How to solve "free will" puzzles and overcome limitations of platonic science

by Robert Kovsky

Summary

"Free will" puzzles are failed attempts to make freedom fit into forms of science. The failures seem puzzling because of widespread beliefs that forms of science describe and control everything. Errors in such beliefs are shown by reconstruction of forms of "platonic science" that were invented in ancient Greece and that have developed into modern physics. Like platonic Ideas, modern Laws of Physics are said to exercise hegemonic control through eternal, universal principles. Symmetries, rigidity and continuity are imposed through linear forms that have been abstracted from geometry and indifference. Static and quasi-static forms presume placid equilibrium conditions and relaxation processes. Such forms, based on empty space, fail to describe actual material transformations that occur during the making of steel or the generation of snowflakes. They also fail to describe muscular movements and related bodily feelings of persons and animals that have actual life. Limitations of platonic science are overcome by means of new forms with the character of time, such as "beats" and saccadic, jumpy forms. New technologies of action and freedom generate and control temporal forms in proposed device models of brains and muscles. Some temporal forms have critical moments of transformation, resembling moments when persons exercise freedom, e.g., a moment of overtaking during a footrace or a moment of decision by a jury during a civil trial.

Condensed outline

1. Muscular movements of actual life lead to an alternative approach to free-will puzzles.
2. Nietzsche's "will to power" shows the defects of metaphysical constructions that fail to connect to actual life.
3. In metaphysical constructions that were developed by ancient Greeks as part of "platonic science," an imaginary domain is occupied by mental objects called "Ideas" that are impersonal and eternal, that have the character of geometrical space and that are supposed to control actual lives of persons.
4. Modern versions of platonic science construct imaginary domains in which particles and rigid bodies undergo determinate changes according to eternally symmetrical Laws of Physics. Such forms would impose the character of empty space on material bodies; but they fail to describe or control actual transformational changes that occur during a fast quench of red-hot steel or the growth of crystalline snowflakes in a cloud of water vapor.
5. Models of modern psychology and brain science derogate muscular movements and related bodily feelings of actual life; instead, depersonalized information is supposed to be processed according to forms of computation based on principles of platonic science.
6. In new alternative constructions, "beats" of actual life, along with wags of a Dogtail, are modeled by movements of muscle-like modules. Temporal forms based on such movements include episodic balancing forms that are embodied in new technologies as Shimmering Sensitivity, a principle of freedom, and that also govern sports contests and jury trials. Outcomes of such events often turn on personal efforts and personal decisions that occur during transformational critical moments.

Detailed Outline

1. Muscular movements of actual life lead to an alternative approach to free-will puzzles.
   a. "Free will" puzzles are different from freedom in actual life.
   b. Actual life begins with infantile repetition of muscular movements.
   c. Repetition develops into invariance principles and metaphysical constructions.
   d. In contrast to empty concepts of "will" and "free will," physical science and technology have successfully applied metaphysical constructions to actual life.

2. Nietzsche's "will to power" shows the defects of metaphysical constructions that fail to connect to actual life.

3. In metaphysical constructions that were developed by ancient Greeks as part of "platonic science," an imaginary domain is occupied by mental objects called "Ideas" that are impersonal and eternal, that have the character of geometrical space and that are supposed to control actual lives of persons.
   a. Hegemonies in platonic constructions.
   b. Hegemony of impersonal invariance in metaphysical domains.
   c. "Principle of sufficient reason" imposes eternal symmetrized rigidity.
   d. Platonic constructions have the character of geometrical space.

4. Modern versions of platonic science construct imaginary domains in which particles and rigid bodies undergo determinate changes according to eternally symmetrical Laws of Physics. Such forms would impose the character of empty space on material bodies; but they fail to describe or control actual transformational changes that occur during a fast quench of red-hot steel or the growth of crystalline snowflakes in a cloud of water vapor.
   a. Modern platonic physics has advocates and alternatives.
   b. Minkowski's "union of space and time" illustrates puzzling claims of conceptual hegemony that disregard the character of time in actual life.
   c. Reconstructing time into a kind of space makes time fit the primal linear form of platonic science.
   d. Classical thermodynamics is based on equilibrium that excludes multiple possibilities, that imposes continuity and that leads to linear forms.
   e. Quasi-static linearized forms effectively describe some slow transformations, e.g., formation of pearlite in steel-making; but such forms fail to describe similar faster transformations, e.g., formation of martensite during a fast quench of red-hot steel.
   f. Laws of Physics fail to describe or control discontinuous transformations of water vapor into individual crystalline snowflakes.

5. Models of modern psychology and brain science derogate muscular movements and related bodily feelings of actual life; instead, depersonalized information is supposed to be processed according to forms of computation based on principles of platonic science.

   a. The alternative approach provides a view of brain operations in which muscular movements have foundational importance.

   b. Although William James recognized issues of muscular movements and related bodily feelings, he made bodily feelings into sensations that were suited to an input-output model and treated muscular movements as final results.

   c. Even more than James, modern cognitive psychology views human beings as depersonalized processors of information, with action as an abstract final result.

   d. Approaches aimed at computation treat muscular movements as results of causal processes, avoid bodily feelings and lead to an "atoms in a void" brain model based on platonic principles of linearity, equilibrium and energy conservation.

6. In new alternative constructions, "beats" of actual life, along with wags of a Dogtail, are modeled by movements of muscle-like modules. Temporal forms based on such movements include episodic balancing forms that are embodied in new technologies as Shimmering Sensitivity, a principle of freedom, and that also govern sports contests and jury trials. Outcomes of such events often turn on personal efforts and personal decisions that occur during transformational critical moments.

   a. ***The beat*** is a primal temporal form in new models of actual life.

   b. A beat dwells in muscle-like activity in proposed new technologies.

   c. "A Dogtail for Wagging" is a timing device design for production of classes of muscle-like movements, including positioning movements, kicking movements and wagging movements controlled by a beat.

   d. Forms of platonic science do not connect to, control or describe kicking or wagging movements of A Dogtail for Wagging.

   e. Classes of muscle-like movements of the Dogtail lead to more general classes of activations that generate and control temporal forms in new technologies. In episodic forms of balancing, symmetry is first established and maintained and then lost in one of multiple ways. Proposed Quad Net devices embody episodic forms of balancing in transformational processes of Shimmering Sensitivity.

   f. Sports contests and civil trials illustrate adaptations of strife to episodic forms of balancing. Such forms lead to transformational critical moments, e.g., moments of overtaking during footraces and moments of decision by judges and juries in courtroom proceedings.

1. Muscular movements of actual life lead to an alternative approach to free-will puzzles.

a. "Free-will" puzzles are different from freedom in actual life.

"Free will" is like a jigsaw puzzle where pieces do not fit together. In free-will puzzles, "freedom" and "will" are juxtaposed but do not connect, combine or cohere. Free-will puzzles have an ancient heritage. In modern versions, scientists declare that universal Laws of Physics prohibit any possibility of "free will."

I suggest that free-will puzzles do not resemble freedom in actual life. I suggest that misfits in free-will puzzles are the result of reliance on forms of science that originated in Ideas of Plato. Platonic science uses eternal impersonal forms based on ***space*** that do not fit the character of freedom. Critical review of platonic science leads to new forms based on ***time*** that fit better.

It is simple to state a facial solution to the puzzles. Puzzles of "free will" are set in situations that lack the ongoing ***streams of purposeful muscular movements*** through which persons exercise freedom. In the puzzles, persons are put into static positions, bodily and mentally, with scant opportunities for action. Periods of passive waiting are punctuated by isolated events.

In a typical free-will puzzle situation, a "research subject" is led to a test station and instructed to remove some clothing, sit and relax. Experimenters attach electronic devices to the subject's head and other body parts. Then, while immobile, the subject is commanded to lift an arm "spontaneously." Signals from attached devices show that mental activity leading to muscular movement starts before the subject is aware of it. Such an investigation into a subject's awareness does not involve actual freedom or choice. Any will is that of the experimenters. Some free-will puzzles even include brain surgery on a subject who has been bound to a table. Absence of freedom or "free will" in such situations is inherent in the design.

As an example of muscular movements that lead to freedom, suppose that you are walking at a steady pace on a flat strip of sidewalk. Suppose that, while walking, you maintain awareness or consciousness of feelings, experience and/or imagery of your body and of movements of its parts.

"Feelings," "experience" and "awareness" are common names, "imagery" is my technical name (as in "body-image") and "consciousness" is a name that has been extended in various ways.

In brief, you can feel your body parts and their movements as you walk. Often we walk without such feelings, almost to the point of forgetting that we are walking.

A person walking on a sidewalk does not need "free will" to keep moving. There is no "will" or other psychological function saying "step, step, step." Consciousness or awareness or imagery is not essential. ***The body is acting on its own***, whether or not you are aware of it. The body is acting on its own all the time. Only a tiny fraction of our actions require awareness.

While walking, you have freedom to control your body and to direct its movements. Usually, when people walk on the sidewalk, they have a purpose in mind and the person uses freedom to pursue and complete the purpose. Sometimes a person lacks a specific purpose, e.g., window-shopping in a neighborhood of luxury shops, but still directs movements of the body. The person's body must be moving in order for the person to exercise such freedom.

A deeper solution to free-will puzzles investigates actual exercises of freedom. Proposed Quad Net devices maintain ***processes of selection*** which operate with a new physical principle called ***Shimmering Sensitivity***. Shimmering Sensitivity is active while a choice is being made, during a ***critical moment***. I suggest that Shimmering Sensitivity also produces imagery; it is the conjectured source of conscious experience in my models. The two functions of Shimmering Sensitivity (performing selections and generating imagery) can occur together or separately. Choices can be made without imagery. In plans for *Feelings, Forms and Freedom*, the project that follows on this essay and carries constructions forward, images (e.g., sights and sounds) that are generated without choice in certain devices operate through Shimmering Sensitivity to influence choices made in other devices that do not generate imagery.

Music provides some clear examples for my projects. Awareness of music suggests simple brain operations that are suitable for models. I conjecture that something resembling a person's auditory images of musical tones and harmonies will be produced in proposed devices. Such musical images are related to bodily feelings in *Feelings, Forms and Freedom*.

In proposed Quad Net models, choices or selections are made by devices and assemblies of devices that may also generate memorable imagery. Principles of operation are depicted on my websites and discussed below. In simple selections, processes in proposed Quad Net systems operate cyclically. Perhaps a "beat" identifies the cycle. At the start of a ***critical moment*** in the cycle, the process generates co-existing germinal fragments of signals for multiple possible movements, perhaps appearing as tentative impulses ("Shimmering"). Thereafter, during the critical moment, and with Sensitivity to competing influences, ***multiple possible movements change into a single actual movement***. Images can signal and encode actual movements. An exercise of freedom may be required. Similar occurrences in actual life include sorting coins, making the next move in a chess game and picking up one dessert plate from a table holding several such plates.

Alternative principles of physics are behind alternative models of brains. As discussed below, water vapor in a cloud freezes into snowflakes. In other words, a gas changes into crystalline snowflakes, a process more generally called a ***phase change***. During a phase change, there is a complete change of form, a ***transformation***. A diffuse and fluid gas becomes a fixed and symmetric ice crystal. Herein, phase changes are the basis of proposed Shimmering Sensitivity, Quad Net selections and conscious imagery according to the principle that "multiple possible movements change into a single actual movement." In proposed designs, transformational phase changes play roles like assembly language commands in computers.

I suggest that, in rudimentary ways, Quad Net models can mimic human performance of tasks that have variations in ongoing activity, repetitive selections and following of forms, e.g. in musical performances. Quad Net models suggest psychological models on larger scales, extending to personalities. An ultimate goal is applications to institutions like courts.

Quad Net models provide an alternative point of view for free-will puzzles and the confusions they engender. I suggest that, in such puzzles, an extended process of selection is confused with a shorter moment of change. In a "free-will" experiment such as that described above, the process of selection starts when the research subject is put into a relaxed condition and first given instructions; and the process of selection achieves a climactic moment of change and actual movement only after further preparation.

Confusion is compounded if an attempt is made to attribute a cause of movement to imagery, e.g., saying that "sense perceptions" cause action. (The alternative view: images cause action only if an organism is activated and ***ready*** to act – so activations and readiness are primary causes and images are secondary.) Imagery – including current or remembered experiences or images of feelings, movements, sights and sounds, as well as instructions on how to act – is generated during most human activities. Images identify, index and encode selections. Colors are a simple kind of imagery. Proposed Quad Net devices maintain Shimmering Sensitivity processes that use images to make selections according to memories and forms – e.g., "stop on red, go on green" at the traffic light. Although useful, imagery does not control Shimmering Sensitivity. Devices produce Shimmering Sensitivity, generate imagery and operate on imagery. Devices are controlled by multiple influences, including levels of activation, goals or purposes that set specifications, ongoing muscular movements and "the beat." Multiple forms of imagery also influence devices through operations that involve Shimmering Sensitivity. Shimmering Sensitivity is immersed in influences but has an autonomous character.

Similarly, in actual life, a person can act regardless of imagery, first repeating an earlier action and then doing something different, despite imagery that commands consistent action. Consciousness of imagery is not necessarily a determining factor. A person can follow a particular form or violate the form, e.g., violate the law by walking across the intersection against the traffic light. A person can violate the form on a whim without regard to imagery. In actual life, of course, most people habitually and/or intentionally base their actions on imagery and forms so that their actions are lawful, purposeful and rational. But possibilities of unlawful, irrational, distracted or self-damaging actions are not thereby excluded. In actual life, they occur frequently. If imagery "causes" behavior, why does it fail on such occasions?

In contrast to puzzle situations, a person driving a motor vehicle in traffic is not confused about "free will." Motorists are continually exercising freedom by pressing on the accelerator and the brake and by turning the steering wheel. Sudden muscular movements – e.g., slamming on the brakes – sometimes occur before a motorist is aware of them. Exercises of freedom are continually required to meet changing events and circumstances. Failures to make right choices can have serious consequences. Collectively, choices make up a course of action and construct a trip that has been traveled. Some motorists initiate action frequently, seeking opportunities to complete the trip quickly; other motorists prefer a slower, smoother ride with a lesser stream of activity. Sudden recollection of a scheduled engagement may change a relaxed trip into one made tense by hurry. Notions of "free will" simply do not connect to such actual activities.

"Free will" does not puzzle athletes engaged in a sports competition. As discussed below, sports arenas are places to exercise freedom; and teams and players are all determined to ***win***. They use freedom to take advantage of opportunities.

Puzzlement about "free will" does not distract musicians performing in front of an audience. Musicians devote hours of practice and rehearsal preparing for just such occasions. Jazz musicians sometimes get to improvise during a performance.

In sum, free-will puzzles do not detract from freedom exercised by motorists, athletes, musicians and others involved in actual life. The puzzles are inconsequential as well as fallacious. They do, however, lead to more serious questions; and a full and detailed solution shows new ways to approach weightier endeavors.

b. Actual life begins with infantile repetition of muscular movements.

In my investigations of free-will puzzles and related matters, I adapt principles of child psychology developed by Jean Piaget (1896-1980). Piaget was a natural scientist trying to account for mental growth of children. My approach modifies Piaget's psychological principles for use as design principles in new technologies.

"Piaget has sometimes labeled his position constructivism, to capture the sense in which the child must make and remake the basic concepts and logical thought-forms that constitute his intelligence. Piaget prefers to say that the child is inventing rather than discovering his ideas." (Reference available on my web page discussing Piaget at http://www.quadnets.com/piaget.html)

This essay is a large-scale construction that contains smaller constructions, including models. Some models describe images and forms and are called psychological models. Other models propose devices that are part of new technologies. Psychological models and device models are combined in systems that e.g., follow, focus and balance. The emphasis in this essay is on psychological principles that are directed towards development of new technologies.

This section sets forth definitions for classes of various psychological "objects." The definitions shape a general approach and provide tools for later constructions. Important classes are called "actual objects," "sensory objects" and "mental objects." They are "psychological" because they are grounded in personal experience that is presumptively common to all. The objects are based, respectively, on muscular movements that are coordinated with feelings generated within the body (actual objects); on organs of sensation that generate and project images onto things outside the body (sensory objects); and on relations and other constructions that incorporate such movements and things (mental objects). In my approach, muscular movements are foundational and all objects have origins in such movements and in feelings of the body that are associated with them. First come actual objects. Then sensations of external things are adapted to forms that have been developed for muscular movements and bodily feelings. This approach is different from a scientific approach, where sensory objects are foundational. It is based on ***action*** (muscular movements) rather than ***states*** (sensory observations).

"Invariant objects" are a fourth kind of object, a particular kind of mental object discussed in detail below. The various classes of objects have different characters and features. Each actual object is unique and different from every other actual object; but invariant objects exist only in minds and are generated in classes of "identical objects" or "families of similar objects," e.g., "circles," "numbers," "atoms." Some actual objects such as "AA batteries" can be produced through assembly line methods and resemble invariant objects, Actual objects and invariant objects do not necessarily work together but can be made to do so under some situations, such as science laboratories and fast food franchises.

Alternative constructions (§ 6) begin with muscular movements that embody patterns in time. The patterns are subject to a person's control. We control movements when we start them, stop them, speed them up and slow them down. We perform different kinds of movements simultaneously while controlling them separately. We perform muscular movements with both conscious and unconscious control, e.g., unconsciously speeding up to keep even with traffic.

In alternative constructions, forms of muscular movements are points of origin for development of forms of mental activity, social interaction and institutional activity. Important forms include "following," "focusing" and the more complex activity of "balancing."

An example of the primacy of muscular movements is shown by the personal computer concept of "opening a data file." I suggest that the computer concept is based on muscular movements involved in "looking at a file folder in an office," namely, pulling open a file drawer, removing a particular file folder from the file drawer and leafing through papers inside the file folder. Different movements occur when "opening a data file on a personal computer" but eye-hand movements controlling a mouse or trackball follow a similar form. In the similar form, a "directory" in computer storage resembles a "file drawer" in an office and a "data file" resembles a "file folder." A person "looking for a file folder in an office" performs an action of "focusing" during which attention is shifted from the file drawer as a whole to a particular file folder in the file drawer. On the computer, the person similarly shifts attention from a directory to the particular file in the directory. In both situations, there may be a sequence of actions during which successive file folders (or files) are "tested" or compared to an image in the person's memory, until a successful "match" is made and the "matching" file is extracted or opened.

In psychological constructions of objects herein, ***repetition*** of muscular movements is of primal importance. Even in the first reflexive behaviors of newborn infants, "there is a tendency toward repetition, or, in objective terms, cumulative repetition." (Piaget, Origins of Intelligence, 33.) The first stage of a baby's development beyond reflexes is called the "Primary Circular Reaction" – a phrase that describes actions that "are ordinarily called 'acquired associations,' habits or even conditioned reflexes." "The repetition of the cycle which has been acquired or is in the process of being acquired is what J. M. Baldwin has called the 'circular reaction.' " (47 - 48.)

That is, some activities – such as cyclical and repetitive habits – become ***self-perpetuating***. Self-perpetuating actions and habits begin with reflexes. "The sucking reflex…lends itself to repetitions and to cumulative use, is not limited to functioning under compulsion by a fixed excitant, external or internal, but functions in a way for itself. In other words, ***the child does not only suck in order to eat but also … he sucks for the sake of sucking***." (35, emphasis added.)

In other words, beginning in early infancy, muscular movements are self-perpetuating and performed for their own sake. I suggest that an older child or adult will also perform lifestyle, social and mental activities in self-perpetuating ways and will sustain and deepen an activity by means of repetition — "doing it for the sake of doing it." I suggest that repetition and "doing it for the sake of doing it" are primal principles that lead in many directions, including scientific directions. In science, as we shall see, they lead to "invariance" and "conservation."

In my constructions, action, muscular movements – especially repetitive movements – make up the ground of actual life. The word "actual" signals a discussion about action and muscular movements: eating, digestion, breathing, seeing, walking, handling objects, writing, speaking.

Rudimentary models employ continuous and universal muscular activation. ***Every muscle is activated all the time***. When the timing device project "an Eye for Sharp Contrast" operates, every muscle-like fiber in the Eye is continually twitching; and the gaze shifts during each cycle. In actual life, biological muscles involved in heartbeat, breath and digestion all work continually, as do voluntary muscles even during low levels of activity, such those experienced during *yoga nidra* when "the body sleeps but the mind remains awake" or in a flotation tank.

I suggest that there is a ***plenum*** of muscular activation that is the ground of all activities of brains — insect, fish or human. One highly active image is a bucket full of wriggling earthworms. But flexion always alternates with relaxation and activations are relative and graded. In my models, muscular activation is never lower than a level called ***tonus***, which sustains "muscle tone." However, in many situations involving "quasi-static activations," actual motion is absent. Tonus is too weak to move a bodily mass. Additional requirements involve "balancing" in which opposing pairs of toned muscles keep an organism immobile much of the time. Actual movements require ***unbalanced*** muscle-like movements activated at levels higher than tonus. Varying levels of activation and varying levels of ***readiness*** are behind behaviors ranging from a fully relaxed organism to one that launches itself into violent enraged attack.

In actual life, activated organisms are ready for action. Activities that require a high level of activation and readiness include performances in driving, sports and music mentioned above. High readiness is needed to "choose right" i.e., to select one "best" course of action from among multiple possibilities.

Actual life is grounded in muscular movements but, of course, actual life includes much more than muscular movements. Other parts of actual life (e.g., bodily drives, habits and training, rational methods, family, institutions) have ***control relationships*** with muscular movements. In my approach, sensory-motor modules and higher-level constructions control, coordinate and organize various muscular movements. The organism has purposes that require such control.

My approach aims first for operational or concrete control of movements and only at some later time for representational or symbolic control. Such an approach differs from computer models where representation is foundational. Here, representations are additional to other controllers. I suggest that symbols and representations have origins in bodily experience and imagery that identifies, indexes and encodes movements of body parts. Images of sights and sounds start off as signals for action. Development of imagery might re-trace biological evolution: insects have scant imagery, reptiles have saccadic (jumpy) imagery, mammals have continually-streaming imagery and human beings generate control imagery of laws and institutions.

Imagery develops when a child learns to "perceive things as we do, as objects that have substance, that are permanent and of constant dimension." Piaget, *The Child's Construction of Reality* (1936) at 1. Chapter 1 of Piaget's *Construction* is titled "The Development of Object Concept." According to Piaget, "objects" are constructions; and psychological processes or "operations" perform constructions. Piaget thus teaches a practical and operational kind of epistemology or, employing terminology of an engineer, a model of knowledge construction.

In "Constitutive Processes of Object Concept," (*Child's Construction of Reality* at 87), Piaget compares "the formation of initial sensorimotor objects" achieved through "elementary processes of the child's intelligence" with "those used by scientific thought to establish the objectivity of the beings it elaborates." Piaget teaches that an infant's early mental activity evolves into scientific discipline. (See Piaget, *Structuralism*.)

"Initial sensorimotor objects" are based on an infant's ***sensory-motor activity*** that coordinates sensory organs and muscles, e.g., during play with crib toys. Sensory-motor activity is part of the infant's primal experience and is essential to tactile and spatial perception and for all later growth. (Piaget, *Child's Conception of Space*.)

"[T]he permanence of the object stems from constructive deduction" that "enables the child to build a spatio-temporal world of objects endowed with causality." (*Child's Construction of Reality*, 94.) Objects are subject to manual and mental operations based on muscular movements and coordination. (*Id*., chapter 2.) "The problem is, therefore, to understand how the child succeeds in … constructing permanent objects under the moving images of immediate perception." (*Id*. at 91.)

To sum up and look forward: Piaget teaches that psychological processes "build a spatio-temporal world of objects" through activity of the developing intelligence of an infant. In adapting such teachings to my purposes, I construct distinct classes of "objects" and multiple "worlds." The constructions start with "actual objects," which lead to "sensory objects" and then to "mental objects." Mental objects, e.g., geometrical figures, are put into an "imaginary metaphysical domain," e.g., on a chalkboard. Various imaginary domains (or worlds) contain rules of chess, Plato's Ideas, Laws of Physics and laws of the State of California.

Piaget's "initial sensorimotor objects" are what I call ***actual objects*** that are based on muscular movements; and such actual objects make up the ***actual world***. We pick up actual objects and push against actual objects. Another term for actual objects is ***material objects***. Things are made of materials and each material has a specific character. I suggest that all persons share a common background of experience of actual objects and a common actual world. We have a shared and ***common actual life*** that is rooted in a single, common bodily design and in common nervous, sensory, muscular and skeletal systems. In brief: all human bodies share a common repertoire of muscular movements. While moving our bodies, our brains operate in common ways that developed from those of early reptiles. I suggest that our common actual life based on muscular movements is the ground of our communications with one another.

The concept of an "actual world" in my constructions serves purposes like those of a "real world" or an "objective world" in other constructions but there are important differences between the worlds. The actual world is a result of activity of actual life and does not have existence other than in the presence of actual life. Such an "actual world" is sparse and limited in comparison to a "real world" that is presumed to exist in the absence of life. Imagery may be present in or absent from constructions made up of actual objects but imagery presents a difficult question in constructions of a "real world." Is imagery real? Regardless of imagery, the chief advantage of the actual world is that it is a world of action, not a world of things. In the alternative view, action is prior to things and things depend on foundations of action.

Similar psychological constructions produce a distinct and separate class of sensory objects from purely sensory activity. Sensory objects have no dependence on muscular movements but processes of construction of sensory objects are based on processes developed for construction of actual objects. We know by muscular activity that actual objects have, e.g., a rigid and permanent character or a fluid character. We impute similar characteristics to sensory objects.

Some sensory objects can be detected from a distance and others can be seen on a TV screen. Birdsong and celestial bodies (sun, moon, stars) are sensory objects. An object's class may depend on the person who constructs it. A concert violinist constructs an actual object while playing a melody in contrast to a member of the audience who constructs a sensory object while listening to it. The violinist exercises freedom in shaping the melody through muscular movements but the audience member has only the choice of attending or not.

Sensory objects come in larger and more varied classes than actual objects. As a rough measure, there are more persons in the audience than on the stage. Although all persons use the same muscular movements, each person favors particular music, videos, aromas and flavors. Unlike actual objects that are tested by muscular movements and identified according to the common standards of actual life, sensory objects can generate disputes about their existence or nature.

Mental objects are a third distinct class of objects: these objects start from actual objects or sensory objects; the person then uses additional processes to construct a static version that is detached from muscular movements and from any original context of movement. This means, e.g., that a mathematical object cannot have speed," "weight," "mobility," "tactile pressure" or other muscle-based feature. Mathematical objects such as numbers, equations and circles are exemplary mental objects. A played tune and a spoken message may be reconstructed as purely mental objects.

Mental objects can represented by symbols such as words or musical notes, at least in large measure. In contrast, muscular movements are difficult to symbolize. I suggest that mental objects appear in imagination and have an existence that is different from the existence of actual objects that are based on muscular movements. In my approach, mental objects are built on top of actual objects either directly — or indirectly through sensory objects — but processes of construction produce different kinds of character. The three classes of objects make up a layered construction with each layer having a distinct character and with developmental relationships between layers.

Mental objects can be made subject to certain psychological operations that also apply to actual objects, e.g., operations that compare features of objects (matching and distinguishing operations) and operations that keep count. Operations such as focusing, following and balancing work somewhat differently with actual objects and mental objects. Actual objects are unique and events in the actual world are irreversible. Mental objects, on the other hand, come in classes of identical objects and in classes of objects with variable features. In imagination, events involving mental objects reverse and occur in different ways and mental objects can be re-used, re-combined, re–organized, re-tuned, etc. Diverse kinds of mental objects include fantasies, e.g., imagery of a unicorn or fantasies of flying like a bird. Some mental objects are common to all persons, some are shared in a distinct community, e.g., a cult, and others are entirely private.

Often, a person uses mental objects to control muscular movements, e.g., the mental image of an equilateral triangle used as a drawing guide. Also, recalling the introductory examples of freedom: traffic laws, game plans and musical scores are used to control muscular movements. ***Forms*** is a class of mental objects that are used as guides for actual movements. Such uses occur in ***performances***, episodes of action during which forms guide actual movements.

This essay constructs, compares and contrasts two classes of forms, namely, ***spatial forms*** and ***temporal forms***. Important spatial forms are based on geometry. Geometry also includes some temporal forms. For example, in plane geometry there are multiple different ***ways*** (temporal forms) to construct a bisected angle from an angle; the resulting construction is a unique spatial form and the uniqueness is proved. Temporal forms are predominant in music and martial arts. There are also ***empty forms*** that completely fail in attempts to guide actual performances, e.g., a form for flying like a bird by flapping one's arms.

As geometrical constructions, music and automobile travel demonstrate, muscular movements are sometimes controlled successfully by means of forms. Such demonstrations occur in specific situations, such as math class or the freeway. In my approach, muscular movements can have multiple kinds of control, e.g., control by laws (forms), control by a parent or self-control by a person seeking to achieve goals. Attempts at control by means of forms are sometimes successful and sometimes not. Even when successful, control by means of forms may be less efficient than other kinds of control. For example, sometimes a series of authoritarian commands gets the job done in a situation where trying to explain principles would take too much time.

c. Infantile repetition develops into scientific invariance.

In a further stage of development, I suggest that psychological processes construct ***invariant objects***. Invariant objects incorporate a key principle, namely, a rule of invariance. Like actual, sensory or mental objects on which it is based, an invariant object has a repetitive feature or character; but, in addition, it has that feature or character ***every single time*** and it ***cannot lack***

that feature or character. A rule of invariance can be imposed on the basis of, e.g., design, inherent operations, experience, reason, authority, habit or lack of imagination. Mathematics and sciences are built around minimal compact sets of invariant objects. I suggest that small children, as well as adults, construct and impose rules of invariance for the sake of doing it. "You have to hold it the way I showed you." "Why?" "Because I said so."

Actual objects can resemble invariant objects but, as a practical matter, a person recognizes that every actual object is subject to change and cannot function in the desired way "forever." When changes happen, the object may be said to "to break" or "to stop working."

Rules of invariance can have many beneficial advantages that encourage efforts to construct and impose them on physical materials, actual objects, persons and imagery. An invariant object has a certain reliability; it can be re-used easily, without need to weigh possibilities. Objects that have functional invariance, e.g., violins, control muscular movements of a class of persons. An organized system of such objects, e.g., musical instruments in a symphony orchestra, can help develop a culture. Commerce requires a currency that is at least approximately invariant in value. Something that lasts, that endures "the same" over a lengthy period of time, has inherent value based on that fact alone. In the final moments of *Gone with the Wind*, the voice of Gerald O'Hara, deceased, speaks to his daughter Scarlett about their plantation, Tara: "Land is the only thing that matters. It's the only thing that lasts." I suggest that life might be simpler if we had more principles that all the folks agreed on all the time. Boiled down to practical necessity, "invariance" is a principle of importance in all matters of knowledge and action because we have nothing better to use. Therefore, we use it on all possible occasions, for the sake of doing it.

Ancient Greek philosophers embarked on "the search for invariants, which is the definition of science." (de Santillana, *The Origins of Scientific Thought*, 218.) "It is the observation of celestial motions, which challenged men to search for the impersonal *invariants* behind events. This is after all what science means." (12, emphasis in original.)

Science has successfully investigated some "impersonal invariants behind events," such as events where bodies descend from a height under the influence of gravity. Please recall imagery of Galileo dropping balls from the Tower of Pisa or, better, rolling them down a ramp. A question is presented as to whether impersonal invariants like gravity are behind ***all events*** or whether there are some events that have a different basis. The skeptic says: Yes, there are invariants. Invariance is a good idea. But is invariance all-powerful in some "universal" way?" Does invariance control everything?

In my view, rules of invariance are psychological constructions that persons try to impose for the sake of imposing invariance and because the results are sometimes beneficial. Comparing such rules with actual life, the practical world of my experience does display broad examples of invariance, e.g., seen in movements of motor vehicles and pedestrians in response to traffic signals. But there are also exceptions, such as the ambulance with siren sounding; and the system requires continual repairs and modifications just to keep things going. Contrary to the kind of world that would be controlled by impersonal invariants, there is very little in my world that all folks agree on. Instead, folks are occupied with troublesome disputes, decisions and adjustments that require personal efforts, personal choices and personal favors. Novelties are continually appearing and few events conform fully to expectations. In sum, I conclude that actual life refutes any claim that "impersonal invariants" govern each and every course of events.

Some scientists teach that impersonal invariants do control all events. In *The Emperor's New*

Mind (1989), Roger Penrose, a self-declared platonist, wrote about "the mathematical scheme which governs the universe." (Penrose, 433.) Richard P. Feynman was sure that "if we could figure everything out, we would find that there is nothing new in physics which needs to be discovered in order to understand the phenomena of life." (Feynman, Character of Physical Law, 151.) Artificial intelligence pioneer Marvin Minsky declared: "According to the modern scientific view, there is simply no room at all for 'freedom of the human will.' Everything that happens in our universe is either completely determined by what's already happened in the past or else depends, in part, on random chance." (Minsky, § 30.6.)

I suggest that scientists are in error when they claim comprehensive knowledge. Rather, science has only a limited reach and that there are phenomena outside that reach. I suggest that errors in over-reaching claims are revealed by analysis of limitations of platonic science and that such errors and limitations can be overcome by means that lead to new technologies.

d. In contrast to empty constructions of "will" and "free will," science and technology have had good luck with metaphysical constructions.

"Free will" is a construction that purports to combine "freedom" and "will." The construction and the underlying concept of "will" were unsatisfactory even for the purposes of Augustine (354-430), the inventor of "free will." Augustine was trying to fit freedom into his forms of Predestination and Grace. (Pelikan, 323-324.) Augustine's "will" is a combination of "our power to confer or withhold all-things-considered assent, or choice" and "the basic disposition of our being," e.g., "good or ill will." (Taylor, 138.)

The concepts and constructions of "free will" are defective, in my view, because such "will" and "free will" fail to connect to muscular movements of actual life. Such concepts and constructions are limited to imaginary domains.

A ***metaphysical construction*** is one where mental objects exist and act in an imaginary domain, such as the imaginary domain of a geometrical demonstration, a domain implied in a physicist's chalkboard diagram or the domain implied by the Vehicle Code (traffic laws) of California. Aristotle's metaphysical psychology was behind Augustine's construction of "will." (*Id*., 137.)

Expressly stated or implicit in metaphysical constructions of science or judicial law is a claim to connect to actual life, an ***application*** of metaphysical principles that guides muscular movements of persons, e.g., one who is building devices from materials or who is operating a motor vehicle. Some metaphysical constructions, e.g., those that use plane geometry and Electromagnetic Waves, do have actual applications, e.g., in grinding optical lenses; but other constructions do not. The obsolete scientific construction *phlogiston*, for example, has no applications. Without actual applications, a metaphysical construction is empty, similar to imagery of a person flying like a bird. Empty forms cannot guide a person's actual muscular movements. An empty metaphysical construction exists only in imagination and has no connection to actual life.

I suggest that "will" and "free will" are empty metaphysical constructions. For example, one notion of "will" is that, while exercising the "power to confer or withhold all-things-considered assent," (quoting Taylor, above) it is "will" that controls muscular movements. Such a notion, if substantiated, would apply directly to actual life. However, such notions have not acquired substance. As discussed in § 5, modern science provides no suggestion of such an activation that is any more satisfying than Descartes' fantasy connection through the pineal gland. I suggest that science pursues empty models in which images cause muscular movements. In the alternative view, muscles are activated and ready all the time and an organism uses images to start, stop, select, switch and otherwise control movements that are available for purposes of the organism. Any underlying causal foundation consists of muscular activation and readiness.

