituation)*, a detachment from old ways of thinking and a new openness to a rush of *seen again for the first time* experiences. Everything in his personal world, no matter how mundane, became a source of new interest and fascination. New thoughts replaced old ideas in a continuing process of new formulation. All of these things feel like they emerge spontaneously, *making ideas about being born again and personal renewal concrete*. We remember that Timothy Leary and his wife in their privately circulated pamphlet, *Neurologic*, described their entheogenic drug-induced escape from the habitual order as supported by the learned and established "...mental-manipulative and socio-sexual brain circuits..." an escape to a fresh new planet of possibilities. Louis Lewin, the early Twentieth Century German pioneering ethnopharmacologist described his subjective responses to *peyote* as a flood of lively, numerous, random fantastic creations of perception and thought, all demanding his fresh attention.

To complement these subjective reports, experimental tasks involving habituation, such as the disappearance of a brain wave sign of arousal to sound or light stimulation, called *alpha blocking*, the eyes-closed resting pattern of 8-14 cycles per second, *hz*, waves perturbed into the arousal pattern of greater than 20 *hz*, did not habituate when the subjects were pretreated with *entheogenic drugs*.

This finding was also true in some subjects as a result of years of meditative practice. In his 1974 *Psychophysiology of Zen*, Hirai reported that Soto Zen monks, after many years of practice in mindful, one pointed, *be here now meditation*, unlike normal controls, continued to show *alpha blocking surprise, brain wave arousal patterns*, throughout the course of repeated stimulation with auditory clicks.

James Austin in his monumental book, *Zen and the Brain* (2000) summarizes other studies of habituation in transcendental meditation, TM, practitioners and other mediators in which eyes open versus eyes closed, the set and setting and variations in other experimental variables also played some role. He developed the case that years of meditation-induced brain states of emptiness, we would say of maximal entropy and minimal form, set the stage for the ecstatically insightful flood accompanying the sudden insight into a *Zen koan's* solution or the transcendent startle induced by a *roshi's shout*. A meditative struggle concerns how one can think about not thinking. That is, thinking of nothing. This is generally thought to be the most important part of Zen meditation, called *zazen*. Achieving high values for brain and behavioral  $H_T$ ,  $H_M$ ,  $AC$  and  $srs$  supply the formless infrastructure for ecstatic transformation.

In healthy people, an awareness of self is not lost during this time of invasion by and fusion with what feels like an independent agency. At full force, the mystical experience is transfixing, tending to paralyze movement and speech, and at the same time bringing with it the capacity for clear sensory and sensory-integrative lucidity. This new seeing *brings previously unnoticed things to attention* and *makes old things new*. Perhaps most striking is the passive (unsought) experience of the

*unification* of erstwhile disparate, apparently unrelated thoughts and feelings. The yield can be the sudden emergence of deep relationships between apparently very different constructs, beliefs and formalisms, often leading to unanticipated and unsought integrative connections. In mathematics, this experience can lead to entirely new kinds of insights and strategies for proofs; in the physical and biological sciences, a previously unseen organization of the data can generate new global relationships and potential scientific laws. In our spiritual life, it can bring all the ineffable richness of the direct experience of God.

Mysticism-negative interpretations of these experiences have always been attendant. To the extent that the mystic's inward turn is seen as a detachment and implicit derogation of the external, consensually "real" world, it is often seen as alienating from established institutions of religion and government. Psychoanalytic practitioners may label it a *regression to primary narcissism*. Most churches tend to discourage its practice as counter to the dominant social hierarchy and its governance. Governments pass laws against its practice and manifestations, a current example being modern Chinese governmental reactions to the *Tibetan Buddhism of the Dalai Lama* and the *yogic practices of the Falon Gong*. Agencies of established society such as the institutions of licensed medical practice make the dominance of the inner world of mysticism subject to diagnoses ranging from the *narcissistic character disorders* to interpretations of the reported extraordinary experiences as manifestations of *schizophrenia*, *manic-depressive disorder* or *temporal lobe epilepsy*.

Rejection and fear of the transcendent states lead to uninformed and politicized anti-narcotic laws, grouping addictive and life-style destroying heroine and cocaine with the *entheogenic* (recall: *engendering connection with the sacred within*) agents such as the *Huichol Indian's peyote* and the *Amazonian Indian's yage*. Legalisms obstruct and misinformation socially taints the personal use of plants and practices that facilitate access to the *mystic way*. Rational, socially responsible and humanistically tolerant Presbyterians, Unitarians and Reformed Jews can be suspicious and rejecting of what appears to them as the politically tinged “mass hysteria” of praying in tongues and other rituals of Charismatic Christian rebirth and renewal, the flagrantly ecstatic states of Orthodox Jewish chant-dancing and the twirling of Sufis.

Modern brain and behavioral scientists, remaining under the philosophical spell of *logical positivism* and its requirement for operational definitions and (external) *experimental disconfirmability*, operate from the position of strong doubt when mystical experience is addressed. What is striking and strange about how science plays the game of mysticism research is exemplified by the increment in credibility concerning a meditation-induced change in state of consciousness when Boston University's William Benson reported the accompanying *relaxation response*, a sudden decrease in heart rate---much like the *dive reflex of a seal* and what the heart rate does when you duck your head suddenly forward into a sink full of water. A documented change in the pulse made a meditative, mystical state more credible. Decades are spent getting professorial tenure for research yielding things we have already experienced and know directly and for ourselves. Recall that the

existence of visual imagery in the human, doubted by an experimental psychology of the time in which William James self-exploratory observations were viewed as revolutionary, was made more credible by evidence for the existence of a *subjective spatial measure*: verbally reporting subjects, when timed, took longer in their minds to go from one room to another when one was down the hall then going to the room that was immediately next door.

We have used brain chemical, pharmacological, neurophysiological and neuroanatomical data and analyses of their characteristic statistical reflections of complexity in time and space to bring “objectivity” to the ultimately subjective experiences of mysticism and spiritual transformation.

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## CHAPTER 6:

### PENTECOSTAL PHASE TRANSITIONS

By their late teens, my two sons, offspring of a born again, originally Christian Scientist mother, and a spiritually struggling and mostly secular, ethnically Jewish, psychiatrist father, had been unfulfilled in their hungry search for a personally meaningful God. They spent their earlier years in academic conversations about religion with their parents, Sunday morning visits to a variety of houses of worship, talks around the table with University of California religion professors and evenings with a Ph.D. psychologist-rabbi and his congregants at the neighborhood synagogue. Dissatisfied, they turned somewhere else. Some of their high school friends, Evangelical Christians, took them to their Assembly of God, Pentecostal and other Charismatic Christian, direct experience of God, churches. They came to look forward to what they called these Wednesday night and Sunday morning “rock and roll,” services. They called the new feelings they discovered, “living in Jesus.”

Struggling with the post-Vietnam cynical mistrust of authority and the marijuana fueled apathetic nihilism of the 60's and 70's, and clearly not enticed by what they regarded as their father's vacuous mélange of New Age Eastern Religions and secular brain science, they spoke about their sudden and life-changing experiences. They studied, memorized and quoted the Scriptures as part of their commitment to their *word churches*. As erstwhile cynical teenagers, now

positive and brimming with faith, what I had once called denial, they described what was happening to them as New Birth. They told me that, paraphrasing Paul in Romans, they had been saved and were living New Life, not earned by good works as in Hebraic Law, but by faith through God's Grace. Jesus had "paid their bills" through His sacrifice at Gethsemane. They both tried to explain inexplicable feelings of new energy, the unseen hand of spiritual guidance and peace. One told me that the wind of the Holy Ghost had taken him to the front of the pulpit, tearfully, thankfully, on his knees, to accept Jesus as his personal Savior. They described how they had opened their lives to the spiritual strength of *living in Jesus*.

Many things about them changed: their tastes in food, from hamburgers to vegetables and fruit; from the jazz of John Coltrane and McCoy Tyner and the cynicism of Frank Zappa's "...only fourteen and knows how to nasty...", to playing strum guitar and singing the hymns of Wednesday night healing services; from t-shirts hanging out of raggedy, Southern California, boutique store purchased, stressed jeans, to polished dark shoes, starched white shirts and gray or tan khaki slacks, sometimes with ties. They became cool, respectful, rational and more distant with me. They told the scriptural story about young Jesus, accidentally separated from his parents on a visit to Jerusalem. When bystanders asked Him about where His parents were, He answered, "I have no mother and father." They told me that they, like God's son Jesus, were filled to completeness with the Father and the Holy Ghost.

On one hand, their experiences sounded like those of the *activated mind* state of Abraham Abulafia, a suddenly emergent *Nevesh* and my father's

metaphysical talks about personal transformation. My secular, personal science brain God spoke to me of the mechanisms of sudden personality change, a *phase transition in complex systems*, in the context of the *nonlinear dynamics of brain and behavior*. On the other hand, their global changes in mind felt both alien and threatening. When I came to learn their churches' full list of expectations, rules, requirements and sociopolitical policies, I found that I could not identify with this system of spiritual knowing at all. It felt rigid, righteous, unforgiving, even angry, and it frightened me. I never anticipated that my culturally enriched, intellectually sophisticated sons would be quoting Pat Robertson and Jerry Falwell. The Freudian psychoanalyst of my younger days tried to write off these (to me) cataclysmic changes as manifestations of male sons' unconscious oedipal strivings to father kill and thus become. After some mulling, this theory did not wash.

They spent time accompanying themselves on guitars, singing hymns and shouted Corinthian Paulisms to small curious crowds gathered in beach parking lots, city parks and inner city street corners of Southern California. They passed out pamphlets containing New Testament tracts and formulaic aphorisms promising the post-repentance blessings of Jesus. The eldest, articulate, bright and prematurely worldly, had been an ardent memorizer and appreciator of Shakespeare, especially the mystical *Tempest*, the music of Aaron Copeland and Igor Stravinsky, the improvisations of Charlie Parker and Cannon Ball Adderley and the provocative literature of the time including Jack Kerouac's *On the Road* and Hunter Thompson's *Fear and Loathing in Las Vegas*. They loved riffing with the Voltairean pungency of Frank Zappa's lyrics. Now, nihilistic humor had become an anathema.

Several weeks after my eldest son's transformation, I found him in the garage using a hammer and an empty barrel for disposal as he destroyed his modern jazz and early rock record collection. He ridded himself of all of his fiction and most of the nonfiction books in his young but relatively large personal library. His new energy and high purpose emerged as a clearly defined set of rules of behavior, a strong stand against abortion, frequent talk about the need to escape from the contaminating influence of MTV culture, as well as our years of talk about the biological and physical sciences. Both boys were particularly critical of my Darwinian flavored attempts at scientific explanation of man's inner life using the selective and adaptive neurobiology of brain mechanisms and behavior. They spent increasing amounts of time with Church friends, seldom seeing their old ones. The eldest's college goals turned from plans for a U.C. Berkeley equipped career in literature and creative writing to a none spiritually challenging, objective and practical, Christian, free market entrepreneurial, finance and accounting degree from U.C.'s Business School.

Gone were shared magical hours of intellectually stimulating, humorous, even scholarly discussions of metaphysical issues. In place of evidential talk in areas of philosophy, literature and science, their opinions and claims derived exclusively from biblical quotation. Their particularly favorites were the strong and intimately vulnerable letters of Paul, the humble and gentle mysticism of John and the poetry of the prophets, particularly Jesus-auguring Isaiah. "In the beginning was the word..." became the reality. The meaning of life was Scripture as explicated by their often degreeless, *book church* pastors. They scribbled notes in the margins of

their Bible pages during sermons They were displeased when I interpreted the wild imagery and 666 symbolism of *Revelations* from the point of view of the historicity of encoded political messages, meanings hidden for the political safety of the early Jews in their world of Greco-Roman governance. Twenty-five years before the glut of books by Tim LaHaye, my well-educated sons claimed that *Revelations* was literal and foretold the coming *tribulation* that augured the end of the world and ascension to heaven of the believers. My youngest, since childhood a well-read history buff, now viewed New Testament scripture as sui generis, divinely and literally true. They said the conduct of their lives and its meaning had been clarified by the truths revealed to them by The Book. What I did not say was that much of the talk seemed to me to be an intellectually and spiritually impoverished miasma of cant and righteousness. At the same time, the remarkable transformation of their lives appeared to be the expression of a powerful and mystical force, an understanding of which has been the ostensible focus my life's scientific search. Why did their alterations appear so alien, strange and forbidding?

Born to a home of psychoanalytically and scientifically oriented political liberals, these precociously bright and worldly sophisticated young men were suddenly transformed into, unrecognizable to me, radical Christian Fundamentalists. They are now in their late thirties and remain just as ardent, Christian patriotic, Right Wing voters to this day. The eldest is now an executive in Morris Cerullo's San Diego based, worldwide missionary movement, raising money for revival and media ministries. He travels to and is involved with hundreds of Fundamentalist Christian churches in countries ranging from Argentina and Africa to

the Middle East and Russia. He has discouraged contact with his children, my grandson and granddaughter, because, in vague talk and mostly silent implication, I and people like me are seen as potential sources of satanic, worldly contamination. He chided me about what he saw as my futile spiritual search in what he called the health food, Eastern and brain religions. My youngest, only a little less ardent though much less critical, visits every summer, and, hands in the air and *speaking in tongues*, prays to the Lord for my salvation.

Of course, this sudden and long lasting personal transformation in the direction of Fundamentalism is now almost commonplace among American, European and Middle Eastern Jewish, Christian and Moslem children of middle class families. The Saudi Arabian World Trade Center bombers were, mostly, well supported children of the educated middle class. We recall the famously tragic American radical Moslem, Richard Reid, the would be airplane shoe bomber. My stomach clenched in recognition as I heard Richard's well educated and obviously caring father share his confusion and struggle to rationalize what had happened to his son. Most of the Madrid and London train suicide bombers were upper middle class and college educated. The commonality of this kind of spiritual and life transformations in the well educated young makes each event no less painful. On the other hand, we know that healing transformations in the name of Jesus and Holy Spirit of the Christian God more characteristically lead to new and positive realities. They are effective in even quasi-secular disguise as in Alcoholics and Narcotics Anonymous, Synanon and in the rehabilitation of the Charismatic Christian, ex-alcoholic, Southern Methodist politician, George W. Bush.

Paul Holmer, Professor of Theology at Yale Divinity School gives thanks to the *evangelicals* who "...keep alive the radical breach that the gospel is from the *nous* of this world...they (*Fundamentalists, Evangelicals*) look marginal if you are churchy...intolerant if you are ecumenical...anti-intellectual if you are trying to systematize... in their roughness and ...abrasiveness." I bring personal and painful witness to these claims. To get to the personal meaning and mechanisms of these transformations, I had to start from somewhere. I am wedded to the belief of the Jewish ecstatic, Abraham Abulafia, and not those of Moses Maimonides, that the human mind in an altered state of *activated intellect*, man's *Nevesh*, can understand such mystical happenings. I continue to work at it.

One of my first personal church experiences with my sons' new religious path came after accepting an invitation to go with them to a Sunday service at their charismatic church. The invitation was long awaited. By then, the eldest was married with children, the youngest, unmarried, was teaching mathematics in English and Spanish in a Southern California high school. The meeting took place in a large, gray, unmarked warehouse building that was crowded in back with high stacks of storage cartons. The large, cement floored, open space in front of the storage boxes was occupied by rows of metal folding chairs. They faced an unadorned, elevated wooden platform upon which was a lectern and microphone. Behind the lectern stood a casual array of a dozen or so young people, singing hymns and playing a variety of instruments. These included piano, two or three guitars and upright bass, tenor saxophone, trombone, trumpet, mouth organ and two snare drums. Sounding a bit like a Salvation Army Band, they played and sang,

“They cast their nets in Galilee just off the hills of brown; such happy simple fisher folk, before the Lord came down...the peace of God, it is no peace, but strife closed in the sod. Yet let us pray for but one thing, the marvelous peace of God.”