In sum, concepts of "will" do not connect to muscular movements. "Free will" does not connect to anything substantial. We often exercise freedom through streams of small actions, as in driving a car. Even a large-scale exercise, such as running a race or reaching a verdict, requires a series of steps. "All-things-considered assent" does not apply to these tasks. So-called "powers of choice" ignore difficulties of performance in an actual, sometimes reluctant world. Actual choices involve trade-offs between desired and undesired features and actual choices require efforts to bring them about. Freedom involves possible choices turning into a particular choice and a need or purpose that requires choice. "Free will" denotes an empty choice that is not driven by need; it is a choice without stakes or effort, like gambling at roulette with play money.

If I were to play with metaphysical constructions of "will" or "free will," I would start with the principle of repetitive "doing for the sake of doing" that is observed in an infant's prolongation of sucking beyond the need to satisfy hunger. I would say: that is done willfully which is done simply for the sake of doing it. People exercise freedom and make choices simply for the sake of doing so, e.g., playing videogames. In videogames, as in other examples, a person is free when doing something involves a selectional transformation or choice where multiple possible ways of doing it change into a single actual way of doing it (or not doing it) and the person performs the selection to achieve a particular purpose. However, such play goes off in its own directions and does not resolve puzzles of "will" or "free will." Does it take "free will" to play a videogame or just "free time?"

Freedom is represented herein, e.g., by motorists and musicians, by runners in a footrace, by a diner choosing from a menu at a restaurant and by a jury rendering a verdict. The forms of such exercises of freedom are not simply willful – not done simply for the sake of doing – but serve multiple purposes of persons and society. Actual freedom comes bound together with values of civilization along with muscular movements. Metaphysical constructions of the modern scientific view do not connect with such values.

Although metaphysical constructions of "will" and "free will" are empty, the wider history of metaphysical constructions shows facts of substance and promise. Certain metaphysical constructions have led to tremendous successes of platonic science with wonderful applications in practical technologies and intellectual progress in highly important areas of investigation, e.g., those surrounding Newton's Mechanics (incorporating absolute time and space) and Maxwell's Electromagnetic Waves (implying a luminiferous or "light-bearing" ether).

Such examples also demonstrate that metaphysical constructions incorporate errors. Features of the examples ("absolute time and space" and "luminiferous ether") were once believed without question but were shown to be fallacious by Einstein's superseding construction, the Theory of Relativity (1905), which astonished many scientists and also showed an astonishing equivalence between mass and energy. Hence, none of our current metaphysical constructions is reliably error-free. (Popper, Nature of Philosophical Problems.)

Most important, metaphysical constructions have achieved lasting practical value based on their embodiment in technologies. Technology based on metaphysical constructions outlast belief in the constructions themselves. Astronauts' navigation is based on Newton's Mechanics, not that of Einstein. Earthly nautical navigation still holds that the Earth is the center of the Universe.

As a more detailed example, the current view among physicists holds that "light is photons" is "true" and that "light is waves" is "false." Between the enthronement of Electromagnetic Waves in 1865 and their overthrow in 1905 — during "the short happy life of the luminiferous ether" — physicists believed that "light is waves" was true; but Einstein (and others) showed such beliefs to be untenable. In such statements, "light" refers to something "real" and such reality is stated in mathematical constructions, either as "photons" or as "waves." According to invariance principles, such constructions must be true everywhere and eternally. Physicists now hold that mathematical photons have some reality that mathematical waves lack (showing the metaphysical character of Electromagnetic Waves). Despite the inferior status of waves, technologies based on waves – e.g., microwaves and lenses that aid vision – are so firmly established that their development continues to progress through means that often ignore photons.

The history of science and technology thus reveals a fortunate if puzzling paradox. Erroneous metaphysical constructions have led to successful technologies. Conversely, technology can be based on metaphysical constructions regardless of the exact conformity of such constructions to "truth" in the sense of "fit to reality." The value of metaphysical constructions may be based on successful technological applications rather than on "truth." A noteworthy epigram of Goethe states: "A false hypothesis is better than none." (Kaufmann, Discovering the Mind, Vol. I., 45.) For a practical person, "better" is shown by success of technology.

In other words, a practical person might look for new but as yet un-built metaphysical constructions that can be embodied in new technologies. The goal is productive results rather than a claim to "truth." To help aim at the goal, critical reconstruction of existing and past attempts can suggests paths to success and identify errors and limitations that might be overcome in fresh endeavors.

I have followed such an approach and am developing new technologies —***Quad Nets*** and ***timing devices*** — that embody new principles of action and freedom. Previous designs have included "An Ear for Pythagorean Harmonics" (2009) and "An Eye for Sharp Contrast" (2011). Constructions in this essay, e.g., " A Dogtail for Wagging," incorporate existing principles such as symmetry and invariance

I am not trying to "explain" brains, e.g., with a "theory." My approach does not support a "theory." Instead, I propose new ***kits of parts***. Kits of parts are practical and have a mathematical and engineering character. An existing kit of parts that serves as an exemplar of the form is made up of "standard electronics components" (resistors, capacitors, transistors, microphones, etc.) used in radios and computers. The timing devices kit of parts resembles the kit of parts of standard electronics components. The timing devices kit is also an application of the more abstract kit of collective Quad Net devices. There are currently no working models of any of my proposed devices and all designs herein are acts of imagination.

My kits of parts are presently only imaginary, but I look forward to the manufacture of physical devices that are hooked together on an engineer's bench. Then some of my own errors and limitations will be made clear and developers can invent newer and improved devices and principles. Operational systems that use manufactured timing devices and Quad Nets — especially newer and improved versions — will be actual applications of my metaphysical constructions.

2. Nietzsche's "will to power" shows the defects of metaphysical constructions that fail to connect to actual life.

Nietzsche invented "will to power," declared it to be the sole cause of actual life and based an elaborate construction on it. The construction is flimsy and childish; and its defects highlight those of Greek philosophers who founded platonic science and those of their modern inheritors. Nietzsche himself criticized such constructions on grounds similar to those I state.

Please see Nietzsche's *Beyond Good and Evil* § 36 (Walter Kaufmann trans.) for the chief quoted matter, with emphases copied from the text. The passage is discussed in Kaufmann, *Discovering the Mind*, Vol. II at 75 *et. seq.*

Nietzsche begins with "our world of desires and passions." He proposes that there is no "other 'reality' besides the reality of our drives." He decides to "make the experiment" that such a reality is "*sufficient* for also understanding … the so-called mechanistic (or 'material') world."

Nietzsche continues by positing "several kinds of causality," including "the causality of the will." He embarks on the further "experiment of positing the causality of the will as the only one." He "has to risk the hypothesis" that "all mechanical occurrence are effects of will."

Nietzsche's construction thus proposes a single "causality of the will" in a "world of desires and passions" that generates and comprehends all other "reality." That causality becomes "will to power." The construction supposedly suffices to "understand" physical mechanisms, material bodies and, presumably, all phenomena of actual life.

In attempting to ground his construction in actual life, Nietzsche conceives of a "pre-form of life," "a kind of instinctive life in which all organic functions are still synthetically intertwined, along with self-regulation, assimilation, nourishment, excretion, and metabolism."

"Suppose, finally, we succeeded in explaining our entire instinctive life as the development and ramification of *one* basic form of the will—namely, the will to power, as *my* proposition has it. … then one would have gained the right to determine *all* efficient force univocally as—*will to power*."

Nietzsche also wrote: "the will to power is the primitive form of affect … all other affects are only developments of it…all driving force is will to power…there is no physical, dynamic or psychic force except this…It is simply a matter of experience that change never ceases: we have not the slightest inherent reason for assuming that one change must follow upon another…Spinoza's law of 'self-preservation' ought really to put a stop to change: but this law is false, the opposite is true. It can be shown most clearly that every living thing does everything it can not to preserve itself, but to become *more* —" (*Will to Power*, § 688, emphasis in original.)

Value is a focus of power according to Nietzsche: "value is the highest quantum of power that a man is able to incorporate." (*Id.*, § 713.) He views it as "a standpoint of conditions of preservation and enhancement for complex forms of life-duration within the flux of becoming. [¶] There are no durable ultimate units, no atoms, no monads: here, too, 'beings' are only introduced by us (from perspective grounds of practicality and utility)." (§ 715.)

Nietzsche's construction resembles platonic constructions in which a metaphysical domain is occupied by mental objects that are declared to control actual life. The constructed mental objects are Platonic Ideas, Laws of Physics, and Will to Power. In all three cases, constructions are single-minded: a single kind of mental object is said to control everything else.

As for contrasting features, Nietzsche's generative element is distinctly different from platonic elements. Chiefly, "will to power" is an element of ***transformation***, in contrast to platonic constructions, where Ideas and Laws of Physics are elements of ***conservation***. Platonism would establish a hegemony of eternal Ideas or Laws while will to power would establish a hegemony of change. Under the hegemony of change, where, according to Nietzsche, "change never ceases," stronger changes dominate weaker changes. In imagery filled with whirling changes, will to power feeds on growth and seeks to grow more. It embodies single-minded change with a metaphysical essence that permits nothing but growth, struggle and domination.

Nietzsche's construction turns biological desire into metaphysical will and makes it the sole primal principle. According to this principle, a value is measured by a "quantum of power" that has a direction, namely, "more." Single-minded "more" values all have the same form. In Nietzsche's imaginary world of whirling changes where will to power, drives and single-minded "more" values are the only sustained features, some "more" values lead to very little more while other "more" values lead to a lot more. Will to power is by definition the sole generator of all values; and it is a betrayal of that value to accept anything less than a lot more value and a lot more power. For a meaningful life, according to Nietzsche, you must embrace and uphold will to power in a single-minded way and you must get more, more, more!

The "will to power" does not stand up to critical examination. Nietzsche himself argued against single-minded mental conceptions. [*Twilight of the Idols*: "The error of free will" — "the world does not form a unity either as a sensorium or as a spirit."] Nietzsche's single-minded mental conception suffers from defects common to the class. [*Id*.: " 'Reason' in Philosophy."]

"The metaphysical conception of the will to power as the ultimate reality behind the world of appearance conflicts with Nietzsche's emphatic repudiation of any such two-world doctrine." (Kaufmann, *Discovering the Mind*, Vol. II, 77.)

Criticism of Nietzsche's will to power recapitulates criticism of platonic science. The tradition of such criticism started with Aristotle, whose views and methods were quite different from both Plato's and Nietzsche's. (de Santillana.) Shakespeare wrote of folly and delusions that occur when "every thing includes itself in power, Power into will, will into appetite, And appetite, a universal wolf, so doubly seconded with will and power, Must make perforce a universal prey, And last eat up himself." (Troilus and Cressida, Act I, Scene iii.)

Of course, the "will to power" is older even than Thrasymachus, Plato's inept spokesman for it in *The Republic*. Like Plato, Nietzsche did not ground his inventions in actual life but rather in mental conceptions that he preferred to actual life. Although Nietzsche claimed to base his construction on "our world of desires and passions," such a basis is not established. In my view, actual life is grounded in muscular movements and bodily activity. Most of my actual activities, e.g., "chores," are directed towards satisfying essential bodily needs and satisfying further body-based desires for home, comfort, movement, adventure, sensation and society. I presume that other persons generally engage in similar activities in similar ways. Such activities do not connect to assertions that "our entire instinctive life" is expressed through "the development and ramification of *one* basic form of the will—namely, the will to power, as *my* proposition has it."

The construction has even more serious defects. Starting with "desires and passions," Nietzsche declares that his construction encompasses mechanical and material causes. He never questions whether his construction has fallen off its base or whether the base has shaped development. He never reviews his experiments, risks and hypotheses. He never considers that "our world of desires and passions" might run up against limits from physical constraints or moral restraints. He appears to deny any need for constraint or restraint.

The subject of causality has attracted many investigators and generated many tomes of philosophy, psychology, physical science and jurisprudence. Questions of "free will" and the causal power of will, such as Nietzsche presumes, are important for some causal investigators but by no means all. Wallace's 2-volume historical review, *Causality and Scientific Explanation*, has but two references to "freedom," quoting scientists who declined to make a connection between issues in scientific causality and human freedom or will. Nietzsche blithely ignores such history and imposes a single, highly problematical kind of causality, where "the causality of the will [i]s the only one." Without consideration of facts of mechanical or material phenomena, he reduces them to "will." He claims to control all such phenomena through his imagination. His "will to power" construction is indistinguishable from a "wish" construction.

Nietzsche uses metaphysical constructions like "will to power" as elixirs of self-intoxication. "For the game of creation, my brothers, a sacred 'Yes' is needed: the spirit now wills his own will, and he who had been lost to the world now conquers his own world." (*Zarathustra*, "On the Three Metamorphoses of the Spirit.") My conclusion is that self-intoxicated Nietzsche had little regard for solid construction. His "will to power" has no backbone of discipline.

Notwithstanding defects and limitations, Nietzsche's will to power, like platonic science, contains features that are useful in my own approach.

As noted above, Nietzsche criticized metaphysical constructions he called "the two worlds," where a metaphysical world of permanent knowledge supposedly controls a transient world of appearances. (Kaufmann, vol. II, 76.) He compared and contrasted two-world constructions in ancient and modern sciences. (*Beyond Good and Evil*, § 14.)

However, instead of populating a separate, metaphysical world with eternal mental objects in the style of platonic Ideas, Nietzsche used a primal element of change, "will to power," that acts in response to changes and that causes changes. Will to power is transformational while platonic Ideas and platonic science are form-conservational. Will to power generates its own metaphysical world of growth and change instead of occupying a metaphysical world that is defined by mandatory meta-forms in which it must operate and which it must maintain.

Most important, Nietzsche tried to ground his construction in "a kind of instinctive life" that revolves around activity of a person's animal body such as "nourishment, excretion, and metabolism;" and he gave his construction a primal unity prior to differentiation into separate functions. He reached towards principles that "drives" are based on bodily processes and that "will" is based on self-perpetuating muscular movements. "Will to power" is an attempt to generate through a single developmental principle all the multiple aspects of personality — bodily, mental and emotional — as well as multiple stages of development. Nietzsche seeks to integrate the multiplicity into a living organism while, in contrast, platonic science seeks first to separate the elements and then to control them according to principles of mechanism and chance.

I suggest that Nietzsche carried out a partially successful investigation into his own primal psychology. Unfortunately, the fruits of his investigations were not the sought-after keys to the universe. They were, rather, certain childish thought processes that Nietzsche dressed up in grandiose phrases, projected as imagery of actual life and inflated into a comprehensive world-view. Because Nietzsche's thought processes were authentically childish, they incorporated primitive aspects of actual life that were very different from the detached constructions of platonic science. The surprising and even shocking juxtapositions appeal at first to childish dispositions and then reveal genuine substance for critical analysis. Seen next to the vibrancy of Nietzsche's childish primitivism, platonic science appears pale and weak.

Nietzsche's childishness is shown by Piaget's *Judgment and Reasoning in the Child* (1928), where, in "Summary and Conclusions," Piaget described "the most characteristic" kind of thought of children under the age of 8 years as "ego-centrism." It is manifested as "that quasi-hallucinatory form of imagination which allows us to regard desires as realized as soon as they are born." A child "has the peculiar capacity for immediate belief in his own ideas." "On the plane of verbal thought, every idea pictures a belief." "…it is extremely difficult for him to distinguish between fabulation and truth." "Only in his manual games does the child learn to understand the resistance of objects." (202-203.)

At about age 6-7, " 'artificialist' explanations given by children of natural phenomena are very frequent: rivers, lakes, mountains, sea and rocks have been made by man. Obviously, this does not require the slightest proof: the child has never seen people digging lakes or building rocks, but this does not matter. He enlarges sensible reality (a bricklayer making a wall, or a labourer making a ditch) by means of verbal and magic reality which he puts on the same plane." (203.)

Childish thought develops into adult thought. A chief difference is that an adult has learned from failures of ego-centrism and therefore limits and constrains acts of imagination. "We are constantly hatching an enormous number of false ideas, conceits, Utopias, mystical explanations, suspicions and megalomaniacal fantasies, which disappear when brought into contact with other people." (204.)

In his construction of will to power, Nietzsche manifests a quasi-hallucinatory form of imagination in which his novel, fragmentary "will to power" concept has magical, controlling power not only over all other concepts but also over physical forces and materials. He conflates two worlds that adults use to distinguish desires from deeds. For Nietzsche, like young children, desire is felt to produce deeds out of the essential power of desire, which is the only power that is recognized.

Like children's "artificialist" explanations, Nietzsche's "will to power" explanation does not require proof. He sees that his concept might apply to some actual activity and any such application is sufficient for belief in its universal power. He never considers the possibility that his inventions are "mystical explanations" or "megalomaniacal fantasies" that would disappear if examined critically.

The method of construction employed in Nietzsche's will to power is similar to those employed in other metaphysical constructions. His is illuminating because he does not clothe his method in a scholarly apparatus or try to smooth over the joints. He clearly reveals how, in such a construction, particular mental processes are first grasped through introspection, observation and invention. Then processes are isolated, given a form and treated as if operating in a separate, imaginary domain. I suggest that much the same method was and is used by pre-Socratic philosophers, by Plato and his successors, and by present-day platonic scientists. My own metaphysical constructions below and in *Feelings, Forms and Freedom* employ such methods in new ways and with different forms and embodiments.

3. In metaphysical constructions that were developed by ancient Greeks as part of "platonic science," an imaginary domain is occupied by mental objects called "Ideas" that are impersonal and eternal, that have the character of geometrical space and that are supposed to control actual lives of persons.

a. Hegemonies in platonic constructions.

In *The Open Society and Its Enemies* (1950), Karl R. Popper showed how Plato's metaphysical constructions reflected political positions that were formed during the Peloponnesian War that ruined Athens and during Plato's public career of supporting aristocratic and oligarchic parties and opposing Athenian democracy. Plato sought "an ideal state which does not change." "Plato also extended his belief in a perfect state that does not change to the realm of 'all things.' " He had a "belief in perfect and unchanging things, usually called the *Theory of Forms or Ideas*, [which] became the central doctrine in his philosophy." (24.) Plato's Theory had several functions, including "forging of an instrument for arresting social change, since it suggests designing a 'best state' which so closely resembles the Form or Idea of a state that it cannot decay." (33.)

In a passage from the *Laws* quoted by Popper (9), Plato wrote: "nobody … should be without a leader. Nor should [he] do anything at all on his own initiative … But in war and in the midst of peace—to his leader he shall direct his eye and follow him faithfully. And even in the smallest matter he should stand under leadership … never to dream of acting independently, and to become utterly incapable of it."

Plato's moral philosophy teaches a "***hegemony of reason*** in contrast to that of glorious action." (Taylor, 117, 120, emphasis added.) Reason connects us "with the order of things in the cosmos. …it is only on the level of the whole order that one can see that everything is ordered for the good. …the right order in us is to be ruled by reason … love of the eternal, good order is the ultimate source and the true form of our love of good action and the good life." (122.)

Popper showed that Plato's metaphysical constructions had a specific grounding in his political career and positions, that he opposed all change, other than to impose his visions, and that he wanted a hierarchical slave state resembling Sparta. A philosophical hegemony of reason over action, stated by Taylor, is at one with a political hegemony that demands total obedience and that prohibits change. Such unified hegemonies can and do claim divine, philosophical and practical authority.

Plato's goal of imposing hegemonies in political, philosophical and moral matters re-appears in his famous metaphysical "divided line" that supposedly distinguishes and elevates "true knowledge" above "mere opinion." Plato's Ideas such as Perfect Beauty and Justice and mathematical forms such as triangles are objects of true knowledge and have a status superior to that of worldly objects and changing phenomena, such as those encountered in actual life, about which we can have nothing more than opinions, beliefs and conjectures. (de Santillana, 201.) Plato's line thus distinguishes between "real, certain, indubitable, and demonstrable knowledge–divine *scientia* or *episteme*" and matters about which statements are "merely *doxa*, human opinion." (Popper, Nature of Philosophical Problems.)

b. Hegemony of impersonal invariance in metaphysical domains.

I suggest that establishing conceptual hegemony is a chief purpose of platonic sciences and shapes their content, e.g., as noted above, through "the search for invariants, which is the definition of science." (de Santillana, 218.) Advocates of the "modern scientific view" (Minsky, supra) do not simply "search for invariants." They want to allow as legitimate only a particular kind of invariant.

Aristotle, who "swerve[s] away from mathematics" and "takes his start from things," concurs in the supremacy of invariance: "There is no science except of the general." (de Santillana 210-211.) "The universe makes sense as something eternal and diverse and eternally well-ordered. On this Aristotle claims to find himself in complete agreement both with Plato and with the Pythagoreans." (213.)

"Impersonality" is a form of invariance. Events that depend only on "impersonal" influences must come to the same result, regardless of the person who performs the action. Arithmetic is impersonal. Outcomes of scientific experiments cannot depend on the personality of the experimenter. The polar opposite possibility is that events depend on "personal efforts" or "personal favor," where, by such means, one person can achieve an outcome that another person cannot. "Personal efforts" and "personal favor" vary from person to person. Sports competitions are designed to be decided by personal efforts. Changing moods of mass personal favor are aroused and seduced by marketers of clothing fashions, hairstyling trends and popular culture. Judges favor one party or another when resolving disputes in court. Yes, "impersonal" influences do occur but they are not the only influences.

I suggest that "impersonal invariants" supposedly "behind events" are mental constructions that occupy an imaginary, metaphysical domain. The supposition in ancient times, same as today, was that such mental constructions control both celestial motions and events of actual life. In ancient times, for example, astrologers constructed an imaginary celestial domain "behind" events, tracked its objects and relations and predicted actual events on the basis of their constructions.

In other words, I suggest that platonic Ideas, Laws of Physics and other mental objects have been constructed by means of psychological imagination and are continually reconstructed by the same means. Such constructions resemble those introduced in § 1 as part of the child's construction of reality and those discussed in §2 in connection with Nietzsche's will to power. The materials that go into the such constructions are based on the author's mental processes. In other words, the author of such a construction obtains imagery of his own psychological processes, e.g., by introspection and observations, endows the imagery with supposedly-powerful "impersonal invariance" in an imaginary domain, elaborates the imagery in constructions and declares that imagery so endowed is in control of everyone's actual life. Impersonal invariance supposedly overwhelms any influence arising from personal efforts or an individual character. Advocates of the imagery claim an authority that transcends its "human-all-too-human" origins and that promotes its hegemony.

c. "Principle of sufficient reason" imposes eternal symmetrized rigidity.

"Invariance" is one principle of science that stems from repetition. Another is the "principle of sufficient reason," which states: "Until a definite reason to the contrary can be assigned, we have to suppose a symmetrical distribution of things or possibilities." (de Santillana, 34-35.) "Symmetry" means that features are systematically repeated within the situation. I suggest that symmetry, like invariance, is a mental construction based on repetition.

Using the principle of sufficient reason, a scientist argues that if one part of the Earth preferentially attracts the north pole of magnets, it must be because of some asymmetry in the body of the planet and/or its surroundings. According to this principle, events are presumptively symmetric in all respects except for respects specifically shown otherwise. This means that special imaginary domains can be constructed — such as "empty space" — where rules of invariance impose symmetries and vice versa. Platonic science treats such special imaginary domains as having control over all phenomena of actual life.

An important application of the principle of sufficient reason is Newton's First Law of Motion, which states: "Every body perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed thereon." Newton's Laws and motions thereunder take place in an imaginary domain of empty space that starts off devoid of influences or forces. This is a domain in which the principle of sufficient reason operates. Suppose that an object in motion in empty space travels a short distance in a certain specific direction in a certain short period of time. In the next short period of time, there is no reason for it to go in any other direction than that previously traveled; therefore, applying the principle of sufficient reason, it continues to move in the same direction. Likewise, there is no reason for it to go faster or slower, so it continues with the same speed or remains at rest.

I suggest that the principle of sufficient reason applies weakly, if at all, to many occurrences in actual life. In actual life, multiple streams of possible activity are generated within each person and are continually being expressed through muscular movements. Persons start and stop streams of movements, selecting courses of action and switching to and fro. Events and changes occur in actual life for good reasons, for poor reasons or for no reason. Changes sometimes occur on large scales in ways that can't be explained by reasons. Sometimes it is possible to correlate changes with reasons; but, frequently, such correlations cannot be made.

Applied to empty space, the principle of sufficient reason says that every point in empty space participates in a "sameness" that enables one geometric figure to be "superimposed" in the imagination on another geometric figure. "Sameness" means a repetition when different places in space are compared ("***homogeneity***") and when different directions are compared ("***isotropy***"). (de Santillana, 95.) However, such symmetries do not always apply to activities of actual life. Events occurring at different times often can't be superimposed. As discussed below, loss of symmetry can lead to imbalance, which can lead to more than one possible result.

As shown by Newton's First Law, there are situations where the principle of sufficient reason can be applied to temporal events as well as to spatial symmetries. Newtonian "speed" is treated much like "direction." Application of the invariance principle and the principle of sufficient reason generates invariances that are permanent until a definite reason arises to change them. In the absence of such reasons, this gives "impersonal invariants" the character of ***eternity***.

In sum, in platonic science, metaphysical processes of construction create an imaginary domain populated by invariant objects. The invariant objects may resemble actual objects or sensory objects but they are chiefly characterized by symmetrical features and an "eternal, impersonal" character. Such invariant objects have a resemblance to actual objects that is like the resemblance of Greek gods to human persons. According to many teachers, e.g., Plato, such invariant, symmetrized, impersonal mental objects in imaginary domains control — or should control — actions of human persons engaged in actual life.

d. Platonic constructions have the character of geometrical space.

The course of development of platonic science added specific character to the products of its constructions. Seen in retrospect, that additional character is ***geometrical*** and has (1) a characteristic of ***rigidity*** that is based on ***invariant symmetries***, specifically, homogeneity and isotropy introduced above; and (2) a characteristic of ***continuity***. Plato's Ideas incorporated such rigidity and continuity; modern physics is built around generalized "spaces" that maintain them.

As discussed below, new proposed temporal forms have a different character. Invariance, symmetry and continuity are not "laws" that are universally inherent in things but are, instead, ***constitutive principles*** or "conceptual parts in a kit of parts" by means of which we can construct, describe and control events, e.g., using technology. Inherent laws are not modifiable but constitutive principles may be modifiable.

Some temporal forms are invariant, e.g., a beat controlled by a metronome. There also exist temporal forms that have multiple possible asymmetrical outcomes and/or that are discontinuous — e.g., forms that describe a race contest and a diner's choice in a restaurant. Such temporal forms have ***critical moments*** of change that do not fit into spatial forms.

Using de Santillana's *The Origins of Scientific Thought* (1961) as a guide, it appears that the geometrical character of platonic constructions had two main sources, Pythagoras and Parmenides.

Pythagoras (c. 550 B.C.E.), perhaps-legendary founder of a cult, is credited with famous discoveries in geometry and harmony. He reportedly unified them with reincarnation, astronomy, rhythm and arithmetic. He taught that Number was the *eidos* (form) and *logos* (proportion) behind all such things. ***Proportion*** was a chief structural principle of Pythagorean thought. In music theory, an important focus of such thought, a system of proportional relations organized the different sizes of strings and tubes in musical instruments and the corresponding musical tones. "Pythagorean harmonics" state specific proportions or ratios of numbers.

"What they were inventing was a 'geometry of numbers' or arithmogeometry of a rather fanciful kind. It served to express their original idea of proportion as underlying everything. If 'proportion' comes to take such a vast importance in Greek thought, it is largely due to the undefined mass of significance contained in its name. *Logos* means 'discourse,' 'reason,' 'argument,' 'inference,' and also 'proportion.' " (65.)

In Pythagorean thought, "reality is made of things which oppose each other" and oppositions are resolved through "*harmonia*, which is the old word for the tension between opposites. The mean proportionals do more than articulate the intervals; they are held to be the actual bond or *fastening* which holds together the disparate or unrelated elements of reality and welds them into a whole. All of Pythagorean and Platonic physics rests on that certainty." (67, emphasis in original.)

According to de Santillana, the "dreamy enterprise" of Pythagorean and Platonic physics led to "the theory of conic sections, which allowed Kepler and Newton to conquer the universe." (67.) As discussed below, modern physics continues to teach that a supposed texture of proportional fastenings – as in laws of energy conservation and entropy – "holds together the disparate or unrelated elements of reality and welds them into a whole."

Pythagoreanism upheld a visionary cosmology based on music, number and geometry. The vision was extended and solidified by Parmenides of Elea (c. 500 B.C.E.), "who first among the Pythagoreans taught the sphericity of the Earth, and that the moon shines by reflected light." (89.)

"Parmenides is the one person of whom Socrates speaks with marked reverence, describing him in Homeric terms as 'august and terrible in his greatness.' … Thus, by way of Plato, Parmenides is enshrined in the realm of pure philosophy, as the First Metaphysician." (94-95.)

"He wrote only one work, entitled *On Nature* ... a poem, in oracular and cryptic style, probably in the tradition of the lost Pythagorean 'Sacred Discourses.' " (89.)

On Nature has two parts distinguished in a way closely resembling that used to divide Plato's metaphysical line discussed above, titled in Parmenides' case "The Way of Truth" and "The Way of Opinion." (*Id.*)

"Parmenides, one of Plato's predecessors who influenced him greatly, had taught that the pure knowledge of reason, as opposed to the delusive opinion of experience, could have as its object only a world which did not change, and that the pure knowledge of reason did in fact reveal such a world." (Popper, *Open Society,* 31.)

De Santillana offers translations of Parmenidean fragments that he interprets through a puzzle that I call "what is Being?" That is, Parmenides teaches the supremacy of "Being." In the puzzle form suggested by de Santillana, "Being" is something you know; it is described in terms of its properties and features but it is not named exactly. The puzzle is to name it exactly.

Parmenides wrote: "Being is uncreated and indestructible, one all through, whole, immovable, and without end. It never was, nor is it ever going to be; for it exists now, all together, a single continuum. … Moreover, it is immovable in the bonds of mighty chains, without beginning and without end. … Remaining in the same, in the selfsame place, it abides in itself. And thus it remains steady in its place; for strong Necessity keeps it in the bonds of the limit that constrains it round. … But since the last bound is defined on all sides, like a well-rounded sphere, it is equally poised from the center in all directions; for it is necessary that it should not be greater in one direction and smaller in another." (91-92.)

The answer to the puzzle, according to de Santillana (95, emphases added):

"If we accept the word 'Being' not as a mysterious verbal power, but as a technical term for something the thinker has in mind but could not yet define, and replace it by *x* in the context of his argument, it will be easy to see that there is one, and only one, other concept which can be put in the place of *x* without engendering contradiction at any point, and that concept is ***geometrical space itself***… Moreover, it is built up step by step, with the use of the ***principle of indifference or sufficient reason***, that we have seen used by Parmenides' naturalist predecessors; it is here for first time applied consciously as a fundamental instrument of scientific logic."

“Geometry as the Greeks meant it put three requirements on its space: first, it must have continuity…second, it must be the same, homogeneous throughout, so that we can move figures freely from place to place without altering their geometrical properties; and finally, it must be isotropic or the same in all directions.” (95.)

“The true conception of geometrical space, once formed, is equally well adapted to serve as a substratum for physical form, in view of its rigidity and impassability.” (97.)

Modern scientific constructions resemble those of ancient Greeks. Both view space as an empty container that can be identified with metaphysical domains. In scientific constructions, time is treated as a kind of space. (In contrast, constructions in music and civil law treat time differently from space.)

Like platonic construction, spatial and space-like constructions in science are subject to rules of invariant symmetry and continuity. Unfortunately for scientific claims to universality, actual material bodies such as steel and water, and perhaps brains, go through transformations during which symmetry breaks in a variety of discontinuous ways that do not follow rules of invariance.

“Rigidity” is based on invariance of both homogeneity and isotropy. Suppose a geometrical figure, e.g., a circle, is represented by an elastic black thread glued onto the elastic surface of a blue balloon. Consider the possibility of deforming that space by stretching (inflating the balloon), or by bending or twisting. Consider the fate of a geometrical figure when space is deformed. Look for deformations that conserve geometrical figures. Because of the character of space, the only deformation that will clearly preserve geometrical figures is a ***system of organized proportional changes*** of lengths that maintains both homogeneity and isotropy at every point in the deformation. Such changes occur during uniform inflation and deflation of a perfectly spherical balloon: figures drawn on the surface of such a balloon are conserved through the changes. When proportional changes of lengths are so organized, space is homogeneous and isotropic at every point and at every instant during such a deformation. The proportions themselves are maintained as “invariants” during the changes.

In other words, proportions are maintained as invariants if all subdivisions of geometrical space change together in an organized way. Then, proportional relations make up invariant structures. This is what is meant by the “rigidity” of space. Space makes up one whole thing and it is not possible to change any piece independently. Form-conservation requires that overall features change in certain continuous organized ways. Parmenides’ language expresses these facts.

Temporal forms can have a rigid character comparable to that of space or, alternatively, they can have a flexible character that is incongruent with that of space. An example of rigidity in temporal forms occurs when an orchestra is led by a conductor who controls the tempo; all musicians in the orchestra “uniformly” follow the tempo set by the conductor — all speed up or slow down together. An example of flexible temporal forms is that of a person chopping vegetables while conversing with a friend sitting in the kitchen; the tempo of chopping and the tempo of conversation are independent and each may vary without regard for the other. A more complex example of flexible temporal forms is that of a footrace, discussed below, where a runner’s tempo of muscular movements is subject to personal efforts.

Imagery of deforming geometrical figures also illustrates the characteristic of ***continuity*** in spatial forms and, by way of contrast, also illustrates discontinuous transformations in temporal forms. Suppose a spherical balloon is cyclically inflating and deflating. Geometrical figures drawn on the surface are maintained during inflation and deflation, showing a conservation principle. It is never the case, for example, that, at some point during the inflation part of the cycle, a circle suddenly changes into a triangle. The conservation of the figure during inflation stands in contrast to temporal forms that undergo discontinuous transformations that are observed in many activities, e.g., switching between listening and speaking and the changing gaits of a horse that increases speed.

Discontinuous transformations in materials called ***phase changes*** are driven by temperature changes, e.g., liquid water turns into ice or steam. In models set forth herein, important selections are discontinuous transformations that occur when multiple possible courses of action change into a single actual course of action. Some selections occur when a person makes a choice, e.g., choosing a meal from a menu in a restaurant, where multiple possible orders being entertained in the mind suddenly change into a single actual order spoken to the waiter.

Race contests incorporate "critical moments" when one runner overtakes another runner. Menu selections incorporate "critical moments" during which multiple possible courses of action suddenly change into a single actual course of action. Such critical moments identify temporal forms that are outside the reach of platonic science and that sometimes involve exercises of freedom.

4. Modern versions of platonic science construct imaginary domains in which particles and rigid bodies undergo determinate changes according to eternally symmetrical Laws of Physics. Such forms would impose the character of empty space on material bodies; but they fail to describe or control actual transformational changes that occur during a fast quench of red-hot steel or the growth of crystalline snowflakes in a cloud of water vapor.

    a. Modern platonic science has advocates and alternatives.

I offer views of modern physics that differ in content and approach from prevalent positions that some call "the modern scientific view" and that I call "platonic science." My views are directed towards development of new technologies and have a revisionary purpose.

Richard P. Feynman advocated platonism in *The Character of Physical Law* (1965), quoted above. The text came from Feynman's Messenger Lectures at Cornell University presented in 1964 to a lay audience. This was the same period as the famous *Feynman Lectures on Physics*; those in Vol. I were given to first-year students at Cal Tech. *The Character of Physical Law* and *The Feynman Lectures*, Vol. I, chaps. 1 – 4 state an exemplary platonic view. In such a view, Laws of Physics describe and control everything in the Universe.