The building, used for commercial storage, packaging and mass mailings during the week and a *Charismatic Christian word church* on Sunday, was located at the rear of an unfinished strip mall. A new and well-polished yellow Cadillac Deville was the only vehicle parked in the no parking zone immediately in front of the entrance to the warehouse. My youngest explained that the car belonged to Carl Austin, the self-discovered and declared pastor, who spontaneously *rose up to lead* without academic religious training or a conventional ordination. The prominently exhibited, bright yellow car was explained as evidence of the power of God. Paraphrasing Mark, my youngest son told me “...he who does not doubt in his heart and believes that those things he says will come to pass, he will have whatever he says...whatever things you ask for when you pray, believe that you receive them, and you will have them.” The car served as a glorious instantiation of the church’s major promise of the rewards of faith. The growth and multiplication of mega churches throughout the land, a recent and largest one occupying a basketball stadium seating 16,000 in Texas, are regarded as further evidence of the Christian God’s work.

Pastor Carl Austin, a tall, blonde, portly man in his early thirties with a resonant tenor voice, was the youngest of several children of a poor Midwest farm family. He had been a state college drop out and without a career or a job. His sermons contained stories about how he had caught spiritual fire at a revival

meeting conducted by Kenneth Hagin of Kenneth Hagin Ministries, aka Rhema Bible Church, Tulsa, Oklahoma. The pastor's witness of the Holy Ghost acting through his life was his personal cure, by transformative Grace, of a triad of self-destructively sinful addictions: alcohol, gambling and promiscuity. Self-chosen and self-declared, he now served this two and a half year old growing congregation of over 200, mostly young, working families. The young men in attendance at the warehouse church were in shirts and ties, very unlike the more casual garments of even dressy occasions in Southern California. Women were dressed simply and modestly. Most of the children were in Sunday school in a small neighboring store in the strip mall during the adult service. The few that accompanied their parents were remarkably well behaved. I was told that most families tithed 10% of their income. They quoted Hebrews, "...king of the righteous...to whom also Abraham gave a tenth part of all...." They believed that their tithe would be returned manifold and the yellow Cadillac Deville served as Pastor Carl Austin's personal evidence. From these funds, the congregation supported the pastor, his car, the rental expenses of the Sunday warehouse church and an orphanage in a small Mexican border town. Some of these Hispanic children, several neurologically disabled, were bussed to the Sunday service for healing. They sat together in a section in the front of the congregation and were the beneficiaries of the second Sunday collection plate, passed around after the first one that was designated for the church and its pastor.

The first Sunday sermon I heard in the warehouse followed several minutes of Pastor-directed warm up hugs of neighboring strangers while the choir sang hymns. I did so awkwardly. The songs were accompanied by instruments playing

the melody in unison sans harmony, and accented by the beats of two loud drums. As the volume and pace of singing increased, I saw several episodes of ecstatic looks and fainting, *dying in the Lord* and *shouts of praise with upraised hands*. The intermittent elevation of the hands during prayer and song appeared to be spontaneous. I was told that the arms were up as antennae, feeling the energy of Lord all around us. The pastor's topic was *forgiveness*. From *Ephesians*, "...let all bitterness, wrath, anger, clamor, and evil speaking be put away from you, along with all malice... be kind to one another, tender hearted, forgiving one another, just as God in Christ also forgave you." In the middle of his sermon, which built slowly in tension and volume, the pastor introduced a forty-ish, sparkly eyed, somewhat overweight, dark haired, slightly made up woman who the Pastor said was a witness for the ultimate in Christian forgiveness. She was someone from whom all of us could learn. She was the mother of the 7-year-old boy that he, the Pastor, had, four years before, accidentally killed during a drunken driving episode in his "other life." That life was the material one he was living before he was saved. I was told that he presented her in a service about forgiveness at least once a year. The woman said that her successful struggle to forgive Pastor Austin led to her being saved. She quoted Ephesians, "And you who were dead in trespasses and sins hath he quickened." She looked radiant and hugged the pastor. When my sons introduced me to him as we filed out at the end of the service, the pastor told me that my visit was important to the congregation. He told me that Jews were special in Charismatic Christianity since we would play an important role in the *return*. He

said he hoped he would see more of me. My boys seemed pleased to have invited me.

After that morning, I accompanied them to their church most Sundays, and often for what they called the “rock and role healing services” on Wednesday night, for over two years. Within three or four months I found myself, the first time while awakening out of a deep sleep, mumbling sounds that I was told sounded like some unknown language, I was praying in tongues. At some services it happened spontaneously, accompanied by an ecstatic feeling. This was usually accompanied by the release of new energy. I recall thinking that the spontaneous, nonsensical linguistics shorted out my verbal and obsessively logical left brain, allowing the unbridled expression of my more emotional right brain. Sometimes in agreement with an insight offered in a sermon or when particularly moved by a hymn, I found my hands lifting skyward, right hand and arm higher than left, with a high feeling of trust and a deliciousness in the surrender of self conscious control.

Reading the *New Testament's Acts*, I learned that we were re-enacting the scene of the *Apostles* in the *upper room*. Those gathered there were the ones chosen by the risen Jesus to be able to see Him, the list including Peter, James, John, Andrew, Philip, Thomas, Bartholomew, Matthew, James, Simon and Judas. “...they were all filled with the Holy Spirit and began to speak with other tongues, as the Spirit gave them utterance...” The secular, psychoanalytical scientist in me tried to make analogy with the joyful jazz lyrics of Ella Fitzgerald’s scat singing, I’d done a little of that during my small jazz group pianistics as an adolescent. I recalled that verbally paralyzed stutterers could often be articulate when singing what they

mean, even though they could not speak it. I wondered about the relevance of the spontaneous *poetry of slams* and *Hip Hop rapping*. We attended what my sons called *charismatic black Baptist churches* in South Los Angeles and Long Beach. These often four hour services usually featured two wonderfully harmonic echoing choirs with organ and drum punctuation of the speech-singing, sermonizing Reverend. Large and beautifully dressed black women sang operatically and danced gracefully down the aisles. I joined my sons in this *joyful noise* for these long services and, so exhausted, I had to go home for a Sunday afternoon nap.

In spite of what could be regarded as validating experiences with the real life Holy Spirit, though apparently engaged, I continued to struggle for some rational understanding of what was happening. An inner counterpoint recalled my spiritual failure as a parent and Christian church attendance felt traitorous to my Jewish ethnic identity. I tried to understand how my sons had traveled from where I thought we were living together into this entirely new world. How did it happen? Could the path going there and back be meaningfully reconstructed and even reversed? This idea would be consistent with the medical dictum that knowing the cause, the treatment logical follows. Modern statistical physics and biophysics suggests that assumptions of the reversibility of global system change may not be true.

Contrary to the beliefs of early physical mechanics, medical and psychiatric history takers and psychoanalysts reconstructing childhood events, the modern physics and mathematics of complex systems indicates that *phase transitions in complex systems* are probably not invertible, at least not simply so. One of the features of global changes in complex systems, often called *bifurcations* or *phase*

*transitions*, is their dramatic discontinuities in behavior. Knowing only the initial and end state, *phase transitions in complex systems* do not allow for *point-to-point backtracking* or *specific linear-causal* understanding. These *discontinuous and global transformations* are the stuff of miracles, not just for physicists. In describing even the initial and end-states, rather than using phenomenological observables, the *quantitative mathematical and physical theories of phase transitions* are usually dependent on derivative physical quantities which often tax ones intuitions. Their verbal representations are often not concrete but metaphoric. This retreat to derived and abstract, far from the primary data computables, may be more evidence of the mysteries that underlie spiritual transformation, even in the mathematical and physical realms.

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Driven by an effect that contributes to cause, like the faith-driven abandonment to God that generates more faith, a drop of water hanging from a faucet is pulled down by its own gravitational field as the thinning neck of the drop facilitates its own further thinning. A goblet connected by a thick neck to the main drop begins to separate. The neck between them thins and breaks, and one becomes suddenly and irreversibly two. A *continuous* structure has suddenly become *discontinuous in finite time* at what is called a *singularity*. Since the single measurable feature that dominates the water's behavior around this singularity is the *diameter of the thinning neck*, a *derivative physical, one-dimensional*

*observable*, neither the details about where it all began (called the *initial conditions*) nor the *path* it followed to get to the moment of fracture, are predictively relevant with respect to the *sudden transition*. Considering this kind of phenomenon going on in our brains, choosing between theories of behavior that involve changes in brain cell groups and/or brain chemicals versus those that involve more global behavioral quantities, may be neither possible nor necessary. The challenge is to place the problems of cataclysmic change in brain and behavior in sufficiently abstract and universal terms that they can be represented in a low dimensional, computationally accessible space of variables. One such abstract and universal term in the spiritual realm is faith, which certainly can increase or decrease continuously and, as we have seen, go through discontinuous and difficult to reverse transitions.

The *simplification and stereotypy of behavior around singularities* reduce the number of features that are required to discuss the dynamics of change in what would otherwise be a complicated situation beyond conceptual reach. One of the properties found around singularities, is the *loss of absoluteness in contextual characteristics* such as the *scale* of the observation. We no longer can say that what we are studying happens in inches or miles, in seconds or days, now or in the past. In the place of a single unit of relevant measurement, we have a distribution of spatial and temporal feature sizes that stretch toward both the infinitely small and the infinitely large.

We can illustrate a dynamical transition involving the *passage of the system through a singularity* by using the metaphor of another kind of water experiment. If we pour a small amount of water through a filter full of coffee grounds, or watch our

coffee maker do it, the first spurt of water makes an incomplete path of wet grounds in the bed of dry ones. The next bit of water soaks this path more thoroughly and may form additional and multiple, new and branching, incompletely penetrating paths. Eventually, on just one more of these pourings, a connection in the paths occur, such that the water snakes all the way through the coffee grounds and the first brown drop of coffee fall into the pot. At this flow singularity and opposite to the dynamic of a faucet water drop, *a discontinuous system of pathways becomes a continuous path in finite time* in a process called *percolation*,

Trying to set up a predictive model, we can count the number of water deliveries that occur before the first drop finds its way through. Repeating the experiment many times yields a statistical span of number of pours required to reach the singular point of percolation. If we do the experiment enough times, the distribution of the number of pours required to reach percolation will range from one toward infinite. In the *neighborhood of the transition, time*, defined as the *number of small pouring events*, may extend.

In a comparable system, described simply and elegantly by Detrich Stauffer in his Springer-Verlag book on *percolation*, multiple discrete and growing hot spots in the woods can suddenly fuse into a global forest fire. Isaiah said, "...glorify the Lord in the growing fires of dawn..." The fires of faith spreading through a faithless dense forest, its hot irregular front damped by the disbelief of water-filled leaves, or disillusionment gaps of already burned out trees, can, under the right motivating conditions of dryness, wind velocity, tree density, kindling temperature and desperation-induced willingness, find faith sweeping through the entire woods in an

encompassing blaze. This can be seen as percolation of the spirit as well as the spirit of percolation. Computer simulations of percolating blazes generate a *multiplicity of life times* of forest fires *near the singularity* that represents the *transition to a global conflagration*.

Recall the discussion of Rudolf Otto's 1917 book about the characteristics of religious experience, *Das Heilige, The Sacred*. It described phases in the discontinuous transition from everyday life to the *wholly other (ganz andere)* reality of the world of the sacred. They include intense, numinous experiences of fearsome ambiguity, dawning awareness of awesome mystery, revelation and appreciation of the majestic power and finally, entrance into a reality of an entirely other place and time than the natural and secular which Mircea Eliade called *profane*. In Eliade's 1958 book, *Patterns in Comparative Religions*, this well-known historian of religion called the revelatory occurrence of sacred reality an *hierophany*. Eliade's classic work, *The Sacred and the Profane*, contrasts the homogenous, spiritually formless and relative world of the profane with the results of passage through spatial and temporal singularities to a place and time that are not of this world.

Poincaré said that the brain did not know of *absolute space*, but rather established a model of it through internal reconstructions of sequential sensory experiences that accompanied our exploratory movements. Activity generates the internalized, *partial differential, equations* (describing changes in the observable with motions in space) required for representing the dynamical cartography of the world. It was Poincaré's habit to *topologize the dynamics of motion* in mathematical problems that lacked *analytic solutions*. In this way, simple algebraic operations

replace some of the insoluble problems of the calculus. Eliade's *sacred space* defining *singularity in the plane* that breaks profane homogeneousness, a center point that is no longer a circle, can be viewed also as Poincaré's *topological center*. His topological brain theory found expression in the formal representation of internal space as the invariant product of an organism's *displacement groups* of imagined or real physical movements around such *singular fixed points*. The operational object called *groups* defines this kind of algebraic, mathematical structure and motion.

The *singularities* we have described in the metaphoric language of the temporal-spatial statistical physics of global brain state transitions, Eliade portrayed as the emergence of *fixed points* that partition and thus differentiate the profane from sacred space. One of his examples of the *singularities of passage* to the sacred was from the mythology of the primitive, hunting and gathering *Arunta Tribe* in Australia. "From the trunk of a gum tree, Numbakula fashioned the sacred pole and, after anointing it with blood, climbed it and disappeared into the sky." The tribe always carried a pole such that though they were constantly on the move, planting it yielded a fixed point that both spatially organized their life and gave them access to the sacred space of the sky, an opening into the transcendent. Eliade described pillars that marked and gave access to the sacred in a wide range of historical contexts, from the *axis mundi* of the pre-Christian Celts to the cosmic pillar, *shambha*, of Ancient India. In his scheme, a sacred place constitutes a *break in the homogeneity and continuity of space*. Its concrete realization can be a threshold at the doorway of the church sanctuary or the chosen corner and cushion we are advised to occupy regularly when engaged in mediation. We regard this path to the

sacred as passing through *singular discontinuities* in global mind-brain dynamics. Having disappeared during the transition, the singularity cannot serve as a marker to use when attempting to reverse the path.

In some schizophrenic patients, near what Thom called a catastrophic transition to a new world of visions and voices, the slowing of perceived events *stretching brain times* and manifested as physically *immobile catatonia* or *mental thought blocking* lead to blank or empty minds. *Phase transition theory* calls this approaching-infinite-time phenomenon *critical slowing*. Similarly, manic-depressive patients who experience transitions from low to high mood in minutes or hours, a transition that Professor William Bunney at the University of California at Irvine called the *switch*, speak about the *ecstatic timelessness of the transient transcendental switch state*. The time compressions and extensions, common in the transitory hypnagogic, felt as real, hallucinatory experiences that occur at sleep onset transitions in normal people, serve as other examples. These nonlinear time distortions near transitions between global states of mind are associated with the loss of habitual temporal-spatial contextual moorings. A mind at time one and the same mind at time two are unconnected. They are *wholly other (ganz andere)*.

In much the same way, for Eliade, *sacred time*, like space, is neither homogenous nor linearly continuous. *Sacred time is circular, recoverable and reversible*. Past, primordial, mythical time can exist in the present. Religious festivals are recurrently ontological, allowing the recovery of the sacred time such that their past and present expressions are felt as the same. *Rebirth is new birth*. In the language of the North American Indian Tribe, the *Yokuts*, the term for world

(cosmos) and year are the same. A year and the world has gone by, only to start again. The *Dakota Tribe* says that the Year goes around the World. As Elaide has said, "...at each New Year...the world (is) recreated and to do this is also to create time...the sick man becomes well because he begins life again with its sum of the energy intact." *Healing by becoming another or renewed self* may become a frontier science in the yet unexplored field of *phase transition medicine*.

The quality of separateness, *discontinuity in states*, as occurs in the *same-different inside world*, is much like that found in the *stages of anesthesia*. Each stage of anesthesia is *ganz andere* from the others. In *Stage I anesthesia*, fast frequency, low voltage brain waves are observed and accompanied by a two Martini-like, mildly activated, sedated but exhilarated high. *Stage II*, the next deeper stage of anesthesia, is marked by the sudden emergence of intermittent bursts of high amplitude brain waves, and animals and man demonstrate bizarre postures, hallucinatory phenomena, fixed staring, and sometimes movements that look like acting out some symbolic drama. This stage marks the beginnings of the loss of responsiveness to painful stimuli. In the sudden drop into *Stage III*, a low voltage mix of mostly slow and some fast brain waves can be seen associated with depressed consciousness, complete insensitivity to pain, slow regular respiration and an unexcitable cardiovascular system. *Stage IV* is the deepest stage of anesthesia. This state is characterized by very low voltage, almost flat brain waves, a loss of spontaneous breathing, the collapse of blood pressure and, finally, cardiac irregularities and death in cardiac arrest. These are both *discontinuous and global brain state phase transitions*.

Some anesthetic agents can produce anesthesia reaching only Stages I or II. They achieve their anesthetic effect by creating a strange and lively altered state of brain in which the person's consciousness is living elsewhere and events are accompanied by amnesia. Normal pain interpretive mechanisms are insensitive to input because the people, though eyes open and breathing normally, are not home. After this experience, they often describe miraculous events such as their hands appearing to be disconnected from their arms, fingers floating in space in front of them. Stage II is the state in which some lightly anesthetized women in childbirth, out of awareness and without memory for the event, may physically attack their nurses and doctors. In this state, surgical patients can, in the middle of their operation, get up from the table and walk out of the room without memory for doing so.

These *caesuras of phase transition* arise when cold water becomes ice, when hot water becomes steam, when the solids in supersaturated solutions precipitate, when rage attacks burst forth from increasing irritability, when orgasm follows increasing lower abdominal and pelvic tension, when neurotic ambivalence is resolved into commitment and when, overwhelmed by the direct and joyful experience of the Divine, God becomes real and near. These *transitions occur at singularities* along the dimensions of temperature, saturation, irritability, sexual excitement, intensity of spiritual conflict, neural membrane excitability, neural network reorganization, neurotransmitter floods and near death experiences.

Sometimes, what was once unified and unambiguously true, fissures into strongly experienced, simultaneous yet incompatible and irresolvable alternatives.

In *statistical physics of global phase transitions*, these are known as *coexistence states*. Jesse Penn-Lewis, the fiery and controversial early Twentieth Century Christian female evangelist, described a new arena for the existential conflict between good and evil for those in the global transitions of *Baptism in the Holy Ghost*. Before the cataclysmic change, "...the believer used his reasoning faculties in judging right and wrong and obeyed...what he believed was the will of God...but in the abandonment to the Holy Spirit he begins to obey an unseen Person and to submit his faculties and his reasoning powers in blind obedience to that which he believes is of God." In this state of spiritually enlivened, coexistent good and evil, the decision about which is which becomes iffy. Penn-Lewis warns that the ambiguity of near transcendent states produces a vulnerability to Satanic influence. In the physical world, states of coexistence include mixtures of water and steam, colloid suspensions of particles rather than substances dissolved into solution, ironic civility and the simultaneous experience of overwhelming love and homicidal hate found in some passionate attachments.

The theoretical biologist, John Maynard Smith, said that competitive selection favors a simultaneous mixture of the capacities to threaten with nascent aggression and to beguile with the implicit promise of affiliative peace. The primate with the greatest number of matings demonstrates neither off-putting wanton attacks, nor is he submissive or avoidant. This coexistence state of beatific charm and latent wrath, one definition of *charisma*, is a mix at the border of *spinodal decomposition*. Spinodal decomposition is the term physicist use to describe the *phase separation* that occurs when previously coexisting states come apart.

The existential battle between simultaneous states of good and evil in newly born and strong believers, what Jessie Penn-Lewis described so well in her 1912 book, *War on the Saints*, can be seen as *unresolved coexistence states in systems caught in the middle of an unresolved global phase transition*. In 1875 Paul Samt, a German psychiatrist, described coexistence states in hospitalized *temporal lobe epileptics*. His descriptions note that they had faces like those of religious martyrs, that they beat their chests, kneeled to pray, saw Jesus in their dreams and got messages from God the Father. At the same time, they stole personal belongings from others, hit people and filled the air with foul curses. They kept prayer books in their pockets, “dear God” on their lips and what Samt described as an “excess of viciousness” in their whole bodies.

From still another perspective, that of the French father of *Structuralism*, Jacques Lacan, these coexistent forces are conflicts between the underlying *primitive linguistic transformational rules* that govern the *deep structure of language* of the unconscious. The language of *entrapment in irresolvable transitions*, linguistics for these ambivalently stuck dynamical mind states, comes close to the idea called *primary process* by Freud and his followers. This forgotten language of the unconscious, an archaic needs and fear-driven tongue lurking beneath our supposedly objective discourse, comes to dominate themes of communication in the middle of these unfinished spiritual transitions. The *Rorschach Test* of master meditators and LSD users overflow with conflictual primary process images, as does the talk of patients on the verge of schizophrenic decompensation. The primitive symbolism of *primary process* provides the major current in the overwritten

prose of the hyper-religious temporal lobe limbic epileptics described previously and called the *Geschwind Syndrome* and in the regressed and iconic transference concerns of patients with tendencies for global and sudden phase transitions, prostitute to saint, righteous obsessional to conscienceless psychopath, called *borderline personality disorder*.

*Primary process* represents a dynamical brain state, one unburdened by linearly predictive connections with reality. It is a state without even a transient single defining physical time or other fixed measure of order. It is without the causal logic or knowledge of an outside reality that a brain implies in supposing to know. Its primitively instinctual style and goals contrast with more physically time-locked, reality oriented thinking which Freud called *secondary process* and Penn-Lewis referred to as ordinary and religiously lawful “reasoning faculties.”

*An absence of absolute time and space scales* with which the *executive ego* orders internal and external time and events, and therefore their relations, results in *primary process thinking* characterized by *condensations* of several, often incompatible, representations into one. Dueling, conflictual and simultaneous feelings and thoughts float from their relevant objects to include others. In the *transitional transcendent state*, there may be confusion of self with others, of objects with their labels, of parts with the whole and of symbols with the things that they symbolize. This state facilitates the experience of the spirits of the Father, the Son and the Holy Ghost at the same time. Mixed inextricably with saintly awareness and charisma, there are signatures of instinctually driven and configured primary process. Freud’s classical work on *slips of the tongue* concerned the intrusion of

these instinctual thought stream condensations from the world of the *ganz andere* and displacements into everyday life. In this intense and quasi-fluid state, saintly priests slip seamlessly into sexual predation; an ecstatic Jewish Orthodox fundamentalist shoots 29 praying Moslems in a cave near Abraham's burial plot for Sarah in Hebron; what were lovingly mystical, Jelaluddin Rumi's Afghanistan (Balkh) descendents become people bashing and women stoning morality police; committed and mesmerizing Christian televangelists attend peep shows and seek child pornography; devoted Islamists crash airplanes into tall New York buildings.

In the physics of *condensed matter*, two common forms of multi-molecular or polyatomic *cooperative arrangements* are the *crystalline condition* and in some ways its opposite, the *amorphous glassy state* that results from rapid cooling through a melting temperature. The *microscopic atomic arrangement in glasses*, in contrast with the *crystalline state*, exhibits no spatial periodicity or long-range order. In contrast with fluids, the friction of passage of molecular elements of glasses past each other, their *shear viscosity*, is large enough such that their macroscopic shapes are maintained in the very slow flow for very long times. In-between the crystalline and glassy states there exists a multiplicity of possible *unstable arrangements* which result from what physicists call *frustration*, the *inability of a system to find a unique, stable, lowest energy ground state*. The generic example of a *ferromagnetic crystal* has two, potentially incompatible, ordering principles: (1) The mutual alignment of the atomic *magnetic moments*, visualizable as the lining up of dipole, positive to negative, magnetic arrows; (2) The geometric crystalline low energy ground state as described above.

When the *symmetry of these two ordering principles are incompatible*, imagine an arrangement of neighboring atoms that prefer anti-alignment of the magnetic moments which are placed on a geometrically triangular rather than a square lattice, there is *no single arrangement that can satisfy both magnetic and geometric principles*. What emerges in this *state of frustration* is the potential for a *multiplicity of nearly equal energy states*. Water has the potential for both geometric ice crystal symmetry as well as arrangements of hydrogen proton (+) to oxygen electron (-) magnetic moments (with well-ordered oxygen lattices but disorder among the hydrogen positions). It is therefore not surprising that a *multiplicity of frustrated water states, ice-one to ice-many*, are known, and with respect to *ice-nine*, even to Kurt Vonnegut. It is perhaps not surprising that, with respect to critical life issues, we may be of many minds.

Jesse Penn-Lewis warns that the joyfully felt new freedom from past enslavement of the *born again transition*, may also evidence, with increased intensity, the "...carryovers of the old man... including tempers, moods, lusts, envying, selfishness and prejudice..." She preached that the personal surrender that yielded the benefits of God's grace could be corrupted by *passivity* such that there was a "...cessation of the active exercise of the will in control over (conflicting themes of) spirit, soul and body..." She recalled the incident in Mark in which Jesus was set up by the Pharisees to violate the Sabbath by curing a person's withered hand. She notes that Jesus, in accomplishing this complete healing, did not Himself stretch out the man's hand, but rather the man himself had to do it, even though it seemed like an impossibility. In this way, she explicated the principle of *disuse*

*atrophy* in the context of both the deformed hand and *flaccid paralysis of the will*. She said that every faculty unused invites their invasion and attempted use by Satan, the enemy.

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I attended my sons' strip mall word church almost every Sunday for over two years. It was a rare and happy family time, a place and situation for a harmonious visit, which included a festive lunch out for all after the services. It was a truce time for the usual sarcastic references to how my past self-important busyness had failed them in childhood. Though the services continued to feel alien, I was grateful for the opportunity to be with my children. Over this time, the congregation grew to close to six hundred families, three crowded Sunday services were required. Like most of the members of the congregation, my sons tithed 10% of their income, which they delivered in weekly aliquots to the plates that were passed around with organ accompaniment in the middle and then again at the end of the service. Under my sons' watchful eyes, I added a ten-dollar bill to the plate on each round. I noted, but did not remark about, that each of the two years brought a new Cadillac to the parking place near the front door. I was approached directly and indirectly by my sons and church elders about joining a study group for personal conversion.

I was surprised to learn that discussions of current political topics were a regular part of these discussions as well as the Sunday and Wednesday night services. We received a weekly political action committee report. Their issues involved abortion, school vouchers, sex education in schools, family planning, school prayer and available choices of Christian elected officials for school boards

and the Congress. As a congregation, we frequently held hands in small circles and prayed for the electoral success of our issues and candidates. Twenty years later, this movement has matured into the public political morality play of the Republican base of George W. Bush.

Laying on of hands, dying in the Lord, speaking in tongues, dancing in the aisles and praying with up stretched arms were common in the band and choir, hymn dense services. The goal for all was the *spiritual transformation of mind* as in Romans, "...be not fashioned according to this world, but be ye transformed by the renewing of your mind that ye may prove what is the good and well-pleasing and perfect will of God..." The pastor told us that the world ruled mind could not grasp spiritual things as in Corinthians "...they are foolishness unto him and he cannot know them, because they are spiritually understood." Abulafia called this understanding, a *state of activated intellect*.

My research took me to a collaborative project at a European mathematics institute for three months. I returned to our town very late on a Saturday night. I planned to surprise my sons by appearing at their usual choice of the middle service the next day. I drove up to the warehouse church fifteen minutes before the service was scheduled and found that the parking lot of the strip mall was nearly empty. There was no Cadillac parked at the front door. I banged on the double door when I found it locked. More than a little surprised, I called my eldest. He told me that four weeks before, the pastor disappeared, I later found that his disappearance accompanied that of the congregation's bank account, and no one knew where he had gone. He had not warned or informed anyone in the congregation about his

plans. Calmly and without apparent awareness of my surprise and distress, my eldest asked me if I would like to attend the late Sunday morning service at their newly chosen Charismatic Christian church. He gave me its address and told me that the service started at 11:00 AM. There still was enough time for us to meet there. I wondered if the Pastor Carl Austin would use this incident in sermons about sin and the grace of redemption to his next congregation.

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## CHAPTER 7:

### AMPHETAMINE ROLL-UP AND SPLITTING

It has been difficult for me to subjectively understand, compassionately identify with, the metaphysics and inner dynamical life of the of Fundamentalist believers. Experiencing this in my sons obligated me to try to do so. Particularly difficult to grasp in these sacerdotally rigid and faithful, is the disenfranchisement and righteous intolerance toward many other denominations held simultaneously with spiritual compassion, mercy and forgiveness for the members of their own. This *splitting* between the “good people” and “evil doers” is not an uncommon phenomenon, seen early in childhood as the inevitable sorting of the desirability status of their class mates. Many psychoanalysts and dynamically oriented brain scientists regard *splitting* as a sometime psychopathological solution to the inevitable ambiguities of living. I am certainly not alone in being fearful of its expression in the extreme Fundamentalists: Jewish, Christian, Moslem and Hindu.

From the overpass above the freeway, bearded Jewish Orthodox men rained rocks onto the roof of my rented car to discourage me from driving on the Sabbath. A research project had taken me to Jerusalem Mental Health Center’s neurochemical laboratories for collaborative work with mostly secular Jewish scientists. *Halachic considerations*, those of Jewish lawfulness, comparable to the

constraints of *Muslim shirah*, forbids working, even driving, on the Sabbath. Orthodox Jews live walking distance from synagogues or benefit from a *rabbinically blessed, network of symbolically covered walkways* for going longer distances on the Sabbath. This Sabbarian grid of permission obviously did not cover driving on the free way to the mental health center.

It is the *splitting* of *us* from *them* that leads to the breakdown in empathy and compassionate identification with others. I obviously suffer from it myself with respect to Fundamentalism. Studies of the dominance of direction of rotation within a closed space in small mammals have shown that *amphetamine-induced intensification* makes the choice of right versus left (or left versus right) rotation, *broken symmetry*, more statistically significant. In contrast, the Heffner Foundation of Switzerland has shown that *entheogenic drugs*, such as *psilocybin* in man, facilitate seeing both of the conflicting, simultaneously presented, right eye and left eye images in place of the usual, drug-free dominance of just one of the two representations. A regular program of meditation has been reported to achieve the same ends. A precondition of *compassion* might be that a person's brain be able to record and comprehend both or several sides of apparently conflicting points of view at the same time. The Fundamentalists do not see things that way. In the Koran, Mohammed says, "...give sustenance to the poor man, the orphan, the captive...and for the unbelievers We have prepared fetters and chains and a blazing fire...." In the New Testament's *Mark* we find the final words of the risen Jesus, "...whoever believes and is baptized will be saved but whoever does not

believe will be damned.” The Crusaders’ claimed scriptural support for their murderous marches to reclaim Jerusalem.