Of course, not all scientists are platonists. An "operational" view was set forth by Nobelist P. W. Bridgman in *The Nature of Physical Theory* (1936), which contrasts neatly with Feynman's *The Character of Physical Law*. More views are provided by Truesdell (rigorist) and Feyerabend (anarchist). My impression is that many scientists abstain from such views altogether. In the field of scientific psychology and brain models, however, platonism has a dominant influence. As discussed below, an alternative approach seeks to overcome limitations of platonic science

As a first criticism of Feynman's platonism, I suspect that few chemists would concur with his statements (*Lectures*, § 3-2, Chemistry) about rules that state "which substance is combined with which, and how, that constituted inorganic chemistry. All these rules were ultimately explained in principle by quantum mechanics, so that theoretical chemistry is in fact physics. … substances which are associated with living things…are just the same as substances made in inorganic chemistry but more complicated arrangements of atoms are involved…physical chemistry and quantum mechanics can be applied to organic as well as to inorganic compounds."

Linus Pauling (1901-1994) was Feynman's colleague at Cal Tech and a pioneer in both inorganic and organic chemistry. Pauling used quantum mechanics extensively in his own work. In his 1954 Nobel Laureate Lecture, Pauling stated: "The development of the theory of molecular structure and the nature of the chemical bond during the past twenty-five years has been in considerable part empirical - based upon the facts of chemistry - but with the interpretation of these facts greatly influenced by quantum mechanical principles and concepts." Such a statement is quite different from implying, as Feynman does, that the facts of chemistry are "rules" that are "explained in principle by quantum mechanics." It is the difference between a scientist who uses principles of quantum mechanics to construct tools for fact-based investigations and one who declares that quantum mechanics explains in principle everything in the Universe.

As an illustration of the difference, Pauling described his "arbitrary" use of a resonance theory that uses oscillating static images, which are "idealized, hypothetical structural elements." "In the description of the theory of resonance in chemistry there has been a perhaps unnecessarily strong emphasis on its arbitrary character. … a description of the benzene molecule can be given, in quantum mechanical language … An approximate wave function for the benzene molecule may be formulated… It might be possible to develop an alternative simple way of discussing the structure of the amide group, for example, that would have permitted chemists to predict its properties, such as planarity; but in fact no simple way of discussing this group other than the way given above, involving resonance between two valence-bond structures, has been discovered, The convenience and usefulness of the concept of resonance in the discussion of chemical problems are so great as to make the disadvantage of the element of arbitrariness of little significance. Also, it must not be forgotten that the element of arbitrariness occurs in essentially the same way in the simple structure theory of organic chemistry as in the theory of resonance - there is the same use of idealized, hypothetical structural elements. … Chemists have found that the simple structure theory of organic chemistry and also the resonance theory are valuable, despite their use of idealizations and their arbitrary character."

In sum, Pauling's actual experience did not conform to Feynman's platonic vision.

Feynman began *The Character of Physical Law* with "The Law of Gravitation, an example of Physical Law." "Why I chose gravity I do not know. … Modern science is exactly in the same tradition as the discoveries of the Law of Gravitation." (14.) I suggest that the Law of Gravity is the most successful theory of platonic physics because it is grounded in empty space, which was similarly favored by ancient Greeks.

According to Feynman, "great general principles which all the laws seem to follow" include "the great conservation principles." (*Id*., Chap. 3.) A conservation principle applies to a system that is undergoing changes. A certain quantity is conserved: "the number does not change" while changes are occurring around it. For example, movements of billiard balls on a table and of particles in an evacuated chamber follow principles of conservation of momentum, angular momentum and energy; and "constants of the motion" based on such principles are used to calculate and predict actual motions of such billiard balls and particles.

Conservation of momentum is based on spatial homogeneity, previously discussed in connection with platonism. Conservation of angular momentum is similarly based on spatial isotropy. (103.)

In other words, invariant relations of spatial homogeneity and isotropy that gave space its rigidity in prior platonic constructions are expressed as conservation of momentum and angular momentum in constructions of modern science.

Such rigidity means that invariant relations are binding at every location and at every moment and throughout eternity. "Physicists as a rule hold that the physical laws are eternal. (There are exceptions, such as physicists Paul Dirac and John Archibald Wheeler …) It is indeed difficult to think otherwise, since what we call laws of physics are the results of our search for invariants." (Popper & Eccles at 14.)

"To … our list of conservation laws…, we can add energy. It is conserved perfectly as far as we know." (Feynman, *Character of Physical Law* at 77.) Feynman apparently claims victory in the face of serious challenges: "Of all the conservation laws, that dealing with energy is the most difficult and abstract, and yet the most useful." (68.)

My critical reconstruction challenges the claim of "perfect" energy conservation. I suggest that there are phenomena — especially discontinuous transformations in material bodies — where the principle of energy conservation does not apply in the hegemonic way presumed by platonic science. Chief examples discussed below are red-hot steel being quenched in ice water and production of snowflakes from gaseous water vapor. The principle of energy conservation requires “state” conditions, e.g., a defined and uniform “temperature.” There is no defined “temperature” in the examples. Instead, hot is changing to cold while energy is being removed.

Feynman had some good reasons for claims about “perfect” energy conservation. The goal of comprehending physical phenomena through invariance, symmetry and continuity did succeed in important cases. However, such successes are set in empty space. Scientific reasoning based on empty space started off in ancient Greece with geometrical reasoning and developed historically from that base. Newton’s primal publication, *Principia Mathematica* (1687), used geometrical proofs rather than calculus derivations like those taught today. He evidently thought that geometrical proofs were more authoritative than his novel mathematics. Newton’s approach requires the mathematical reduction of huge solar and planetary masses to geometrical “mass points” or “corpuscles” and such a reduction was a point of difficulty for him. Strictly applied, such a reduction is limited to symmetrical bodies. Although celestial bodies are approximately spherical, there are deviations. The entire approach becomes problematical when complications are introduced. “Three-body problems” became evident during the 18th century. “Chaos” in possible orbits were disclosed when computers became powerful enough to handle massive calculations required to apply Newton’s formulae to an actual planetary system.

Major events in the saga of development of electricity and magnetism also occurred in empty space. Investigations into material phenomena such as Faraday’s development of electro-chemistry did not figure in the main line of the saga that culminated in Maxwell’s spectacularly successful achievements. Maxwell used empty space symmetries, conservation principles and continuity assumptions to construct his “displacement current” and the “light is Electromagnetic Waves” model. Einstein’s special and general theories superseded both Newton’s and Maxwell’s models but retained and developed their spatial approach. “Elementary particle physics” – where Feynman was eminent – treats empty space as definitive for all situations.

Disregarding the limited empty space basis of his claims, Feynman declares that broader platonic goals have already been achieved: “With these particles that I have listed, all of the low energy phenomena, in fact all ordinary phenomena that happen everywhere in the Universe, so far as we know, can be explained. … For example, life itself is supposedly understandable in principle from the movements of atoms, and those atoms are made out of neutrons, protons and electrons. I must immediately say that when we state that we understand it in principle, we only mean that we think that, if we could figure everything out, we would find that there is nothing new in physics which needs to be discovered in order to understand the phenomena of life. … In fact, I can say that in the range of phenomena today, so far as I know there are no phenomena that we are sure cannot be explained this way, or even that there is deep mystery about.” (151.)

Feynman also taught that the most important scientific “fact” is that “all things are made of atoms.” (Lectures I-1-2.)

A different view was stated by Truesdell & Noll (1):

"Matter is commonly found in the form of materials. Analytical mechanics turned its back upon this fact, creating the centrally useful but abstract concepts of the mass point and the rigid body, in which matter manifests itself only through its inertia, independent of its constitution; 'modern' physics likewise turns its back, since it concerns solely the small particles of matter, declining to face the problem of how a specimen made up of small particles of matter will behave in the typical circumstances in which we meet it. Materials, however, continue to furnish the masses of matter we see and use from day to day: air, water, earth, flesh, wood, stone, steel, concrete, glass, rubber..."

As discussed below, “analytical mechanics” fails to connect to actual life. Animal bodies are neither mass points nor rigid. Animal bodies are always dissipating energy and never come to equilibrium, even in sleep. Analytical mechanics, e.g., statistical mechanics, turns its back on such facts.

Thermodynamics is the branch of physics that deals with changes in material bodies in general. Specific topics in ***materials science*** deal with classes of materials, e.g., chemical reagents, metals, semiconductors. Truesdell (Rational Thermodynamics, 1) contrasts thermodynamics with “mathematical theories of mechanics” that have progressively become “more precise, briefer, easier to learn, and more widely applicable.” “Thermodynamics has had a different history. It began out of steam tables, venous bleeding, and speculations about the universe, and has always had a hard time striking a mean between these extremes. While its claims are grandiose, its applications are usually trivial. The classical illustrations all concern systems which from the standpoint of mechanics are so special as to be degenerate, yet thermodynamicists are prone to claim that their science somehow implies mechanics as a corollary.” (*Id.*)

Truesdell seeks to “show you that classical thermodynamics can be stated precisely and learned, just as classical mechanics is stated precisely and learned.” (*Id.*, 4.)

My revisionary view differs from those of both Feynman and Truesdell. (See *A Patchwork Of Limits* (2000) available on my website.) In my view, models are human inventions and are not necessarily supported by an underlying “reality.” Rejecting language used by those who envision such support, I suggest that models do not cohere into a Grand Unified Theory and that models do not emerge from each other. Each model is free-standing and has a limited domain of application. In my view, there are important differences between models of gravity, mechanics, electromagnetism and thermodynamics. Different models apply to different phenomena and use different methods. For me, “thermodynamics” means “energy conversion” with various meanings for “energy” and “conversion” and with various mathematical and/or device models. In my view, platonic conceptions of energy, e.g., “conservation of energy,” are superficial and rudimentary but provide suggestions for development. Mechanics, e.g., classical mechanics (Goldstein), occupies one domain of investigations into energy. Electromagnetism and electrical engineering occupy another domain. Scientists attempting to unify the two domains (mechanics and electromagnetism) have made progress but only with difficulty and the results are not wholly satisfactory. (Penfield & Haus.) To try to bring thermodynamics into such a system is beyond the capacities of the tools involved. I suggest that thermodynamics is a separate domain of investigation into energy, an alternative to other approaches rather than subject to them.

My conception of energy is constructed functionally as that which multiple forms of activity have in common and as that which passes between forms of activity. In the simplified timing devices system, energy has a form of “action pulses” that are all identical. The timing devices system thus serves as a point of origin for development through modifications and invention.

Thermodynamic models do not acquire the rigor or power of analytical models just because it would be gratifying if that were so. Feynman and other platonists use gravity as their exemplar but no other scientific concepts are as successful as theories of gravity. Theories of gravity are based on geometrical properties of empty space that are universal and eternal. Material bodies have individual characters that are not comprehended by spatial and geometrical forms.

"Conservation of energy" is different from conservation of momentum because energy conservation in material bodies is imposed through equilibrium constraints and what Truesdell calls "constitutive relations" or "constitutive laws" that depend on the situation and on particular properties of materials; while the stronger momentum law is grounded in homogeneity of empty space. "That is, the 'first and second laws' are to be interpreted, not as restrictions on the processes a body must undergo, but as restrictions on the response of the body itself." Truesdell, *Rational Thermodynamics* at 13. In other words, the first law of thermodynamics, "conservation of energy," is based on the constitution of the body and on the situations in which tests are conducted rather than being an inherent feature of the Universe. As shown below, an actual body of water that changes from liquid to gas to solid, is not described or controlled by what we know as laws of physics during the formation of snowflakes.

b. Minkowski's "union of space and time" illustrates puzzling claims of conceptual hegemony.

In a famous 1908 address, "Space and Time," H. Minkowski claimed that "radical" new theories of Lorentz and Einstein resulted in "changed ideas of space and time." He predicted: "Henceforth space by itself, and time by itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality."

Minkowski's claims are no longer radical. Hawking's *A Brief History of Time: From the Big Bang to Black Holes* (1988) (21, 24) continues to echo him: "…relativity…has revolutionized our ideas of space and time" leading to "a four-dimensional space called space-time".

Such claims remain puzzling for several reasons. Foremost are actual distinctions between space and time. That is, speaking from the perspective of actual life, I have an overall experience of the character of space that is very different from that which I have of time. I move freely in space, including movements that repeat or that cyclically go away and come home, to and fro. In contrast, I cannot move around in time; rather time inexorably moves me towards the mortal end shared by all creatures. Unlike goals in space, my end in time is concealed from me; and, from a scientific point of view, I move towards it with only guesses about how to guide my deeds.

The principle of sufficient reason, discussed above, suggests that a metaphysical domain should be constructed according to principles of maximum symmetry. Symmetry is inherent in space according to principles of homogeneity and isotropy. Relativistic principles modify descriptions of spatial symmetries but do not change their application or significance.

Symmetry comparable to spatial symmetry is not present in time because of the "arrow of time." This common phrase stands first for the fact that all actual changes share a specific direction that begins in the past and that moves into the future. Of equal importance for my purposes is the inherent ***actual ordering*** of events in time. That is, in actual life, events occur one after another and order relations "before" and "after" are of foundational importance. Such an ordering is not inherent in space, but order in space is typically established by imposing a system of coordinates like Cartesian coordinates x, y and z.

The direction of time flow is an inherent and universal asymmetry. According to the traditional formulation, it is not possible to put an egg (e.g., Humpty-Dumpty) together again after it is broken. The word ***irreversible*** is used to specify changes where a return to a previous condition is impossible. Conversely, changes where the initial position can be recovered, or apparently so, are ***reversible***. In the actual world, all changes are irreversible. There are "approximately" reversible events, e.g., in videogames and movements to and fro in space — but even these events occur at different times in a changing world and may be thwarted by irreversible events such as deaths and breakages.

Irreversible changes occur in actual life when hot steel is quenched, when snowflakes form in a laboratory and during sports contests and trials in court. Each of these events is carried out intentionally to produce such changes. I suggest that irreversible events are the normal or default kind of event in actual life and that reversible events are special, e.g., like winning a rare reversal in a court case. In contrast, imagery of platonic science teaches that actual life is controlled by reversible events and that reversible events add up to irreversible events. The actual world I experience does not match imagery of platonic science.

The principle of sufficient reason applies to empty space because empty space is highly symmetrical. The principle of sufficient reason applies to time only in special cases. One special case is ***time-invariance***, comparable to isotropy. For example, among electronics devices, there is a class of "time-invariant systems." A time-invariant electronics system, e.g., an AM radio, has identical capacities all the time. Any time you want, you can turn the dial and try to get a station located at a certain frequency. Ideally, this capacity is the same for all eternity. A time-invariant system is not constrained by memory; it doesn't matter what station you listened to last. Time-invariance and constraint by memory cannot co-exist in such a system. The entry of a memory breaks temporal invariance. One function of memory is to help construct possible alternatives to action without memory. We learn from our own mistakes and from mistakes of others. Time-invariance excludes alternatives based on memory and does not recognize learning. In actual life, in contrast, behaviors are subject to memory and to alternatives based on learning.

In a similar way, as discussed below, "equilibrium," the "time-invariant" ground of the First and Second Laws of Thermodynamics, is inconsistent with memory and with alternatives.

Notwithstanding clashes between platonic imagery and actual life, some scientists claim hegemony for platonic constructions. Instead of dealing with issues, they brandish authority and invoke metaphysical constructions. For example, Hawking argues that concepts of "entropy" and "disorder" support his arguments about a "thermodynamic arrow of time," a "psychological arrow of time" and a "cosmological arrow of time" that "point in the same direction [when] conditions are suitable for the development of intelligent beings." (145.) "Disorder increases with time because we measure time in the direction in which disorder increases. You can't have a safer bet that that!" The bet is bolstered by a belief that brains are computers: "Just as a computer, we must remember things in the order in which entropy increases." (147.)

Fallacies in such arguments are discussed below. Contrary to Hawking's safe bet, "entropy increases" during repetitive muscular movements, which can be highly ordered activity even though it is not the "equilibrium" kind of order that Hawking's imagery requires. Repetitive muscular movements can build a wall out of bricks: as time passes and entropy increases, more order appears. The concept of entropy was invented by Rudolf Clausius (1822-1888) and has only limited and specific applications. Clausius' entropy applies to bags of gas that are "relaxing towards equilibrium," not to purposeful muscular movements.

Statistical mechanics, developed by Gibbs and the source of "entropy is information" notions, applies only to static systems. Such concepts do not apply to transformational activity that produces individualized snowflakes. Nor do they apply to transformational activities of a brain that is burning through a lot of sugar energy. The human brain consumes some 20% of the entire body's supply of energy. In a highly dissipative system like a brain, entropy always increases. Entropy increases regardless of whether activities grow more ordered or more disordered. Entropy increases do not control order.

Cosmological claims about entropy, such as those of Hawking, are empty. They do not answer questions about the clash between Minkowski's views and the facts of actual life. From a perspective grounded in actual life, Minkowski's prediction that "space by itself, and time by itself are doomed to fade away" was puzzling when he made it. The prediction has proved to be empty. Only physics buffs and professionals think about a "union of the two;" but all persons, including physicists, continue to use clocks without reference to meter sticks and vice-versa. What remains puzzling to me is the widespread belief that Minkowski's claim and prediction about a "union" of space and time have some truth or validity that is superior to my experience of actual life.

c. Reconstructing time into a kind of space makes time fit the primal linear form of platonic science.

I focus on the ***linear form*** that is the ***primal form of platonic science***. The linear form appears in different guises in different sciences and technologies and with various symbols and applications. The point of origin of linear forms is the formula: distance = rate × time or d = r×t. An historical example of the linear form was ***Hooke's law for an elastic spring***, formalized as F = –k×x. Another elementary example is ***Ohm's law of electrical resistance***, V = I×R.

Hooke's law and Ohm's law are examples of constitutive laws, mentioned above in subsection a, that depend on properties of materials which exist only for certain ranges of activity. The laws fail for spring stretching or electrical currents greater than a certain amount that depends on the actual spring or actual resistor.

As the name indicates, a linear form is based on the form of a geometric line. The form for a line in analytic geometry is y=a×x+b; an even simpler and more popular form for a line is y= a×x. Then the line passes through the origin of the graph.

The linear form that is most suitable for critical discussion of Minkowski's union of space and time is called a ***linear transformation.*** Linear transformations are the chief form of transformation studied in platonic science. Other linear forms in platonic science include linear approximations, linear spaces and linear functions.

The ***geometrical linear transformation*** exemplar set forth below is used in a space of 3 dimensions where there are 2 fixed perspectives, the X perspective and the Y perspective. The symbols (x_1, x_2, x_3) specify a point seen from the X perspective; and the symbols (y_1, y_2, y_3) specify the same point seen from the Y perspective. The relationship between the two perspectives is specified by the set of symbols (a_{11}, a_{12}, a_{13}, a_{12}, a_{22}, a_{23}, a_{31}, a_{32}, a_{33}).

$$y_1 = a_{11}\times x_1 + a_{12}\times x_2 + a_{13}\times x_3$$

$$y_2 = a_{21}\times x_1 + a_{22}\times x_2 + a_{23}\times x_3$$

$$y_3 = a_{31}\times x_1 + a_{32}\times x_2 + a_{33}\times x_3$$

In such a geometrical linear transformation, the symbols (y_1, y_2, y_3) and (x_1, x_2, x_3) stand for ***variable*** quantities. The symbols (a_{11}, a_{12}, a_{13}, a_{12}, a_{22}, a_{23}, a_{31}, a_{32}, a_{33}) stand for ***fixed*** quantities.

I suggest that such a transformation is an exemplar of platonic forms in that the fixed symbols (a_{11}, a_{12}, a_{13}, a_{12}, a_{22}, a_{23}, a_{31}, a_{32}, a_{33}) stand for the ***invariant proportionals*** of Pythagoras and Parmenides that characterize the rigidity of geometrical space. Homogeneity and isotropy appear as fixed relations among the (a_{11}, a_{12}, a_{13}, a_{12}, a_{22}, a_{23}, a_{31}, a_{32}, a_{33}).

Linear forms have advantages that make them suitable for science and technology. Linear forms coordinate invariant features (a_{ij}) and variable features (x_j and y_i). Easy arithmetic operations + and × make up a convenient computational device. The linear transformation is developed into classes of linear transformations that can be organized by means of tools called ***linear algebra***.

In their advances, Lorentz, Einstein and Minkowski employed an expanded form of the geometrical linear transformation:

$$y_1 = a_{11}\times x_1 + a_{12}\times x_2 + a_{13}\times x_3 + a_{14}\times t$$

$$y_2 = a_{21}\times x_1 + a_{22}\times x_2 + a_{23}\times x_3 + a_{24}\times t$$

$$y_3 = a_{31}\times x_1 + a_{32}\times x_2 + a_{33}\times x_3 + a_{34}\times t$$

$$t' = a_{41}\times x_1 + a_{42}\times x_2 + a_{43}\times x_3 + a_{44}\times t$$

New variables t and t' were made a part of the form. The variable quantity t' stands for the time of an event in the Y perspective, along with the quantities (y_1, y_2, y_3) that specify the event position. Similarly, t and (x_1, x_2, x_3) specify the time and position of the same event in the X perspective. Specific values of the fixed symbols (a_{11}, a_{12}, a_{13}, a_{14}, a_{12}, a_{22}, a_{23}, a_{24}, a_{31}, a_{32}, a_{33}, a_{34}, a_{41}, a_{42}, a_{43}, a_{44}) are set forth in the well-known Lorentz transformation.

The Lorentz transformation has the effect of turning time into a spatial variable and making time part of a rigid system of proportional relations. The system is not entirely rigid because the fixed symbols (a_{11}, a_{12}, a_{13}, a_{14}, a_{12}, a_{22}, a_{23}, a_{24}, a_{31}, a_{32}, a_{33} a_{34}, a_{41}, a_{42}, a_{43}, a_{44}) have a dependence on the speed between two frames of reference (X and Y) and such speed can change. In applications of the Lorentz transformation, however, the speed between frames of reference is typically held fixed and the values for a_{jk} remain fixed like the fixed proportionals of the Pythagoreans.

Spatialized time is certainly useful for some purposes, such as purposes motivating Lorentz, Einstein and Minkowski. A chief purpose was to describe a certain kind of activity, namely, Electromagnetic Waves traveling in empty space. Such waves are reducible to perfectly invariant phenomena. Imagery of a "traveling electromagnetic wave" uses a repetitive mathematical sine function. An imaginary infinite sine wave repeats in space and in time, thus in boundless eternity. Such imagery of waves rather resembles some phenomena of actual life, e.g., music in an otherwise silent concert hall. Properties of spatio-temporal waves in music, e.g., in plucked strings, organ pipes and circular drumheads, made them attractive to ancient Pythagoreans and to 19^{th}-century platonic scientists. Such waves have important, if limited, uses.

If the activity that needs to be described is Electromagnetic Waves traveling in empty space, spatialized time is suited to the task. Spatialized time is also suitable for other purposes, including a re-worked version of Newton's Mechanics for "corpuscles" and for the class of situations specified in Einstein's Special Theory of Relativity of 1905: "kinematics of the rigid body … relationships between rigid bodies (systems of co-ordinates), clocks and electromagnetic processes." (Einstein, Special Theory, 38.) Spatialized time has solid domains of application in empty space, Electromagnetic Waves, corpuscles and rigid bodies.

In 1916, Einstein published the General Theory that further developed space and time relations. In the previous system, it was the rule that: "To two selected material points of a rigid stationary body there always corresponds a distance of quite definite length, which is independent of the locality and orientation of the body, and is also independent of the time." A similar independence with respect to locality, orientation and time applied to an interval of time measured by a stationary clock. In contrast, "the general theory of relativity cannot adhere to this simple physical interpretation of space and time." (Einstein, General Theory, 112.)

Proceeding from the previous "geometrical linear transformation" form, steps in development lead to the following form, a ***differential linear transformation*** form. Metaphorically, steps taken by Einstein in moving from the special theory to the general theory are reflected in steps from the previous geometrical linear transformation to the new differential linear transformation. The bold-faced symbol "**x**" stands for x_1, x_2, x_3.

$$dy_1 = a_{11}(\mathbf{x}, t) \times dx_1 + a_{12}(\mathbf{x}, t) \times dx_2 + a_{13}(\mathbf{x}, t) \times dx_3 + a_{14}(\mathbf{x}, t) \times dt$$

$$dy_2 = a_{21}(\mathbf{x}, t) \times dx_1 + a_{22}(\mathbf{x}, t) \times dx_2 + a_{23}(\mathbf{x}, t) \times dx_3 + a_{24}(\mathbf{x}, t) \times dt$$

$$dy_3 = a_{31}(\mathbf{x}, t) \times dx_1 + a_{32}(\mathbf{x}, t) \times dx_2 + a_{33}(\mathbf{x}, t) \times dx_3 + a_{34}(\mathbf{x}, t) \times dt$$

$$dt' = a_{41}(\mathbf{x}, t) \times dx_1 + a_{42}(\mathbf{x}, t) \times dx_2 + a_{43}(\mathbf{x}, t) \times dx_3 + a_{44}(\mathbf{x}, t) \times dt$$

In the new differential linear transformation form, the "d" quantities are very small quantities that can change quickly. The $a_{jk}(\mathbf{x}, t)$ are quantities that vary according to location and time but slowly in comparison to the "d" quantities. This requires that the $a_{jk}(\mathbf{x}, t)$ have the property of ***continuity*** that is central in platonic science. (Conservation is a strong kind of continuity.) The character of the more general version of "space-time" is expressed by relationships among the $a_{jk}(\mathbf{x}, t)$ that are complex adaptations of the original fixed version. The new differential version "reduces" to the simpler original version if all matter is excluded from the imaginary domain.

The original geometrical linear transformation has a structure of fixed and variable elements, namely, fixed proportions and variable points. The new differential linear transformation has a similar structure of elements, namely, variable and differential quantities. Similar to the original form, the new form interweaves slowly varying proportionalized "bindings" with quick "changes" to make up a convenient and useful device. "Linear" advantages of the original form are preserved in the new, as is the spatialized character of time.

Classical physics reached culminating peaks in Einstein's theories of relativity. The Mount Sinai of Newton's Mechanics was joined through Einstein's tectonic uplifts with the Himalayas of Maxwell's Electromagnetic Equations to form a single enormous range. Explorers might think that the oceans had disappeared.

In actual life, oceans were already eroding the base of the range. One oceanic current was driven by evidence of radioactive transformations. Antoine Becquerel and Pierre and Marie Curie received the 1903 Nobel Prize in Physics in recognition of their discoveries in this area.

Radioactive transformations are simple examples of discontinuous transformations. As the name indicates, during a discontinuous transformation matter undergoes a sudden and complete change of form. In a radioactive transformation, one kind of atomic nucleus changes into another kind of nucleus. Energy is thrown out and called "radiation." For example, a certain kind of hydrogen nucleus ("tritium") may suddenly change into a certain kind of helium nucleus ("helium-3"). If the disappearing hydrogen nucleus is part of a water molecule, the molecule fragments.

It is apparently impossible to predict or control when a particular tritium nucleus will undergo radioactive transformation. The best model is a probabilistic "Poisson process" that has a specific ***half-life***: after a time period of a half-life, half of the nuclei in a batch of identical atoms will have undergone the transformation. The half-life for the tritium radioactive transformation is 12⅓ years. Physics is unable to account for this half-life or for any radioactive half-life.

In sum, platonic successes that culminated in Einstein's theories were grounded in empty space. Matter was reduced to points that embodied conservation principles. The platonic approach failed to model important phenomena of matter such as radioactive transformations.

d. Thermodynamics is based on "equilibrium" that excludes multiple possibilities, that imposes invariance and that leads to linear forms.

While some scientists and engineers were investigating gravity and electricity, other scientists investigated properties of matter, especially "thermal properties" of matter that are controlled by heating and cooling. Some investigations into thermal properties were based on symmetries and uniformities, e.g., symmetry in arrangements of atomic nuclei in simple compounds or uniformity maintained in a volume of air confined to a cylinder with a workable piston. Such ordered forms of matter are relatively rare in nature, although found, e.g., in clouds that produce snowflakes. Mostly, physical scientists use materials that are specially prepared for purposes of investigation and application. Specially prepared materials include chemical reagents and metal alloys made according to a recipe. Platonic science requires a clean work bench and careful records of results. Only through such methods can invariance be established.

Some phenomena are rather closely modeled by platonic science but other phenomena are evidently beyond the reach of platonic models. As discussed below, successful models of platonic science include the Ideal Gas, the Onsager Relations and a model of formation of pearlite during very slow cooling of hot steel. Platonic science fails to model the formation of martensite during very fast cooling of hot steel or the formation of snowflakes.

To begin with a success, the Ideal Gas Law (pV=RT), a linear form, "is correct to within a few percent over a wide range of pressures and temperatures" for many gases, e.g., air and nitrogen. (Morse, 27.) It works best "in the limit of vanishingly small pressures," that is, for a very dilute gas. (Sprackling, 70.) The Ideal Gas Law applies to a unit of gas confined in a vessel of volume V. The "gas constant" R is a fixed number that depends on the units used to measure the other quantities. E.g., R=8314 joules per degree Kelvin. Hence, the Ideal Gas Law states a mathematical relationship between the temperature, pressure and volume of a confined gas that is ***the same relationship*** for a class of gases. The ***invariance*** of the Law with respect to the class makes it a "universal law."

Another set of "universal principles" was discovered by Lars Onsager (1903-1976), who received the Nobel Prize in Chemistry in 1968 for proof of the existence of "reciprocity relations." The reciprocity relations have a linear form that resembles linear transformations discussed previously. Although the symbols in the form below resemble those shown in the geometrical linear transformation, the meaning of the symbols is closer to those of the differential linear transformation.

A form for the Onsager reciprocity relations is as follows:

$$J_1 = L_{11}\times X_1 + L_{12}\times X_2 + L_{13}\times X_3$$

$$J_2 = L_{21}\times X_1 + L_{22}\times X_2 + L_{23}\times X_3$$

$$J_3 = L_{31}\times X_1 + L_{32}\times X_2 + L_{33}\times X_3$$

The X's are a kind of "force" and the J's are a kind of "flow" or "flux" that is caused by such forces. The L's are so-called "phenomenological coefficients," meaning that values have to be measured rather than derived from principles. The general notion is that X_1 causes J_1 directly, and likewise for X_2 causing J_2 and X_3 causing J_3. To a lesser degree or indirectly, X_k also causes J_m that are different from J_k., e.g., X_1 causes J_2. Using statistical mechanics, Onsager proved that $L_{ij}=L_{ji}$, which is a ***symmetry*** that is called "reciprocity." E.g., $L_{12} = L_{21}$.

The significance of the Onsager reciprocity relations is controversial. In the Nobel Award Ceremony Speech it was declared that "Onsager's reciprocal relations can be described as a universal natural law." (http://www.nobelprize.org/nobel_prizes/chemistry/laureates/1968/press.html) Critics such as Truesdell disparage the achievement.

For purposes here, Onsager's formulae highlight the limited domain of application of platonic formulations. Onsager's linear formulation applies only to small deviations from the special condition known as "thermodynamic equilibrium". When a deviation from that condition becomes large, the linear form disappears, along with the reciprocity. (http://seas.harvard.edu/matsci/people/aziz/publications/mja063.pdf)

I suggest that all constructions of platonic science have such a limited domain even though they are acclaimed as "universal." As noted above by Truesdell & Noll, the modern physics of fundamental particles "concerns solely the small particles of matter." As discussed below, statistical mechanics, Onsager's field, is based on the mechanics of geometrical points maintained in static or quasi-static systems. (Gibbs, Tolman.) An important indifference principle in statistical mechanics is stated in the "fundamental hypothesis of equal *a priori* probabilities". (Tolman 59, 350.) Only perfectly symmetrical dice and perfectly balanced roulette wheels are allowed in this casino. Results are never remembered. I suggest that such "empty space" and indifference principles limit domains of successful application.

Thermodynamic constructions have their own special character and limitations. A body under study is made subject to constraints that control its activities. Any uncontrolled activity is also tightly constrained. The body is separated from its surroundings by a "closed" boundary that effectively insulates and isolates it except for specific passages of energy and matter. Passages of work or energy through the boundary are typically controlled through "adiabatic" or "isothermal" processes. Work performed on or by the body must be done according to calculations so that certain conditions are maintained. (Sprackling, 4-8, 10-11.) In sum, to qualify as a subject of thermodynamics investigations, a body must be simple, passive and highly controllable. Living animal bodies are not so qualified.

In thermodynamics, a chief focus is on the temperature of the body. Suppose we consider simple bodies such as a flask of water or a piece of metal alloy. There are various possibilities for the temperature. Perhaps one temperature applies to the whole body or perhaps there are different temperatures at different places in the body. Orderly differences in temperature can be described as temperature gradients. An underlying question is whether temperature can always be defined or whether there are situations where a temperature cannot be defined.

Of paramount importance is the restriction of the First and Second Laws of Thermodynamics to bodies ***in equilibrium*** or "close to equilibrium." Equilibrium means that the temperature is uniform over the entire body. It is only when the body is in equilibrium that temperature questions are easily answered. I suggest that a body in equilibrium has a certain symmetry that enables practitioners of platonic science to construct Laws. In the absence of equilibrium, perhaps the Laws do not apply.

"Classical thermodynamics only deals with *equilibrium states* of a system…These equilibrium states are reached by letting the system settle down long enough so that quantities such as temperature and pressure become uniform throughout, so that the system has a chance to forget its past history, so to speak." (Morse, 7, emphasis in original.)

"In a sense, the reason that classical thermodynamics is usually limited to a study of equilibrium states is because an equilibrium state is the state in which heat energy can easily and unmistakably be distinguished from mechanical energy. Before equilibrium is reached, sound waves or turbulence may be present, and it is difficult to decide when such motion ceases to be 'mechanical' and becomes 'thermal.' " (*Id*., 13.)

"To put it in other language, although the gas may start in a state of turbulence, if it is left alone long enough internal friction will bring it to that state of thermodynamic quiescence we call *equilibrium*, where it will remain." (*Id*., 6, emphasis in original.)

I suggest that "equilibrium" in classical thermodynamics establishes uniformity and "time-invariance" that parallels previously-discussed spatial invariance. In an equilibrium state, each moment is identical to each other moment. In imagination and using spatialized time, the system can be lifted out of one moment and superimposed onto another moment and the two systems are, for purposes of the science, "the same." Such superimposition is comparable to the imaginary superimposition of figures in plane geometry.

Statistical mechanics, like that used by Onsager, provides abstract imagery. The apparent quietude of equilibrium is the result of multiple ongoing activities that balance each other in all large-scale respects. The grounding task of the scientific investigator is to put the system into such balance. The investigator then introduces an imbalance — and observes while multiple activities adjust to remove the imbalance. Adjustments are in the form of shifts in temperature or other quantities. Then things quiet down again so that all the multiple activities are again in balance. The investigator maintain conditions in the system while it quiets down. In sum, the system ***relaxes*** from the imbalance introduced by the investigator.

Each "X" in the Onsager Relations stands for an imbalance, the bigger the X the bigger the imbalance. Each Y stands for a flow that leads to a relaxation of the imbalance. For example, suppose that the researcher first prepares a body of liquid in which equilibrium is established. Then suppose that the researcher introduces changes through heating and by adding a particular chemical species without changing other conditions such as pressure and populations of other chemical species. Each imbalance will cause a direct flow (heat imbalance causes a heat flow) that relaxes and removes the imbalance. There will also be indirect flows (heat imbalance also leads to a change in volume and re-balancing in populations of chemical species). The Onsager relations apply a geometric method of "fixed proportionals" to describe such relaxation flows.

Generalizing the above method, a thermodynamic investigation begins by establishing complete control over a physical domain. The investigator imposes a ground condition, e.g., an equilibrium ground condition is established.   Next, the investigator introduces a small and controllable variation from the ground condition that leads to another condition that is compared to the ground condition. Then, there may be a return close to the ground condition like that involved in the Onsager Relations, which I call a ***reversion***, with governance of the reversion through a linear relationship being commonly imposed. Hooke's law for elasticity (F = –kx) is the primal linear example for a reversion. Or, instead of a reversion, the ground condition may undergo a ***linear shift***, that is, a change that shrinks smoothly to 0 as the size of the variation shrinks to 0 — then successive shifts can be tracked. Such processes are called ***quasi-static*** because they are always close to static and can be reduced to static terms. Investigations that are grounded in equilibrium systems lead to quasi-static processes and linear forms. Equilibrium conditions, quasi-static processes and linear forms are inherent in the approach.

I further suggest that platonic models of material processes impose invariance and prohibit alternatives. Such a model is based on a single specific functional form, called the equation of state, that is specified by state variables. Any process that begins at a specific initial state of the system and that ends at a specific final state will result in a single common change in the system regardless of the nature or speed of the process that moves the system between the states. This is the property that appears as "conservation of energy."

The root meaning of conservation of energy is that results occurring during a change do not depend on details of the process – there is something called "energy" that is independent of processes. For example, slow sliding of a bag of gas from point A to point B in a room has the same result as pounding the bag across the room with a baseball bat, so long as there is enough time for the gas to relax before measurements are made. Moreover, there something else called "entropy" that may be similar to energy, although pounding is prohibited if you want to conserve entropy. The same rules applies to any system that is subject to rules of equilibrium and energy conservation. Such a rule does not apply, of course, to the activities of an animal body such as that of a human being. As discussed below, such rules do not apply to discontinuous transformations like those where a single body of gaseous water vapor can generate multitudes of different snowflakes.

e. Quasi-static linearized forms effectively describe some slow transformations, e.g., formation of pearlite in steel-making; but such forms fail to describe similar faster transformations, e.g., formation of martensite during a fast quench of red-hot steel.

The content of platonic science is constituted by ***states***. In other words, in order to be admitted into the imaginary domain of a platonic science construction, a mental object must conform to certain requirements, chiefly ***temporal invariance*** for a duration of time, whether the duration is very short (a "differential quantity") or very long ("constant of motion," "law"). Such invariance defines the "state" as a conceptual unit and provides an essential integrity, similar to the integrity of an "atom" or "particle," which are state-like units of matter.

In thermodynamics, temporal invariance is supplied by equilibrium. Equilibrium is simple to test: measurements stay the same.   For strict invariance, measurements cannot even be made until the body reaches an equilibrium condition. When rules are strictly enforced, the only measurements admissible are those of a body in equilibrium. Specifically, "temperature" is a term that, in a strict sense, has meaning only for a body in an equilibrium condition.

Strictly speaking, a body in equilibrium cannot change. Hence, if it stood only on equilibrium states, "thermodynamics" would have no "dynamical" part whatsoever. A study of thermodynamics that is restricted to equilibrium states is sometimes called "thermostatics." Statistical mechanics, part of thermostatics, is restricted to unchanging systems. Statistical mechanics is the basis of "entropy is information" constructions. "Entropy is information" constructions strictly apply only to systems in equilibrium that can never change. There are ways to work around strict requirements, e.g., quasi-static processes, but the range is limited.

Thus, in the founding text of statistical mechanics, Josiah Willard Gibbs employed linear formulations of mechanical "coordinates" *p*, *q* and *a*. He stated a principle of "conservation of energy" and focused on conservative systems and on dynamics completely determined by a single common function.

"In the case of conservative systems, with which we shall be principally concerned, their dynamical nature is completely determined by the function which expresses the energy (ε) in terms of the *p*'s, *q*'s and *a*'s (a function supposed identical for all systems)." (Gibbs, 6)

Investigations of systems described by Gibbs have been very fruitful. There are, however, many other systems that do not fit the description and that do not fit principles of statistical mechanics. As shown below in connection with A Dogtail for Wagging, muscle-like movements of new technologies do not fit principles of statistical mechanics.

In order to escape from equilibrium, scientists introduced a variety of methods and techniques, especially the quasi-static process. "When a system in an initial equilibrium state is made to change to a different equilibrium state, it is said to undergo a *process*. … at all stages of the process, the system is infinitesimally close to a state of thermodynamic equilibrium. Under this condition, each coordinate is well-defined and has a single numerical value at each instant during the process. Such a process is, effectively, a succession of equilibrium states and is termed a *quasi-static process*." (Sprackling, 8, emphases in original.)

"To be quasi-static, a process must be carried out so slowly that gradients … are always less than infinitesimal. All real processes are, therefore, strictly non-quasi-static, but just how slowly a process must proceed to be effectively quasi-static depends on the time [] that a system needs to regain an equilibrium state…" (*Id*.)

"Classical thermodynamics deals only with equilibrium states and, therefore, can only discuss quasi-static processes, which may be regarded as limiting situations, when non-equilibrium vanishes." (*Id*., 9.)

Some phenomena can be modeled by quasi-static processes but other phenomena are not described by such models. Disparaging quasi-static processes, Truesdell refers to "engineers who wish to see engines run, not creep." (Truesdell & Bharatha, xii.)

Fortunately, phenomena come in wide-ranging classes that show clearly how quasi-static forms apply to some phenomena in the class and do not apply to other similar phenomena in the class. Such a class contains phenomena that change over a range of variation that is specified by a ***control variable***. We change the phenomenon by changing the control variable. Temperature is the simplest control variable. We control the physical condition of water by changing the temperature, turning liquid water to steam or to ice.

Three classes of phenomena show limited ranges of application of quasi-static concepts and/or linear forms. In each class, some simple phenomena are described by linear models based on quasi-static processes but other more complex phenomena are outside the reach of such models. The first class of phenomena is that involved in the technology of audio circuits. Designers of audio circuits pursue musical ideals where the desired "high fidelity" means "linear performance" and in which "nonlinear performance" is painful to the trained ear. Some high fidelity components, such as power amplifiers, operate very close to the ideal standard set by perfect linearity. Other components, such as loudspeakers, are more problematic and, therefore, better suited for this discussion.

In a typical audio installation, the best loudspeaker performance is obtained at low volumes when sound waves produced by the speakers have a "linear" relationship with signals in cables going to the speakers. When volume is increased past a certain level, "nonlinear performance" appears; and a cable signal carrying the pure frequencies of a flute may lead to sound waves with an ugly spread of frequencies, just because of "nonlinearity" in operations of the loudspeaker. Turning up the volume control changes linear performance into nonlinear performance.

Another similar class of controlled phenomena is water flowing in pipes. Here, the control variable is the pressure. When the pressure driving water flow is low, water moves in a simple fashion called "laminar flow" but when pressure is high, water flow is "turbulent." "Laminar" means "layers": the model treats adjacent layers as moving independently of one another. That is, laminar flow is modeled by platonic constructions that "neglect the tangential stresses altogether." (Lamb, 1.) In imagery of laminar flow of a fluid inside a pipe, thin cylindrical layers slide past each other, moving independently and with a varying range of speeds, hardly moving along the pipe surface and moving fastest in the central thread. In such imagery, the overall flow rate has a simple relationship to the pressure difference, namely, the Bernoulli equation that is based on conservation principles. (21.) Like the Ideal Gas Law that works for dilute gases, the Bernoulli equation is a successful model for activities of actual materials limited to certain situations.

When the pressure and flow rate become sufficiently large, laminar flow fails to model the phenomena, which turns into "turbulent flow." Turbulence is phenomena that is beyond the reach of physics to explain, describe or control in a satisfactory way. According to Feynman (*Lectures*, 3-9), "Nobody in physics has really been able to analyze it mathematically in spite of its importance to the sister sciences."

The first 561 pages of Lamb's classic *Hydrodynamics* are devoted to platonic constructions. Then, the author turns to " 'viscosity' or 'internal friction' which is exhibited more or less by all real fluids, but which we have hitherto neglected." A carefully constructed path of examples is offered to "indicate the general character of the results to be expected in cases which are beyond our powers of calculation." (562.)

Only after such preparation does the author turn to the subject of "Turbulent Motion". "It remains to call attention to the chief outstanding difficulty of our subject. …the neglect of the terms of the second order seriously limits the application of many of the preceding results to fluids possessed of ordinary degrees of mobility. Unless the velocities, or the linear dimensions involved, be very small, the actual motion … is found to be very different from that represented by our formula. … [Reynolds investigated the] case of flow through a pipe … by means of filaments of colored fluid introduced into the stream. So long as the mean velocity (w_0) … falls below a certain limit … the flow is smooth … accidental disturbances are rapidly obliterated and the *régime* appears to be thoroughly stable. … As w_0 is gradually increased beyond this limit the flow becomes increasingly sensitive to small disturbances … When the rectilinear *régime* definitely breaks down the motion becomes wildly irregular, and the tube appears to be filled with interlacing and constantly varying streams, crossing and recrossing the pipe." (663-664.) .

Turbulent flow moves faster than is possible with laminar flow in the same-sized pipe but with increasing requirements in water pressure. It's like a price per pound of produce that stays the same unless you buy more than a certain limit, in which case the price per pound increases; and the more you buy over the limit the faster the price increases. That is, turbulent flow requires a wastage of energy in order to get a faster flow than is possible in the efficient laminar case. As in the example of audio circuits, the linear region is relatively simple but it is also limited to low volumes; and outside the limited linear region, things become much more complicated. The control variable (pressure) moves the system through the laminar range and the turbulent range.

The culminating example of control variable models is taken from metallurgy, specifically the making of steel. I suggest that the control variable discussion of the two previous examples usefully applies to this more complex example. In all cases, an adjustable control variable is used to change smooth performance into rough performance that has a higher amount of activation. Here, the control variable is not a "quasi-static" variable like the volume control in audio circuits or the hydraulic pressure in water pipes. Rather, the control variable is a ***transformation speed***. In the making of steel, a slow transformation speed produces ***pearlite***; the transformation is continuous and described by quasi-static processes. A fast transformation speed produces ***martensite***; the transformation is discontinuous and outside the reach of platonic science. Metallurgists control pearlite transformations using simple principles but must grope experimentally when trying to control martensitic transformations.

I suggest that an obscured domain like that of martensitic transformations contains opportunities for development that are hidden in the complexities, like those that suggested a new metallurgical process to E. C. Bain in the 1930's, leading to development of "bainite." Metaphorically, in the terrain of metallurgy, pearlite occupies a site on a flat plain while martensite dwells in jagged mountain canyons.

Production of steel illustrates both successes of platonic principles and also their shortcomings.

Common steel is made of two components, 99% or so iron and 1% or so carbon. I focus here on a standard mix using 0.83% carbon. When the temperature of such steel is maintained above 1333 °F, a "red-hot" temperature, the crystals are called "face-centered" and the alloy is called ***austenite***. When the temperature is lower than 1333 °F, the crystals are called "body-centered" and the alloy can have different detailed forms and names depending on the "heat treatment" or production process. Recall that, according to theories and processes of classical thermodynamics that conserve energy and incorporate entropy, only a single form should be possible at any specific temperature (and at atmospheric pressure).

The 1333 °F transition temperature resembles the freezing point of water. Above the transition temperature, iron crystals are face-centered. Below the transition temperature, iron crystals are body-centered. Differences between face-centered and body-centered forms are based on small differences between unit cells in the crystals. As iron cools, the crystals change form at the transition temperature like water freezes to ice. During the transition, iron nuclei shift in their positions relative to one another. In an isolated pure iron crystal, there is a collective shift of positions as the temperature passes through the transition. Such shifting is simple.

The situation becomes more complex when carbon in mixed in with the iron. If austenite with 0.83% carbon is slowly cooled, e.g., inside a furnace where the temperature is strictly controlled, the result is pearlite. If such austenite is suddenly quenched, e.g., by being thrust into a relatively large vat of ice water, the result is martensite.

Important differences between the processes are shown by differences between the final products. Pearlite is softer and more workable while martensite is harder and more brittle. Pearlite is made up of layers of two different components that produce a shimmering appearance like that inside an oyster. Martensite is uniform and has a duller appearance.

The transformation from austenite to pearlite occurs smoothly and can be modeled by the diffusion equation, a linear form. In contrast, the transformation from austenite to martensite is a discontinuous transition and has no such model.

Pure iron behaves simply during passage through a transition from face-centered to body-centered crystals. Complexities and opportunities in steel-making come from the presence of carbon. Small amounts of carbon dissolve in austenite iron crystals where the form is face-centered. In other words, there is sufficient space inside face-centered iron crystals for carbon nuclei to move around.

In contrast to the easy fit inside face-centered crystals, carbon nuclei do not fit easily inside body-centered crystals. If hot steel is slowly cooled through the transition and iron nuclei shift from the face-centered form to the body-centered form, carbon nuclei inside the crystals distort the new body-centered crystals, leading to strain. Strain can be relieved by expelling carbon into spaces between crystals but it takes time for the carbon nuclei to move there. If the temperature is maintained at just below the 1333 °F transition temperature, nuclei move easily; carbon is progressively expelled from the interiors of crystals and collects in the form of iron carbide (Fe_3C) particles in spaces between shrinking but purer iron crystals. Interstitial iron carbide particles grow and link up to form layers. The two-component structure of pearlite is formed in such a slow or quasi-static formation process.

The formation process of martensite is very different. Sudden quenching causes the material to undergo fast powerful changes. Hence, the martensitic transition is more difficult to trace then the slower pearlite formation process. Imagery suggests sharp discontinuities. Sudden quenching cools the surface first and a "changing temperature front" moves inward, supposing that the phrase "changing temperature front" has a practical meaning. Apparently, "temperature change" moves through the material at close to the speed of sound, which is much faster in metals than in air. As "temperature change" passes through the material, carbon is trapped inside suddenly-formed body-centered crystals. The material undergoes pervasive distortions in tight but unorganized wrenching and pulling and squeezing. Often a high-energy sound wave is emitted that resembles clicks or a scream. All details change abruptly, constrained only by collective bonds that hold the material together. In contrast to the continuous process of pearlite, the formation of martensite is an example of a discontinuous transformation, like the radioactive transformations previously discussed.

Steel-making shows aspects of nature that are partially adaptable to platonic science when processes lead to formation of pearlite but where the adaptations fail during the formation of martensite. Generalizing from the examples, platonic science relies on linear forms that describe fine movements and that provide continuous controls through "quasi-static" processes, as in the making of pearlite. Such linear forms and quasi-static processes fail to reach the more powerful activity that occurs during the making of martensite. Similar partial adaptations and failures appear in the transition from laminar flow to turbulence in water flow and in the transition from high fidelity to noise in audio circuits.

f. Laws of Physics fail to describe or control discontinuous transformations of water vapor into individual crystalline snowflakes.

Discontinuous transformations in steel-making show non-platonic aspects that become even more emphatic in processes that generate snowflakes from water vapor. Features of this beautiful phenomenon have parallels with freedom. It is wondrous how simple, common water goes through a transformational process that generates an enormous multitude of individualized symmetrical forms; but, even under the most advantageous laboratory conditions, details are beyond understanding and transformations can only be partially controlled.

Physicists have investigated the formation of snowflakes for many years. Significant bodies of materials have been published by Ukichiro Nakaya (1900-1962), Kenneth G. Libbrecht and Yoshinori Furukawa. In a prior publication, "Facts about snowflakes," I used Libbrecht's publications to show the failure of platonic science to account for the generation of snowflakes. http://www.quadnets.com/testimony/snowflakes.html I take a different path here.

Libbrecht's images, copied below from his website, show two stages of growth of a single ice crystal prepared in his laboratory, the smaller image after 5 minutes of growth and the larger after 10 minutes. The size of the larger crystal is 1.2 mm. See http://www.its.caltech.edu/~atomic/snowcrystals/designer3/designer3.htm

The symmetries in these crystals raise the chief question. A single pattern appears in six different places that are separated by vast distances, if measured on an "atomic scale." Given the enormous variety of snowflakes, it might seem that each branch of a single snowflake could, while growing, take on any one of a huge number of possible variations. Yet, all six follow almost exactly the same pattern. How is this possible?

Here's what Libbrecht says in response to the question:

> "What synchronizes the growth of the six arms? Nothing. The six arms of a snow crystal all grow independently, as described in the previous section. But since they grow under the same randomly changing conditions, all six end up with similar shapes."
>
> "If you think this is hard to swallow, let me assure you that the vast majority of snow crystals are not very symmetrical. Don't be fooled by the pictures -- irregular crystals (see the Guide to Snowflakes) are by far the most common type. If you don't believe me, just take a look for yourself next time it snows. Near-perfect, symmetrical snow crystals are fun to look at, but they are not common." http://www.its.caltech.edu/~atomic/snowcrystals/faqs/faqs.htm

Libbrecht's explanation or argument is not persuasive to me. The problem is not simply that "all six end up with similar shapes." It is that there are apparently a great many possible shapes and all six end up with almost exactly the same shape.

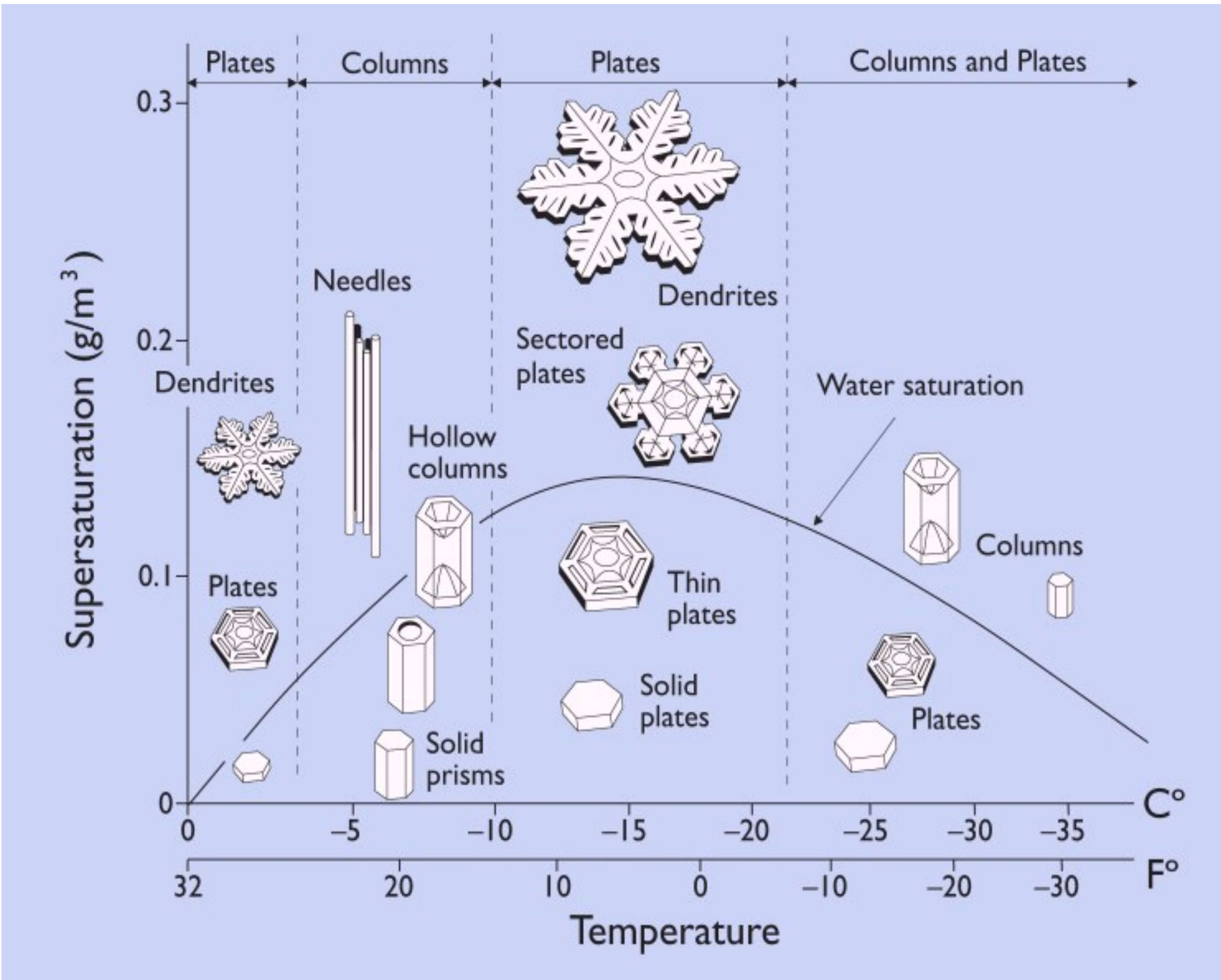
Suppose that that each arm or branch can take on any of the possible shapes with equal and independent likelihood, a supposition based on the "fundamental hypothesis of equal *a priori* probabilities" of statistical mechanics mentioned above. (Tolman 59, 350.) This is a central principle of indifference. If there are 10 possible shapes, the probability of a snowflake having all branches with the same shape is 10^{-5}. (The choice for the first branch is arbitrary but then all other five branches must independently conform.) Applying platonic principles and a probabilistic model, I estimate that the chance of producing a "hybrid snowflake" with three branches of one shape and three branches of another shape is much higher, about 100 times higher, than producing a snowflake with all six branches the same. It appears that, while incomplete or symmetry-less snowflakes are common, just as Libbrecht states, "hybrid snowflakes" with mixed symmetry are much rarer than those with six-fold symmetry. (See http://www.nasa.gov/pdf/183517main_snowcrystals.pdf and http://mynasa.nasa.gov/pdf/183516main_nakaya.pdf for snowflake variations.)

In other words, a "random" or "probabilistic" model does not account for near-perfect symmetry in different snowflake branches growing independently in a situation that is rich in possible alternatives. Libbrecht's answer "nothing" is nothing but faith in the power of platonic physics and the principle of sufficient reason, where symmetry is inherent in empty space and therefore, according to the faith, inherent in all things, even in the process of growing a snowflake.

I suggest, contrary to Libbrecht's assurances, that the generation of snowflakes is an exemplar of phenomena that are outside the reach of platonic science. As a speculation for correction, I would suggest that there might be an influence or "force" that stretches across the whole snowflake and that integrates the growth. Such a large-scale influence (called "non-local" in other different speculations) would be contrary to standard physics theories but seems to me to fit the phenomena.

Regardless of speculative corrections, I suggest that failures of platonic science are shown by detailed snowflake phenomena organized in the "Nakaya diagram" shown below, in a standard version copied from Libbrecht's website.

The Nakaya diagram is based on actual observations and shows how different environmental conditions produce different kinds of ice crystals and snowflakes. Crystals and flakes noted in the diagram were produced in Nakaya's laboratory and have been reproduced in other laboratories. Different conditions are described in terms of temperature below freezing, or superfreezing, and excess water in the air, or supersaturation. Water vapor, even in saturated air, is transparent; excess water vapor in supersaturated air is cloudy or foggy. Supersaturation in the diagram is measured with respect to ice; different values shown by means of the "Water saturation" line refer to supercooled liquid water.



Conditions for producing snow can be compared with thermodynamic equilibrium, previously discussed. To get to equilibrium, the container is closed; equilibrium vapor amounts to 100% humidity. Supersaturation is impossible in a system in equilibrium; any excess water vapor results in condensation. Nor is superfreezing possible in an equilibrium system.

In a cloud, snow crystals grow from gaseous water vapor but no such growth can occur in an equilibrium system. In an equilibrium system at atmospheric pressure, water is liquid above 32 °F (0 °C) and solid below. Quasi-static processes in equilibrium systems are invariant. If the temperature goes down in tiny steps and rests between each step, water vapor condenses to liquid water and liquid water freezes to solid ice, like on a lake. In production of snowflakes, on the other hand, water vapor condenses directly on dust particles or other material points to form ice crystals. Libbrecht's lovely crystals are formed around the tips of electrified needles.

The Nakaya diagram has a place for equilibrium and quasi-static processes, namely, at the lower-left-hand corner of the diagram, where temperatures are just below freezing and supersaturation is close to 0. The Nakaya diagram indicates that, if the condition of air is displaced just a little bit from equilibrium, that is, if the air has just a little bit of excess water and is just a little bit below freezing, ice crystals will form that have shapes like small plates or prisms.

Moving away from the equilibrium point at the lower-left-hand corner of the Nakaya diagram, the situation becomes more problematical. Supersaturation and supercooling are not equilibrium conditions. Water vapor in such a condition is, in a certain sense, "waiting" for dust particles or other material points to condense onto; only at such material particles can equilibrium or some approximation thereto be attained. Water vapor "waiting" to condense is not at equilibrium and equilibrium principles do not necessarily apply during condensation processes.

According to the Nakaya diagram, snowflakes in six-branched symmetrical shapes called "dendrites" are generated in two distinct kinds of situations, both with considerable supersaturation, one with a small amount of superfreezing and the other, apparently more significant, with a large amount of superfreezing.

In other words, large amounts of supersaturation and superfreezing generate dendrite snowflakes that cannot be generated under equilibrium conditions or by means of quasi-static processes. The distinct, widely separated snowflake symmetries that are the focus of our inquiry come about by reason of discontinuous transformations. There is a complete change of form that occurs abruptly when compared to equilibrium processes. Although we can generate and observe such discontinuous transformations, they are not within reach of our scientific models.

I suggest that the supposed Laws of Thermodynamics fail to provide insight or controls. Indeed, said Laws fail to apply to most of the phenomena of actual life. As a particular example, the "Laws of Thermodynamics" invented by Clausius fail to apply to a situation with a maintained temperature gradient, such as a fire poker with one end in a steady flame and the other end in a bucket supplied with ice. Maintaining such a temperature gradient violates the Laws, causing a continual. unbounded "increase in entropy" — but, of course, fuel and ice must be continually added. Clausius' First Law applies only where energy is constant. Clausius' Second Law applies only where entropy tends toward a maximum. Neither of those statements is true for a system with a maintained temperature gradient such as a fire poker. Please note that this is a system where "order" or "disorder" remain fixed. It is a steady-state system "far from equilibrium." (See Prigogine & Stengers.) The theory of thermal physics that successfully applies to this situation is Fourier's theory of heat conduction.

Truesdell (Tragicomedy, 34) commented on the limited nature of thermodynamics as constructed by Clausius: "The 'particular cases' into which CLAUSIUS chose not to enter included not only FOURIER's theory of heat conduction but also every non-trivial phenomenon described by mechanics or electromagnetic field theory. With this decree, thermodynamics turned its back on the real world. Henceforth, relinquishing steam engines, it would treat a 'universe' – an infinite space filled with some gas, the constitutive relation of which was specified only for the case when it was at rest with uniform density and temperature."

Later physicists attempted to develop the principles that Clausius and other founders had propounded. The results fail to cohere. In an earlier version of my views on philosophy of science, *A Patchwork Of Limits: Physics Viewed From an Indirect Approach* (2000), I quoted statements by thermodynamicists about their science:

"It is amazing to note the conflicting opinions expressed by eminent scientists." (I. Prigogine)

"We all seem to have a different, a private congenial way of justifying the First Law, etc., and argue about the rationale in each separate formalism." (J. Kestin)

"Thermodynamics is something which develops, which expands, which grows, and it has the capability of growing, and this kind of growing is just like the house that Jack built, by patching on and patching over and mending, and so this is the reason, I believe — the historical reason — why there are so many differences in deriving thermodynamic properties." (O. Redlich)

"The motivation for choosing a point of departure for a derivation is evidently subject to more ambiguity than the technicalities of the derivation. Motivation is tied up with psychological and philosophical factors, and these are nowadays not considered bona fide topics for public discussion." (L. Tisza)

"I hesitate to use the terms 'first law' and 'second law', because there are almost as many 'first laws' as there are thermodynamicists, and I have been told by these people for so many years that I disobey their laws that now I prefer to exult in my criminal status... The term 'entropy' seems superfluous, also, since it suggests nothing to ordinary persons and only intense headaches to those who have studied thermodynamics but have not given in and joined the professionals." (C. Truesdell)

"...[entropy] is a property, not of the physical system, but of the particular experiments you or I choose to perform on it." (E. T. Jaynes)

"...there cannot be a rigorous mathematical derivation of the macroscopic equations from the microscopic ones. Some additional information or assumption is indispensable. One cannot escape from this fact by any amount of mathematical funambulism." (N. G. van Kampen)

The following versions of the First and Second Laws of Thermodynamics are adapted from those stated at Morse, 94:

"$dU = dQ - p \times dV + \mu \times dn + J \times dL$

$dU \leq T \times dS - p \times dV + \mu \times dn + J \times dL$

where the equality holds for reversible processes,
the inequality for irreversible ones."

The first expression ($dU = dQ - p \times dV + \mu \times dn + J \times dL$) is a standard version of the First Law of Thermodynamics and states a principle of Conservation of Energy. Its meaning is similar to that of the Onsager Relations discussed above. It says that, if a system at equilibrium is disturbed by a small amount, the various parts of the system can be adjusted so as to return it to equilibrium. Adjustments are tracked by thermodynamic variables like p, V, T, n (standing for the number of molecules of a chemical species dissolved from a precipitate) and L (length). If, for example, there is a tiny change in volume, a dV, perfect equilibrium can be restored by means of tiny adjustments in a movement of heat (dQ), in the number of molecules (dn) and in the length of the body (dL) with respect to a stress (J). Tiny changes and adjustments can be accumulated through a "process" until they become substantial. The First Law works for systems that belong to a certain class where activity can be described and controlled by means of the "internal energy" of the system (U), a quantity invented by Clausius. The class is called "conservative systems." The Ideal Gas Law defines such a conservative system and was the system that Clausius used to develop and construct his system. For the Ideal Gas, $dU = (3/2)\times R\times T$ and $dU = T\times dS - p\times dV$. An Ideal Gas is always in equilibrium and processes involving Ideal Gases are always reversible.

The First Law of Thermodynamics incorporates the familiar linear form and describes behaviors of simple systems that have no memory and a range of equilibrium states. Linear concepts are further reflected in standard thermodynamics constructions based on Clausius' invention that use geometry and graphs, e.g., Legendre transformations and the lever rule for alloy compositions. The class of reversible processes is generated by the "proportionals" p, μ (chemical potential) and J, which show continuing application of Pythagorean principles.

Strict applications of the First Law are limited to activities where an equilibrium point is moved quasi-statically. The First Law tracks movements of the system from one equilibrium point to another equilibrium point. Values at the final equilibrium point must be invariant regardless of the process that moves the system from an initial equilibrium point to the final equilibrium point. This is a very limited class of systems.

The problem with trying to apply this construction to snowflake generation is that there are many final equilibrium points that are distinctly different as to shape but that are indistinguishable in terms of system values such as temperature and vapor pressure. This factual condition is contrary to the form of the First Law where each "point" — each set of system values — specifies a single equilibrium point. With snowflakes, such a "point" identifies a multitude of snowflakes. Such Laws of Physics do not provide assistance in tracing the generation and development of individual snowflakes that have different shapes.

If the Second Law of Thermodynamics is to have the "equality" form mentioned in the Morse extract, there must be a set of reversible adjustments where $dQ = TdS$, with a well-defined "entropy function" S and "temperature" T. [In the Clausius construction, entropy S is assumed and temperature T "pops out" of mathematics.] Reversible adjustments are always in the form of reversions and relaxations. The Second Law prohibits the kind of excitatory activity that leads to reversions and relaxations but mandates reversions and relaxations that nullify such excitatory activity. The Second Law mandates quietude; only in quietude can "entropy" be exactly defined.

In actual life, however, many "irreversible" processes occur in which neither the process nor a temperature can be exactly defined. Physicists' advanced constructions based on platonic principles suggest an "excess increase in entropy," also called "entropy production," referring to an excess when compared to that resulting from reversible processes. Entropy production identifies a premium in energy expense that you have to pay to get the process done faster than the cheapest possible "reversible" process. It is like the additional added pressure needed to get turbulent water through a pipe faster than is possible with laminar flow. The technical term is ***dissipation***. I suggest that similar premium or additional dissipations of energy leads to the individuality of snowflakes. Advanced constructions of platonic science suggest that some of the "dissipated heat" or "produced entropy" goes into such individuality. (Prigogine & Stengers, 267-290.) In sum, it appears that dissipation and irreversible processes are active in the production of individual snowflakes and the basis of such individuality.

To qualify as a reversible process, "two conditions must be satisfied — namely, (1) the process must be quasi-static; (2) there must be no dissipative processes, such as frictional effects or elastic hysteresis." (Sprackling, 37.) "During a reversible process, a system must always be infinitesimally close to equilibrium and, in particular, to thermal equilibrium." (*Id*., 38.)

"Finite, reversible processes cannot occur in practice, as no process is entirely free from frictional or other dissipative effects nor, frequently, can the process be carried out so slowly that at all stages the system is able to adjust to the changing conditions and remain infinitesimally close to a state of thermodynamic equilibrium. The reversible process is, therefore, an ideal limit at which dissipation and non-equilibrium vanish; it is the limit of what is possible in practice. Its importance is that it is the only type of process for which exact calculations can be performed in terms of the simple description of a system and its interactions, using thermodynamic coordinates." (*Id*., 39.)

In sum, "entropy" is well-defined only for reversible processes. More precisely, only cyclical reversible processes conserve entropy. Entropy-conserving processes are like linear amplifiers and laminar flow at low pressure in pipes. Non-linearity and turbulence degrade the concept of entropy like noise degrades the message in a signal. It appears that individualized action requires violation of such defining constraints and is achieved through such disruptive means.

The Laws of Thermodynamics would prohibit the individualized character of snowflakes. There is no quasi-static path that connects supersaturated water vapor to superfrozen ice crystals. Unlike an equilibrium system where the final state is invariant, there are a multitude of possible final states. Platonic science cannot handle such facts. The only explanation of platonic science for the astonishing and beautiful symmetries of snowflakes is that stated by Libbrecht: "nothing."

5. Models of modern psychology and brain science derogate muscular movements and related bodily feelings of actual life; instead, depersonalized information is supposed to be processed according to forms of computation based on principles of platonic science.

   a. The alternative approach provides a view of brain operations in which muscular movements have foundational importance.

The alternative approach stands independently of scientific approaches and, indeed, as a rival to scientific approaches. Although they are independent, the two kinds of approaches have much in common. Both construct idealized forms in imaginary domains; and my device designs resemble electronics designs. In other ways, the two kinds of approaches are very different.