Carl Jung wrote about the New Testament’s *Revelations* in his *Answer to Job*: “...a terrifying picture that blatantly contradicts all ideas of Christian humility, tolerance, love of your neighbor and your enemies and makes nonsense of a loving father in heaven and rescuer of mankind. A veritable orgy of hatred, wrath, vindictiveness and blind destructive fury that revels in fantastic images of terror breaks out...overwhelming a world which Christ endeavored to restore to the original state of innocence and loving communion with God...” As Princeton University philosopher, Walter Kaufman, has noted in his *Religion in Four Dimensions* “...compassion for unbelievers is implicitly condemned and proscribed...Augustine argued expressly against compassion for the damned and Luther used invectives against his (religious) enemies...” How can this be God’s setting for the spiritual work toward that promised in *John* “...that you love one another; even as I have loved you, that you also love one another.” I carry a pen with Baba Muktananda picture embedded in its dilated top. Inscribed on its side is his instruction, “See God in each other.” As a route to compassion, one may run less risk of getting narcissistically self involved than the instruction about knowing the God within oneself.

As a metamathematical counterpoint to the phenomena surrounding *splitting*, we will explore the possibility that in complex systems such as man, his brain and social relations, a fear and anger-driven transitional sequence is composed of the narrowing the range of behavioral variation, loss of the countervailing expanding

and contracting influences of *hyperbolicity* followed by *bifurcation* to rigidly oscillatory, repetitious, stereotyped patterns of thinking and behavior. This one of a finite number of *universal global dynamical scenarios is called the Hopf bifurcation*. In contrast with what has been described as the *entheogenic drug-induced transitions to a non-uniformly hyperbolic spiritual mind*, we call these righteous Fundamentalist states, the *amphetamine-induced, Hopf bifurcation, splitting religions*.

On the Sunday mornings of professional football, the Los Angeles Ram's Hall of Fame defensive end, the Baptist minister, Deacon Jones, was on high doses of amphetamine, 125 milligrams compared with the diet dose of 5 milligrams. Taken four hours before the Sunday games and then playing in what looked like rage, he used his famous and consciousness annihilating head slap to daze the opposing offensive tackle in order to gain access to and impair the functioning of the other team's quarterback. As evidence for a drug-induced induced bifurcation, discontinuity, in consciousness, before taking the handful of *Dexedrine spansules*, Deak would tell me, "See you on Tuesday." Along with the Deacon's destructive aggression was another invariant feature of the actions of high doses of amphetamine, *compulsive stereotypy*, the fixity and driven repetition of over simplified actions and thoughts along with the loss of breadth of vision and adaptive flexibility. Deacon, against the orders of the line coach, consistently *rushed inside, took the inside lane*, in spite of offensive linemen, who, having studied previous game films, were set up to expect this route. They used this knowledge often to take him out of the play.

Five milligrams of amphetamine or a mile or two of running that led to what was previously referred to as the *first second wind* gives me some empathy with what I perceive to be an underlying feeling in Fundamentalism. I become full of faultless energy, an arrogant feelings of “rightness.” My mind gets fixated in grand and simple ideas that I believe to be absolute and correct solutions to most of life’s mysteries. I am irritably intolerant about anyone or anything different. It is my virtuous duty to set everyone straight.

Though we are currently preoccupied with Muslim extremism, its accompanying array of amphetamine states is certainly not unique. In the 1980’s, Moishe Zar, a desert castle dwelling, settlement organizing, ardent Orthodox Jewish Zionist, now 65 years old, was the leading vigilante of the West Bank He planted bombs in the cars of Arab mayors and plotted to blow up the Dome of the Rock. Buying up farmland from the Palestinians beginning in 1979, many of whom were then killed by their own because they were seen as collaborators, Zar and his group of young volunteer settlers took over harvesting the Palestinian’s olive trees and shooting rifles over the heads of those that would take them back. Fundamentalist Christians share his vision that the coming of the Messiah, the second for Christians, the first for the Jews, is dependent upon the complete return of all of the land of Israel to the Jews.

I recall that in the middle 1940’s, my father took me to a fund raising dinner for the local chapter of the *Jewish Antidefamation League*. The whispered talk was about blowing up a warehouse in which anti-Semitic pamphlets were stored, planned for the middle of the night when it was unoccupied. Even at the age of 10, I

could tell that their quiet anger and firm commitment made these threatened men feel less vulnerable. I understood a little more about the motivation for this proposed nighttime property destruction when, the following year, my father explained the reason for our being refused overnight rooms at several motels as we drove along the A1A highway in Southeast Florida. It took us until late night to find a place to sleep. This was America's muted version of what Hitler and his legions were doing to Jews that at that time. The Holocaust was not publically known, except for the broadcasts of Walter Winchell, in America. Resonant with this chemical-cultural theme are the many reports that Hitler was taking an amphetamine drug, *Benzedrine*, daily and in high doses for the last 20 or more years of his life. One can hear the characteristic, amphetamine-induced, higher pitched, rageful rants in his recorded radio tirades. Compare the higher pitched and strained voice quality of the culture critical singing of Bob Dylan in his early records made while he was on *speed*, with the gravely, lower pitched philosophical voice, now that he is not. Amphetamine states occur cross species. In our behavioral neuropharmacology laboratory at the Brain Research Institute at UCLA, Professor Charles Spooner and I used an *audiographic oscilloscope* to monitor the sounds of baby chicks whose peeps became suddenly higher in pitch and rate as they began to aggressively peck each other following injections of amphetamine. The earliest members of the methadrine-amphetamine chemical family were synthesized by the great organic chemists of the German pharmaceutical industry in the early 1930's.

I felt this force in a small way as a child. The sequence of parallel streets in the neighborhood of my home and first grammar school in Kansas City, Missouri

were my street, Virginia, then Tracy, Forrest and Troost. My school, Bancroft Elementary, was on Tracy and one block down that street was the Lutheran Day School established by German immigrants under the aegis of the Missouri Synod. Starting in the third grade in 1943, I was intermittently and unpredictably chased by rock throwing, “damn Jew” and “Christ killer” shouting boys from the Lutheran Day School. I had my choice of running for safety directly from Tracy to my family’s half duplex at 4232 Virginia Street, or running away from school via Troost and then down several blocks and around to sneak back to my home on Virginia without being spotted. One run-for-it afternoon, my parents took me to the emergency room of the Menorah Hospital to have my scalp sewed up where a sharp rock had landed.

When I asked my synagogue’s young people’s spiritual counselor, Rabbi Kleigfeld, to explain the feelings and actions of these children of Martin Luther’s Post-Reformation Christian Church, he answered that I already knew about similarly difficult places and times of our Twelve Tribes’ like Rome, Medieval Europe, the Spanish Inquisition, Persia (Iran) and, it was rumored, in Germany as we spoke. “Conversion or death” was its most benign form, in places like Spain and Iran, many Jews faked it, staying alive and practicing Judaism secretly. Kleigfeld told me that the causes of this historical theme of persecution of Jews were complex and had millennial roots.

Among the frequently unmentioned events recorded in the later part of the worldly life of Mohammed, who lived from 570 to 632 AD was, “...in the name of Allah, the Compassionate, the Merciful...” his participation in the crushing of the

Jewish tribe of al-Nadhir in 626 A.D., the beheading of 800 Jewish men of the tribe of Qurayza who refused to accept Allah as their God in 627 A.D. and putting to the sword the Jews of Khaybar in 629 A.D. As in the section of the Koran called *The Cow*, Mohammed proposed to "...fight against them (the infidels) until idolatry is no more and Allah's religions reigns supreme..." In contrast, the more entheogenic spiritual orientation of the ecstatic followers of Mohammed in his earlier years speaks of the multiplicity of valid *Ways to Deep Truth*. The acceptability of many ways is supported in the tales from the millennial oral tradition of the Sufi Masters in their *Teaching Stories*. One of them, *What Befell the Three*, is attributed to the early 18<sup>th</sup> Century Sufi teacher, the Dervish Murad Shami. In it, an apparition is mobilized by the concentrated Truth seeking efforts of three *Sufi Dervishes* named *Yak, one, Do, two* and *Se, three*. When this "...white smoke head of the very old man..." was asked what he was, he answered "...I am what you think me to be...have you never heard the saying 'There are as many ways to the Deep Truth as there hearts of man.'" In the narratives about the lives of the *Mevlevi Islam dervishes* called *Munaquib el-Arafin* (1353), *Jalaludin Rumi*, the Sufi saint, instructs his ill and troubled petitioner to ask forgiveness from the Christian he recently spat on saying "...whether a ruby or a pebble, there is a place on His hill, there is a place for all..." Cole Barks and Michael Green's *The Illuminated Prayer* (2000) notes that the Rumi follower, *Bawa Muhaiyaddeen*, a modern Sufi guru, was said to be keenly aware how quickly spiritual *entheogenic systems can become amphetamine-like* and "...develop rigid marching orders ...which turn into a dumb obsession with other people's behavior..."

It appears that entheogenic and amphetamine spiritualities can coexist contemporaneously, in Islam as well as in all the other of the world's great religions.

One day, sneaking home from school, taking the long way around via Troost, I was spotted and chased up some stairs into an apartment building's dark hall. Terrified, I swung hard and hit the leading angry and noisy head with a propitiously found snow shovel that had been left near the apartment's entrance. An ambulance was called to tend to the twelve-year-old, transiently unconscious, Lutheran boy. He recovered completely within a day and the chases after school and my desperate escapes stopped suddenly, never to reappear. After several months, our family crossed the socioeconomic divide in Kansas City to a more tolerant, upper middle class, Southside neighborhood near Rockhill Road, to a suburban home, one block from Missouri's border with Kansas. There, persecution for my Jewishness took more subtle forms such as not being permitted to play teen-age golf with my friends, though invited, on their Blue Hills and Kansas City Country Club's golf courses. It was decades later that the first Jewish member of the KCCC was the founder of H and R Block. Unable to afford membership in the single all Jewish country club of the region, I practiced for my high school golf team on Armour Hills Public Golf Course, where, at the time, mostly white working class golfers played.

How can it be that spiritual states include both personal humbleness and loving mercy toward some of mankind and judgmentalness, nonacceptance and commitment to seduction, threat and even violence in the service of invoking changes in the beliefs of others. How can the *high energy calm* of being home at last in the *born again condition* with its new freedom from self assaults about sin,

most importantly that of disbelief, but also peccadilloes such as drunkenness, promiscuity and familial abuse, be associated with readiness to judge, harass even persecute others. Psychoanalysts would say that it is a riddance mechanism, the projection of unwanted personal traits onto others. From the standpoint of rational thought, this seems more like non-Aristotelian cognition, two, not either-or, countervailing orientations toward mankind held simultaneously. The newborn parishioners of these *charismatic amphetamine churches* express their fealty to God with strongly held beliefs that diagram logically as contradictions. The perception of the world's peoples into believers and infidels, good and evil, our people and your people, ourselves and the others. It is generally believed among social psychologists that it is the perceived *nonpersonness of others*, which allows the cruelty that empathic identification with them would never permit. *Splitting* feels like resolution, its *stereotypy* reducing the complexity of spiritual thought as well as true to life perception.

The *amphetamine bifurcational conversion* has been demonstrated experimentally. The sudden transition to a high energy, fixated, and delusional state called *amphetamine psychosis* was demonstrated in a study in humans conducted by Professor John Griffith at Vanderbilt University in the 1960's. These experiments would not be allowed by today's human research committees or medical ethicists. Every one of a group of psychologically screened-as-normal graduate student volunteers, at an individually unique amphetamine dose, suddenly developed a personally quasi-relevant and peculiar system of new beliefs, held as obsessively irrational thoughts. Ten milligrams of amphetamine were administered to volunteer

subjects every hour until every subject crossed their particular threshold for *personality change*. The graduate students underwent a global mind-brain-person transition at differing total doses of amphetamine. The subject's world was suddenly transformed into one of threatening enemies and few friends. The syndrome dissipated over several hours when the drug was stopped and the plasma levels of amphetamine and its metabolites declined. As amphetamine makes memory formation and recall stronger, the subjects were embarrassed when remembering what strange and forbidding things that they so strongly believed. These included plots such as: they were part of a group of good people caught in a network of evil Russian spies; some one among them arranged for poison gas to be seeping out of the water faucet; the white coated scientists were CIA undercover intelligence officers hoping to get information about their small pornography collection. The subject's world had become unarguably threatening and, for each person, in a personal yet stereotyped way. They spoke in guarded fearfulness and anger at their undeserved persecution.

After a couple of weeks of return to normal living, the experiment was repeated. Each subject again developed his or her individually unique set of good-guy, bad-guy delusional beliefs and at approximately the same dose of amphetamine as before. Like those of strong faith, their ideas once again resisted the logical arguments made by the professional staff: that the new realities had an obvious pharmacological origin. While on the drug, all stuck to their story, even while being shown the movie record of their first drug-induced episode. There is reliable scientific literature describing kamikaze pilots on high doses of

amphetamine in an ecstatic state of Shinto nationalism. With their planes loaded with explosives, they deliberately crashed their planes onto American aircraft carriers in the Pacific Theater of World War II. One wonders if these drug-induced states occur in the drug-free condition in today's abstemious Muslim suicide bombers.

As noted above, a more abstract and general way of thinking about the sudden emergence of fixation, repetitiousness and splitting in feelings and thoughts involves the emergence of regular *limit cycle oscillations* in a complex system that was behaving previously in a stable but flexible way. *Locking up* into a fixed, *closed loop*, is a common way for electrical circuits, computer programs, brain mechanisms and other complicated systems, even cultural or spiritual movements, to behave when one or more important control parameters crosses a threshold. Doyne Farmer of the Los Alamos's Prediction Company once said about this vulnerability in complex system, "Those things can hardly wait to roll up." The *limit cycle lock-up* occurs most often as a sudden, discontinuous change, a *bifurcation*, into *autonomous self-oscillations* from an equilibrium state around which there was some random variation. A *bifurcation*, a *discontinuous change in outcome from a smooth change in cause*, characteristically occurs when the amount of an important influence, a metabolic state, a drug, a psychodynamic conflict or level of emotional stimulation crosses some critical value. The switch from one type of dynamical behavior to another looks like the system has suddenly changed into something else with an *entirely new kind of life* of its own. In the new life *of rolled up, locked-up repetitious motion*, almost all new starting conditions follow pathways that lead into

the same limit cycle pattern. Some Evangelical Christians regard *born again life as being fixed in a complete set of moral, social and political beliefs, ideas and judgments*. Rigid interpretations use The Book as the text. The *limit cycle* gets its name because the end state of the orbits of almost all starting points of the dynamics winds up being drawn into the same fixed, repetitious pattern of a stable cycle. Visualizing the simulation of one kind of *bifurcation to a limit cycle* on a computer screen, we see a slightly jiggling point explode suddenly into an orbit of ceaseless rotations around a circle.