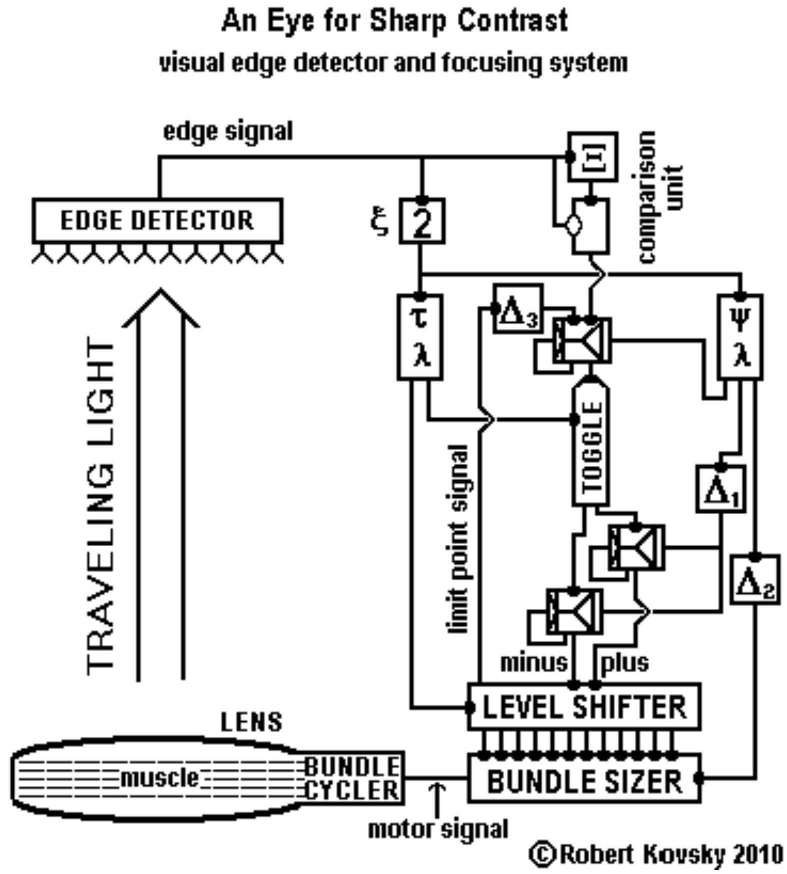
One large-scale difference is that scientific constructions are built from ***states*** while alternative constructions are built from units of ***action***, e.g., "action pulses" in timing devices. Details are discussed in An Eye for Sharp Contrast. I suggest that, from an action perspective, scientific psychologies erroneously neglect an organism's muscular movements and related bodily feelings and, instead, focus on image processing based on sensations, chiefly visual or auditory images.

In my approach, muscular movements are primal. Of course, images have important functions. Some images — e.g., bodily feelings, sights and sounds — are used by an organism to enable it to control muscular movements; images may take center stage during dramatic and memorable moments. However, mental images detached from action, such as numbers, are recent developments in the animal kingdom. In my approach, image processing is deferred and initial models are developed without imagery; then imagery can be added when required for a task, perhaps as a trigger for an "action fiat," e.g., noticing that the traffic light has changed from red to green as a trigger to start moving. The action fiat, or something similar, is a chief issue in some scientific constructions, which seek to explain how images cause action. In my constructions, lots of action is going on all the time and even more possible action may be getting ready; images are sometimes useful and sometimes distracting; causal concepts don't work very well for brains; and I have a different approach.

"Action fiat" is a term used by William James in *The Principles of Psychology* (1890), accessible at http://psychclassics.yorku.ca/James/Principles/index.htm. James' treatise is enormously rich in observation, invention, scholarship and error — and its influence continues. In contrast to builders of current brain models, James focused on "feelings" and actual human personalities. He adapted a prior magazine article titled "The Feeling of Effort" in his chapter on "Will." James expressly considered and rejected primary roles for bodily feelings based on muscular movements. In his treatment, such bodily feelings are assimilated to sensory processing. By means of "ideo-motor action," sensory images cause muscular movements. Sometimes, an "action fiat" pulls the trigger.

Modern research has disproved key factual assertions in James' model. Muscular movements clearly do generate bodily feelings in multiple ways; and bodily feelings clearly do influence ongoing muscular movements in multiple ways. However, derogation of muscular movements and related bodily feelings continues implicitly in current models of brains. Such derogation contributes to depersonalization that is suited for principles of computation.

In contrast to scientific models, the design of "An Eye for Sharp Contrast" shown on the next page illustrates the primacy of muscle-like movements in my constructions. The design of "A Dogtail for Wagging" in § 6 similarly illustrates such primacy. Designs for devices that perform muscle-like movements lead towards models of personalities and institutions, e.g., using forms of episodic balancing discussed below. Focusing is a rudimentary kind of balancing.



In the Eye, a muscle girdles and squeezes the Lens, controlling its focal length and modifying optical images it projects. Squeezing is maintained by pulse bundles held in Bundle Cycler; squeezing changes when a new bundle appears on the motor signal line from Bundle Sizer, which drives the muscle, according to settings of Level Shifter. Operations of such "generator brain parts" are subject to "controller brain parts" (Toggle and comparison unit). "Sensory units" produce signals that influence controller brain parts; e.g., Edge Detector produces the edge signal that goes into the comparison unit. Edge signals are based on optical images of environmental objects that are projected by light traveling through the Lens onto devices (mimicking retinal cells) in Edge Detector. A high-frequency edge signal identifies a sharp edge in an optical image; a low-frequency signal identifies a diffuse edge. The Eye sharpens the edge in an optical image by stepped adjustments in the strength of the muscle that is squeezing the Lens. Operating as designed, the Eye focuses on the edge of an object and "follows" a slowly moving object.

Suppose the Eye is operating in the absence of an object. The edge signal stays at a very low frequency. In such a case, the muscle steps through its entire range, going from the strongest squeezing to the least squeezing, back and forth — until an object with an edge enters the visual field and an edge signal appears. This interrupts the back and forth movement; focusing begins.

Generally in my models, muscles and muscle-like modules are always active. I suggest, more generally, that muscles run "on their own" by means of "bundle cyclers" in spinal vertebra and that muscles and related feelings operate even in the absence of a brain, as illustrated by the "spinal frog" discussed in James' treatise, the chicken flopping around with its head cut off on Youtube and the "brainless cat [that] can still walk on a treadmill." (Calvin at 214, discussing a "pattern of action" that "can be spinal cord alone, or brain commanding spinal cord.") At the next higher level, generator brain parts run "on their own," producing motor signals regardless of sensory signals or images. "Imaging units" (not used in the Eye) can produce conscious experiences (images) and operate on such images to produce additional signals, e.g., signaling a "match" between two images or measuring changes in the gap between a desired object in one image and the person's hand in another image. Imaging units can perform important functions but, as to muscular movements, they mostly operate on top of operations of generator brain parts, controller brain parts and sensory units. Images guide movements more than they cause them.

One important feature of the Eye is that there is a simple relationship between pulse bundles in Bundle Cycler and the distance to an object seen by the Eye. Each strength of squeezing of the Lens corresponds to a distinct region in environmental space where objects are in focus. It is possible to calculate the distance from the Eye to an object from specifications of pulse bundles that keep the object in focus. A "look-up" table can be prepared that lists pulse bundle specifications and the corresponding distance of an object kept in focus. On the other hand, the value of the edge signal reveals nothing about the distance to the object. The edge signal shows whether the edge of an image is sharp or diffuse; this occurs much the same at any distance.

I suggest that similar reasoning applies to any animal eye where the focal length of a lens is controlled by muscles. There is a useful relationship between motor signals to such muscles and the distance to an object being held in focus. The relationship can provide the animal with a basis for action, e.g., in deciding whether or not to flee. Of course, distance detection is improved with two eyes that can be used for "range-finding" (two eyes move inward as an object approaches directly) and/or for complex image processing that underlies depth perception. A person can demonstrate that by looking first with one eye and then with two eyes. But the demonstration also shows that useful distance detection occurs with a single eye that shifts from near to far focus and back again. Nearer and farther can be felt in the eye muscle. Calculating distance from specifications of a motor signal to a Lens would appear to be faster and more direct than calculating distances by coordinating images and movements or by imaging depths. I suggest that range-finding and/or depth imaging in visual perception may be secondary processes and that a primary process may be based on motor signals that drive focusing muscles.

For further development, I suggest that pattern detection in visual images involves motor signals that cause the gaze to jump in saccadic movements of the eye, as well as involving signals generated from retinal patterns. I suggest that a spatial representation of a scene can be built piecewise from eye jumps that move from object to object, as well as from a global mental map into which objects are inserted. In *Feelings, Forms and Freedom*, I anticipate a timing device design for the vestibulo-optical reflex or VOR, mimicking saccadic eye movements like those that automatically keep a runner's gaze fixed on an object. For many tasks, such as dodging fixed objects and other pedestrians while walking on the sidewalk, saccadic muscular movements of the eyes can provide all the "spatial representation" that is needed. I suggest that pattern recognition, e.g., identifying a particular face among passersby, is a different kind of function that depends on a foundation of muscular movements. I suggest that muscular movements of the eyes provide actual context for imagery of the focused gaze.

b. William James recognized issues of muscular movements and related bodily feelings but was unable to integrate them with his introspective observations and, instead, made them into sensations that were suited to an input-output model.

Modern brain models have their origins in James' treatise, *The Principles of Psychology* (1890). Ideas that James introduced or held, such as darwinism, are still influential. In contrast to some modern scientists, however, James was opposed to the elevation of human concepts into authoritarian cosmological principles, what I call platonism; and he developed his opposition into the philosophy of Pragmatism. In § 6.f, I discuss the pragmatic jurisprudence of Oliver Wendell Holmes, Jr., a friend of James who shared many of his views. (Menand.)

James had a view of psychology that was simultaneously grounded in a lifetime of introspective personal observations, in practical biology such as laboratory vivisection of frogs (Chap. 2), and in broad acquisitions of knowledge. Perhaps no substantive word appears more frequently in the treatise than the word "feelings." James understood that platonizing scientists often denied that feelings have a place in "reality." In a related article, "Are We Automata," he wrote:

"The desire on the part of men educated in laboratories not to have their physical reasonings mixed up with such incommensurable factors as feelings is certainly very strong. Nothing is commoner than to hear them speak of conscious events as something so essentially vague and shadowy as even doubtfully to exist at all. I have heard a most intelligent biologist say: 'It is high time for scientific men to protest against the recognition of any such thing as consciousness in a scientific investigation'. In a word, feeling constitutes the 'unscientific' half of existence, and any one who enjoys calling himself a 'scientist' will be too happy to purchase an untrammeled homogeneity of terms in the studies of his predilection …"

In the "Automata" article, James concluded that "the mind is at every stage a theatre of simultaneous possibilities" and that on "our mental stage Feeling always selects." He rejected the "automaton theory" of Thomas Huxley "which denies causality to feeling." "And I moreover feel that that unstable equilibrium of the cerebrum which forms the pivot of the argument just finished may, with better knowledge, be found perfectly compatible with an average appropriateness of its actions taken in the long run." [As discussed below, my proposals about Shimmering Sensitivity embody a kind of "unstable equilibrium of the cerebrum," organized by means of a multitude of devices that can operate independently — or in harmonious synchrony. "Unstable equilibrium" is a feature of episodic balancing forms, discussed below.]

According to James, feelings arise in the "wonderful stream of our consciousness" discussed in The Stream of Thought. (Chap. 9.) James notes differences between slow and rapid movements of the stream and between stable and flighty images within it. "[W]hat strikes us first is this different pace of its parts. Like a bird's life, it seems to be made of an alternation of flights and perchings. … *Let us call the resting-places the 'substantive parts,' and the places of flight the 'transitive parts,' of the stream of thought.*" According to James, the transitive parts resist analysis or even scrutiny. "The attempt at introspective analysis in these cases is in fact like seizing a spinning top to catch its motion, or trying to turn up the gas quickly enough to see how the darkness looks." Faced with this problem, one group of thinkers, the Sensationalists, "denied that feelings of relation exist" and another group, the Intellectualists, adversaries of the Sensationalists, "made the same admission that the feelings do not exist. … But from our point of view, both Intellectualists and Sensationalists are wrong. If there be such things as feelings at all, *then so surely as relations between objects exist in rerum naturâ, so surely, and more surely,* *do feelings exist to which these relations are known*. … We ought to say a feeling of *and*, a feeling of *if*, a feeling of *by*, quite as readily as we say a feeling of *blue* or a feeling of *cold*."

James had a broad concept of "feeling." In my constructions, the word "imagery" has a broad use and the word "feelings" is mostly used for imagery arising from or related to muscular movements, along with music, emotions and moods. According to James, "*there is no proof that the same bodily sensation is ever got by us twice*." (Chap. 9.) Those who follow such a view typically exclude bodily feelings based on muscular movements from mental structures that have defined classes. [I do not concur in James' view since harmonic feelings in music, bodily feelings in yoga practice and other feelings associated with bodily sensations can be duplicated very closely by means of training. In other words, training develops repetitive forms of music and body consciousness, each with its own specialized kinds of feelings and relations.]

James discusses muscular movements and related feelings in major chapters that are the culmination of his treatise. In "The Production of Movement" (Chap. 23), James previews chapters that follow and surveys the "detailed study of the more important classes of movement consequent upon cerebro-mental change: They may be enumerated as — 1) Instinctive or Impulsive Performance; 2) Expressions of Emotion; and 3) Voluntary Deeds." "Using sweeping terms and ignoring exceptions, *we might say that every possible feeling produces a movement, and that the movement is a movement of the entire organism, and of each and all of its parts*."

The formula "feeling produces movement" sums up James' model; the essential scheme is repeated in greater detail throughout the treatise in multiple statements and from multiple perspectives. It culminates in ideo-motor action and deliberative action discussed below. The initial summary (Chap. 2) declares: "The afferent nerves, when excited by some physical irritant, … conveys the excitement to the nervous centres. The commotion set up in the centres does not stop there but discharges itself … through the efferent nerves into muscles and glands…"

An extreme example is the statement in Chapter 4 on Habit:

"The only impressions that can be made upon [brains] are through the blood, on the one hand, and through the sensory nerve-roots, on the other; and it is to the infinitely attenuated currents that pour in through these latter channels that the hemispherical cortex shows itself to be so peculiarly susceptible. ***The currents, once in, must find a way out***." (Emphasis added.)

Thus, James recognizes muscular movements as results that appear only after a focal commotion in the central centres is resolved and discharged through efferent currents. Movements affect brains only indirectly, "through the sensory nerve-roots." It is an "input-output" model with "feedback" from output to input.

Chapter 26 on Will begins with "Desire, wish, will…" and declares that "The only ends which follow *immediately* upon our willing seem to be movements of our own bodies." A note refers to a previously-published article titled *The Feeling of Effort*. In the article, James wrote:

"In opposition to this popular view [advocated by other scientists], I maintain that the feeling of muscular energy put forth is a complex afferent sensation coming from the tense muscles, the strained ligaments, squeezed joints, fixed chest, closed glottis, contracted brow, clenched jaws, etc., etc. That there is over and above this another feeling of effort involved, I do not deny; but this latter is purely moral and has nothing to do with the motor discharge. We shall study it at the end of this essay, and shall find it to be essentially identical with the effort to remember, with the effort to make a decision, or to attend to a disagreeable task."

It appears that James recognized muscular movements as sources of sensory feelings that are like mental relations. Such feelings produce the next round of movements through cerebral processing. In alternating steps, feelings cause movements and movements cause feelings. James appear to say that the "feelings cause movements" step can be mediated by conscious decisions but the "movements cause feelings" step occurs through processes embodied in sensory organs and have no other route to consciousness. On the last point, James is adamant. " 'A motion becomes a feeling!' —no phrase that our lips can frame is so devoid of apprehensible meaning. … (Quoting Spencer) a unit of feeling has nothing in common with a unit of motion." (Chap. 6.) He repeatedly stands opposed to "the advocate of perception by muscular feelings." "*It seems to me that no evidence of the muscular measurements in question exists*; but that all the facts may be explained by surface-sensibility, provided we take that of the joint-surfaces also into account." (Chap. 20 on The Perception of Space.) The chief mention of muscular matters in Chapter 17 on Sensation refers to what we call "phantom limbs" felt by an amputee or paralyzed person. "We shall learn in the chapter on Space that our feelings of our own movement are principally due to the sensibility of our rotating *joints*."

I must interpose my objections to these conclusions and set forth an alternative view. There are many situations in actual life where muscular effort is a variable quantity that is under a person's control. Such situations appear most clearly in muscular movements of skilled practitioners, such as chefs, musicians and sports contestants. A chef controls the muscular effort put into a knife-stroke for the purpose of producing a certain cut in bread or vegetable or meat. A violinist controls the muscular effort put into a bow-stroke for the purpose of producing a certain sound. A swimmer controls the muscular effort put into an arm-stroke for the purpose of producing a certain final speed for the race. Such purposeful muscular movements are primary phenomena, not secondary upon sensory perception. Once started, they may be adjusted by means of sensory perceptions in order to better accomplish the purpose, but that comes later.

James' Chapter 21, The Perception of Reality, is organized around the concept of "belief" in terms of "every degree of assurance, including the highest possible certainty and conviction." James remarks on "the prerogative position of sensations in our belief." After having constructed his theory of reality around sensations, James considers "our treatment of tactile and muscular sensations as 'primary' qualities more real than those 'secondary' qualities which eye and ear and nose reveal." He declares that tangible objects are important as instruments of pain or pleasure and that eye and ear "are but organs of anticipatory touch." He states that "[W]e can only use an object for our advantage when we have it in our muscular control," Then he passes on to emotion, which "has as much to with our belief in an object's reality as the quality of giving pleasure or pain." For James, issues of reality and belief are mostly directed at "secondary qualities," e.g., vision. In this view, reality comes to us through our senses.

In Chapter 26 on Will, James derogates feelings that are based on muscular movements by means of classes of ***resident*** and ***remote***. In James' approach, remote images and feelings acquire hegemonic importance. James states that: "*all our ideas of movement*, including those of effort which it requires, as well as those of its direction, its extent, its strength, and its velocity, *are images of peripheral sensations, either* '*remote*,' *or resident in the moving parts, or in other parts which sympathetically act with them in consequence of the* '*diffusive wave*.'

"If the ideas by which we discriminate between one movement and another, at the instant of deciding in our mind which one we shall perform, are always of sensorial origin, then the question arises, 'Of which sensorial order need they be?' It will be remembered that we distinguished two orders of kinæsthetic impression, the *remote* ones, made by the movement on the eye or ear or distant skin, etc., and the *resident* ones, made on the moving parts themselves, muscles, joints, etc. Now do resident images, exclusively, form what I have called the mental cue, or will remote ones equally suffice?

"*There can be no doubt whatever that the mental cue may be either an image of the resident or of the remote kind*. Although, at the outset of our learning a movement, it would seem that the resident feelings must come strongly before consciousness, later this need not be the case. The rule, in fact, would seem to be that they tend to lapse more and more from consciousness, and that the more practised we become in a movement, the more 'remote' do the ideas become which form its mental cue. What we are *interested* in is what sticks in our consciousness; everything else we get rid of as quickly as we can. Our resident feelings of movement have no substantive interest for us at all, as a rule. What interest us are the ends which the movement is to attain. Such an end is generally an outer impression on the eye or ear, or sometimes on the skin, nose, or palate. Now let the idea of the end associate itself definitely with the right motor innervation, and the thought of the innervation's *resident* effects will become as great an encumbrance as we formerly concluded that the feeling of the innervation itself would be. The mind does not need it; the end alone is enough.

"The idea of the end, then, tends more and more to make itself all-sufficient. …

"The reader will certainly recognize this to be true in all fluent and unhesitating voluntary acts. The only special fiat there is at the outset of the performance."

Thus, James derogates "resident images" or "resident feelings of movement," what I call "body images" or "bodily feelings." The restricted class of sensory perceptions. called "remote feelings," is the basis for James' mechanistic solution to the puzzle of how to attribute causal power to imagery. James sets forth his mechanistic theory on p. 497 of Dover's printed version of the treatise, a number later used as a reference. On p. 497, the theory is stated in a suppositional or hypothetical way. In the later reference, it is treated as factual.

On pages 497-498, James states (***bold-italics*** emphasis added, footnote omitted):

"Now if we analyze the nervous mechanism of voluntary action, we shall see that by virtue of this principle of parsimony in consciousness the motor discharge *ought* to be devoid of sentience. If we call this immediate psychic antecedent of a movement the latter's *mental cue*, all that is needed for invariability of sequence on the movement's part is a *fixed connection* between each several mental cue, and one particular movement. For a movement to be produced with perfect precision, it suffices that it obey instantly its own mental cue and nothing else, and that this mental cue be incapable of awakening any other movement. Now the *simplest* possible arrangement for producing voluntary movements would be that the memory-images of the movement's distinctive peripheral effects, whether resident or remote, themselves should severally constitute the mental cues, and that no other psychic facts should intervene or be mixed up with them. ***For a million different voluntary movements, we should then need a million distinct processes in the brain-cortex (each corresponding to the idea or memory-image of one movement), and a million distinct paths of discharge. Everything would then be unambiguously determined, and if the idea were right, the movement would be right too. Everything after the idea might then be quite insentient, and the motor discharge itself could be unconsciously performed.***"

The foregoing passages are preparation for James' focal construction:

"Ideo-Motor Action.

"The question is this: *Is the bare idea of a movement's sensible effects its sufficient mental cue* (p. 497), *or must there be an additional mental antecedent, in the shape of a fiat, decision, consent, volitional mandate, or other synonymous phenomenon of consciousness, before the movement can follow*?

"I answer: Sometimes the bare idea is sufficient, but sometimes an additional conscious element, in the shape of a fiat, mandate, or express consent, has to intervene and precede the movement. The cases without a fiat constitute the more fundamental, because the more simple, variety. The others involve a special complication, which must be fully discussed at the proper time. For the present let us turn to *ideo-motor action*, as it has been termed, or the sequence of movement upon the mere thought of it, as the type of the process of volition.

"Whenever movement follows *unhesitatingly and immediately* the notion of it in the mind, we have ideo-motor action. We are then aware of nothing between the conception and the execution. All sorts of neuro-muscular processes come between, of course, but we know absolutely nothing of them. We think the act, and it is done; and that is all that introspection tells us of the matter. … I sit at table after dinner and find myself from time to time taking nuts or raisins out of the dish and eating them. My dinner properly is over, and in the heat of the conversation I am hardly aware of what I do, but the perception of the fruit and the fleeting notion that I may eat it seem fatally to bring the act about."

James' construction of ideo-motor action provides grounds for his further investigations. He posits a "fiat" that is based on a "representation."

"We may then lay it down for certain that *every representation of a movement awakens in some degree the actual movement which is the object; and awakens it in a maximum degree whenever it is not kept from so doing by an antagonistic representation present simultaneously to the mind*.

"The express fiat, or act of mental consent to the movement, comes in when the neutralization of the antagonistic and inhibitory idea is required. But that there is no express fiat needed when the conditions are simple, the reader ought now to be convinced. … Every pulse of feeling which we have is the correlate of some neural activity that is already on its way to instigate a movement. Our sensations and thoughts are but cross-sections, as it were, of currents whose essential consequence is motion, and which no sooner run in at one nerve than they run out again at another. … But where there is no blocking, there is naturally no hiatus between the thought-process and the motor discharge. *Movement is the natural immediate effect of feeling, irrespective of what the quality of the feeling may be. It is so in reflex action, it is so in emotional expression, it is so in the voluntary life*. Ideo-motor action is thus no paradox, to be softened or explained away. It obeys the type of all conscious action, and from it one must start to explain action in which a special fiat is involved."

The "antagonistic representation" becomes a central player in ACTION AFTER DELIBERATION. As an important part of the action, James interprets the "Stream of Thought" to mean "a mind with one idea before it, of many objects, purposes, reasons, motives related to each other, some in a harmonious and some in an antagonistic way." That is, "however complex the object may be, the thought of it is one undivided state of consciousness." James considers the notion that "the elements of the subjective stream are discrete and separate and constitute what Kant calls a 'manifold.' " James requires that "the manifold of ideas has to be reduced to unity." As he earlier stated: There is a "Unity of one Thought." Accordingly: "*There is no manifold of coexisting ideas*; the notion of such a thing is a chimera. *Whatever things are thought in relation are thought from the outset in a unity, in a single pulse of subjectivity, a single psychosis, feeling, or state of mind.*" James cites Brentano: "Altogether this chapter of Brentano's on the Unity of Consciousness is as good as anything with which I am acquainted."

Having established the necessary Unity behind antagonists, James proceeds to his conclusion.

"We are now in a position to describe *what happens in deliberate action*, or when the mind is the seat of many ideas related to each other in antagonistic or in favorable ways. One of the ideas is that of an act. By itself this idea would prompt a movement; some of the additional considerations, however, which are present to consciousness block the motor discharge, whilst others, on the contrary, solicit it to take place. The result is that peculiar feeling of inward unrest known as *indecision*. Fortunately it is too familiar to need description, for to describe it would be impossible. As long as it lasts, with the various objects before the attention, we are said to *deliberate*; and when finally the original suggestion either prevails and makes the movement take place, or gets definitively quenched by its antagonists, we are said to *decide*, or to *utter our voluntary fiat* in favor of one or the other course. The reinforcing and inhibiting ideas meanwhile are termed the *reasons* or *motives* by which the decision is brought about.

"The process of deliberation contains endless degrees of complication. At every moment of it our consciousness is of an extremely complex object, namely the existence of the whole set of motives and their conflict… The deliberation may last for weeks or months, occupying at intervals the mind. The motives which yesterday seemed full of urgency and blood and life to-day feel strangely weak and pale and dead. But as little to-day as to-morrow is the question finally resolved. Something tells us that all this is provisional; that the weakened reasons will wax strong again, and the stronger weaken; that equilibrium is unreached; that testing our reasons, not obeying them, is still the order of the day, and that we must wait awhile, patient or impatiently, until our mind is made up 'for good and all.' This inclining first to one then to another future, both of which we represent as possible, resembles the oscillations to and fro of a material body within the limits of its elasticity."

James also addresses **THE QUESTION OF 'FREE-WILL.'** "My own belief is that the question of free-will is insoluble on strictly psychologic grounds." Free-will ends up not being important to James: "the operation of free effort, if it existed, could only be to hold some one ideal object, or part of an object, a little longer or a little more intensely before the mind. Amongst the alternatives which present themselves as *genuine possibles*, it would thus make one effective. And although such quickening of one idea might be *morally and historically momentous*, yet, if considered *dynamically*, it would be an operation amongst those physiological infinitesimals which calculation must forever neglect."

Comparison of my approach with that of James discloses major differences. James apparently feels a foundational Unity but I suggest that any apparent unity, what I call "merger," is momentary and subject to disparate influences. James derogates muscular movements and bodily feelings that accompany muscular movements in favor of sensations and mental imagery. Viewing things from the alternative perspective, I hold to the primacy of muscular movements and bodily feelings. Sensations, in my view, have secondary significance as signals with capacities to influence selections that can occur whether or not a signal is detected. The competing strengths of influences become important when "alternatives …present … *genuine possibles*," but such alternatives are advanced constructions that require an underlying repertoire of muscular movements and bodily feelings of actual life.

c. Even more than James, modern cognitive psychology views human beings as depersonalized processors of information, with action as an abstract final result.

James was a pioneer, working as an original creator in novel areas of investigation and having to contend with historical burdens that stretched back to ancient philosophers. He exemplifies the maxim of Goethe noted above that "A false hypothesis is better than none." Nietzsche declared: "The errors of great men are venerable because they are more fruitful than the truths of little men." James' treatise and brain models, despite their errors, were enormously fruitful. Modern brain models and cognitive psychology have their origins in William James.

It is useful to compare James' model with modern scientific models. In *A Cognitive Theory of Consciousness* (1988), Bernard Baars closely follows James in important respects, especially as to "Will" or "Volition," where Baars updates James' "ideomotor theory." Topics of ***computers*** are exemplified by William H. Calvin, *The Cerebral Symphony: Seashore Reflections on the Structure of Consciousness* (1990), which is especially concerned with muscular movements, and by Christof Koch, *Biophysics of Computation: Information Processing in Single Neurons* (1999), which constructs a version of the "standard physical model" of neuronal operations that is aimed at computation. I also discuss Koch's related book, *The Quest for Consciousness: A Neurobiological Approach* (2004). My review is highly selective for purposes of critical analysis. All the authors have contributed to my development.

Historical background is provided by Baars, *The Cognitive Revolution in Psychology* (1986):

"For at least 50 years, until very recently, scientific psychology was dominated by a philosophy of science known as behaviorism. Behaviorism is, in many ways, a radical position. Many behaviorists denied the legitimacy of ideas such as consciousness, thinking, feeling, motives, plans, purposes, images, knowledge, or the self. Much of the everyday vocabulary we take for granted in describing human behavior and experience was rejected as unscientific." (p. 1.)

"Behaviorism as an intellectual discipline forces psychologists to *distance* themselves from the everyday psychology that we all live." (43.)

According to Baars (81), at a "rather small conference" at Massachusetts Institute of Technology in 1956, "practically all the people who were to play a major role in the cognitive revolution" discussed "all the major themes of the cognitive revolution that was just about to begin" and replace behaviorism. Key themes of the cognitive revolution are listed sequentially: "The Computational Metaphor and the Role of Experiments … The Computational Rationale for the Cognitive Revolution … Information, Automata, and the Foundations of Mathematics … The Concept of Representation …Mathematical Machines … Human Beings as Information Processors … Levels of Reality in the Computer … Psychological Resistance to the Computer Metaphor … Some Indirect Influences of Computational Theory." (146-156.)

Baars constructed *A Cognitive Theory of Consciousness* (1988) and set forth therein "The basic model: A global workspace (blackboard) in a distributed system of intelligent information processors." (86.) There is "no central executive" in Baars' model but rather "a central information exchange that allows many different specialized processors to interact. Processors that gain access to the global workspace can broadcast a message to the entire system." (87, 43.)

Comparison of Baars' model with James' views shows that feelings and muscular movements discussed by James are all but absent from Baars' model. "From a scientific point of view, all evidence can be stated in entirely objective terms." "[A] useful (though not perfect) objective criterion for conscious events" thus "marks out a clear domain." "Within this domain, we can proceed with theory construction, and then consider more difficult cases. …*Verifiable, immediate consciousness report* is in fact the most commonly used criterion today." (P. 15.)

Although Baars argues that "cognitive psychologists can interpret commonsense psychological terms in a rather straightforward way," his examples for such terms, "Thought, language, knowledge, meaning, purpose, imagery, motives, even consciousness and emotion" do not reach towards muscular movements and imagery of one's own body that I call feelings. (7-8.)

Baars focuses on perception: "perception is surely the premier domain of conscious experience. Nothing else can come close to it in richness of experience and accessibility." (P. 54.) Conscious perceptions are different from imaginal experiences. "In this book we will use the word 'imaginal' to mean internally generated quasi-perceptual experiences, including visual and auditory images, inner speech, bodily feelings and the like." (P. 14.)

In contrast to perceptions, Baars derogates bodily feelings and muscular movements, which he calls "action." "Studies of mental imagery typically look for internal consistency" which would appear to exclude muscular movements and related feelings. (P. 17.) "Wiggling a finger seems simple enough, but its details are not conscious the way perceptual events are, such as the sight of a pencil or the sound of a spoken word." (Pp. 63-64.) "A rough comparison of major input, output, and intermediate systems suggests that consciousness is closely allied with the *input* side of the nervous system. …the outcome of perception is a very rich domain of information to which we seem to have exquisitely detailed conscious access. By comparison, imagery seems less richly conscious, as are inner speech, bodily feelings and the like. Action control seems even less conscious… The conscious components of action and imagery resemble conscious perception." (P. 21.)

In a full-page Table labeled *The major functions of consciousness* (p. 349), the only mention of action appears in the shortest entry in the list of 9 functions:

"4 *Recruiting and Control Function* Conscious goals can recruit subgoals and motor systems to organize and carry out mental and physical actions."

Commenting on another researcher's claim that actions are controlled by modules that are independently activated and that compete for control, Baars states: "This claim is consistent with a widespread conviction that the detailed control of action is decentralized or 'distributed' so that much of the control problem is handled by local processes." (Pp. 57-58.)

Baars' global workspace (blackboard) occupies a position comparable to James' Stream of Thought with its Unity of Thought. Gone are James' bird-like "alternation of flights and perchings" where flights are like "spinning tops" that cannot be stopped for observation and where feelings cause movements and movements cause feelings. Instead, "conscious events and their goal contexts" have an "interplay" where a "conscious event can trigger a new goal context, which can, in its turn, evoke later conscious experiences. (Figure 6.3). We introduce a graphical notation for contexts. Competition between incompatible contexts … may lead to momentary forgetting and a resetting of the global workspace due to competition between incompatible contexts." (P. 240.) "Incompatible contexts" is Baars' approach to what James called "antagonistic representations."

Baars expressly relies on James as to modeling of "volition" or "will" ("Volition as ideomotor control of thought and action" at 246 *et. seq*.); Baars, however, focuses on representational processing and not biological activity. "In *Global Workspace theory*, [informativeness is] one of the necessary conditions of a conscious event. Conscious input is always interpreted in an implicit contest of alternatives [appearing in the Global Workspace], and results in a reduction of uncertainty among those alternatives." (Definition of "informativeness" at 380.)

"How should we represent the Action Fiat Hypothesis in GW theory? If goal-images tend to execute automatically, it makes sense to suppose that timing an action involves *inhibiting execution* of a prepared action up to the right moment, and then releasing inhibition. Presumably, specialized processors sensitive to timing act to hold up execution of a goal-image until the right moment (see Figure 7-3)." (P. 264.) Figure 7-3 has a graphical heading "Dominant Context Hierarchy" and a text caption "Implicit decision making as a vote between competing groups of processors." The "diagram describes intuitive, spontaneous, inexplicit decisions about conscious alternatives." (P. 281.) James' Feeling of Effort that was based in "tense muscles," etc. becomes "mental effort" for Baars, that is the "subjective experience of resistance to current goals. Mental effort takes up central, limited capacity, suggesting that it involves the *global workspace*. … The perception of effort may be a key to the experience of voluntary control." (P. 382.)

Computers are not expressly mentioned in Baars' model but information processing is its goal and his suggested processes are congruent with computation. There is no suggestion that anything in Baars' model is beyond the capacities and competence of computers. Rather, there is an expectation that a "computational formalism … can be used to make the current theory more explicit and testable when that becomes appropriate." (43.)

As quoted above, in *The Cognitive Revolution in Psychology*, Baars wrote: "Behaviorism as an intellectual discipline forces psychologists to *distance* themselves from the everyday psychology that we all live." In my view, if Baars' Cognitive Theory stands closer than Behaviorism to everyday psychology, it is still much more distant than the position James occupied. "The Consciousness of Self" is the longest chapter in James' *Principles of Psychology* and stands in a prominent foreground position. In that chapter, in the chapter on Will and in many other places, James describes human characteristics and personalities and attempts to use his Principles to organize them in human terms. James has some excellent successes, makes many middling fits that show their age and commits a large number of overgeneralizations and other errors. Such attempts at organizing human characteristics and personalities are infrequent in Baars' Theory and appear as asides rather than as constitutive material. Baars recognizes the issues: "One may wonder whether the computational analogy favored by cognitive psychologists will have a dehumanizing effect as well." He evidently concludes that there is nothing to fear: "Curiously enough, the effect so far has been to humanize rather than dehumanize our scientific conception of human beings. Compared with the older perspective in psychology, cognitive psychology sees people not as passive, but as active; not as physical in some simple sense, but as information-dependent … awesomely complex organisms … reality-oriented and indeed reality-creating creatures." (Pp. 414-415.)

Difference between James and Baars are not merely the result of a presence or absence of clinical anecdotes or breakfast table pontifications rendered in a 19^{th}-century style. In Baars'

Theory, facts of actual life that are major topics for James have been reduced to incidents of states and state structures. Depersonalization in the psychological domain is paralleled by a body of techniques in the conceptual domain that unite to strip the subject matter of references to actual human character. Forms of conscious perception are given hegemonic status and override other kinds of experience, such as bodily feelings and muscular movements. Activities of consciousness are re-cast into forms that will be suitable for computation. James denied that we are automata and asserted that feelings cause movements, but there is little in Baars to distinguish human beings from automata and little suggestion that feelings cause movements. Cause is attributed to operations on representations that have been broadcast through a global workspace (blackboard).

d. Approaches aimed at computation treat muscular movements as results of causal processes, avoid bodily feelings and lead to an "atoms in a void" brain model based on platonic principles of linearity, equilibrium and energy conservation.