Ralph Abraham, the University of California at Santa Cruz pioneer in graphical approaches to nonlinear systems, describes, cinemagraphically, the emergence of limit cycles from a single point. He starts with a picture of an *attractor* of water flow in the shape of a basin. All water that enters the basin, rolls down its sides to the bottom, to what physicists say represents a *potential energy minimum*. A little more technically, this *attractor basin* is composed of the set of all points such that the orbits that flow from them tend to end up inside the basin as time goes toward infinity, no matter where they start. Changing the value of a control parameter of the system changes the shape of this basin-like landscape, of the surface of the systems dynamical actions called a *manifold*, which can intuitively predict how the fluid will flow upon it. If we start with a simple bowl, a *parabolic basin*, then the *attractor* itself is a point at the bowl's very bottom. Changing the value of some influential parameter may induce the sudden formation of a small hill, growing at the center of the basin's bottom. Now fluid flow in the attractor bowl runs down to a path around the hill at its bottom. The autonomous motion of the fluid

flows takes place now in a *circular orbit*. The *basin of the new attractor* is the original bowl minus the point at the top of the central hill. The fluid flow around the hill at the bottom of the basin is circular and is called a *limit cycle*. Note that the *direction of the rotation of the limit cycle can circle in one direction or the other*. In some computational simulations, *motion alternates between directions*. This suggests the good versus evil aspect of the born again *amphetamine splitting religions*. There is an intermixed probability of right versus left turning directions and their alternation. This vulnerability to directional *splitting* and often *unpredictable alterations* in action themes can represent what seem to be paradoxical combinations of both good and evil in the same strongly faithful; for example, the apparent bidirectional morality of generous and loving, pederast priests.

These mathematically flavored images of the sudden emergence of a limit cycle following an amphetamine bifurcation in complex systems was made even more biologically concrete to me by the research program conducted by one of my first graduate students, David Segal. He is now a professor of psychiatry at the University of California in San Diego. His program of work involved the administration of very gradually increasing doses of amphetamine to rats while their behavior was being monitored and recorded by a continuously running video camera. He documented the behavior of rats in a walled rectangular space within which, without drugs, they first wandered about randomly and then settled down to rest in an individually selected, favorite *home corner*. Segal called all of these quantifiable phenomena, *patterns of exploratory behavior*. At doses of amphetamine below 2.5 milligrams (mg) per kilogram weight (kg), the exploration of the entire

bounded space proceeded faster than was the case with their salt-water treated controls, their paths being more uniformly distributed throughout the box. They spent less time resting in their home corner. At almost precisely 2.5 mg/kg, the rat's behavior changed dramatically into an entirely new pattern of *continuous circling*. As was the case in the *abstract manifold* picture of *bifurcations to limit cycles*, some rats tended to circle their chamber to the left and some to the right and switching directions was also seen.

The influence of amphetamine and other brain dopamine neurotransmitter-mediated drug manipulations on *directional turning tendencies* in rats, mice and cats were the focus of brain and behavioral research of Professor Stanley Glick of the University of Massachusetts. The asymmetry of dopamine concentrations in the two sides of the brain, particularly in the *medial prefrontal cortex* and the brain stem's *nucleus accumbens*, predicted both the paw preference for pellet reaching and direction of turning in several studies in rats. These findings were statistically true over a population of rats, but not necessarily predictive for any single one. Reminiscent of the conflict between good and evil in our human spiritual analogy, naturally right turning male rats and left turning female rats, when compared with the opposite paired group, were greater voluntary ingesters of alcohol placed in their water bottles.

*Turn directional splitting* as a part of the phenomenology of *limit cycle bifurcations*, with implications for good and evil doing, has neurological support in humans as well. Recall that in the context of contrasting *right versus left hemispheric temporal lobe syndromes*, that temporal lobe seizures with a right side

excitatory focus leads to the development of the *Geshwind Syndrome*, a high, softly energetic and saintly state of spiritual preoccupation and voluminous writings, loving and generous kindness toward all and disappearance of sexual interest but not sexual potency. A left temporal lobe excitatory focus leads to the development of the *Kluver-Bucy Syndrome* of indiscriminate aggressiveness and hypersexuality. Experimental simulations of this syndrome in cats lead to them mounting and attacking living and nonliving things, even chairs. A variety of manipulations of the symmetry of brain dopamine concentration and dynamics by its characteristic drug, amphetamine, interact with lateral brain lesions such that we conclude that the stimulant-induced limit cycle lockup remains a phenomena influencing and influenced by drugs, sexual variables, psychological state, genetic predisposition and social circumstances. This situation is perhaps not so different in variety and complexity from the range of representations in art and literature of the *left hand of evil* and the *right hand of grace*.

Oscillations that appear spontaneously in nonlinear systems without external periodic input were known to Henri Poincaré in 1882, and were systematically studied and made accessible to non-mathematicians by early 20<sup>th</sup> Century Russian mathematicians and physicists, well represented by a 1949 book, *Theory of Oscillations* by the Russian engineer-mathematicians, A. A. Andropov and C.E. Chaikin. Another relatively early classic is *Nonlinear Oscillations* by Nicholas Minorsky. The most common form of an apparently spontaneous *transition from a fixed point to a limit cycle* was pictured as changes in the surface of the action, the *bowl-hillock manifold* described above, and is called a *Hopf bifurcation*. Recall that

bifurcation means a discontinuous change in an observable over a continuous change in what is known as a *control parameter*, such as dose of amphetamine or intensity of an experience. The mathematical mechanism resulting in circular directional motion represented by the (*eigen*)*vectorial states*, was named for the German mathematician, Eduard Hopf. His 1942 paper was a mathematical proof of its existence and was discussed in the context of *fluid flows* that role up such that *circling vortices* arise from smooth, called *laminar*, water flow, at a critical value of the flow rate. Hurricanes are another example of these kinds of dynamics.

The *Hopf bifurcation to limit cycles* has been found in several, many dimensional, physical, chemical and biological systems. The latter include calcium conductance oscillations in the excitable membranes of muscle, heart and the brain, cardiac arrhythmias such as *ventricular flutter* as well as oscillations in population numbers in foxes and rabbits, more generally called predator-prey systems. Interesting examples include the *self stimulation limit cycles*. The experiments of California Institute of Technology's Professor, James Old and Johns Hopkins Professor, Joseph Brady demonstrated the potential for repetitive human compulsion and the brain's inclination to get locked up into limit cycle behavior. They demonstrated that animals, from rats to monkeys, could get fixated in cycles of apparent self torture, repeatedly and endlessly pushing a bar to deliver current to pain systems in the their brains. These pushes induced almost unremitting screams in monkeys and what appeared to be rageful biting and then immobilized resignation in behaviorally depressed rats.

Freud's last paper, *Analysis, Terminable and Interminable* (1939), featured examples of what he perceived to be the unsolvable mystery of helpless psychological entrapment in repetitious patterns of self-destructive behavior. He blamed the Iliad's and Odyssey's villainous immortal, *Thanatos*, the ever-threatening spirit of death and destruction in contrast with the good, life giving *Eros*. The Yiddish word for a personified *Thanatos* is *Moloch ha-Moves*. A range of fixations in self-excitatory, repetitious, self-mutilating behaviors is documented in domesticated animals. Dogs, particularly German Shepherds and Labrador Retrievers, can lock up in compulsive grooming cycles of what is called *acral lick* in which endless licking of paws or flanks lead to the break down of skin into seeping-sore dermatitis, which, in turn, stimulates more licking.

Mark Twain wrote a story about his getting stuck in ceaseless mental repetitions of a catchy, clangy poem. He could not stop reciting it to himself even after days of distraction and sleep loss. He was finally cured by relating his problem and the poem to his pastor who he then heard unwittingly creating a community epidemic by including the rhyme in his following Sunday's sermon. Psychologists, who study this form of human *mental limit cycle attacks*, call this state of internal, repetitiously recited, poetic stuckness, *earworms*.

There are additional invariants of sudden transformations into spiritual-mind-brain bifurcations into a limit cycle lockups and one of them, as noted, is psychological *splitting*. In psychoanalytic theory, as first suggested by Freud in his 1937 written and posthumously published paper, *Splitting of the Ego in the Process of Defense* (1940), *splitting implies two simultaneous and contrary psychological*

*reactions*, one can be conscious and the other unconscious. They can both emerge in conflictual situations involving adaptive efforts of the personality to deal with the opposition between some form of powerful instinctual pressure and attendant perceived or imagined danger. Otto Fenichel's *Psychoanalytic Theory of Neurosis* (1950) elucidates multiple manifestations of *splitting of the I* (more technically, the *ego*) into a *conscious* part that knows reality versus an *unconscious* part that denies it. In some situations, a logical view contends with a more irrational, magical one.

Today, the White House morning group praying, evening hymn singing, Christian Republican Right Wing, not unlike the Muslim and Jewish Fundamentalists, feed their feelings of being on the side of God by dividing people into those that are like them and good and those that are not, the evil ones. Their splitting impairs policy development and strategic thought. Recall that psychoanalytic theory posits that the evil doings of others represents the projected repository of our own unacceptable impulses and inclinations. It became quite clear in own my life, through my psychoanalysis and psychoanalytic training, that the *healings of my splitting* will require the knowledge and acceptance of my own unacceptable things. The hope is that will lead to compassion and love manifested by my understanding and forgiveness of others. The reader must, by now, be aware that with respect to my attitude toward Fundamentalism, there is still much work to be done. My own undercurrent of rigid judgementalness of judgementalness feels like fear and anger and alienates me from an understanding of and compassion for these others. The Platonic excuse to myself is the mathematical universality in the behavior nonlinear complex, systems such as the mind, brain and society.

As we dig deeper into global brain-mind dynamics of *emergent high-energy fixation, stuck repetitiousness and splitting*, we encounter their universality in the structures of mathematical thought. Did we just make them fit? Do these thought forms map onto internal and external physical reality? Are these abstract concepts and operations simply products of our biological brains manifested as psychological mechanics and used to explain to ourselves what we perceive and think? Does a square have external reality or is it a universally imagined something, and, as such, represented only in our minds and the pictures of it we draw? Is mathematical understanding simply inborn perceptual skills combined with developed and practiced logical cognition? Or, do we take the *Platonic view of mathematical relations*: these abstractions are the *ultimate realities*, antedating and persisting through the past, present and future of the universe and omnipresent.

Where can the conceptual boundary be drawn between the physical reality of the Babylonian surveyors use of the *Pythagorean theorem* to calculate distances, that the sum of the squares of the lengths of the two legs of a right triangle is equal to the square of the length of its hypotenuse, and its abstract, pencil-marks-on-paper, algebraic development as in the definition of *Pythagorean numbers*, *a, b, and c* such that  $a^2 + b^2 = c^2$ . The dichotomy between the abstract and concrete, consistently blurred in our work, is between a *natural science* with ideas that can be disconfirmed, directly or indirectly, by experimental observation and the thinking of mathematics as an *a priori field* in the sense of Kant. The modern Platonic view such as that held by Rene Thom is that once accepting a set of *natural givens*, called the *axioms*, the rest of the knowledge of this reality grows in the form of

theorems that relate to the axioms and each other through their logical consistency. Knowledge of reality is moved by the ever-forward mathematical refinement of *a priori* conditions to *do away with the theorems' exceptions*, called *counter examples*.

The Hebraic Bible's view of *signifiers* such as words and symbols is close to, but not identical with, the Platonic view of mathematical formalism. According to the Torah, God made the word with words. God spoke and the world became real. The Aramaic for "I create in speaking" is *avara k'davara*, or as the magician says, as he waves his wand over an apparently empty black high hat, *abracadabra*. The Hebrew word for *word*, *davar*, also signifies *thing*. This view contrasts with the mathematical *formalists*, among them Hilbert, who considered the *signifiers of abstract mathematics simply symbols used in a game, the rules of which being arbitrary, must include proofs of consistencies among them*. Consistency from the point of view of physics was addressed by Hertz, in *Die Prinzipien der Mechanik*,(1894), where he expressed the formalist theoretical physicist's work as "...within our own minds we create images or symbols of the external objects, and we construct them in such a way that the logically necessary consequences of the images are again the images of the physically necessary consequences of the objects."

In another set of related contrasts about mathematical ritual and faith, the *constructionist* mathematician will argue that mathematical assertions are only true if they can be demonstrated, found or constructed. In contrast, the *classical school* of mathematics develop the case for the truth of mathematical statements if they are consistent with field's network of theorems and proofs, even if, up to the current

time, no specific example of this truth can be demonstrated. The former can be thought of as a *builder*, the latter as a *discoverer*. For example, suppose we try to make a proposition about *perfect numbers* where a perfect number is defined as being equal to half the sum of its divisors. Using the perfect number 6, we find that its divisors are 1, 2, 3 and 6; half of their sum, 12, is 6 thus our perfect number. We could make the proposition: either there exists an odd perfect number, or else there exists no odd perfect number. An expression of this forced decision between yes and no is called the *excluded middle*. The *constructionist mathematician*, an orientation partially defined as one without the excluded middle, asserts that “an odd perfect number exists” would only be meaningful if one could show that such a number had been found or constructed. The practicing faith of *classical mathematician* would find the phrase “no odd perfect number exists” meaningful without a concrete example, if the assumption of its existence would lead to a no (versus yes) contradiction encountered in the proof-relevant network of established theorems and their relations. The symbolic operations of these formal schools of mathematics and their relationship to the objective and ideational realities of brain-mind-spiritual life have been viewed by some as Western cultural products rather than expressions of secular or spiritual Absolutes. Still others have argued that cultural relativism is not relevant here because mathematics and mathematicians worldwide constitute the unified language of a monoculture.

In my faith in the real world existence of underlying and pervasive abstract mathematical structure, the Platonic bias must be obvious. It sounds somewhat coldly intellectual but its not. The thrilling experience of a new reality I get to know

from finally understanding how a theorem works and the rush of peering into the grandeur of the geologists' God's gift, the Grand Canyon, feel like the same kind of full-of-wonder high to me. I blend them here without reservation. Perhaps this world of spiritual abstraction is closer to the orientation of the school of *intuitionist mathematics*. Its founder, L.E.J. Brouwer, required that every mathematical construction be so immediately apparent to the human mind that no formal proof was necessary. This experience became a form of *spiritual transcendence*, which led naturally to my *mathematical, mystical faith*.

We carry the explication of this kind of abstract, mysterious reality further. Reflections of the good versus evil, right versus left, clockwise versus counterclockwise, moral directional biases and their relative weightings in *born again bifurcations* to *bidirectionally rotating invariant circles* called *limit cycles*, are symbolically mediated by what are called the *complex eigenvalues* of differential matrices describing the system's motional tendencies with changes in context and control parameters. The behavior of these *complex eigenvalues* underlies and characterizes the deepest aspects of the mathematical mechanism of the *Hopf bifurcation* as well as my personal excuse, inevitability, for my own splitting between Fundamentalism and a relativistic, humanistic hope for my seeing God in everybody, and therefore myself.

Before taking on this final small piece of an example of universal mechanics, I have to admit that the subject of complex eigenvalues brings up in me (and perhaps in some readers) the emotionally disturbing subject of *imaginary* and *complex numbers*. I can still feel a little of my earlier anxiety. The episode started

benignly enough. Our high school's freshman algebra class was studying how to solve quadratic equations, equations in which the highest power of an expression was two. Told to work at the blackboard in front of the class, I was given the problem of finding the two values of  $x$  that were the roots of the equation,  $5x^2 + 3x + 4 = 0$ . I had been taught to use the memorized *quadratic formula*,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a},$$
 in which  $a = 5$ ,  $b = 3$  and  $c = 4$ . After making these substitutions,

I always calculated the square root part first and wound up with the expression,  $\sqrt{9 - 80} = \sqrt{-71}$ . I can still feel the sinking feeling in my stomach as I looked at the result. I waited for the usual snide remarks and embarrassment as I thought about doing what I did not know how to do, *taking the square root of a negative number*.