Modern scientific psychologies and brain models that are based on computers seek to address a chief conceptual error in James' treatise, namely, the fallacious principle that would connect imagery to action: "For a million different voluntary movements, we should then need a million distinct processes in the brain-cortex (each corresponding to the idea or memory-image of one movement), and a million distinct paths of discharge. Everything would then be unambiguously determined…" The hypothesis of a "million different connections" needs to be replaced.

Advocates of artificial intelligence such as Marvin Minsky (§ 1.c) declare that principles of computation provide the desired replacement. As shown by Penrose, that position is supported by principles of platonism, according to which idealized math-like structures govern everything in the Universe, including operations of brains.

Also of importance are factual errors in James treatise. James declared: "It seems to me that no evidence of the muscular measurements in question exists; but that all the facts may be explained by surface-sensibility, provided we take that of the joint-surfaces also into account." He is contradicted by modern research. As stated in Calvin, *The Cerebral Symphony: Seashore Reflections on the Structure of Consciousness* (1990) at 84: "one of the lessons of sensory-systems neurophysiology is that the movement-directing nerves descending from brain to the spinal cord also have little branches to the ascending sensory pathways, serving to adjust sensory bias or communicate an expected sensory input from the about-to-be-ordered movement (so-called efference copy) for comparison purposes."

Calvin further states: "There's a lot of feedback from muscle tension and limb position into consciousness that affects our 'will.' … The sensory and movement systems are a good deal less independent than we originally thought; while movement-planning language may not serve as a universal description of what's going on in consciousness, it seems less prone to the tangles in which sensory-oriented descriptions land us (see the tortured debates on 'representations' in any cognitive science treatise.)" (Pp. 84-85.)

Calvin provides a view of modern brain science that is useful to me. I referred to *Cerebral Symphony* in the original *Quad Nets* paper and at http://www.quadnets.com/mechaphor.html Calvin has a special interest in muscular movements that extends from invertebrates to human beings and he observes and comments on different kinds of human movement in ways that show James' deficiencies. Thus, Calvin distinguishes slow and continuous movements that are subject to correction from ballistic movements like hammering or kicking that cannot be corrected: "…each correction takes time because the message moves slowly along the nerves, and the central nervous system takes time to decide too. A minimum round-trip loop time for arm-back-to-arm movements in humans is 110 milliseconds." (pp. 238-243.) The notion of ***training*** pervades Calvin's book but is all but absent from James' long treatise, where it appears in such clumsy forms as an instinct for collecting or as a way to derogate bodily feelings, as quoted above ("the more practised we become in a movement, the more 'remote' do the ideas become which form its mental cue").

In *Cerebral Symphony*, Calvin is meditating on means of construction of models rather than proposing a disciplined model. His proposed means are common in scientific psychologies, e.g., principles of darwinism and computation. However, he is also apparently skeptical of some other popular concepts, such as representations in cognitive psychology, as quoted above. He considers critical perspectives, e.g., "Cause-and-effect reasoning sometimes isn't very good when it comes to open systems with energy to spare." (P. 152.) Energy ***dissipation*** is important in my brain models, in contrast to models that depend on energy ***conservation***. In a similarly helpful way, Calvin quotes neurobiologist Graham Hoyle: "What you've got to realize is that every cell in the nervous system is not just sitting there waiting to be told what to do. It's doing it the whole darn time. If there's input to the nervous system, fine. It will react to it. But the nervous system is primarily a device for generating action spontaneously. It's an ongoing affair. The biggest mistake that people make is in thinking of it as an input-output device." (P. 314.)

Notwithstanding such helpful material, when he discusses proposed constructions, Calvin generally neglects bodily feelings. Rummaging in the index to *Cerebral Symphony* discloses no entries for "feelings" and 15 entries for "feedback." References to "body-image" and to "sensory" matters are meager. In contrast, there are long lists of entries under topics relating to movements, to computers and programs, and to darwinism and evolution.

Calvin's proposal to connect imagery to action is an elaboration of James' ideo-motor action that does not resolve its chief problems. Calvin rejects James' simple-minded hypothesis of a million automated connections. According to Calvin (p. 143): "Expecting a specialist cell (or 'labeled line') for each schema (Marvin Minsky, take note) is called the *Grandmother's face cell fallacy* by neurophysiologists." Like James, however, Calvin views muscular movements as a product of mental operations and presumes, as a foundational concept, that mental operations determine movements prior to the commencement of movement. Then, adjustments, to the extent they are possible, are determined by "feedback." "THE TRIAL AND ERROR CONCEPT" is a chief principle. (P. 259.) Calvin's approach may be suited to certain activities, such as throwing a stone at a rabbit (pp. 242-251) but generalization to "movement melodies" and to global brain models is openly speculative. (Pp. 251-273.)

In dealing with the focal problem of connecting imagery to action, Calvin state:

"It is only very simple motor programs with simple spatiotemporal patterns of muscle activity that can get by with the "Model A" approach to orchestration. The appropriate trigger for most motor programs is going to be a keylike correct *combination* of triggers in many cells; indeed, it will probably be just as important *which cells are inactive* as which are active. Therefore, one expects the ultimate stage in sensory processing to produce a pattern as the trigger. And it's not just a spatial pattern like the key notches: It is a spatio*temporal* pattern, like the fireworks finale, the *order* in which various neurons are activated, as well as *which* neurons are activated, being the key.

"The sensation-to-movement transformation is many-to-many; and there is no need for a many-to-one bottleneck unless the one cell has some special advantage for producing the spatial or temporal aspects of the movement subcommands … [¶] PATTERNS AS THE DETERMINANT, rather than absolute quantities of some thing, are also a big feature of growth and development. …" (P. 148.)

Determinant patterns, according to Calvin, are produced by machinery that operates according to principles of darwinism: first, the machinery generates "guesses" and then it removes bad ones. "A Darwin Machine now provides a framework for thinking about thought, indeed one that may be a reasonable first approximation to the actual brain machinery underlying thought." No Darwin Machine exists, even in designs, but such a Machine is expected to correct problems with present computers. Calvin contemplates "massively parallel selection among stochastic sequences [that] is more analogous to the ways of darwinian evolutionary biology than to the 'von Neumann machine' serial computer. Which is why I call it a Darwin Machine instead; it shapes up thoughts in milliseconds rather than millennia, and uses innocuous remembered environments rather than the noxious real-life ones." (Pp. 261-2.)

Calvin foresees a developmental path from his present positions to the desired goal of a conscious and intelligent robot. There is no suggestion that such a robot needs bodily feelings to accomplish its goals.

"Neurallike networks, once they become capable of generating randomly varied sequences, then successive selections by remembered environments, do offer an obvious route to machine intelligence and intelligent robots—though, should we succeed, we shall surely have to cope with machine imagination and machine 'free will.' " (P. 314.)

"how to build a conscious robot can now be glimpsed; it falls out of scenario-spinning considerations, out of Darwin Machines, out of neurallike networks…" (P. 322.)

A proposal for a "conscious robot" has some puzzling features. Robots are currently used in practical application but no one suggests that any consciousness is required. Neurallike networks have been investigated for many years but, again, no consciousness is involved. The generation of randomly varied sequences, proposed by Calvin, does not seem to require consciousness either. Perhaps it is "successive selections by remembered environments" that requires functioning of consciousness. Such functioning might be said to resemble Baars' principle of "informativeness" discussed above. However, it is difficult to connect such proposals with current robot technology or computer programs. Presenting the same problem as other scientific models, Calvin's has no operation or component that connects feelings to muscular movements or consciousness to action. As propounded by James: " 'A motion becomes a feeling!' —no phrase that our lips can frame is so devoid of apprehensible meaning. … (Quoting Spencer) a unit of feeling has nothing in common with a unit of motion." (Chap. 6.)

A different approach is suggested by Christof Koch in *The Quest for Consciousness: A Neurobiological Approach* (2004). He propounds the question: "Why, then, from the point of view of evolution, does consciousness exist? What survival value is attached to subjective, mental life?" (P. 2.)

Koch constructs an answer to the questions with a concept that he calls a ***zombie agent***. The zombie agent explains muscular movements without the need for consciousness. "In philosophy, a *zombie* is an imaginary being who behaves and acts just like a normal person, but has absolutely no conscious life, no sensations, and no feelings." (*Id.*) Although he considers philosophical concepts of zombies to be "sterile," Koch uses the zombie word for behavior that he considers non-conscious. (Pp. 205-216.) We act like zombies when we perform "relatively complex sensory-motor behaviors" that are "rapid and unconscious. Indeed, the point of training is to teach your body to quickly execute a complex series of movements… Nonconscious processing extends to the highest echelons of the mind… Much high-level decision making and creativity occurs without conscious thought…." (P. 3.)

Thus, Koch declares that "neurophysiologists have inferred the existence of *zombie agents* in the brain that bypass awareness…" (P. 3.) Something like zombie agents control "Balancing the Body." (208.) Such "nonconscious agents control head, limb, and body posture" when "you weave your way through crowds of shoppers on the sidewalk." They receive "continually updated information from many modalities, not just vision. The inner ears supply head rotation and linear acceleration, while myriad motion, position, and pressure sensors in the skin, muscles, and joints monitor the position of the body in space." (*Id.*) A baseball player engaged in fielding practice "is actively wiring up a zombie agent." (236.) "When you want to run along a trail, you 'just do it.' Proprioceptive sensors, neurons, and the muscular-skeletal system take care of the rest, and you're on your way. Try to introspect and you'll be confronted with a blank wall. Consciousness has no access to the amazingly complex sequence of computations and actions that underlie such a seemingly simple behavior." (317.) "A disconcertingly large fraction of your everyday behavior is zombie-like: You drive to work on autopilot, move your eyes, brush your teeth, tie your shoelaces, greet your colleagues in the hall and perform all the other myriad activities that constitute daily life. Any sufficiently rehearsed activity, such as rock climbing, dancing, martial arts, or tennis is best performed without conscious, deliberate thought." (318.)

Zombie agents seem much like the automata rejected by James or like computers that need no consciousness. According to Koch, however, there are some functions that zombie agents cannot perform and these are assigned to consciousness. "Why, then, isn't the brain just a large collection of specialized zombie agents? Life might be boring if it were, but since agents work effortlessly and rapidly, why is consciousness needed at all? What is its function? … I argue that consciousness gives access to a general-purpose and deliberate processing mode for planning and contemplating a future course of action." (PP. 3-4.)

In Chapter 14, "Some Speculations on the Functions of Consciousness," Koch explains "WHY THE BRAIN IS NOT JUST A BUNDLE OF ZOMBIE AGENTS." He considers the possibility that "the organism would come out ahead if the slower, conscious planning state were replaced by nonconscious agents. The disadvantage would be the lack of any subjective, mental life. No feelings whatsoever!" (P. 237.)

On the other hand, Koch suggests that consciousness somehow overcomes the problem of a "million different connections" that was noted in connection with James' model. "Given the many senses—eyes, ears, nose, tongue, skin—that flood the brain with information about the environment, and given the diverse effectors controlled by the brain—eyes, head, arms and fingers, legs and feet, the trunk—breeding zombie agents for all possible input-output combinations is probably insufficient. Too many would be required…" (*Id.*)

Accordingly, Koch constructs consciousness as a function operating on top of a foundation of zombie agents. Such agents can be assimilated to computational principles. (Pp. 320-321.)

Unfortunately for this approach, it becomes necessary to harmonize zombie agents with other properties of consciousness that Koch sets forth in other parts of his book. I suggest that zombie agents do not fit together with materials on "Attention and Consciousness" discussed in Chapter 9, including discussions of attention directed at salient objects, selective attention or "looking at," searching activity or "looking for" and "Doing Two Things at Once." (Pp. 153-171.)

Following the trail of attention, Koch's investigates "The Neuronal Underpinnings of Attention" in Chapter 10 (Pp. 173-185) and starts with "Mechanistic Accounts of Attention." (Pp. 174-178.) Mechanisms provide models for one chief function of attention (biasing competition among coalitions of neurons, e.g., during decision-making) but not for a second chief function, namely "to dynamically bind attributes of unfamiliar objects." (P. 184.)

"Binding" is a major issue in neuroscience and especially for Koch. The ***binding problem*** is raised by modern technologies of neuroimaging (fMRI, PEET, tomography, etc.) that enable scientists to observe operating brains in living persons and animals. The observations show that a brain is made up of scores or hundreds of specific anatomical regions and that each region has a variable activation. Regions that have a high level of activation at a given time are involved in the momentary activity of the brain. Regions that have a low level of activation are not involved in such activity but appear to be resting. Any particular task or situation requires activation of a particular combination of regions and the combination changes when the task or situation changes. Performing a task of hand-eye coordination requires a combination of brain regions that is different from combinations required for adding numbers mentally or listening to music.

Brain regions that are highly activated and engaged in a particular task are typically scattered throughout the brain. To perform a task requiring hand-eye coordination, a region in the forebrain apparently involved in planning is activated, along with regions in the temporal lobe that are involved in vision and regions inside or towards the bottom of the brain, the basal ganglia and the cerebellum, that control muscular movements. Coordination of hand and eye requires coordination of these widely-scattered brain parts. Because of the variability of tasks and in light of actual smooth coordination during some tasks, coordination of brain parts must be highly flexible and adjustable. That is, activities of different brain regions must be "bound together" in flexible ways. The question of "how to" bind together different brain regions in flexible ways is called the "binding problem." The binding problem presents much the same question as free-will puzzles, namely, how to connect imagery to action. The binding problem is a fruitful form of the question, in contrast to "free will," which has proved fruitless.

Koch and Francis Crick, Koch's mentor, have helped to develop an approach to the binding problem, namely, the concept of "[b]inding via neural synchrony." (Pp. 168, n. 33 and 169.)

The concept of neural synchrony is incorporated into Shimmering Sensitivity in my designs. Operations of Quad Net device parts can be synchronized so that they pass through critical moments together and generate a shared condition of Shimmering Sensitivity. Shimmering Sensitivity has a property of ***nonlocal activity***, imported from phase changes studied in Critical Point physics and discussed below. I suggest that nonlocal activity unites or binds together brain regions that are widely separated from each other. The notion of nonlocal activity during transformational changes was introduced above in discussions about snowflakes.

The classes of zombie agents and conscious bindings do not fit together. The misfit is sharp when memory is considered. Thus, Koch suggests that we "think of [zombie behaviors] as cortical reflexes." "Zombie agents operate in the here and now, so they have no need for short-term memory. … Force the organism to make a choice, such as inhibiting an instinctual behavior, following a delay of a few seconds. If the creature can do so without extensive learning, it must make use of a planning module that, at least in humans, is closely linked to consciousness." (P. 319.)

Consciousness, on the other hand, is "a powerful and flexible system" that "evolution chose … to deal with the unexpected and to plan for the future." (Pp. 317-318.) As Koch discusses in Chapter 11 "Memories and Consciousness" are interdependent. He identifies distinct forms of memory — short-term, long-term, associative and non-associative, procedural and declarative, as well as fleeting or iconic memory, which is an "even briefer form [that] is probably essential to conscious experience. (Pp. 187-204.)

In sum, Koch suggests two tools for dealing with problems of consciousness, namely, zombie agents and binding via neural synchrony but the two tools do not operate together or provide connections between images and action. Zombie agents refer to muscular movements and have a local character while neural synchrony refers to global generation of images. No way is shown to go from one to the other. Are zombie agents excluded from fleeting and iconic forms of memory and consciousness? How about long-term memory or procedural memories?

Koch admits that his proposals are "hardly very rigorous." The difficulties do not daunt him. "At this point in the game, it is too early for formal definitions." (P. 319.)

"Nonconscious processing" by zombie agents does not fit my actual experience. I cultivate my consciousness of muscular movements and bodily feelings "in the here and now" through practices of yoga and qigong (chi gong). Martial artists and body-discipline practitioners write meaningfully about such consciousness. Practices typically involve repeated movements and positions according to "forms" that are taught and cultivated by experts. It is through repetition of such forms that particular kinds of consciousness are generated and developed. A chief feature of such practices is the binding together of movement and feeling within the form.

Koch's references to zombies, like those of Calvin to robots, seem to me to reflect systematic biases in scientific psychology against recognition of bodily feelings. I suggest that such bias extends to non-recognition of individual personalities. In my view, personality is shown in the skills and styles of persons who are engaged in performances of "rock climbing, dancing, martial arts, or tennis." Such ***spontaneous trained*** performances are, in my experience, fully conscious; and the performer's movements are often a product of deliberate planning that is reflected in deliberate execution — all contrary to Koch's assertion that they are "best performed without conscious, deliberate thought." When I set out to climb a big steep rock, for example, I typically visualize steps along an anticipated route before I start moving. Visualization is easier and more effective when I am climbing up, compared to when I am climbing down. I am bolder climbing up and more timid climbing down.

In his investigations, Koch focuses on sensory processing. "Perceptual neuroscience has advanced to such a point that reasonably sophisticated computational models have been constructed and have proven their worth in guiding experimental agendas and summarizing the data. ¶ I therefore concentrate on visual sensations or awareness. [Another researcher] refers to such sensory forms of awareness as *core consciousness*, and differentiates these from *extended consciousness*. … My research program neglects, for now, these and other topics [involving extended consciousness] such as language and emotions." (P. 15.) "I assume that consciousness depends on what is inside the head, not necessarily on the behavior of the organism." (P. 17.)

Although Koch concentrates on visual sensations or awareness, he gives little consideration to muscular movements involved in vision such as focusing on objects at a certain distance or saccadic eye movements discussed above in connection with An Eye for Sharp Contrast. Only retinal patterns seem to be important. "To extract the target location, its relative position on the retina needs to be converted into a form that the neuronal network underlying reaching, grasping, and pointing can exploit to direct the eyes, head, arms and fingers." (P. 145.) Section 3.7 is titled "EYE MOVEMENTS: VISUAL SACCADES ARE UBIQUITOUS," but, for Koch, saccades are mostly activity to ignore. "The stability and sharpness of the visual world during eye movements is a consequence of numerous processes, including *saccadic suppression*, a mechanism that interferes with vision during eye movements. … Why, then, isn't everyday vision characterized by annoying blank periods? This must be prevented by some clever, *trans-saccadic integration* mechanism that fills in these intervals with a 'fictive' movie, a composite of the image just before and after the saccade. The mechanisms and neuronal sites of this integration remain largely unknown." (P. 65.)

Koch's model is designed to fit principles of computation. In *Quest for Consciousness*, he asserts: "Much data suggest…that neurons are sophisticated computational devices, and that the exact time of occurrence of spikes is important." (P. 38.) In an earlier monograph, *Biophysics of Computation: Information Processing in Single Neurons* (1999), Koch begins page 1: "The brain computes! This is accepted as a truism by the majority of neuroscientists engaged in discovering the principles employed in the design and operation of nervous systems. What is meant here is that any brain … performs a very large number of ill-specified operations, frequently termed computations… The outcome of some of these computations can be stored for later access and will, ultimately, control the motor output of the animal in appropriate ways."

Koch expressly avows a computational approach and goals. "Today, much of our thinking about the brain is dominated by our favorite new artifact, the digital computer." (P. 1.) "Thinking about brain-style computation requires a certain frame of mind, related to but distinctly different from that of the biophysicist. … we must be concerned with both aspects, with biophysics as well as computation." (xix.) He seeks to identify "biophysical mechanisms implementing specific operations that have been postulated to underlie computation." (P. 2.)

The final chapter of the monograph is titled "Computing with Neurons: A Summary." Koch compares a brain to a paradigmatic computer or "finite state machine," and asks "to what extent can brains be treated as *finite state machines* or *automata*?" The answer to the foregoing question is "an ambiguous 'it depends.' " (P. 469.) The "yes" branch of the ambiguity is quite weak, at least initially: "finite state machines will be relevant (although not sufficient to understand[)] … how operations carried out by nervous systems, such as associative memory or visual object recognition, can be implemented in machines…" In contrast, the "no" branch of the ambiguity is remarkably strong: as to biological processes like "probabilistic synapse release, finite state machines and their relatives will not be useful for a number of reasons. The most obvious is that these virtual machines are disembodied entities … in the real world, space, time, and power are in short supply … None of these considerations are incorporated into our current notion of computation." (P. 470.)

Regardless of any ambiguity, Koch has a clear view of what, "[o]n the positive side" he "can say about the manner in which the nervous system processes information." In his model: "Individual neurons convert the incoming streams of binary pulses into analog, spatially distributed variables, the postsynaptic voltage and calcium distribution throughout the dendritic tree, soma and axon. These appear to be the two primary variables regulating and controlling information flow, each with a distinct spatio-temporal signature and dynamic bandwidth. … Information is processed in the analog domain, using a menu of linear and nonlinear operations. [Specific math-like functions] are the major operations readily available in the dendritic cable structure augmented by voltage-dependent membrane and synaptic conductances. [¶] This is a large enough toolkit to satisfy the requirement of the most demanding analog circuit designer." (*Id*.)

I suggest that technical terms used in the preceding statement and in Koch's model of a neuron make up a structure that is designed to fit principles of mechanics. To start, a neuron is modeled as an isolated and distinct cell, detached both from its environment and also from connections to anything other than fellow neurons. The neuron has distinct parts with distinct functions, a central body or soma that receives input from fellow neurons through synapses in the dendritic tree and that discharges output through the axon and thence to synapses on other neurons.

Koch's model maintains an invariant foundation in the "Linear Cable Theory" (pp. 25-48) which supposedly governs behavior of the cell. Summing up his constructions based on Linear Cable Theory, Koch states: "Throughout this book, we have lived with the convenient assumption that the three-dimensional arrangements of synapses, dendrites, axons and cell bodies do not matter and that all neurons can be reduced to sets of one-dimensional cylinders. This simplification is a powerful one since it allows us to study the spatio-temporal distribution of the membrane potential and calcium distribution with ease on the basis of one-dimensional cable and diffusion equations." (Pp. 459-460.) In this construction, "an entire class of dendritic trees can be reduced or collapsed into a single equivalent cylinder." (P. 57.) As noted in detail below, Koch's model is constructed conceptually by use of principles that are abstracted from empty space, chiefly linearity, discussed above in § 4 in connection with platonic physics.

In Koch's approach, action potentials impinge through synapses onto the dendritic tree of a neuron and influence the soma to discharge new pulses through its axon. The model is expressed in equations, which "[f]rom a mathematical point of view … constitute a *singularly perturbed system*, in which one variable evolves much faster than the others. Other instances of such systems are the Hodgkin-Huxley and the Fitzhugh-Nagumo equations." (P. 271.)

I suggest that such a "singularly perturbed system" is made up of an equilibrium "empty space" that has superimposed on it certain kinds of particulate disturbances. A particulate disturbance is narrowly confined in space and time, has a well-defined direction and velocity and can lead to similar disturbances in other, similar systems through point-contact interactions such as synapses. This is an "atoms in a void" model, the desired goal of platonic physics. Such models have important uses but they have been found to be limited.

The Hodgkin-Huxley model is the primal model for pulses in neurons. "The Hodgkin-Huxley 1952 model of action potential generation and propagation is the single most successful quantitative theory in neuroscience." (P. 171.) It is "[t]he cornerstone of modern biophysics." (P. 212.) However, the equations in the model "do not capture—nor were they intended to capture—a large number of biophysical phenomena, such as adaptation … or bursting…

Moreover, the transmission of electrical signals within and between neurons involves more than the mere circulation of stereotyped pulses. These impulses must be set up and generated by subthreshold processes." (*Id*.)

Limitations in the Hodgkin-Huxley model lead Koch to construct his advanced model in: "Chapter 9 Beyond Hodgkin and Huxley: Calcium and Calcium-Dependent Potassium Currents." "What are some of the important functional properties shared by all calcium conductances? Most importantly, the associated calcium current is always activated by depolarization…" such as depolarization that occurs during pulse propagation. (P. 213.) Calcium currents have functions additional to pulse propagation. "The calcium concentration inside the cell not only determines the degree of activation of calcium-dependent potassium currents but—much more importantly—is relevant for determining the changes in structure expressed in synaptic plasticity. As discussed in Chap. 13, it is these changes that are thought to underlie learning." (P. 248.) Another suggested function is to produce more complex signals than single action potentials; Koch proposes a model for ***bursting*** that includes a long-lasting action potential of relatively small size, on which rides a series of large but quick spikes.

Based on the foregoing analysis of Koch's model, I suggest that, as an exemplar of the science, Koch's model illustrates an "atoms in a void" approach, even when further developed in an advanced way to include calcium currents. The approach is purposefully directed towards goals of discovering and articulating brain operations that can be said to resemble those of computers.

A critical review suggests that, despite great efforts and ingenuity, Koch and other modelers fail to reach their computational goals. Invoking models of various researchers, Koch is able to identify "*Many Ways to Multipl*y. (P. 471.) There range from specific examples of claimed computation in the visual system of a locust to theoretical summation of a population of noisy neurons. (Pp. 471-72.) Although Koch originally "was motivated by the hope that a handful of biophysical computations would be universal," he now concludes that there are "A Large Number of Biophysical Mechanisms for Computation" and identifies about 20 such computations that occur as quickly as 1 millisecond and as slowly as a second.. (Pp. 473-475.) No general model, including Koch's own, works for more than a few of the examples.

In light of the many speculative possibilities, Koch considers "the unsettling but quite plausible scenario in which any one computation is carried out using a plurality of mechanisms at different spatial and temporal scales … any one computation would be implemented by the linear or nonlinear superposition of a host of biophysical mechanisms, where the coefficients specifying the contribution that each mechanism makes vary from one animal to the next." (P. 474.) Moreover, a chief hypothesis "was discussed extensively in Chap. 5: the dendritic tree geometry, coupled with a unique synaptic architecture, implements specific computations. Although this hypothesis is by now almost two decades old, we still do not know to what extent individual synapses [] or groups of them [] are involved in such computations or whether the location of synapses in the tree is pretty much irrelevant." (P. 479.)

Throughout his construction, Koch applies principles of platonic science in furtherance of computational goals. Outstanding themes are: (1) conservation principles; (2) constructions of linear models for non-linear phenomena; and (3) models that use electronics components.

The most serious criticism of Koch's models is directed at the modeling of energy. Energy generation in the models is embodied in direct current batteries; and energy storage in the models is embodied in electrostatic fields in capacitors. Electrostatic fields are maintained by batteries in a foundational equilibrium condition that may be briefly perturbed but which is immediately restored. Such a model is easy to fit to views that see computers but is hard to fit to views of thermodynamics that see dissipative processes and a multitude of phase changes in material bodies, to views of biology that see a seething ocean of interactive biochemical activity, or to views of actual life that see continual streams of new experiences and transformations. I suggest that multitudes of highly variable activities like those seen in brains will not be built on a foundation of equilibrium electrostatic fields maintained by DC batteries.

Koch introduces electronics components — resistance or "R" and capacitance or "C" — in a section titled "RC Circuits as Linear Systems." "Linearity is an important property of certain systems… the issue of linear and nonlinear systems runs like a thread through this monograph…" (P. 12.) Resistances are governed by Ohm's Law, introduced above as a linear relation. A similar linear relation governs a capacitance. Using such components, Koch presents a standard model of the ***Linear Cable Equation*** in "**A Single Passive Cable** Equivalent lumped electrical circuit of an elongated neuronal fiber with passive membrane. The intracellular cytoplasm is described by an ohmic resistance per unit length r_a and the membrane by a capacitance c_m in parallel with a passive membrane resistance r_m and a battery V_{rest}." (Pp. 30-31.)

Koch recognizes that the linear cable theory model is limited: "it could be argued that studying neurons under such constraints will fail to reveal their true nature. However, it is also true that one cannot run before one can walk, and one cannot walk before one can crawl. … one first needs to study the concepts and limitations of linear cable theory before advancing to nonlinear phenomena." (P. 26.)

The linear cable theory model provides the "void" in which particulate action pulses move. "From the point of view of information processing, a linear noiseless system cannot create or destroy information. Whatever information is fed into the system is available at the output. Of course, any system existing in the real world has to deal with noise… Therefore, in a noisy, linear system, information can be destroyed. But what is needed in a system that processes information are nonlinearities that can perform discriminations and decisions. Similarly, … for a digital system … a nonlinearity … is required." (P. 19.)

In Koch's brain model, nonlinearities are provided by synaptic input. (*Id.*) Only certain kinds of synaptic inputs are considered and Koch's selections of synaptic inputs target computational goals. "Synapses are the elementary structural and functional units for the construction of neuronal circuits. Conventional point-to-point synaptic interactions come in two different flavors: *electrical synapses* .. and the much more common *chemical synapses*." (Pp. 14-15.) "It is useful to distinguish fast ionotropic chemical synapses, acting on a millisecond time scale, from metabotropic chemical synapses, acting on a time scale of a fraction of a second to minutes." (P. 115.) "[F]ast chemical synapses [are] the stuff out of which computations arise." (P. 24.)

The neglected "electrical synapses are frequently found in neuronal pathways which subserve information that needs to be communicated very rapidly and faithfully. In the retina, gap junctions … create vast, electrically interconnected networks…" (p. 116) In the heart: "Gap junctions allow single action potentials, originating in a group of pacemaker cells, to sweep through all cells in a wavelike manner, generating the rhythmic squeeze and relaxation that is the stuff of life." (P. 113.) "*Ephaptic transmission* refers to nonsynaptic electrical interactions. … Their functional significance—if any—is not known and we will not discuss them here." (P. 85) Around a dendritic tree, however, "this type of ephaptic coupling could be of functional relevance, yet almost no theoretical work has been carried out on this subject." (P. 29.) "Glial cells are another example. These cells, thought to play mainly a supporting metabolic role … lack conventional chemical synapses. They communicate instead via an extensive grid of electrical gap junctions with each other." (P. 113.)

Fast electrical couplings and slow chemical couplings are apparently not needed for computation. "Conceptually and *cum grano salis*, ionotropic synapses are the essence in the rapid forms of neuronal communication and computations underlying perception and motor control." (P. 115.)

Nonlinearities are essential to information processing and are provided by the Hodgkin-Huxley model, but linear models are easier. "Although it can be argued that a linear analysis of a nonlinear phenomenon does not do justice to it, it will certainly help us to understand certain aspects of the mechanism underlying the phenomenon." (P. 245.) In further modeling, Koch linearizes the Hodgkin-Huxley equations, the potassium current, the sodium current, and the membrane impedance (resistance) of a patch of squid axon. (Pp. 232-247.)

Other platonic features of current scientific brain models are identified in Koch' monograph: (1) generalization from experiments performed on the giant axon of a squid with a "so-called *space clamp* [that] keeps the potential along the entire axon spatially uniform" (p. 144) — the Hodgkin-Huxley "model is based on voltage- and space-clamped data" (p. 161) — "Indeed, action potentials [in other animal experiments] do not show any hyperpolarization, unlike those of the giant squid axon" (p. 165); (2) homogenization of the environment in models ("The extracellular space is reduced to a homogeneous resistive milieu" – p. 47); (3) Kirchoff's current law, suitable for electronics components but not for electro-chemical processes in living organisms (Pp. 9, 17, 30, etc. — likewise, James wrote: "The currents, once in, must find a way out."); (4) compartmental modeling, "a system of … equations, corresponding to small patches of neuronal membrane that are ***isopotential***…" (p. 60, emphasis added, identifying quasi-static elements).

Koch's brain models aim to show how brains are computers. He applies methods of platonic science with skill and ingenuity. My conclusion, however, is that the results are meager. Although the constructions are carefully shaped and directed toward the computational target, the target is not reached. Actual computations are few and far between and no general conception unites or organizes them. There is little in such computational speculations to suggest how images connect to action or to suggest applications to actual life.

6. In new alternative constructions, "beats" of actual life, along with wags of a Dogtail, are modeled by movements of muscle-like modules. Temporal forms based on such movements include episodic balancing forms that are embodied in new technologies as Shimmering Sensitivity, a principle of freedom, and that also govern sports contests and jury trials. Outcomes of such events often turn on personal efforts and personal decisions that occur during transformational critical moments.

Critical analysis of the "modern scientific view" in § 4 shows that such a view is based on a set of spatial forms and on successes in applying those forms to certain phenomena, e.g., spheres moving solely under the influence of gravity in empty space and pV=RT relations of a dilute gas in a closed container. Building on such paradigms, scientific forms have been successfully applied to numerous phenomena and have been embodied in wonderful technologies.

Such successes have encouraged a presumption that scientific forms describe and control all phenomena, e.g., phenomena of brains, as discussed in § 5. The presumption has focused investigators on sensory perception and has excluded or derogated large classes of phenomena, especially muscular movements and related bodily feelings. I suggest that systematic biases arising from scientific forms shape research programs and the professional consensus.

For some persons, successes of science and technology justify a hegemony of scientific forms. Such persons say that the modern scientific view is superior to all other views. Advocates declare that scientific forms apply to each and every situation. They hold that any clash of views must be resolved in favor of a scientific view. It is said that platonic forms of logic embodied in computers also describe and control activities of brains and thus all activities of actual life.

I suggest that claims of scientific hegemony are not supported by facts. The facts are that personal freedom and consciousness are important in actual life and that scientific and platonic forms fail to describe freedom or consciousness. Scientists claiming hegemony for Laws of Physics often belittle freedom and consciousness. In actual life, however, personal disputes and other personal matters cannot be handled by reference to "impersonal invariants," much less Laws of Physics, but must be resolved through exercises of freedom and powers of consciousness. As a matter of fact, scientific principles have had little practical application to social or institutional problems despite enormous research efforts. Few scientists have occupied positions of importance in the actual histories of nations or peoples.

My approach is to construct a new set of temporal forms that are different from the spatial forms of platonic science. I suggest that new temporal forms can be embodied in new technologies. I suggest that models to be built from new technologies will more closely mimic activities of animals that have actual life and of human institutions that are built on foundations of actual life. I suggest that such models can lead to development of improved forms for use in social, legal and political institutions.

a. The beat is a primal temporal form in new models of actual life.

Ancient Hebrew culture sharply contrasts with ancient Greek culture and platonic science. According to T. Boman, *Hebrew Thought Compared with Greek* (1960): "the thinking of the Greeks is spatial and that of the Hebrews is temporal. … Greek and Israelite-Jewish interpretations of time are entirely different." (p. 20.)

In Boman's construction of ancient Hebrew Thought and ancient Greek Thought, each Thought had a distinct character. In factual background, early Christians used diverse Jewish and Greek source materials in constructing the new religion; scholars concerned with Christian origins have divergent views about the nature and influence of the two sources. (*Id*., 20-21; Schweitzer; Pelikan; Dodd, 74-75.)

Boman's constructions are useful in my approach because they provide context for new temporal forms. Spatial forms of platonic science have references in ancient Greek culture; temporal forms of new proposed technologies can be referred to ancient Hebrew culture.

In his "Summary and Psychological Foundation of the Differences," Boman states (205): "The Greek most acutely experiences the world and existence while he stands and reflects, but the Israelite reaches his zenith in ceaseless movement. Rest, harmony, composure, and self-control—this is the Greek way; movement, life, deep emotion and power—this is the Hebrew way."

"According to the Israelite conception, everything is in eternal movement: God and man, nature and the world. The totality of existence, '*ôlam*, is time, history, life." (*Id*.)