Mr. Kirby, the retired mechanical engineer, who was my high school freshman algebra teacher, tried to help, but I did not trust him. It seemed to me that he had already humiliated me in front of the class several times. He asked, "... what number when squared, multiplied by itself, would equal  $-1$ ." He then asked it another way: solve the following equation for  $x$ :  $x^2 + 1 = 0$ . Seeing something I could do, I wrote the next line quickly  $x^2 = -1$  and then, taking the square root of both sides, I wrote  $x = \sqrt{-1}$ . He then asked me what that meant. I answered by writing quickly, glibly and blindly that what it meant was  $\sqrt{-1} \times \sqrt{-1} = -1$ . He asked me to give him an example of this operating in the real world. Even then, I was of the mind that operating with abstract mathematical symbols was a real world. Not yet knowledgeable about imaginary and complex (the latter combining real and imaginary) numbers, and without the full confidence my current faith in the invisible,

real existence of the mystical mathematical world, I stood head down and silent, thinking that my smart friend, Jerry Blau, would get the answer immediately. Mr. Kirby said he would go on with the class while I continued to stand in front of the blackboard and thought about it. He told me to interrupt him when I was ready to answer. Some classmates were smirking, others giggled aloud. They had seen him do this to me before.

Mr. Kirby was a short, muscular man, an ex-marine with a military haircut and a brusque manner. Woven into his lectures was the opinion that mathematical competence and obedience to authority and personal discipline were all of a piece. I asked him about mathematical creativity and he said that this algebra class was certainly not about that. I feared and disliked him. He felt (and wrote a note to my parents to the effect) that, being “too arrogant” I needed to be “brought down a peg or two.” I had gotten the best grades in the first two exams and was enjoying the role of after school tutor for some of my friends. I suspect I was getting pretty egotistical. In class, I found myself eagerly shouting out answers without holding up my hand, behavior that Mr. Kirby met with a look of fatigued disgust. Twice I was thrown out of class, to stand in the hall, for my introjections. He then began to give me problems that I could not do, for which I was not prepared. This left me standing at the blackboard until the end of the hour, after all the rest of the students had solved theirs and sat down. On parent’s night, Mr. Kirby told my father that I needed more “social and intellectual discipline.”

His class room became a place of potential humiliation and fear. I dreaded going in and was relieved to get out. I spent the time only partially listening, mostly I

relaxed into sexual fantasies, which I had recently discovered were like anti-anxiety medications. Later, as a psychiatrist, I saw many instances of the use of erotic preoccupation and acting out in patients who felt the fear and threat of humiliation and diminishment in their careers or marriages. I had become a secret reader of the book on one of the top shelves in my father's library by Jack Hanley called "How to Make Mary; A Gentlemen's Guide to Seduction." One day, in an impulsive gesture, inspired by the book, I reached behind me, through the crack in my desk seat, to caress the inside part of the long smooth legs of the well developed, tall and beautiful brunette girl behind me. She made no objection and it became almost a daily occurrence. Her posture became more slumped and she extended her legs so I experienced the delight of gently rubbing where her panties were moist. My resonant sexual excitement and adolescent pride to me out of the humiliating dungeon of Kirby's harassment. I began to look forward to the class and the comfort and affirmation that her voluntary participation made possible. I was never caught and she pretended that nothing was happening. In fact, she never talked to me outside of class. I continued to do well in the class, but now, quietly. On my next report card, in the section for comments, Kirby noted that I had obviously gotten the message and had become a more respectful and well behaved good student. I felt then, vaguely, and now, more specifically, that a content enriched, instinctually titillated and excited unconscious, an "activated mind," could lead me to the solutions of both emotional and intellectual challenges, if it were both sufficiently indulged and untrammelled, left alone in its joyful work of being itself.

Since then, among my graduate and post-doctoral students in the neurosciences, I have learned that the Mr. Kirby's of modern American educational practice have ruined generations of potential mathematicians and physical scientists. Worse, they have created generations of very bright math phobics who run to other graduate fields such as biology and medicine and come to resist the potentially humiliating incursions of new and potentially helpful abstract ideas and operations from mathematics and physics into their fields. They do not want their persecutory versions of Mr. Kirby to take up residence once again in their heads. I can still feel his negative presence during long hours of struggle with the ego deflating feelings of dumbness that an understanding of almost any new mathematical concept requires of me. Holding Mr. Kirby's voice off as long as I can until, sometimes, the wonderful "aha!" experience arrives. I have tried to forgive him since but forgetting him has not been possible.

It turns out that in the world of elementary, physically representative, real numbers, the *square root of a negative number* has no simple meaning. Such an obviously different kind of number symbol has understandably come to be called *imaginary*. Was this the answer Mr. Kirby wanted? There was some conflict among mathematicians in the 17<sup>th</sup> and 18<sup>th</sup> Century about the arbitrary definition of  $\sqrt{-1}$  as an *imaginary number*. It was symbolized by a letter,  $i$ , that is  $\sqrt{-1} \equiv i$ . The existence of  $i$  extended the range of algebraic definitions so that a solution of the quadratic formula as above could be written for the square root of a negative number. A

further expansion of this idea was to that of a *complex number* that can have both a real and an imaginary part.<sup>18</sup> .

Closer to an image that helps make *intuitive connections with human born again bifurcations, limit cycles and directional splitting* is the geometric interpretation of a complex number, let us now call it  $z$ .<sup>19</sup>

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<sup>18</sup> For example, letting letters be generalized representations of numbers, a complex number might be written,  $a + bi$ , real number  $a$  + real number  $b$  times  $i$ , the letters such as  $a, b, c, d...$  symbolized real numbers. Consistent with membership in an algebraic system,  $a + bi$  and  $c + di$  can be added and multiplied. This extension of the real numbers into the imaginary realm permitted d'Alembert's and Gauss's proofs (and many, more complete ones since) of the powerful *Fundamental Theorem of Algebra* from which the faith derives about always being able to find at least one solution to an algebraic equation. It was proven that *any  $n^{\text{th}}$  degree algebraic equation (e.g.  $x^n + x^{n-1} + \dots = 0$ ) with real or complex coefficients always has at least one real or complex root*

<sup>19</sup> As above, algebraically,  $z$  is the sum of a *real part*  $a$ , plus  $b$  times the imaginary part,  $bi$ ; that is,  $z = a + bi$ . We can then set up a *geometric space* to represent  $z$  by imagining a *two dimensional plane* with the horizontal *real axis* extending from left to right, the usual  $x$  axis, and the vertical dimension, called the *imaginary axis*, extending from bottom to top like the standard  $y$  axis. These two axes, going from negative values to positive ones, left to right and bottom to top, cross at the shared value of 0. Thus  $a$  and  $b$  can be visualized as the rectangular coordinates of a point in the plane and the point locates the complex number,  $z = a + bi$ . Since real parts and imaginary parts are like apples and pears and for addition, like must be added to like, if two complex numbers,  $a + bi$  and  $c + di$  are equal, then  $a = c$  and  $b = d$  and their sum is written  $(a + c) + (b + d) i$ .

Now that we've set up a point  $z$  on the plane, located with a complex number at  $z = a + bi$ , we can then draw an arrow, called a *vector*, from the intersection of the imaginary and real axis at  $0$  to this point  $z$ . Its *length* from  $0$  to  $z$ ,  $Oz$ , we'll call that length  $\rho$ , is the size or amplitude-like *modulus* of the complex number,  $z = a + bi$ . The *angle* this  $Oz$  vector makes with the real,  $Oa$ -axis, lets call this angle  $\phi$ , is called the *argument* of complex number  $z = a + bi$ .  $\rho$  is a length that can grow or shrink,  $\phi$  is an angle that can rotate. We imagine vectorial movement like that of a variable length hand of a clock. This geometric explication of *complex numbers* prepares us to visualize *complex numbered eigenvalue* solutions to matrices representing the relevant equations that bifurcate to limit cycles and directional good and evil splitting.  $\rho$  represents the dilatable clock's radial amplitude of circular motion and  $\phi$ , the angle of vectorial turning from the  $Oa$ -axis.

The *complex conjugate* of the complex number,  $a + bi$  is the complex number  $a - bi$  in which the sign of the imaginary part is reversed. Geometrically, this means that a pair of complex conjugate numbers with the  $\rho$ 's of both having below zero values relative to the  $Oa$ -axis, that is *negative real parts*, could be imagined as the points indicated by two same sized, mirror image, clock hands pointing at 8:00 and 10:00 o'clock. Note that the  $\phi$ , the angle of vectorial deviation of the arrow pair from the  $Oa$ -axis, turn in opposite directions in

The mathematical mechanism underlying the *Hopf bifurcation of fixed points* into *limit cycles* (associated with bi-directional splitting that accompanies the *amphetamine transformation* into limit cycle stereotypy of rigid ideas and equally likely mirror image motions in the directions of good versus evil) is the crossing of the systems real valued parts, the  $\rho$ 's in Footnote 19, of its *complex conjugate eigenvalues* into positive territory,  $\rho > 0$ . The mirror image of clock arrows is transformed from 8:00 and 10:00 o'clock to the clock locations of 4:00 and 2:00. *At a Hopf bifurcation, a pair of complex conjugate eigenvalues crosses the imaginary (vertical) axis such that its real parts have positive value.* In the orbit representing the motions of the system itself, the fixed point disappears to be replaced by the action spiraling out to an *invariant circle*. This is analogous to our *manifold* image of the disappearance of the central attractive point and the sudden appearance of a small hill at the bottom of a *parabolic basin of attraction*.. The new attractor is an invariant circular path around the hill, with the *spiraling out to the invariant circle* being a two dimensional picture of the disappearance of the bowl-bottom and appearance of a missing point, hill top fixed point and a spiral flow to the path circling the hill. *Underlying the transition from a fixed point to a limit cycling, invariant circle, are a pair of mirror image complex conjugate eigenvalues that turn*

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these mirror image moving clock hand vectors. Without going deeper into the representation of the actions of the system in question (its differential equation) in the form of what is called its *Jacobian matrix of partial derivatives* (a matrix representation of the differential equation indicating orthogonal directional velocities of change of locations of the components of the motion with respect to changing values of the control parameter), we know that when the  $\rho$  of the matrix's set of two *complex conjugate eigenvalues* is less than zero,  $\rho < 0$ , the orbit representing the system, spirals into a *stable fixed point*. This is analogous to going to the *bottom of the parabolic attractor basin* as described above. *Values of the invisible eigenvalues and their changes constitute the abstract mathematical mechanisms underlying the physically observable dynamics of the system.*

*in mirror image, we could say, good versus evil, opposite directions. The Hopf bifurcating system inevitably has both.*

The implications of this *very abstract metaphor for the emergent limit cycle-splitting style* of spiritual transformation can be made deeper by considering the common practice of Rumi's Mevlevi (and other) orders of Islamic Dervishes that facilitate the onset and maintenance of their ecstatic states by an improvisational dance which goes from rocking to irregular whirling. The Dervish teaching tales place a symbolic emphasis on the power of the rotating wheel, the circling of the heavenly bodies, the mill wheel and the millstone. As Rumi said, "The mountain of the sun I'll fashion to a mill. And as my waters run, I'll turn thee *at my will*." Note that their work toward spiritual transformation results in neither the emergence of the involuntary and rigid limit cycles of invariant circles or the associated divisive internal eigensplitting of good self from evil other. The *Sufi compass points to an integrated field of divine consciousness, which contains the appearance of the world's multiplicity. In this profound unity, all humankind is perceived as one family.* The singular direction of all prayer, Salat, five times a day, at dawn, high noon, afternoon, sunset and an hour after sunset, turns the entire world into a unified directional field of prayer. At its center, the Islamic pilgrims wander round and round the black cube of the *ancient shrine of Kaaba,*

This leaves one with the speculation that we started with: that the simple, authoritarian rules of the *amphetamine, roll-up and splitting religions* may be intrinsically more vulnerable to unpredictable breakouts into morally inconsistent actions and that the righteously rigid limit cyclists are invariantly split into

ambivalence. In contrast, the more free form, *chaotic turns* of the entheogenic dervish define us all as belonging to one unified ecstatic field.

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## CHAPTER 8:

### TRANSCENDENCE AND RATIONALITY

It was my belief that, without subjective evidence of the energy of the Holy Spirit, the rush of reconfiguring transcendent experience, some glimmering of grace no matter how fleeting, an experience of intoxication with God, Martin Buber's self authenticating *I-Thou encounter*, the many good citizens of this world, without these moments of illumination, must be attending church or temple to negotiate a better now and hereafter. It was one of the premises of this book that these signs of Abulafia's, the Jewish ecstatic's, *activated mind* indicate a doorway into spiritual knowledge. Regular attendance at synagogue or church, without the anticipation of the insightful accoutrements of mystical high, seemed like a superstitious rabbit foot rubbing for personal health and safety and a sharing of propitious contacts for social and economic advantage. Perhaps my desire and rationale for cataclysmic ecstatic transcendence is to be expected from only a partially rehabilitated Freudian psychoanalytical therapist indoctrinated in the theory's implicit message that Love is sublimated sexual instinct. The psychic energy of *eros* of the philosopher Plato is isomorphic with the libido of psychoanalysis, its spiritual manifestations, no matter high minded, are Freudian forms of the *inhibited aim* and *sublimation* of the sexual impulse. It's a scenario of potential crisis and change.

On the other hand, I have experienced the good feeling of ethical rightness in doing what Jews call *Tzedakah*, the sharing of supplies by the haves for the betterment of the have nots. Much of the spiritual work of the Reformed Jew is called *Tikkun Olam*, doing meritorious deeds in the interest of improving ones human and physical environment, doing works that make the world a better place than we found it. I have known the satisfaction and quiet calm of human right action as in the Unitarian Universalist's serving the needy, being open and flexible, in intimate mindfulness of others and their needs. Considering *E.O. Wilson's* brand of herd brain biology of *altruism* gives me the optimism about the intrinsic goodness of man. This love is not *eros* but *agape*. This word for love was used in the Greek translation of the two commandments, "Love the Lord your God with all your might" and "Love your neighbor as yourself." As C.S. Lewis pointed out in *The Four Loves*, unlike *eros* which derive from and focus on feeling, "...*agape* is a state of the will." It changes ones world in a different way. Lewis argues that if you will the best for someone and act upon it, even if its someone you don't like, you begin to dislike the person less, even like him a little more and in reflection, yourself. Lewis felt that *eros* was a transient experience, born to habituate and if chased, yielded personal and social chaos. In contrast, *Agape* aged like fine wine, even turning erotically driven romance into deep and long lasting mutual caring and respect.

*Eros* arrives and departs like an episode of reconfiguring experience and has as its metamorphical mathematical language in bifurcations and turbulent phase transitions. *Agape* is achieved with a steady will and faith and maintained as a homeostatically compensated, statistical equilibrium.

It is a comparison and choice with which I still struggle. Compared with the *Jamesian brands of ecstatic transcendence*, minds blown in Sufi twirling, Orthodox Jewish chanting, rocking and dancing, hands-in-the-air praying and hands-on-the-head healings of Wednesday night Pentecostal services, the soberly serious social engagement and responsibility sermons of Reformed Judaism and the Unitarians as well as the 19<sup>th</sup> Century hymns and high I.Q. apologetics of some Presbyterian and Methodist clergy, feel like near beer. Formally equivalent but without the rush and the delicious risk and promise of life long addiction.

Current national opinion polls have found the inclination toward churchly fireworks in religious experience growing more common. My Charismatic Christian sons are among the many with a preference for and loving labeling of these kinds of houses of worship as rock and roll churches; megachurch arenas with stage lights, elevated pulpit, multiple choirs, a pit orchestra and many large and dangling flat t.v. screens. A Starbucks can often be found in the lobby. The pastor often dressed quite casually, works at plain spoken accessibility and belief in miracles. After his conversion and described in *Surprised by Joy* and *Miracles*, C.S. Lewis defined a miracle as an "...interference with Nature by supernatural powers...." Today's Charismatic Christian are taught by the Pastors of the megachurches to expect them. In a recent survey of Americans, 46% of respondents claim to be twice born, Evangelical Christians. Perhaps somewhat impairing with respect to their children's academic and professional ambitions, particularly in fields related to biology and medicine, 48% do not accept a Darwinian view of biology. Over fifty million American readers have in the past few years bought books with plots taken from the

*Babylonian prophecies* and anticipate the *Rapture of Return* with weekly, joyful, mini-rehearsals. They include praying in tongues as the Spirit moves them like Peter, John, James and the rest of the one hundred and twenty in the upper room on the day of Pentecost.