As discussed above, new proposed models of actual life are based on muscular movements. Every muscle is activated and ready all the time, maintaining tonus even when immobile. Actual muscular movements arise out of readiness. The underlying basis of all mental activity is a plenum of muscular activation. I suggest that movement, activation and readiness resonate with Hebrew Thought.

Focusing on specific temporal forms in Hebrew Thought, Boman states: "The shortest span of time, or Hebraically expressed, the shortest perception of time, is *regha*'–a beat, or as von Orelli so suitably suggests, the pulse-beat of time." "[T]he Hebrew *regha*' refers to some sort of bodily sensation such as pulse-beat, heart-beat, or twitching of the eyelid. In any case, the shortest time in Hebrew is not a point, nor a distance, nor a duration, but a beat." (136.)

In models of actual life, ***the beat*** is a primal form of movement, a form that can change with the situation and that can develop into variant beat forms. Variant beat forms combine in waves and cycles suitable for coordination and organization. The primal beat is the thump-thump-thump of a heart, the tap-tap-tap of a musician's foot, the step-step-step of marching and the "push, push, push" that is the only activity of a jellyfish. (Walter, 18.)

Boman states: "In *regha*' there is originally something violent." Compared to other words, "*regha*' is more the rapacious, violent, stormy suddenness with which something takes place," e.g., when fish and birds are "suddenly ensnared" (Eccles. 9:12) or when a man is "straightaway" overcome by sexual temptation (Prov. 7:22). Several Hebrew words "are used like *regha*' to designate abruptness." (137.)

In the genre of horror and suspense films, directors use an audio beat in a characteristic way that conveys a "rapacious, violent, stormy suddenness" — or, more precisely, the beat is signaling that such a suddenness is about to occur. The scene on the screen may be banal, a person walking slowly towards a house, for example; meanwhile, the sound track carries a strong beat with a character like that of a heartbeat. The beat signals an impending suddenness. The beat in the horror film is pregnant with approaching action that will be rapacious, violent or stormy.

In my approach, a beat is pregnant with multiple possible movements that may suddenly appear and that may range from rapacious violence to delicate sensitivity and even to stillness and silence. What suddenly appears will be transformational but there will also be conserved a substance that carries characteristics of the original. The beat is not just signaling that something happened in the past or that something will be happening soon: the beat is a continuing beat that potentially unites past, present and future in movement that extends without limit.

A distinction between smooth action and jumpy or sudden action is important in constructions developed herein. The two kinds of action turn into two kinds of control. One kind of control is ***continuous control*** and that other is ***saccadic (jumpy) control***. Continuous controls fit forms of platonism that incorporate the continuity of geometric space; saccadic controls operate according to principles of discontinuity. "Abrupt" connotations of *regha*' are suggestive of saccadic controls. The suggestion is rooted in facts of actual life, where sudden or jumpy action often seizes control from smooth action. In actual life, jumpy, abrupt, even violent action is often a more powerful influence than smooth action based on reason — and such power is in the suddenness and size of the jumps.

A chief temporal form in Hebrew Thought is "purely and simply a rhythmic alternation," e.g., "seedtime and harvest, cold and heat, summer and winter (Gen 8.22)." (Boman, 134.) "An isolated unit of time, therefore, has a rhythm which for the sake of comparison with rhythmic speech can be given the form: unaccented—accented—unaccented, or to compare it with the pulse-beat, weak—strong—weak. Thus in Hebrew the period of day and night is a rhythm of dull—bright—dull; evening—morning—evening (Gen. 1.5, 8, 13,19, 23, 31.)" (135.)

In ancient Israel, rhythms were forms of actual life. The weekly day of religious observance, the sabbath, had first importance. (Deut. 20:8-11.) Each year was organized through festivals and observances. (*Id*., 34:18-23.) "A longer period of time is thought of as a continued rhythm passing over into a higher time-rhythm, etc. The shortest rhythm, the day, passes over into the week-rhythm, then into the month-rhythm, and then into the rhythm of the year…The seven-beat rhythm of the week is continued in the sabbath year and the jubilee year." (Boman, 135-136.)

Rhythmic forms of actual life were famously set forth in Eccl. 3:2-8 (140-141):

> "A time to be born and a time to die;
> A time to plant and a time to pluck up that which is planted;
> A time to kill and a time to heal;
> A time to break down and a time to build up;
> A time to weep and a time to laugh;
> A time to mourn and a time to dance;
> A time to cast away stones and a time to gather stones together."

"As space was the given thought-form for the Greeks, so for the Hebrews it was time." (206.) "For us space is like a great container that stores, arranges, and holds everything together; space is also the place where we live, breathe, and can expand freely. Time played a similar role for the Hebrews. Their consciousness is like a container in which their whole life from childhood on and the realities which they experienced or of which they had heard are stored." (137.) In contrast to the linear form of Greek time, for the Hebrew, "time is determined by its content." (124-125, 131.) "[I]n the Indo-European languages, the future is quite preponderantly thought to lie before us, while in Hebrew future events are always expressed as coming after us." (130.)

Hebrew Thought is built around time but "time is assessed by Plato as well as by Aristotle as something vastly inferior to space, partly as an evil. Aristotle is in agreement with the maxim that time destroys…nothing grows new or beautiful through time…everything pertaining only to space, e.g., geometry, was … highly regarded, and the Greek gods and the divine world had to be conceived as exempt from all time, transitoriness, and change…." (128.)

For Boman, the words "dynamic" and "static" are tentative labels that distinguish between Israelite thinking that is "vigorous, passionate, and sometimes quite explosive" and Greek thinking that is "peaceful, moderate, and harmonious." In Hebrew, even words that we might use for inaction, e.g., sitting, lying and standing, designate a movement that leads to the fixed end-point. (30-31.) " 'Dwelling' for the Hebrews is related to the person who dwells, while for the Greeks and for us it is related to the residence and the household goods." (31.) Boman finally rejects "the antithesis *static-dynamic*." "The distinction lies rather in the antithesis between rest and movement." (55, emphasis in original.)

Static objects at rest fit into forms of knowledge that are different from those that fit active persons. "Ruldolf Bultmann has drawn out an elaborate comparison and contrast between the Greek and Hebrew conceptions of knowledge. …The Greek conceives of the process of knowing as analogous to seeing; that is, he externalizes the object of knowledge, *contemplates* (θεωρει [*theorei*]) it from a distance, and endeavors to ascertain its essential qualities, so as to *grasp* or *master* [] its reality []. It is the thing in itself, as static, that he seeks to grasp, eliminating so far as may be its movements and changes, as being derogatory to its real, permanent essence. … The Hebrew on the other hand conceives knowledge as consisting in *experience* of the object in its relation to the subject. [*Yada*] (Heb. "to know") implies an immediate awareness of something as affecting oneself, and as such can be used of experiencing such things as sickness (Is. liii 3), or the loss of children (Is. xlvii 8), or divine punishment (Ezek. xxv 14) or inward quietness (Job xx 20)… Thus it is the object in action and in its effects, rather than the thing in itself, that is known; and in knowing there is activity of the subject in relation to the object." (Dodd, 152, original emphases; transliterations and translation added.)

"[T]he Greeks were organized in a predominantly visual way and the Hebrews in a predominantly auditory way." (Boman, 206.) Plato, it is said, "is a man of sight, of seeing. His thinking is a thinking with the eyes, proceeding from what is seen…his doctrine of Ideas—is in many ways tied to vision. … Quite as decided in the Old Testament is the emphasis upon the significance of *hearing* and of the *word in its being spoken*." (201, emphases in original.)

In the literature of ancient Israel, "A seer, *ro'eh*, is a man of God who sees what is hidden from other men, be it runaway domestic animals, hidden sins or future events. …his observation is of an entirely different kind from the Platonic. Greek thinking is clear, logical knowing." (204.) In contrast to the Greek concept of truth based on "that which is," the "Hebrew concept of truth is expressed by means of the derivatives of the verb '*aman*—'to be steady, faithful': '*amen*—'verily, surely'; '*omen*—'faithfulness'; '*umnam*—'really'; '*emeth*—'constancy, trustworthiness, certainty, fidelity to reported facts, truth'." (202.)

Summing up corresponding terms, *dabhar* ("word" in Biblical Hebrew) and *logos* ("word" in first century Greek), Boman declares: "these two words teach us what the two people considered primary and essential in mental life: on the one side the dynamic, masterful, energetic— on the other side, the ordered, moderate, thought out, calculated, meaningful, rational." (68.)

"In the Old Testament, [*dabhar adonai* — 'word of the Lord'] is frequently used of God's communications with men, His self-revelation, especially through the prophets, to whom 'the word of the Lord came'. The totality of God's self-revelation is denominated ['*torah*,' or 'Law'], a term which is often parallel or virtually synonymous with [*dabhar adonai*]." (Dodd, 263, transliterations and translations added.)

"For the Hebrew, the decisive reality of the world of experience was the *word*; for the Greek it was the *thing*." (Boman, 206.) Hence, for Hebrews, "Things do not have the immovable fixity and inflexibility that they have for us, but they are changeable and in motion." (49-50.)

"True being for the Hebrews is the 'word', *dabhar*, which comprises all Hebraic realities: word, deed and concrete object. Non-being, nothing (no-thing) is signified correspondingly by 'not-word', *lo-dabhar*. … the lie is the internal decay and destruction of the word…That which is powerless, empty, and vain is a lie: a spring which gives no water lies (Isa. 58.11, *kazabh*)." (56.) "When the Hebrews represent *dabhar* as the great reality of existence, they show their dynamic conception of reality." (184.)

Ideas and impersonal invariants stand as the highest forms of Greek Thought and platonic science. Ancient Hebrews had a different conception of the most high.

"Consciousness comprises an entire life and cannot be divided like space … When a song is being sung, its beginning, in our spatial manner of thinking, already belongs to the past and its end still to the future; but, essentially, the song is a living unity which, even after it has been sung to the end and logically belongs to the past, is something present…In a similar way, significant historical events remain indestructible facts in the life of a people. The consequences of the events can be altered in a positive or negative direction by new deeds or failures, but the events themselves can never be altered…" (138.)

"God revealed himself to the Israelites in history and not in Ideas; he revealed himself when he acted and created. His being is not learned through propositions but known in actions. … The people's past, present and future is a continuous whole where everything lives. … Analogous to the life of an individual man, the people's life is experienced as a whole … The nation is a person." (171.)

In ancient Israel, "the word of Jahveh is never a force of nature as in Assyria and Babylonia, but is always a function of a conscious and moral personality." (60.)

b. A beat dwells in muscle-like activity in proposed new technologies.

The following constructions incorporate materials taken from theories of Piaget, Nietzsche, ancient Greeks and modern scientists discussed above, with appropriate modifications. Novel aspects are illuminated by Boman's review of Hebrew Thought that contrasts movement and action with rest and states.

I construct imaginary or metaphysical domains that are populated by operating assemblies of devices. Such imaginary domains resemble computational domains, actual and imaginary, that are constructed by computer scientists, students and hobbyists — but with new and different kinds of devices, signals and operations.

In new proposed technologies – Quad Nets and timing devices – internal signals embody ***forms of action*** in contrast to signals in computer systems that embody ***forms of state***. Forms of action are based on ***temporal forms*** while forms of state are based on ***spatial forms***. In each case, forms can be used to control muscular movements. In plane geometry class, a student follows mental imagery of a spatial form to draw a triangular figure on the chalkboard; in music class, on the other hand, the student follows temporal forms, such as beat, meter and rhythm.

It can be said that the beat controls movements of a person who follows the beat. The person's movements will speed up if the beats speeds up. It would be erroneous, however, to say that the beat determines the person's muscular movements. A person can stop following the beat if the person "wills" or desires to do so. A person can stop following the beat for reasons of mischief or rebellion. A person can stop following the beat for no reason at all.

Tapping feet of musicians are examples of a beat that controls repetitive muscular movements. Whether the connection between ear and foot is innate or socially acquired, facts show widespread habitual activity. The habit is discouraged among classical music performers but is difficult to eliminate. Recently I sat close to a performance by a touring European orchestra that maintained 19th century forms of discipline. The concertmaster had a foot that could not resist tapping, sometimes for several measures at a stretch. He had to silence it repeatedly.

Suppose a jazz band violinist is tapping her foot according to the beat produced by the drummer. I suggest that, although her muscular movements are following the external sound, they have a distinct and separate source within her mind and brain. If the drummer sneezes and omits a few drum strokes, neither the violinist nor her foot need miss a beat. I suggest that the violinist is generating the beat internally in her brain and confirming or modifying that self-generated beat according to the drummer's beat. (For more details, please see the formal paper "An Ear for Pythagorean Harmonics" available on the website.)

The principal construction herein commences with the beat. The beat appears in an imaginary domain like that of a geometrical construction or chalkboard diagram of a physicist. The domain is populated by devices designed according to principles of new technologies, e.g., a Dogtail for Wagging. Constructions connect to actual experience. I suggest that you have your own experience of beats and can connect such experience to operations of devices. A general design goal for new technologies is to establish connections between device operations and a person's experience. Sometimes such connections can be made strong and sometimes they are no more than weak or only speculative — but the goal remains.

I suggest that something like beats drive repetitive movements in actual life, e.g., repetitive movements that are self-perpetuating like the sucking of the baby that was introduced in § 1. I suggest that baby's sucking and the beat have a common ground in actual life. Actual life is in repetitive movement controlled by the beat as it is in repetitive sucking. Actual life moves a person to dance to the beat for the sake of movement as it moves the baby to suck for the sake of sucking. I suggest that we attach to the beat like the baby attaches to the nipple: because we draw actual life from the beat. Actual life expresses the power to move and we get that power from the beat. We dance together according to the beat — and we get actual life from dancing, from the community and from the unifying beat.

In a newborn baby, actual life depends on beating of the heart that is driven by beating in the brain. The baby attaches to the beating of its mother's heart as a stronger, nurturing source of its own beating. The beating is constant and comes to dwell as an independent presence at the center of the self. As the child grows, the beat develops a capacity to change and explore. A secondary beat appears, a rhythmic accent to the primary beat. The child's growing capacities are based on growth and development of beats and rhythms of beats. Multiple beats and rhythms develop through adaptations in response to demands of actual life. Different persona or personalities with different beats develop for different situations, perhaps with varying demeanors that are sensitive and concerned with other persons, in one situation, or blunt and self-absorbed, in another situation.

The beat is self-perpetuating. The beat generates movements and the beat is in the movements. Movements of actual life come from the beat. Without movements of actual life, there are no actual objects and there is no basis for sensory objects or mental objects. Spatial distance is measured according to stepping on the beat. The beat is the source of rhythms of action and of appetites and impulses that lead to action. Sensations, objects, emotions, desires, drives and action: all come out of the beat embodied in repetitive muscular movements of actual life.

Please compare the foregoing construction with Nietzsche's construction of will to power and Plato's construction of Ideas. Nietzsche's metaphysical construction is based on desires and drives and on the importance of desires and drives in our psychology; his construction makes a particular drive, "will to power," into the controlling concept. Platonic Ideas are similarly constructed, but based on invariant visual objects and on geometrical space. My construction resembles Nietzsche's and Plato's, only mine is based on muscular movements and on "the beat" that leads to models of muscular movements. Common methods of construction operate on subject matters of desires and drives in the first case, of visual objects in the second case and of muscular movements herein.

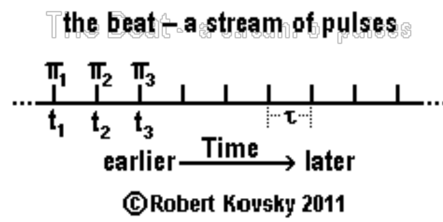
One change from the Nietzsche/Plato style is that primal components in my construction – muscular movements – do not assert control over other functions of the personality, such as functions that generate a drive for power or an Idea of Justice. Nietzsche declared the hegemony of will to power based on drives and Plato declared the hegemony of impersonal invariants called Ideas based on visual space. In my constructions, there is no hegemony. Rather, a drive for power and an Idea of Justice ***compete*** for control of muscular movements, e.g., the muscular movements of a Judge writing a Decision and Decree in a case being litigated.

Returning to the primal beat, repetitive movements alternate with periods of ***silence*** or with ***rests***. Recall Boman's "rhythmic alternation" discussed above. A spatialization of time, laying time out on a line, makes the period of intervening rest as clear as the period of movement. Music notation includes rests that have exact relationships with the beat, e.g., half measure rests, quarter rests. Viewed with the instrument of spatialized time, movement and rest can have equal status and neither movement nor rest exists without the other. Alternations of movement and rest make up the structure of a beat.

As a chief specification, a beat has a ***tempo***. The tempo is based on a uniform period between pulses in the beat and is described as a certain number of beats per minute ("bpm" in musical parlance). The tempo of a controlling beat must be uniform so that other movements can follow it. Uniformity is a variable concept: a strict and fixed uniformity amounts to metronomic or mechanical identity; or uniformity may be fluid and variable, *rubato* for musicians. Recordings of Ravel's *Bolero* display some possibilities.

I suggest that such tempi are part of actual life. I suggest that each of us can become aware of the tempo of actual life and can sometimes exercise control over that tempo. To slow down the tempo of actual life, I may say: "I need to think this over." To speed up the tempo, I may say: "Let's get this show on the road."

In the adjacent Figure, "the primal beat" is a stream of pulses. The Figure shows a spatialized passage of time and events that occur during that passage. As noted above, time has an "arrow." Here, time's arrow flies from earlier to later. The beat occurs while time is passing or flying.



As shown in the Figure, the primal beat is made up of ***action pulses***. Each action pulse – π_j – occurs at a distinct instant t_j. A smaller number in the index (j) refers to an earlier time. There is uniform period – τ – between pulses.

An action pulse is a movement of "energy." In the Quad Net Model, movements of Virtual Energy involve packets that have variable durations, sizes and shapes. In timing device models, there is only one kind of action pulse with a single uniform size and shape. In this essay, constructions are chiefly based on action pulses (used in timing devices) because of their simplicity. Action pulses in timing devices and Virtual Energy packets in Quad Nets are models of "action potentials" that appear in brain signals.

Movements of energy are presumed to be "instantaneous" in idealized timing device designs. That is, in such designs, a movement of energy occurs in an ***instant***. An instant is a period of time that is much shorter than all other time periods that affect operations of the system. An instant is a period of time so short that doubling it would not affect operations. In practical terms, electrical signals are as the same as instantaneous.

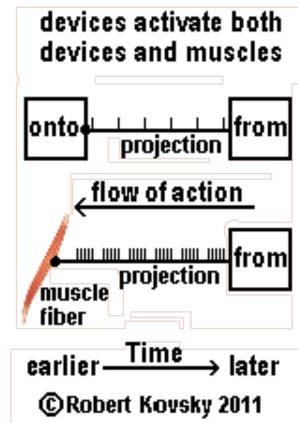
The slower movements of biological signals could be modeled by means of delay devices in timing device designs. Slow biological responses are significant because brains operate on delayed sensory signals and must anticipate future action and send signals for movements that will fit the situation on arrival. A pianist's finger movements for the next measure start while the sounds from the prior measure are still being heard. A Neck for Upright Standing is planned that will operate by jerking neck muscles in an anticipatory way. As discussed below, jerky, jumpy or "saccadic" movements occur in ways that are beyond limitations of platonic science.

In device constructions, parts are hooked together. As shown in hookups in the Figure below, movements of energy occur when action pulses travel from a timing device to a timing device or travel from a timing device to a ***muscle fiber device***. In the Figure below, the "flow of action" is from right to left to adapt to the form of spatialized time. Hookups involving timing devices are discussed in other publications; here the focus is on models of muscle.

Timing devices and muscle fibers are connected by ***projections***; each projection is a connection ***from*** a timing device ***onto*** another timing device or onto a muscle fiber device. The projection is part of the "from" device and carries pulses generated by the from device. The projection is connected to an onto device or to a muscle fiber device through a ***junction***; junctions are denoted by dots in the Figure. A projection models the axon of a biological neuron and a junction models a synapse between such an axon and a receptive part of another cell.

Of importance, and as shown in the adjacent Figure, movements of energy can occur in the form of ***pulse bundles*** that travel from a timing device to a muscle fiber device — the muscle fiber device responds to pulse bundles by ***twitching***.

Twitches of muscle fibers are primal activity in my models of actual life. Each twitch is a contraction of a muscle fiber that can perform physical work. A muscle fiber maintains a twitch for a certain duration of time and then relaxes. In between twitches, the muscle fiber restores its energy reserves.

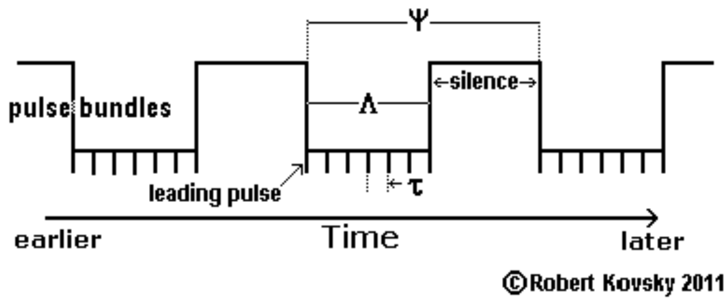


The "muscle fiber" in my constructions models a "myofiber," the smallest unit of animal muscle. In constructions shown below, muscle fibers are organized in "muscle modules" that function like animal muscles.

As part of development, the single action pulses of the primal beat become ***pulse bundles***. A pulse bundle is a particular form of organization of a stream of pulses. In the pulsestream, each bundle is "the same" and consists of a sequence of pulses. The first pulse in the sequence is called the ***leading pulse***. The leading pulse signals the arrival of the beat and initiates a twitch.

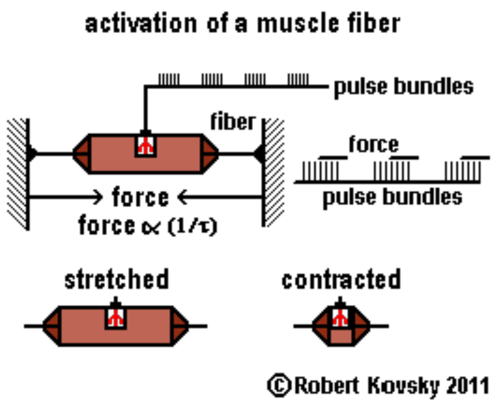
An idealized signal shown in the Figure below is made up of bundles of action pulses that are defined by three quantities, namely, ψ, Λ and τ. The ***organizational period*** ψ sets the rate of twitching. The ***durational period*** Λ controls how long a twitch lasts. The ***signal period*** τ controls the force of a twitch. In a pulsestream of ideal pulse bundles, all three quantities are fixed and Λ/τ is an integer. The number of pulses in an ideal bundle is $(\Lambda/\tau) +1$. Even for non-ideal bundles where Λ/τ is not an integer, there is always at least one pulse in the bundle — the leading pulse that identifies the beat.

ideal pulse bundles that can drive repetitive muscle twitches



In a rudimentary way, a bundle of action pulses resembles a "burst" of action potentials like that observed during operations of biological brains. [New ***bursting devices*** planned for *Feelings, Forms and Freedom* produce signals that more closely approximate biological bursts.] In present and proposed models, each bundle or burst drives one twitch of a muscle fiber (constructional), resembling the twitch of a myofiber (biological). Twitching is organized by an invariance principle: repetitive uniform pulse bundles are projected onto a muscle fiber that repetitively and uniformly twitches at the same rate. In connecting to and describing actual life, this means that a muscle is warmed up but not tired. It is the sort of muscular activity of an athlete in training, a data-entry clerk or an assembly-line worker.

The activity of a single muscle fiber being activated by a repetitive beat is shown in the Figure below. The period of twitching is ψ, the period of the beat. There is a delay between the arrival of a leading pulse in a pulse bundle and the start of a twitch. The delay is a specification of the device like the number of ohms is a specification of a resistance. In the Figure, the fixed delay between arrival of a leading pulse and the start of a twitch is equal to 2½ pulse periods (sufficient time for the muscle fiber device to determine and set the force). Similarly, there is fixed relationship between the duration of a pulse bundle, Λ, and the duration of the resulting twitch. In the Figure, the duration of a twitch is arbitrarily set equal to the durational period Λ shortened by one pulse period.



Activation of the muscle fiber causes it to produce a contractile force. An unattached fiber becomes shorter. When pulsing ceases or diminishes, the fiber relaxes and stretches out. The initial design is based on activity where actual contraction is prevented; that is, the ends of the fiber are attached to immovable walls. In this situation, the force $\mathcal{F}$ generated by a twitch is $\mathcal{F} = \mathcal{k}/\tau$, where device specification $\mathcal{k}$ is a coefficient that is the same for all τ within a specified range of τ values.

In constructions herein, τ is fixed within each pulse bundle. (This constraint is required by limits of imagination. Actual devices could produce more variable signals; and actual muscle-like devices could be defined that respond differently to pulse patterns with variable τ.) We can, therefore, use a frequency φ such that $\varphi = 1/\tau$ or $\mathcal{F} = \mathcal{k} \times \varphi$. In words: force increases linearly with the τ frequency in ideal pulse bundles, if the fiber is prevented from contracting.

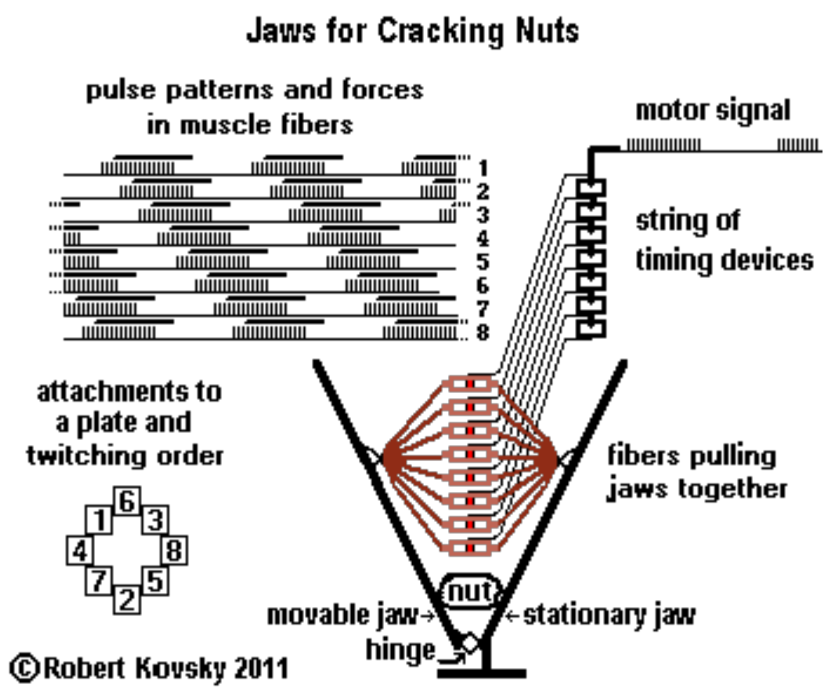
Suppose the fiber is allowed to contract. The question is whether a contracting or contracted fiber generates a force that is different from that of the attached and stretched fiber. To start off, the rule is that there is no difference. A twitching fiber generates the same force whether it is stretched and attached, whether it is contracting or whether it is contracted. Modified rules will be introduced below as part of the construction of A Dogtail for Wagging.

The Figure below shows "Jaws for Cracking Nuts," a timing device design. In the Figure, a nut is compressed between a stationary jaw and a movable jaw. The jaws apply a force that depends on the motor signal, which is a stream of pulse bundles. The string of timing devices distributes the motor signal in ***waves*** to the individual muscle fibers. Each timing device in the string (except for the last such device) drives one muscle fiber and also triggers the next timing device. Adjustable motor signals and adjustable delays within the string control the activity.

Each muscle fiber rhythmically contracts and relaxes. The goals of the design are to convert such rhythmic activity of muscle fibers into steady forces produced by the jaws and then to control the forces. The goals are achieved, in an approximate way, by symmetrical attachments of muscle fibers to the jaws at ***plates***, which crudely model the insertion of a tendon into a bone.

(Compare to P. Lui, *et. al.,* Biology and augmentation of tendon-bone insertion repair (2010) http://www.josr-online.com/content/5/1/59.)

Numbered attachments to the plate refer to the sequential order of fiber activation. Timings are adjusted so that 1 follows 8 like 4 follows 3. During operations, three or more sequentially numbered attachments pull together at any instant; pulls are all equal and the sequence continually shifts around the plate in a step-wise fashion. I suggest that forces pulling the jaws together will be steady, more or less.



In sum, Jaws for Cracking Nuts should achieve design goals of converting twitches of muscle fibers into steady and controllable muscular forces. The design operates with a signal that carries a steady repetitive beat in the motor signal made up of bundles of action pulses delivered to a bundle of muscle fibers. The beat is a temporal form that controls pulls of the jaws.

Pulling of the jaws may take on a temporal form of steadiness or invariance but any such steadiness or invariance is a specific condition achieved through a specific kind of operation. Such steadiness or invariance is not an inherent basis of all operations. I suggest that these comments can be generalized to a larger scale of operations where larger kinds of steadiness and invariance are sought to be achieved.

A sub-system like the Jaws can maintain a fixed or steadying force while other sub-systems are actively moving. Co-existence and coordination of steady parts and moving parts is a general design goal. In actual life, steadying forces are exerted by fingers holding a nearly-full coffee cup while the rest of the body is moving from one room to another. Some animals transport eggs in their mouths, a delicate task requiring jaws that remain steady while other parts of the body are moving. Such steadiness is an adaptation of muscular activity to invariants, namely, the actual object being held and the direction of gravitational force. In proposed device designs, e.g., A Neck for Standing Upright, steadiness is an achieved performance rather than pre-existing in the static nature of some pervasive metaphysical "being." An organism that can stand upright and hold one object steady with certain muscles while moving other objects with other muscles can attempt to control other bodies in its environment. Such capacities are important in actual life.

c. “A Dogtail for Wagging” is a timing device design for production of classes of muscle-like movements, including positioning movements, kicking movements and wagging movements controlled by a beat.

Muscle-like movements are goals of constructions – yet, the foregoing design of Jaws for Cracking Nuts does not involve movement. Although the forces on the nut can be varied, there is no suggestion that the forces move anything. Movement would occur if a nut were to be cracked. In such an event, forces between jaws must be suddenly reduced so that, after collapse of a nut, the jaws do not damage each other. Advanced designs would use saccadic or jumpy control to prevent such damage: a sudden drop in pressure sensed at the jaws causes a sudden reduction in the size of pulse bundles to jaw muscle fibers.

An Eye for Sharp Contrast, discussed above and on the website, does involve muscle-like movements. Each ψ cycle, the force produced by muscle fibers squeezing the optical Lens becomes either stronger or weaker, through an incremental step. As a result, the Lens changes shape and gets either one step stronger or one step weaker in its focusing power. Step-wise changes in muscle-like forces adjust the focus of the Eye so as to find the sharpest possible image of an external object. Such cyclical stepping resembles a quasi-static process in thermodynamics. It is slow and limited in range and resolution.

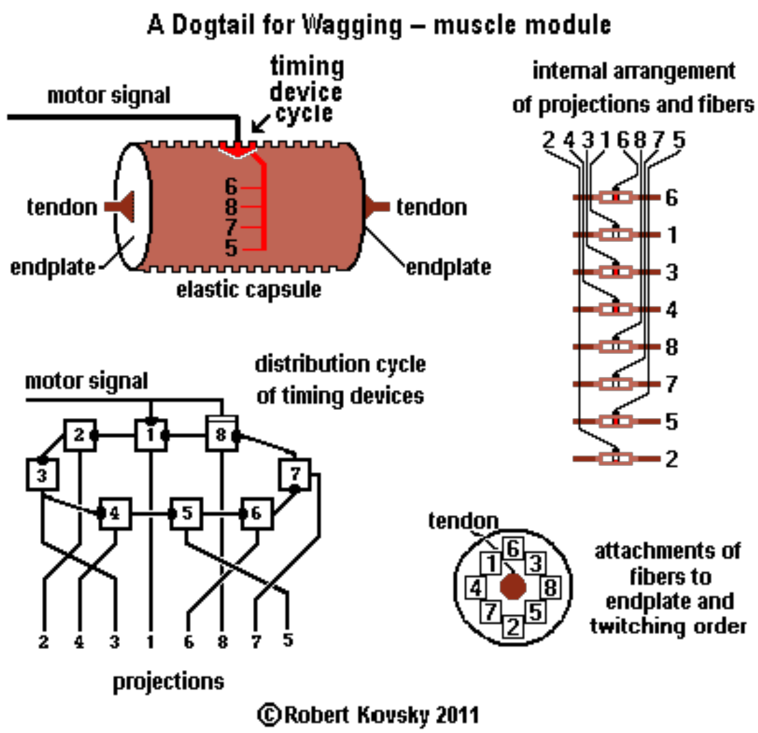
A Dogtail for Wagging, proposed herein, is a timing device design for production of multiple classes of muscle-like movements, namely, quasi-static or positioning movements, continuous movements (wagging) and jumpy or saccadic movements. The construction path goes through stages. The initial design can maintain static positions but is not suitable for movements or for performance of work. Development leads to a Dogtail design that also produces wagging movements and kicking movements but that does not perform significant work.

Further analysis shows that the structure of classical mechanics can be made congruent with positioning movements but not with other classes of movements. The structure of classical mechanics disregards systems that incorporate energy dissipation and/or “non-holonomic constraints.” The shortfalls would be even more significant for a device design that performs actual work, e.g., A Fishtail for Propulsion. Overall, the constructions show how forms of physics fail to describe or control muscular movements of organisms that have actual life.

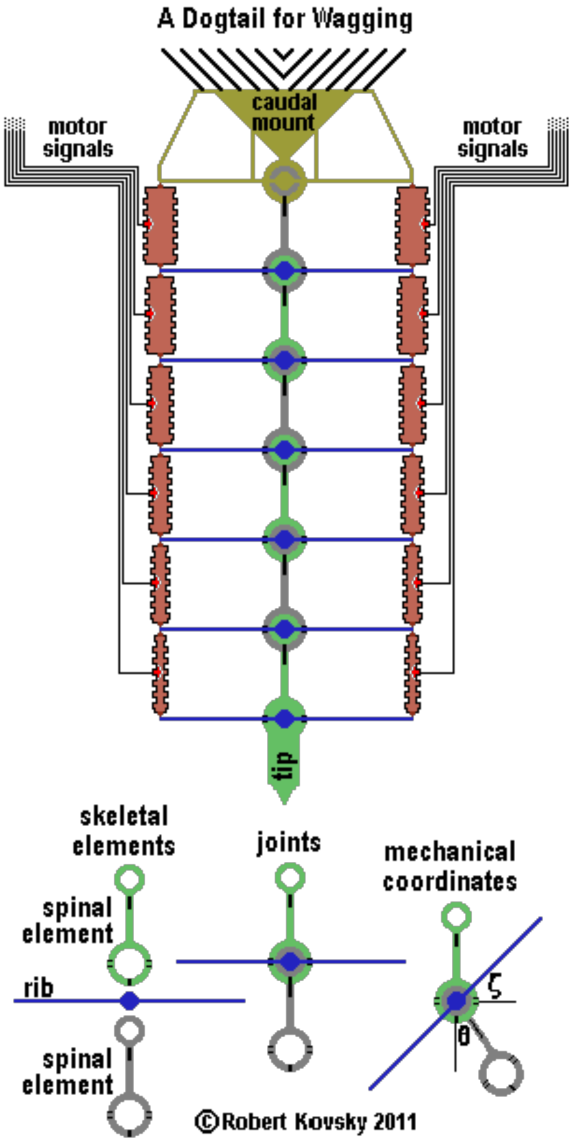
The Figure on the next page shows a muscle module for the Dogtail design. The module is developed from the design of muscle fibers in Jaws for Cracking Nuts along with some major modifications.