Those of us with two or more available cable religious networks can, on any given Sunday morning, can choose a smiling, kind, Proverbs quoting, rational Presbyterian liturgical stylist. In his seventies, standing tall with a full head of white hair and in a quietly resonant voice, he delivers a sermon about seven ways to avoid growing old. His list includes learning new things and continuing to work. Most of all, he quoted Paul in Romans 12, continue to live in agape love, "Love one another with brotherly affection, giving precedence and showing honor to one another." His spiritual proposal was about personal faith, about always leaning on the Lord.

At the same time on another network, the three hundred pound, restlessly pacing preacher of the Cornerstone Assembly of God Church of San Antonio, Texas, stood in front of large maps of Iraq and the Middle East. He preached from Ezekiel about the refleshing of dry bones and a return of all Jews to Israel. He said that contributions to his church over the past year helped finance the return of 4000 Russian Jews to Israel. He reiterated the promise that, when the return was completed, there would be a massive Islamic attack on Jerusalem and "we will all rise up to Heaven" in an ecstatic disappearance. Jews, as long as they accepted Jesus as their Savior, were welcomed along on the ride. And we better hurry, as in Revelations 12, "...the devil has come down to you in fierce anger because he

knows that he has only a short time left.” More than two thousand parishioners erupted into loud applause along with shouts of “praise Jesus.”

An experience of something entirely different, neither human psychology nor frenzy, was an unanticipated benefit of being on a sabbatical at England’s Warwick University in residence in Math House #2. It was here that I met the intellectual fellowship and Christian *agape* that I had only read about in the writings of C.S. Lewis. This large, round, many windows and black boards, study with a small upstairs bedroom was one of the apartments for visiting professors behind the Warwick Mathematics Institute in the English Midlands. Though I went there to benefit from the experts in statistical descriptions of dynamical systems, called *ergodic theory* and applied mathematics of Christopher Zeeman and Ian Stewart, surprisingly, at lunch I found myself in conversations about metaphysics and God and taking up some of the faculty’s invitations to a variety of churches and synagogues on the weekends.

The perspectives that emerged for me at Warwick was that rabbinic *Haggadah*, inferences to be drawn from imaginatively spawned narrative, isn’t the same thing as *Halakhah*, the law dictated by Jewish legal tradition; that geometric insight and other intuitions aren’t the same as mathematical proofs; that the mystical visions of the English romantic poet and illustrator, William Blake, were not necessarily consistent with the scientific observations and logical arguments of the contemporary Scottish philosopher, David Hume. Paul Tillich wrote that the wisdom attendant to primary spiritual experience that was without the unconditional character of sensible moral obligation was not to be trusted without critical analyses.

I learned that among Episcopal and Jewish English academics, God is not a hallucinogen, but more like a spiritually based, ethical social contract that rewarded with fellowship with God and man. Nonetheless, even in this high altitude intellectual environment, as C.S. Lewis developed in what some believe was his best known sermon, *The Weight of Glory*, people must be convinced of the unwelcome diagnosis of sin before they can welcome the news of the remedy. The redemption of soul is a requirement for the joys of union with God. Very much alive today among Christian English academics are the messages of Lewis's *Mere Christianity*, the World War II, BBC radio talks, confirming the spiritual reality of the Incarnation, Christ's effectual sacrifice, the Resurrection, the Trinity, Heaven, Hell Sin and Salvation. I didn't expect these elements of Christian faith among Oxford and Cambridge "Firsts" that were now professorial Fellows.

In his 1929 essay, *Mysticism and Logic*, Bertrand Russell noted mysticism's preference for: (a) Insight over discursive analytic knowledge; (b) Belief in the unity of all things over oppositions or divisions in representational thought; (c) The denial of the reality of time, even in the divisions of past, present and future; (d) Belief that evil is unreal, manufactured by the innate divisiveness in some analytic intellects. In modern brain hemispheric and other neuropsychological philosophies, these countervailing descriptions of external observables can grow naturally out of the brain's abilities to *maintain logically incompatible perspectives simultaneously*. *Right-brain aesthetic holism* in contrast with *left-brain categorical analytics* recalls a popular example. Would one chose Blake or Hume to better explain how the time dimensions of memory disappear with the scent of a past lover or the hearing of his

favorite music for lovemaking. The right brain experience of Christian joy by Lewis was accomplished, he said, by being a left brained "...empirical Theist...I have arrived at God by induction."

In the inevitable mix of primitive instinct with high purpose, the visiting professors' Math House #2 had an aura of infamy. It was the one in which, by the accidental intrusion of a campus security officer, the brilliantly eccentric Northern California mathematician, Ralph Abraham, was famously arrested for pot smoking. The campus officer told me that, late one night, thinking he had smelled fire, he used his master key to make an unwelcome entrance. The incident became part of the record in House of Commons hearings about the intellectual and moral decay of English Universities. Apparently, even among English intellectuals, there can be trivial and politicized definitions of virtue. It was said that when visiting Oxford, Bob Jones, the founder of a Southern Christian university named for himself, judged Lewis for his pipe smoking and his regular evening "mouthful" of whiskey.

Christopher Zeeman was the head of the English Midland's Warwick Mathematics Institute and a world-class topologist who, among other things, demonstrated biological and social-psychological applications of Rene Thom's *Catastrophe Theory*. He invited me as a brain person and amateur mathematician, to see what might result from my mixing with members of his world class mathematics faculty. In addition to learning some bifurcation and lots of ergodic (geometric-statistical) theory, my chats with Christian and Jewish mathematicians on Saturday and Sunday morning visits to the synagogues and chapels of Oxford and Cambridge gave me a personal experience with the English intellectual's

religious tradition. I found that the spirit which I first met reading the work of C.S. Lewis was still very much alive. More than a few of these rigorous scientific scholars believed in the elements of Christian faith in full menu: virgin birth, incarnation, crucifixion, resurrection, original sin and the promise of salvation. I was disabused of my belief that these elements of Christian belief were incompatible with high logical and analytic capacity and intellectual sophistication. In this context, evolutionary theory is seen not as a violation of Genesis but, in the opinions of clergyman contemporaries of Charles Darwin, such as Charles Kingsley, Darwin's theory is more evidence for the majesty of God. It was argued that evolutionary theory implied the time-dependence of all material things as we know them. Even discontinuities in evolutionary emergence, what Steven Gould called *punctured equilibrium* and we have called *bifurcations* and *phase transitions*, represented awe engendering, nonlinear dynamical evidence of the miracles of God.

The spiritual climate among these English professorial Christians is dramatically different from today's post, post Vietnam return of the religious themes of the turn of the Twentieth Century, *big tent revivalism* and Billy Sunday's brand of *Christian patriotic America*. Today's fusion of the doctrinaire elements and political policies of Christian patriotism infuses George W. Bush's Republican base, Secretary of State, Condoleezza Rice's after dinner hymn singing and recalls Attorney General John Ashcroft's required early morning bible study groups for his Assistant Attorney Generals. Even the most religious of my English math buddies are without the adventitious baggage of today's faith based governance by ministerial politicians including the belief in the immorality and godlessness of

teaching evolution in schools, what has been called the massacre of the innocents in stem cell research and abortion clinics, the right to bear heavy arms and the intrinsically venal sinfulness of a man's commitment in love to another man. Was the clustering of these apparently diverse concerns the accidental result of a sociopolitical-religious short circuit, a politically opportunistic, class-resentment-driven, spiritual split in geographic, socioeconomic and educational class? Tim LeHay is selling millions of books, whole tables full at Wal-Mart's, which come packaged with these assumptions.

In the intimate life of these high I.Q. English theists, today's evil is seen as more subtle, abstract and pervasive, involving inner life themes of envy, vengeance, aggression and the absence of empathically made moral choices involving interpersonal kindness and evidence of caring about the well being of others. My contact with serious Christian English academicians taught me that even the mathematics of hard science can be viewed as a gift of grace and belief in the possibility of a continually emerging, Christ-centered, evolutionary process. Protestant philosopher mathematician Alfred North Whitehead in his 1926 *Religion in the Making*, Catholic anthropologist priest, Pierre Teilhard de Chardin in his *The Phenomenon of Man* and the more modern school of *process theology* as represented by New York's Union Theological Seminary do not exclude Christ's involvement in evolving science and all other new knowledge. They see Him participating in a spiritual evolutionary progress which does not gather the barnacles of fixed ideas about the murder of less than hundred-cell blastula or the psychoneurohormonally determined sexual partner preference. They know about

the ever-changing cultural and political appearances of faux and real evil. Nonetheless, what I learned from my Christian and Jewish friends at the mathematics institute was that, though the definitions of evil may change, evil as a construct and spiritual mechanism is an essential component of their spiritual experience. On Rosh Hashanah, Jews commit themselves to *Teshuvah*, making up for past evil deeds. The good versus evil dichotomous view of man's existence is true in the lives of Assembly of God Fundamentalists of Georgia as well as the sophisticated Readers, Professors and Dons of the Episcopal churches and university chapels of Oxford and Cambridge.

Finding high-level mathematical thinkers at home in metaphysical surrounds and sophisticated metaphysicians diligently practicing mathematics is certainly not new. Some instructive examples include the Pythagoreans, the 15<sup>th</sup> Century Catholic Cardinal Nicholas Von Cusa, who used geometric symbols to record his spiritual philosophy, and the Talmudic-Cartesian style of argumentation of Nicholas de Spinoza. The invisible reality of metaphysical truth take the form of mathematical universalities. This approach to an examination of metaphysical systems, sometimes called *mathematicism*, exploits the machinery of the mathematical mind to evaluate the consistency and completeness of thoughts, to create *representative axiomatic structures* and to operate within them using *syntactic calculus*. The frontier of that description continues to evolve in the body of mathematical theorems and proofs as well as the inner work of spiritual practice. The exercise of the rational dialectic of mathematicism, working for moral purity of heart, develops a brain-somatic discipline much like the exercises of Yoga.

As we have worked toward where we are now, it is evident that the evidence for a blend of intellectual and rational work yielding transcendent states comes in conflict with the original premise of these essays: my belief in the necessity of what William James and others have called the *primary religious experience* in order to know God. Recall that my father's favorite Jewish mystic, Abraham Abulafia, said this experience gives birth to an *activated mind* that can then immediately and completely inform the Spirit in a miraculous, not work-a-day, transformation. From the religious English mathematicians, I learned that it doesn't have to happen this way. One can work at thinking oneself to It. As noted, a well known example of a modern theistic Oxford type, the Magdalene College English tutor and Don, C.S. Lewis, in his introduction to St. Athanasius's *The Incarnation of the Word of God*, wrote, "...I believe that many who find that nothing happens when they sit down or kneel down with a book of devotion, might find that their heart would sing unbidden while they are working their way through a tough bit of theology with a pipe in their teeth and a pencil in their hand..." In contrast, without my personal experiences with joyful transcendence, the direct feeling of His presence, I would not have known about the goals of his intellectual analytic efforts. It was a struggle for me to use a rational mind to share the meanings of the poetry of his BBC lectures, *Mere Christianity*. This Reader from Oxford with two firsts in Latin and Greek followed by another first in English Literature (who failed his math entrance exams several times and got into Oxford by war service related exception) described the world as "...enemy occupied territory..." the omnipresence of the Good Power turned Dark

Power of the Prince of Darkness and the Christian as "...a man who is enabled to repent and pick himself up..."

For C.S. Lewis, religious faith came from intellectual hard work. He was put off by spirituality that arrived by "thoughtless" emotion. He found difficult to accept the efficacy of living in simple and loving direct conversation with the God within, as described by Brother Lawrence. Lawrence was described by Lewis in an uncharacteristically unkind way, as the simple "great awkward fellow who broke everything." Lewis had little faith in what he perceived as the mindless spiritual methodology of this selfless, silent, hard working Parisian monastery cook for a hundred fellow monks who was also their dedicated smelly sandal repairer. Perhaps reflecting his place in the British intellectual class system, Lewis wrote that Lawrence's conversations and letters in the brief pamphlet, *Practice of the Presence of God*, "...full of truth... but unctuous and repulsive." Yet, Lewis spoke of his own evidence for God as personal and experiential. In *Surprised by Joy* he concludes that, "I am an empirical theist. I have arrived at God by induction." It is likely that Brother Lawrence did not know and did not need to know the difference between the inductive and deductive methods.

For most of my years, I have been a subject of Jamesian transcendent experience, LSD expansive visions, Sufi moving meditation, long distance running, Black Baptist ring shouts, Tantric orgasmic withholding, Yiddish Labovicher dancing, Charismatic Christian Church rock and rolling, Hindu meditative rising Kundalini; almost any ecstatic crisis inducing the personal awareness of God. Recall that I am from a generation of seekers that a Donovan song inspired to

smoke bananas. I did not personally access Brother Lawrence's calm, work-a-day, devotional, quietly persistent, perspective yielding, inner conversations with God until my sixth decade. The opportunity came from growingly severe, unfixably chronic, pain. The counter-intuitive insight and helpful identification was gained from reading about Joseph de Beaufort's conversations with Brother Lawrence. Beaufort said Lawrence was born with the name Nicholas Herman in 1611 and renamed Lawrence in honor of his parish priest. As young soldier in the Thirty Years War of the 17<sup>th</sup> Century, he was severely injured. He was left with both sciatic nerves trapped between bone spurs and tissue scarring from his early twenties. These injuries, involving the two biggest pain-conducting nerves in the body, left him crippled in gait and in chronically severe lower back and leg pain from which he would never be free. It was after this time and a few years of looking for God in what he called "wandering in the wilderness" that he began his 40 years of monastery service as cook and sandal maker. He was described as amazingly selfless and a "...gentle man of joyful spirit..." who "...continually walked with God...not from the head but from the heart..." Doing long hours of selfless work with such painful disabilities, how was it that he maintained his joyful, loving and calm contact with God and his fellow man? How did he do it? I found that, as with all miracles of God contact for me, it happened by itself.

I suffered my first testicular cancer in my thirties. I felt the little hard rock by accident while scratching. It was on the left side. Surgical removal was followed by a five-hour radical abdominal lymph node dissection that left me with incidental abdominal sympathetic nerve damage, urinary hesitancy and ejaculating backwards

into my bladder. The tissue diagnosis was of embryonic cell carcinoma with chorionic elements. The U.S. Armed Service Pathology Department's statistical book gave me 5% chance of living beyond two years. My second testicular cancer occurred in my late fifties and on the right, two little joined lumps found by my wife. It was a seminoma with cure rate of 85% requiring, after surgery, four weeks of almost daily x-ray treatment. The combination of radiation induced blood vessel scarring (they had to blast widely since my earlier lymph node dissection confused the usual radiological anatomy), a pre-existing laterally curved spinal column and the arthritic changes resulting from fifteen years of running over 10 miles per day with this kind of back led eventually to the degeneration and collapse of four of my lumbar vertebral disks. The sharpest pain came from my right leg nerve roots that were pinched between bone spurs and radiation-induced scarring. The neurosurgeon said I was beyond repair. I have have been in inescapably increasingly severe back and leg pain for fifteen years. One day, suddenly much worse, my body began another life with an intermittent feeling of a sharp knife in my right knee. This became a transformational singularity.

It was in this way that I fell heir to both Brother Lawrence pain syndrome and what I now think was his strong inclination to live in the Spirit, as far as possible outside the concerns with his own mental and physical body. This led naturally to the irrelevancy of my life long narcissistic preoccupations and diminished my ego-driven achievement obsession. It led to a new and insulating inner seating for conversations with God. The choice was between fully embracing a God-oriented, spiritual place for most of my daily existence or the chronic use of enough narcotics

to eliminate complexity of thought, real interpersonal feelings and hope for meaningfully creative work. The remarkable thing to me was that people began to talk about my “improved disposition,” an increase in out-of-my-psychiatrist’s office personal empathy and kindness as well as a significant decrement in my overweening, ego-stoking ambitious and competitive urges. Any return to the earth body of tense readiness to competitively succeed, protect with ego defensive anger, fantasies of aggressive sexuality, standing tall with inner grandiose notions of intellectual superiority, even getting up for scientific combat, was accompanied by a return to a material world dominated by a knife blade. Only lovingly detached, unpretentious, other-directed caring and quietly calm inner dialogue with Him helped me find a place that I could live. This was a land of still another kind of God than I had previously known. I could even read and struggle with theological ideas thoughtfully, without referencing self-gratifying, mystical, psychopharmacological, Holy Ghost-mimetic experiences. I could better understand the rational, social responsibility valuing, spiritual peace of a Presbyterian Sunday morning service. I could attend Reformed Jewish Friday night services about man’s responsibility to man. No longer seeking the feeling of God’s thrill, I could think and know about Him, even without being in my father’s and Abulafia’s *activated mind*.

If I had been benefited with an ancient language education beyond the high school and early college Latin of Julius Caesar and Cicero, so I could study classical texts or matriculate in an academic theological seminary, I would have already studied, maybe even worn out, the deeper aspects of what once seemed like a paradox of the *consonance of faith and reason*. I would have been familiar

with the rhetorical argumentation in the patristic Latin commentary on sacred texts by Tertullian and other Fathers of the early Christian Church, the Talmudic discussions (the Mishna in Hebrew and Gemora in Aramaic) of the oral Torah by the Rabbinate, the Muslim explication of Koranic Islam in the oral tradition of the Hadith. Robert Wilken in his recent *The Spirit of Early Christian Thought* was in no doubt about the harmonic relationship between rationality and faith: "...by putting itself in the service of truth, faith enables reason to exercise its power in realms to which it would otherwise have no access..." It is perhaps strange to come to this common knowledge so late, but I came to my life with my forbearers and father's magical, mystical biases.

My father had parodied what he thought was the "wasteful time" spent in rational, Talmudic discussion. He said that is what Jewish men spent their time doing to avoid physical work while sitting near the gates of Jerusalem. It was the women who raised the crops and cared for the cattle and children. He had a favorite conundrum satirizing these male village gate discussions. Jewish males, after the age of thirteen, accompany their morning prayer of commitment to loving and serving God with the ritual of wrapping scripture embedded animal skin, *tefillin*, and winding them seven times around the left arm, near the heart, and around the head, symbolizing the mind. This contextualizes how my father made fun of a typical topic of these all male Talmudic seminars: "If one had seven arms, would one wrap the *tefillin* once around each appendage or seven times about one of them. If the latter is the case, how would one chose which arm." In fact, there remains an on-going debate about the order with which the embedded four passages from Exodus and

Deuteronomy should be arranged and inserted in the *tefillin*, such that some none compromising orthodox Jews wear two types of *tefillin*, each representing one of the theoretically justified orderings. I know now that there is an implicitly positive confirmation of a jointly held faith and feeling of ethnic belonging, and its attendant life's work of Tikkum Olam, making ones world better, achieved by such apparently abstract discourse and argumentation.

In truth, I had not come to Warwick to explore the relationships between faith and rationality using the cognitive style of mathematicism, but rather to be saved by the mathematical miracles of the Brain God. Not unrelated to what C.S. Lewis saw as a prominent characteristic of spiritual experience, "wonder," and what Philip Davis and Reuben Hersh in their 1981 book, *The Mathematical Experience*, spoke of as "beauty" and "surprise." I know about the attack of excitement that comes with the sudden emergence of counterintuitive conceptual connections while exploring new mathematical ideas. In energetic high, I start skip reading, underlining the book frantically, jotting commentary on the margins, copying the relevant equations into my notebook. Was this the same break through to a glimmering of grace, everything beautifully in order and precious, that I experienced on LSD while sitting for hours inside Paris's towering, echoing, Notre Dame Cathedral, hearing Latin chants in the dank sweet smell of old church and chained, swinging canisters of smoking incense as the pipe organ roared? These are the realities that George Berkeley, the 1721 author of *Treatise Concerning the Principles of Human Knowledge*, the theist whose name was given to a mostly agnostic Northern California city, saw as grounded in the spirituality of God's infinite mind and broadcast as universal ideas through our

derivative, finite minds. Rational religion and mystical religion are joined in faith by the presence of implicit and universal mathematical ideational structure.

I spent about two years at a mathematics institute in France, *Institute des Hautes Etudes, IHES*, sitting at the guru feet of the mathematical great and metaphysician, Rene Thom. His mathematical pallet was breathtakingly broad, a taste of what in past centuries was called *natural philosophy* and what seemed to me to be about the unapologetic geometrization of the Intuitive God of the Mind. Natalie Angiers, erstwhile mathematician, now reporter and atheistic hard ass, writing in the New York Times, called Thom's ideas the talk of "...an Emperor without clothes..." The Kantian theme of the personal *a priori* status of an intuitive geometry, an already in us representation of all that's in here and out there, was implicit in his *Catastrophe Theory* research program and was published first in his classical *Structural Stability of Morphogenesis* (1977) and made more mystically general in his later (1990) *Semiophysics*.

To get a feeling for the rational-logical versus mystical-intuitive spiritual issue in a mathematical context, consider the following: most of us remember the struggle to unify the strange and difficult cognitive duality of the high school geometry experience. On one hand, shapes and their relations and rearrangements could be intuitively grasped, even manipulated; on the other hand, we were taught that these mental images and the results of their intuitive transformations were not to be trusted.

In mathematics, as in my belief in the fireworks of primary religious experience, seeing is not necessarily believing. In my high school geometry class,

what was to be believed was what followed from the proper practice of the tightly organized, Euclidean system of axioms, postulates and the derivative logical operations resulting in the surety of proofs. The unresolved tension about what I believed from intuitive experience and what I was allowed to believe from the logic of theorem and proof, perhaps not unlike my belief in the transcendent experience over logical theological argument as Reality, continued throughout my life. For example, many decades later at *IHES*, I saw the world class dynamical systems theorist and differential geometer-topologist, Dennis Sullivan, use a projector to display a computer-generated, intricate and beautiful, mathematical object, the well known, computer screen saver, *Mandelbrot set*. It represents the control parameter plane of the well studied *complex analytic map*,  $z \rightarrow z^2 + c$ . Sullivan was pointing to a small, discrete complicated little part of it that looked, close up, like a little version of the whole of it and, from a distance, like a point. He said, "An important Ph.D. dissertation is waiting to be done on the question: is this (pointing to the little object) really there?" In the audience of about a hundred professional mathematicians and one amateur, I was the only one that laughed. I had been surprised by the spiritual depth and universal applicability of that question.

Historians of mathematics point to the successful generalization of Euclidian geometry via its abstract axioms, postulates and logical operations to a new, not naturally intuitable, almost nonvisualizable, curved space, *non-Euclidean geometry* (with the new geometric axiom, *parallel lines do meet at infinity*). This served as evidence against the Kantian idea of the intuitively accessible, *a priori* status of geometry. This served as an example of where mathematics naturally resides, and

argues in favor of the thought control imposed by the modern set theoretic and logical rituals of mathematical theorem and proof. Thom, in a hereditary-evolutionary biological argument developed in *Semiophysics*, said “Objections raised to the Kantian apriority of Euclidean geometry after the discovery of non-Euclidean geometries, and the theories of twentieth century physics (restricted and general relativity, quantum mechanics) appear to me to be irrelevant...they deal with ...the infinitely small and infinitely large...which lies outside the normal cognitive activity of man.”

In my discussions with him, Thom found equivalence relations between mental and real world objects and their behaviors. He described what he called an abstract *physicalist* truth that describes a *psychic universe*, which, in turn, simulates outside things and processes. Much like the transcendent experiential God I have experienced, seek and think I know about, Thom was not after the logical proofs of geometry but rather viewed mathematical theorem and proof work as activity *derived* from intuitive experience with geometric relations as the thought forms that represented *real Reality*. Though a Field’s Medal winner in mathematics (recall that it is the Nobel Prize in mathematics awarded every four years at the International Congress of Mathematics) and for his life time, one of the most brilliant and fecund mathematicians in the world, so many mathematicians admit that they got the seeds of their life work from his throw away remarks, Thom, with a little smile and his eyes twinkling, admitted to me with apparent pleasure that “I have never proven any theorem in my life.” All his discoveries came from insightful moments of grace and the courage to pursue them. Riding back from Paris late one night on a train that

didn't stop at *IHES's* town of *Bures sur Yvette*, I watched him use the red emergency phone to call the train's engineer to stop the train suddenly for our exit. I loved him, in part, because he had the courage to believe in and act on my kind of intuitively realizable, experiential God.

In keeping with his characteristic style of generalizing mathematical systems beyond their carefully defined specifics, Thom defined the concept of *singularity* very broadly, speaking of them as distinctive and noteworthy things, points *where the usual or expected properties, laws and definitions fail, where smooth and continuous processes become discontinuous*. The knife in my knee is a singularity. For Thom, these were the *settings for the unexpected and miraculous*. He believed that his work and that of many others, now and in the future, would indicate that the *set of miraculous singularities were finite, systematic, universal and describable*. Most importantly for our purposes, Thom believed them to be *archetypal*. *It was through the structure of archetypal singularities that he regarded inside and outside realities of the Spirit as mutually reflective*.

I was blessed by hours of discussion with him during his car travels to lecture around France. Thom often asked me to accompany him as he drove from *IHES* to various branches of the University of Paris. He used these times to exercise my geometrically flavored, mathematical intuitions. He used words to create visualizable structures without the diagrammatic aid of a blackboard. He used mental topological structures created by the properties of imagined motions, *flows*, which led to examples of some of his universal singularities that he claimed could be found in the emergence of all physical, biological and psychological

systems. It was, in a way, a kind of mathematical creationism. One of his archetypal singularities was a *boundary* at  $x = 0$  such that the *flow* couldn't spread from where it was in  $x \geq 0$  into  $x < 0$  and was therefore like the border, the membrane, between the inside and outside of a cell as well as the hoped for sociopolitical functions of the Great Wall of China and the Maginot Line. If we were to blow up the boundary line from two to three dimensions,  $R^2 \rightarrow R^3$ , the straight boundary line becomes a *cylinder* for directionally organizing and connecting flows as in blood vessels, oil pipes, cables and wires. Since production and delivery need not occur at similar rates, temporary storage is required and may take the form of a spherical blow-up in the vertical segment of  $R^3$  leading to an open *bottle* which may serve as a dead end storage branch of a network of connected cylinders. In the conceptual reductionism of *Semiophysics*, Thom said, "...life is essentially a question of embankment, canalization and the struggle to stem dispersion." These structures of mind and world are built and maintained. Coagulation of blood is an example of a canalized fluid repairing gaps like a tubeless tire. Thom considered apparent the problem of *making something from nothing, birth*, that of finding the *hidden sources*: the bubbling spring emerges from an unseen, underground network of canalized fluid flow converging on the apparent source, birth being the invisible becoming visible. In contrast, a canalized flow emptying into lake can represent disappearance as a flow.

Mathematicians from all over the world attended Thom's 65<sup>th</sup> birthday celebration at *IHES*. His Field's Medal winning work on the topology of *differentiable (smooth) manifolds, cobordism* and related ideas, was mentioned frequently, and

great homage paid to him with respect to these areas of his work. However, in two days of lectures of personal and professional tribute by the world's great mathematicians, his work relevant to *Catastrophe Theory* and *Semiophysics* was not mentioned, even once. The form taken by mathematicians' most severe judgment is silence. As the New York Times' Natalie Angier's comments indicated, this is not the time for the intuitive conduct of applied mathematics.

It was upon Thom's recommendation to Christopher Zeeman led to my spending the next year in the Mathematics Institute in Warwick, England. He said my stay there would complement his mathematical mysticism. From there I made many trips to Oxford University and Cambridge. It was in these places that I learned first hand that belief in the Resurrection was not simply a matter of socioeconomic class. I scheduled my trips to Oxford or Cambridge to coincide with the weekend so I could hear the remarkably literate sermons at the Universities college chapels. In these places, for hundreds of years, just because one was a top-notch practitioner of mathematics or linguistics did not mean that the Don did not have within him the faith in beliefs attendant to the Christian God.

Maybe this easy combination of logic and Spirit derives from the character of English mathematics. There are graduates with professorially enfranchising Masters of Art Degrees in Mathematics from Cambridge University where the subject is considered by many to be part of the culture of the humanities, closely akin to philosophy and linguistics. In the universities of United States, for example the Massachusetts Institute of Technology, an academic degree of Ph.D. in mathematics is seen by most faculties as an indication of the intellectual equipment

required for a life of scientific work in which disconfirmable experiments are the ultimate criteria for knowledge. Even the field of pure mathematics (not ostensibly relevant to the real world outside the mind) has itself moved in this direction. Recently, a physical scientist, a theoretical physicist, Edward Witten, was given the mathematician's ultimate award, the Field's Medal. In American universities in general, very few mathematics departments are in schools of the humanities. Most are in the schools of science. This variation in bureaucratic, metaphysical, sorting reflects our continuing struggle with the true nature of reality and the role of mathematics in its knowing. The now emergent field of computer science adds layers mathematical logic, intuition and Spirit. Difficult problems such as proofs of theorems can be systematically examined for all possibilities quickly by trying them out in what is now known as a *computational proof*. On the other hand, pointing at the computation's graphics, the theorem and proof mathematicians still ask, is *this really there?*

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One of humankind's beacons, Pythagoras, the intellectual and spiritual progenitor of Plato taught the disciples of the *Pythagorean Brotherhood* in Crotona, Italy, that material and metaphysical reality at its deepest level was mathematical thought. Their studies incorporated philosophy, geometry, music and astronomy, all at the service of achieving closer union with the Divine. To Plato's geometric-algebraic reality, composed of *points*, *lines* and *circles*, Newton added the elongated circle, the *ellipse*, and the Nineteenth and Twentieth Century

mathematicians and physicists, the transcendent existence of *positively and negatively curved space*. Pythagoras and his school, only his student's writings remain, were working at unifying elements of the ancient tribal mystery cults with the observables of worldly events through meditative, mathematical, philosophical mysticism. Knowledge was gained through spiritual intuition made harmonious with rigorously formal systems of thought. As Plato said, quoted by Thomas Heath in his 1921 *History of Greek Mathematics*, about the study of the motion of stars, "...leave the heavens alone...because what one sees is only an approximation of the real and perfect mathematical reality..."

I no longer seek material descriptions and biological analogies for the existence and location of God. I've found him, in all possible ways, in the ideation and imagery of mathematical thought. The way there involves both the thought through and thoughtful analysis and caring for others and thus the self, as well as the psychobiologically intuitive Brain God and its ecstatic rush of insightful illumination. I know now that they are all one.

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