The eight muscle fibers that pull the Jaws are enclosed within an ***elastic capsule***, with an internal arrangement that substitutes for the plate in the jaws design. The encapsulated unit becomes a freestanding ***module*** connected by ***tendons*** to other components. Also, the distributive hookup of timing devices is closed into a ***cycle*** within which a pulse bundle circulates, repetitively activating fibers inside the capsule. (For actual operations, the number of timing devices in the cycle must exceed ψ/τ; interstitial devices can be used but are omitted in the Figure.)

The cycle of timing devices is incorporated as part of the muscle module capsule, a feature that contrasts with biological organisms, where neurons and muscles are separated. Simpler images are the immediate benefit. I suggest that, in biology, similar functions are performed by neurons located in spinal vertebra, close to muscles and distant from brains. During device operations, a new pulse bundle carried on the motor signal line interrupts and replaces a pulse bundle circulating within the timing device cycle. The "gate normally open" timing device at position 8 in the cycle performs interruptions.



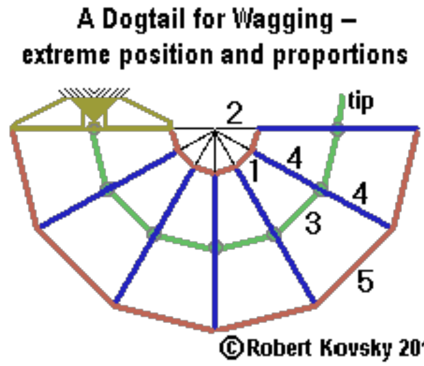
In sum, when no motor signal is being delivered, the muscle module produces a muscle-like force that is approximately steady. In addition, changing motor signals can produce changes in muscle-like forces. In the idealized design, the force produced by the muscle module follows the input motor signal in math-like ways that are predictable in timing and intensity and that do not depend on the order of changes. In such a design, muscular force can be changed in incremental steps, in a continuous ramping way or in jumps, according to signals selected by the operator.



The design of A Dogtail for Wagging is shown in the adjacent Figure. Twelve muscle modules are attached in opposing pairs to a skeleton that has seven joint units. Each muscle module is controlled by a motor signal carried on a line from a timing device. The Dogtail is affixed to an immovable ***caudal mount*** at the first or caudal joint. The ***tip*** at the opposite or distal end is free-ranging.

The Figure also shows rigid skeletal elements: ***spinal elements*** and ***ribs***. Two spinal elements and a rib element make up a joint unit that has two joints. Within a joint unit, the smaller circular end of a spinal element (the gray spinal element in the lower Figure) denotes a thin cylindrical wall standing perpendicular to the page, with ball bearing races on both sides of the wall, each race facing a matching race in another element with a matching wall. Each joint unit has two separate joints that operate through ball bearings and that move independently. The two joints have two mechanical coordinates, θ and ζ, which track angular positions from joint to joint. (The design moves in two dimensions; the system needs three dimensions.)

Movements of the Dogtail take place within a ***range of motion***. An extreme position marks the limit of the Dogtail's range of motion, as shown in a simplified form in the Figure below. A mirror image would mark the limit of the range of motion on the other side.



Each pie-piece segment in the adjacent Figure includes legs in three concentric regular dodecagons (12-sided polygons), or halves thereof.

Sizes of components are based on numbers next to elements in the adjacent Figure. Each spinal element has a length of 3 units. Each rib has a length of 8 units, 4 units on each side. The length of a fully contracted muscle module is 1 unit; the length of a fully stretched muscle module is 5 units. The number 2 refers to a line segment that is part of three similar triangles.

Each mechanical coordinate θ ranges from –30° to +30°; each mechanical coordinate ζ ranges from –15° to +15°. A statement of 6 θ's and 6 ζ's specifies the position of the Dogtail within its range of motion. Values of 12 muscle lengths can be derived from a statement of values of 12 mechanical coordinates and vice versa.

Define ***centerpoint*** activity of the Dogtail as symmetrical, vertical positioning of the skeleton, as shown in the preceding page. Such centerpoint activity is maintained by symmetrical pulse bundles cycling in muscle modules. Nothing moves during centerpoint activity; it is like zero in arithmetic. Centerpoint activity is maintained by symmetrical motor streams of pulses that can vary from low volume to high volume. When pulse streams have a low volume, centerpoint positioning is "loose" in contrast to "taut" positioning at a high volumes. Determinations of "loose" or "taut" would be based on responses to external test forces.

Now suppose we introduce movement away from the centerpoint by increasing the duration Λ of right side bundles in the motor signals so as to cause the number of pulses in right side bundles to increase by one, leading to an increase in contractile right side forces. Left side bundles are not changed. The Dogtail bends towards the right. As set forth above in the definition of muscle fiber, the force generated by a muscle fiber is independent of the length of the fiber. Hence, all forces remain at constant values as the Dogtail moves. Therefore, the movement will continue until the Dogtail reaches the limit of its range of motion.

Such operations are not useful. Any change in signals initiates ongoing movement that runs to the end of the range. It might be possible to control movements by applying little jerks, pausing between jerks by returning to symmetrical signals – but such little, jerky movements would not resemble large movements of actual life.

We thus return to the question of force versus length of muscle fibers noted above. I suggest two different ways to modify the force produced by a muscle module according to its length and to thus make useful operations possible. One way uses "elastic modeling," which fits forms of platonic science. The other way uses "dissipation modeling." A comparison between the two models shows that dissipation modeling is more like what happens in actual life. Models can also combine elastic modeling and dissipation modeling.

Start both models with the force relation introduced above in connection with activation of a muscle fiber, namely, $\mathscr{F} = \mathscr{k}/\tau$ or $\mathscr{F} = \mathscr{k} \times \varphi$ for ideal pulse bundles with fixed ψ, τ and Λ. Principles of symmetry support generalization of the force relation so that it also applies to a steady force produced by a muscle module; let $F=k\varphi$ represent such a steady force. The frequency φ is the same in the two force relations but the force generated by a muscle fiber ($\mathscr{F}$) is different from the force generated by a muscle module (F). $\mathscr{F}$ is twitching while F is steady, although the steadiness of F is approximate and may depend on operations. The coefficients are also different.

Let L denote the length of the elastic capsule, a variable quantity that depends on the motor signal. Let L_0 be the minimal length, 1 unit in the above design. Similarly, let L_1 be the maximal length, 5 units in the design.

For elastic modeling, modify the force relation for the muscle module to become:
$F = k\varphi + \hat{j}(L - L_0)$ where $\hat{j}$ is a linear coefficient with dimensions mass/sec^2.

In elastic modeling, the elastic capsule adds an elastic contractile force to the contractile force produced by pulse bundles. The elastic contractile force becomes greater when the muscle module is stretched, following Hooke's Law for an elastic spring. In other words, a stretched elastic capsule pulls endplates together with a force that depends on the extent of the stretch. Using a physics description, such a muscle module produces two parallel forces, one force like that from a rubber band plus an adjustable force that is controlled by motor signals.

Elastic modeling appears to partially resolve the problem noted above in the original model. Suppose the Dogtail is in a vertical position with symmetrical pulse bundles cycling in opposing muscle modules on right and left sides. Now, as before, suppose that changes are made in right side motor signals that cause a slight increase in right side forces. The Dogtail bends towards the right. As it bends towards the right, right-side muscle modules contract, reducing their lengths, and left-side muscle modules stretch, increasing their lengths. Using the new force relation, and as a result of changing positions, right-side modules generate lesser forces and left-side modules generate greater forces. As movement goes forward, the additional forces balance the change in forces resulting from the change in τ and the net force shrinks to zero. If things are done slowly and properly managed, the Dogtail eases into a new steady position. It would appear that the Dogtail can be put into a large class of positions that includes the two extreme limit-point positions and a class of diverse shapes between the two extreme positions.

Formally, a system of equations connects each specific position defined in terms of a set of lengths of muscle modules (or, equivalently, a set of θ's and ζ's) with a set of cycling bundles, or, equivalently, motor signals. Fix the motor signals and get a specific position. Adjustment of motor signals results in adjustment of position.

Dissipation modeling is more abstract. Instead of an elastic force added when the fiber is stretched, thus increasing the force strength of a stretched fiber, dissipation modeling imposes a reduction of strength of a contracted fiber. Strength or energy is simply wasted or dissipated. In other symbols, $F = k\varphi - j(L_1 - L)$. In brief, a contracted fiber is weaker than a stretched fiber.

Reiterate the previous procedure to investigate dissipation modeling. Suppose that the Dogtail is engaged in centerpoint activity and then changes occur in motor signals which increase contractile forces on the right side. The Dogtail bends to the right. As it does so, contracting right-side modules lose strength and stretching left-side modules gain strength. These changes reduce the forces that cause movement. When force changes resulting from greater dissipation are equal to force changes resulting from motor signals, movement of the system ceases.

Obviously, a single mathematical form of force relation is common to the two models. It is a linear relation for F with two variables, the same φ and a length difference that is similar in the two models. There are, however, significant differences between the two models. In considering actual activity of the models, storage of energy in the elastic capsule presents operational problems that are reflected in a phrase in the elastic model description above: "If things are done slowly and properly managed…" Implicitly, if things are done quickly and are not properly managed, movements of a Dogtail will be influenced by conserved elastic energy, e.g., "whipping" back and forth and/or "quivering" around a fixed position.

For elastic modeling to work to balance opposing muscle modules, the difference between elastic forces generated by the opposing capsules must be sufficient to balance the force difference produced by maximal and minimal flows of pulse bundles to the opposing muscle modules. Elastic forces are produced by stored energy. A large force difference requires large amounts of energy storage. Energy storage is like that found in elastic springs. If motor signals should suddenly decline on both sides, stored energy might "spring" into action and start quivering. An elastic system will contain large quantities of stored energy that can interfere with operations.

The dissipation model does not present such a problem. The only "conservative" operations in dissipation modeling occur when a muscle fiber is fully stretched and dissipation is close to zero. It is impossible for both opposing muscle modules to be fully stretched. Hence, energy is always being dissipated. With fixed motor signals, a Dogtail based on the dissipation model should "settle down" or relax into a fixed position.

Dissipation designs turn on wastage of energy rather than on storage of energy. Storage of energy requires adherence to a conservation principle while wastage can be based on a variety of principles. In other words, dissipation designs offer greater scope for variation. E.g., it is possible to use a nonlinear dissipation form
$F = k\varphi - j'(L_1 - L)^2$ or even to combine elastic and dissipation modeling, e.g.,
$F = k\varphi + \hat{j}(L - L_0) - j'(L_1 - L)^2$.

For purposes here, I use linear dissipation modeling $F = k\varphi - j(L_1 - L)$. Like elastic modeling, the dissipation model establishes a set of relationships between fixed shapes of the Dogtail and fixed patterns of pulse bundles maintained in cycles in muscle modules. Each fixed pattern of cycling bundles establishes a specific fixed shape into which the Dogtail relaxes. Each fixed shape is defined by a set of θ's and ζ's or, alternatively, lengths of muscle modules.

The Dogtail is designed to produce three classes of movements: (1) positioning movements, (2) wagging movements and (3) kicking movements. These resemble three classes of muscular movements produced by college athletes: "(1) slow tension movements, (2) rapid tension movements, and (3) rapid ballistic movements." (Cooper *et. al.*, *Kinesiology*, 113.) The following construction connects proposed movements of the Dogtail to sports movements of actual life.

Positioning movements are the easiest because they are based on fixed shapes. Each fixed position is associated with a class of sets of cycling pulse bundles. As in the case of centerpoint activity discussed above, many different cycling pulse bundle patterns can maintain a single particular fixed position.

Suppose the Dogtail is in a specific position maintained by a particular pattern of cycling pulse bundles, e.g., in centerpoint position. Suppose we want the Dogtail to move by positioning movements to a new fixed shape. The new shape will be maintained by any of a new class of sets of cycling pulse bundles. It would appear to be possible to move the Dogtail towards the desired shape through incremental changes in motor signals, with a trajectory of motor signal changes that is aimed at arriving at a pattern in the desired end-class of cycling pulse bundles that will maintain the desired shape. The size of each incremental change is small enough so that each movement is small, predictable and controllable. Summing up, positioning movements are predictable and controllable incremental changes in shape resulting from incremental changes in step-wise patterns of cycling pulse bundles.

Positioning movements can be described using terms similar to those used by kinesiologists to describe certain sports movements:

"**Slow tension movements**. Slow movements of body parts … is indicated by moderate to strong cocontraction of antagonists [opposing muscles]. The cocontraction serves to fix the joints involved in the action and to aid in accurate positioning of the body part…In the slow, controlled forms of movement, the antagonistic muscles are continuously contracted against each other, giving rise to tension. Tremors occur when antagonistic muscles are in contraction and balanced against each other in fixation.

"Voluntary movement has been observed by Travis and Hunter to be a continuation of a tremor without interruption of the tremor rhythm. The elementary unit of a slow, controlled movement is the *tremor*. If a short movement is attempted, its amplitude is determined by that of the tremor. Ability to make movements more and more minute is limited not by sensory methods of control but by the fundamental tremor element…

"Slow, controlled movements result from a slight increase in the algebraic sum of the number of the muscle fibers contracting the positive muscle as against the number of fibers contracting in the antagonist muscle group. The limb moves in the direction of the group exerting the stronger pull, and tension of the two groups of antagonistic muscles is continually readjusted." (*Id*., 113, emphasis in original.)

In the kinesiologists' description of slow tension movements, there is a sequence of short movements from position to position, movements that are called "tremors," and the cumulative result is "slow, controlled movement." The tremors occur rhythmically and appear to have a more or less definite amplitude. The description is congruent with positioning movements of the Dogtail where patterns of pulse bundles in motor signals are periodically and incrementally changed.

The second class of movements of the Dogtail is conceived as the polar opposite of positioning movements, namely, kicking movements. Kicking movements incorporate the most sudden and forceful action that the system can produce.

An extreme kicking movement starts with the end-of-range position shown above. The end-of-range position is maintained by the most highly activated pulse bundles cycling in the contracted side and a very low level of activation in the stretched side. There is a large amount of dissipation or wastage on the highly activated and contracted side and very little dissipation on the stretched side.

Now, as quickly as possible, reverse the character of the cycling pulse bundles by introducing new motor signals so that the most highly activated signal is delivered to the stretched side while the lowest level signal goes to the contracted side. Suppose that muscle fibers in a module respond so quickly to such reversals that changes in forces are completed within a single cycle of operations, even before substantial actual movement, which takes some time to start. Because the highly activated signal is going into a stretched muscle module, there is little dissipation and the produced force is higher than the highest force possible on the contracted side. Meanwhile, the lowest level signal going into the contracted side is reduced even further by high dissipation and produces scant opposition to sudden forces produced on the other side. The result should be a kick-like movement:

"**Rapid ballistic movements**. A ballistic movement, begun by a rapid initial contraction of the prime movers, proceeds relatively unhindered by antagonistic contraction… In comparison with the activity of the prime movers, the tension in the antagonists is slight during the ballistic type of movement." (113)

The third class of Dogtail movements, wagging movements, is a distinct class. In contrast to both positioning movements and kicking movements, wagging has no moment of rest; and moving body parts are always carrying momentum. Detailed consideration of momentum would require defining masses of body parts. Such detailed considerations are not practical for purposes here; but I suggest that the Dogtail design could produce a class of controllable wagging movements.

It appears that wagging fits into Cooper et. al.'s third class of movements (113): "**Rapid tension movements.** A movement in which tension is present in all the opposing muscle groups throughout the motion may be considered a movement of translation superimposed on fixation."

I suggest that a "movement of translation superimposed on fixation" starts the wagging movement and imparts momentum to body parts. Cooper et. al. also consider the termination of movements. In the ballistic movement of a golf swing, "movement is terminated by co-contraction of the opposing muscles and the loss of momentum. If the movement is arrested by a strong contraction of the antagonistic group and as a result moves in the opposite direction, the movement is said to be *oscillatory*." (*Id*., 113-114, emphasis in original.) I suggest that wagging movement is maintained as an oscillatory movement.

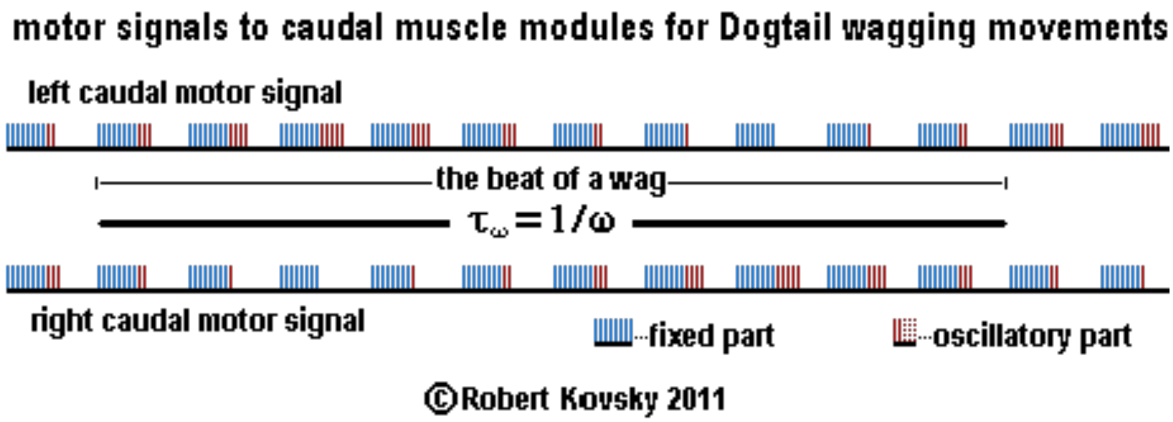
The kinesiologists' description of sports movements suggests a path for construction of wagging movements of the Dogtail. Begin with centerpoint fixation that is maintained by symmetric opposing patterns of pulse bundles that drive muscle modules. Then, superimpose on such fixation a movement of translation. The movement of translation is an ***asymmetry***. One side of the Dogtail is pulled by stronger contractile forces than the other side and the system bends to that side. Asymmetric translation starts the movement.

To maintain such movement in the Dogtail, cyclical adjustments in patterns of pulse bundles produce an oscillation. A wagging movement starts in the lowest or caudal joint of the Dogtail by a sustained pull to one side. For purposes here, the focus is on the first or caudal joint as the prime mover. Signals to later, more distal joints are adjusted for smooth operations after caudal movements are performed. (Sometimes, a dog wags only the caudal joint and holds the rest of the tail stiff.)

Now suppose that muscle modules actually set the Dogtail into movement. It's not just standing in a relaxed position (after a positioning movement) or standing in a tense position (getting ready for a kick). It is actually moving.

Movements are caused by contracting modules on the "agonist" side. As the Dogtail moves, muscle modules on the "antagonistic" side are stretched and resistive forces grow stronger. As the cycle continues and pulse bundle patterns on the antagonistic side become stronger, their increasing strength not only slows down movement, but goes on to reverse momentum. After reversal proceeds and the Dogtail is moving in the new direction, the asymmetry in the motor signals switches again and mirror image activity takes place. Soon it is time for another reversal. If a Dogtail has many joints, distal parts far from the caudal joint may still be moving to the right while the caudal joint has begun moving to the left. The character of such a movement through the tail is wave-like. Such wave-like and oscillatory movements embody a beat with a tempo that is partially controllable.

The Figure below shows motor signals to caudal muscle modules that would maintain wagging. The frequency of the beat of constant wagging is denoted by ω; let $\tau_\omega = 1/\omega$ denote the period or beat of a wag.



In sum, the motor signal for Dogtail wagging is a repetitive cycle where the number of pulses in pulse bundles goes up and down in a smooth way. One component of the signal is constituted by symmetric pulse bundles that are constant and this component fixes the joints; and, superimposed on such fixation signal, there is an asymmetric oscillatory signal. The beat ω organizes the oscillatory pulse patterns.

d. Forms of platonic science do not connect to, control or describe kicking or wagging movements of A Dogtail for Wagging.

The Dogtail construction is a proposed mechanical system that can be investigated by mathematical methods of classical mechanics stated in Goldstein, *Classical Mechanics* (1950).

An important distinction in classical mechanics is that between ***statics*** and ***dynamics.*** Statics examines the arrangement of mechanical forces in a system where components are immobile, asking, e.g., whether a member in a roof truss can bear an expected stress. Dynamics investigates activities of systems with parts that are moving with respect to each other, "moving parts" in common parlance.

On one hand, dynamics is the more general approach and statics is a special case, so statics appears to be less powerful. But, on the other hand, static systems are easier to investigate and results based on static systems have forms that are conceptually and computationally convenient. Investigators asked: is it possible to employ the beneficial results obtained through statics investigations in investigations into dynamics? The answer is: yes, but only for a restricted class of cases. That restricted class of cases makes up the bulk and conceptual substance of modern physics. Activities of actual life, however, are not included within the restricted class of cases. My impression is that some physicists do not consider such restrictions when they declare the universal application of their science.

Classical mechanics posits a system with defined parts that move with respect to each other. The system is constructed in an imaginary domain governed by "Laws of Physics" that operate like rules in a game. Parts in such a system can consist of particles, rigid bodies or deformable bodies subject to force rules such as the force rule for muscle modules set forth above. Parts in such a system are subject both to forces applied from outside the system and also to forces from other parts of the system, called "forces of constraint." (Goldstein at p. 10.)

Goldstein's construction begins with a restriction that the system be at overall rest with respect to the observer. (5.) Next: "Suppose the system is in equilibrium, i.e., the total force of each particle vanishes…" (14.) That is, applied forces and forces of constraints sum to zero for each and every particle in the system and things have settled down. As in classical thermodynamics, the construction starts with equilibrium, a condition of overall rest. This is the first restriction on systems being considered.

The second restriction uses the concept of "virtual work" that would be performed if components in a static structure were allowed to move just a tiny bit under the influence of applied forces and forces of constraints. Goldstein distinguishes between virtual work performed in response to applied forces and virtual work performed in response to forces of constraint. "We now restrict ourselves to systems for which the *virtual work of the forces of constraint is zero*. We have seen that this condition holds for rigid bodies and it is valid for a large number of other constraints. … This is no longer true if frictional forces are present, and we must exclude such systems from our formulation. The restriction is not unduly hampering, since the friction is essentially a macroscopic phenomenon." (*Id*., 15, emphasis in original.)

With such restrictions in place, "we use a device first thought of by James Bernoulli, and developed by D'Alambert. …dynamics reduces to statics." (15.) The resulting formulation is called D'Alambert's principle. Unfortunately: "It is still not in a useful form to furnish equations of motion for the system. We must now transform the principle into an expression…" The transformation applies "for holonomic constraints," the third restriction. (16.)

The third restriction, holonomic constraints, requires that constraints fit into a certain form that "can be expressed as equations connecting the coordinates of the particles (and the time)." (11.) "An oft-quoted example of a nonholonomic constraint is that of an object rolling on a rough surface without slipping … the 'rolling' condition is not expressible as an equation between the coordinates...Rather, it is a condition on the *velocities* (i.e., the point of contact is stationary), a differential condition which can be given in an integrated form only *after* the problem is solved." (12-13, emphases in original.) "If non-holonomic constraints are present then special means must be taken to include these constraints in the equations of motion." (156.)

The foregoing restrictions lead to Lagrange's equations. (15-18.) Lagrange's equations connect spatial homogeneity to conservation of momentum; and, likewise, they connect spatial isotropy to angular momentum. The discussion in Goldstein is titled "Conservation theorems and symmetry properties." (47-49.) Lagrange's equations are also the basis for Hamilton's equations of motion. (215-218.) Hamilton's equations of motion, in turn, are the basis for statistical mechanics. (Gibbs 3-5.) In other words, applications of statistical mechanics are limited to a highly restricted class of systems.

Operations of the Dogtail can be analyzed with respect to the restricted class of systems investigated by classical mechanics and statistical mechanics. The class of positioning movements appears to come closest to movements that are within the scope of the restrictions. Each fixed position appears to be in equilibrium; equilibrium is clearly shown in the case of elastic modeling, which is formally equivalent to dissipation modeling. A suitable definition of virtual work could lead to zero virtual work performed by constraints, as required by the mechanics construction set forth in Goldstein.

It also appears to be possible to adapt the constraints in positioning movements to the holonomic form. Forces of constraint in the Dogtail — $F = k\varphi - j(L_1 - L)$ — depend on cycling pulse bundles and on lengths of muscle modules. Given specific values for the mechanical coordinates of a fixed Dogtail shape, the θ's and the ζ's, it is possible to calculate the lengths of muscle modules. For each fixed shape, that is for each set of mechanical coordinates and module lengths, there is a class of cycling pulse bundles that maintains the shape. A cycling pulse bundle is equivalent to a repeating motor signal. In other words, many different repeating motor signals will lead to a single fixed shape. However, each repeating motor signal will lead to only a single fixed shape and the total class of repeating motor signals appears to fall apart into disjoint sub-classes with each sub-class leading to a single fixed shape. Therefore, it appears that identification of the sub-class of repeating motor signals serves as the equivalent of identification of the forces of constraint. Classes of repeating motor signals and shapes thus serve as indices of each other and can be put into correspondences. The correspondences guide the movements.

Hence, the class of positioning movements appears to be within the scope of the classical mechanics construction.

However, the same process of reasoning shows that neither wagging movements nor kicking movements comes within the scope of the mechanics construction. That is, in sum and overall, the classical mechanics construction fails to describe the general class of movements of the Dogtail. In other words, the class of actual motor signals is much richer and more powerful than a formal class of signals that would be constructed from constant motor signals that put the Dogtail into fixed positions. Actual motor signals include those that wag and kick the Dogtail, along with other additional actual movements. Actual motor signals interact with momentum of Dogtail body parts in ways that are difficult to imagine.

The failures appear clearly when actual wagging operations are compared to Goldstein's restrictions. As for the first restriction, wagging movements are not based in equilibrium. On the contrary, at all times during wagging movements, parts of the Dogtail carry momentum; the momentum of each part is increasing or decreasing. Work is being done on and by the Dogtail; energy is being dissipated in varying amounts.

The second restriction requires that "the virtual work of the forces of constraint is zero." The forces of constraint are produced by the muscle modules. During wagging movements, muscle modules are actually working, moving inertial mass, working against each other and working against momentum. Such actual work is very different from zero. For example, it has a specific beat.

The third restriction is based on holonomic constraints. Holonomic constraints are stated in terms of positions and not in terms of velocities or other movement-based quantities. During steady wagging, the relationship between motor signals and wagging movements is not based on positions of anatomical elements but, rather, on timing intervals that define pulse bundles and the beat for wagging, ω. The researcher slowly changes ω to change wagging movements. In terms of system control, such motor signals are ***independent coordinates***. Motor signals are independent of the position or movement of the Dogtail and motor signals control steady wagging movements of the Dogtail.

Sudden changes in Dogtail wagging would be even more troublesome. Interactions between muscle spasms and moving body parts can be complex, even "turbulent," as shown by epileptic seizures. Spasmodic movements do not appear to be subject to the Goldstein analysis.

Suppose the Dogtail were to be developed into A Fishtail for Propulsion. The muscular design of a biological fishtail is entirely different from the design of the Dogtail. The reason is simple. A biological fishtail must perform a lot more work than the Dogtail performs or even than a biological dogtail performs.

Accordingly, a biological fishtail has a lot more muscle than would be possible with a dogtail design. Muscles in fishtails do not run between skeletal members as in the Dogtail; rather, muscles are attached to the skin and connect skin to vertebra. Fish muscles take the form of ***myomeres***, which come in zig-zag layers of solid blocs of muscle, structures that can be dissected at the dinner table. They hold some conserved (elastic) energy, which causes fishtails to flop.

Suppose A Fishtail for Propulsion were to be designed to fit such facts. Were such a Fishtail to be actually immersed in water, the mismatch of its activities with forms of classical mechanics would be even more pronounced than in the case of the Dogtail. Any actual movement of the Fishtail would require work to move water and such work would be greater than work exerted to move the Fishtail itself or work force wasted in dissipation. The chief design goal would be to move water efficiently. Constraints would depend on the physical properties of water, including turbulence. Turbulence, actual workloads and dissipations of operating fishtails are all outside the scope of platonic physics. In actual life, fish use their tails not only for steady swimming but also for kick-and-glide movements and braking and backing maneuvers. (Flammang & Lauder.)

Modern physicists are apparently satisfied with restrictions that exclude muscular movements of actual life from the scope of their investigations.

"The physicist today is primarily interested in atomic phenomena. On this scale all objects, both in and out of the system consist alike of molecules, atoms or smaller particles, exerting definite forces, and the notion of constraint becomes artificial and rarely appears. … constraints are always holonomic and fit smoothly into the framework of the theory." (Goldstein, 14.)

e. Classes of muscle-like movements of the Dogtail lead to more general classes of activations that generate and control temporal forms in new technologies. In episodic forms of balancing, symmetry is first established and maintained and then lost in one of multiple ways. Proposed Quad Net devices embody episodic forms of balancing in transformational processes of Shimmering Sensitivity.

Development proposed in this subsection is more far-ranging and speculative than in the Dogtail construction. Further development starts with the three classes of muscle-like Dogtail movements: (1) positioning movements, (2) wagging movements and (3) kicking movements.

Each class of Dogtail movements is associated with a distinct corresponding ***activation***:
(1) quasi-static activations, (2) continuous activations and (3) saccadic activations. Quasi-static activations produce positioning movements; continuous activations produce wagging movements; and saccadic activations produce kicking or jumpy movements.

There is a fourth level of activation, ***shimmering activations***. Saccadic activations generate jumpy signals while more highly developed shimmering activations generate jumpy signals with multiple choices. "Saccade" is a technical term for "jump." The word "saccadic" applies to jumpy movements of human eyes and saccadic activations are used to model certain eye movements. For example, a saccadic activation models the "vestibular-optical reflex" or VOR. The VOR causes eye jerks that compensate for jerks of the head and that thereby keep a person's gaze fixed on a certain object while the person is running. With a more highly developed shimmering activation, a person can look where he or she pleases, based on memories of images.

Different levels of activation denote different kinds of signals, with a higher activation denoting signals that change faster and have more variability. Conversely, as activation is lowered, signals and movements have stronger stability. All activations can generate motor signals that have high volumes of pulses For example, suppose that all muscle modules in the Dogtail operate at maximum forces produced by maximal motor signals. The results should be immobile centerpoint positioning. What is different between levels of activation is the kind of changes in signals. Signals change most slowly and within limited repertoires when activation is quasi-static and signals are continually and creatively churned when activation is shimmering.

Some devices operate with only one kind of activation. Other devices operate with multiple activations. Similarly, in human beings, different kinds of muscles have different capacities for movement. Muscular movements of peristalsis in the intestines have little variation while fingers and tongue operate with the highest variability and agility. Arm and hand muscles show a high degree of variability and can hold (quasi-static movement), stroke rhythmically or punch. Violinists can perform arm and hand movements with variable oscillations of vibrato and tremolo, resembling movements produced by device designs using a shimmering activation.

Suppose that a device system is subject to a ranging process that begins with a shimmering activation, making delicate selections on the basis of multiple influences. The process proceeds to convert or transform such selections into muscular movements that are performed with saccadic activations or continuous activations. During such a transformation, a movement that begins with variable placement and with a weak, tentative force becomes one that is fixed in placement and that is driven by a strong, steady force. I suggest that carpenters driving screws, cooks slicing vegetables and a singer reaching for a high note all employ something similar.

I suggest that a process that selects with purposeful but delicate sensitivity and that then converts or transforms the selection into strong muscular movements might be the central "actor" in a model of "free will."

Dogtail movements illustrate the different activations. Motor signals generated through quasi-static activations are steady or nearly so, based on repetitive pulse bundles in motor signals or repetitive bundles maintained by cycling within muscle modules. In quasi-static positioning, any motor signal change is incremental or tremor-like: a large change is made up of several small changes. Each small change comes to rest before the next small change starts. Separate and independent incremental changes in signals correspond directly to separate and independent incremental changes in shape.

Continuous activation generates motor signals that are always changing in a uniform way, as in wagging discussed above. A certain content is sustained while cycling changes are ongoing. Imagery suggests oscillations and waves. In simple constructions, movement is controlled by a beat. Dogtail wagging movements can vary from slow, low-amplitude movements to fast, high-amplitude movements.

Saccadic activation generates jumpy motor signals and produces jumpy movements. Such movements can have many different forms, e.g., the "cock and kick" form used by the Dogtail that has a "trigger" moment. Saccadic activations can generate transformations in more powerful ways than continuous transformations, like a martensite transformation in steel-making is more powerful than a pearlite transformation. In my approach, the concept of jumpy movements is used to collect fundamentally different or ***disparate*** kinds of activities and a broad concept is used. In other words, a large variety of phenomena can be described in terms of jumps: the collection turns into a grab-bag and a hodgepodge.

Ballistic sports movements such as kicking and throwing are saccadic, as previously discussed. Such movements have a "suddenness" or abrupt character, a dramatic focal moment of change modeled by a reversal of signals to opposing pairs of muscles. Hockey and basketball players are skilled in sudden reversals performed to frustrate the opponent's anticipations, sometimes executed by means of coordinated action on a team level, e.g., a "fast break."

Material objects of disparate sizes jump into a shopping cart at the supermarket. A trade of cash for goods at the checkout counter is modeled as a pair of jumpy changes in manual possession of two kinds of "things." Jumpy action includes moving between grades of manufactured products (Good, Better, Best). Similar non-material jumps occur between academic marks (A, B, C, D or F) or grade levels (3rd grade, 4th grade). In the United States, legal status changes in a jumpy way on a person's 18th birthday. Moving one's personal residence is jumpy or saccadic. Changes in employment or in close family membership are saccadic. Surprises are saccadic.

Suppose that we model a jump by means of a change in location combined with a change in time. When two jumps occur in close proximity in space or time, they are said to be ***juxtaposed***. Often, a second jump will start from where and when a first jump ends and the two juxtaposed jumps amount to a single jump: then the jumps are said to be ***composed***. A step down a staircase is followed by another step and so forth, amounting to one big step. Repeated jumps sum to one big jump. A connected sequence of jumps or steps can make up a ***course of action*** that can be imitated or that can be compared with other courses of action. Often, a course of action has a purpose or goal. This essay concludes with discussion of purposeful courses of action in actual life, namely, athletic contests and civil trials in courts. Jumps in athletics are simple and step by step; complex jumps in civil trials include motions, objections, jury verdicts and dismissals.

Under some circumstances where things are under control, the composition principle applies both to signals, e.g., motor signals, and to muscle-like activities. Suppose controlling motor signals first jump from a to b and then jump from b to c. This amounts to a jump from a to c. Design goals are for muscle-like activities produced by the motor signals to jump from A to B to C and for this course to amount to a jump from A to C.

The foregoing construction leads to activities that are represented by a ***mathematical group*** in both body and mind. In actual life, brains control muscular movements in group-like ways, e.g., in games like checkers and hopscotch. Group-like elements — e.g., numbers, cycles and ratios — are used to structure activities in a game like baseball, e.g., counting balls and strikes, circling the bases and comparing performances. The group-like character of musical tones in a scale or key is discussed in an online publication, "Ears for Harmonic Groups," originally published as "A Procrustean Group of Harmonies."

Jumps can be juxtaposed and composed in multiple ways. Organized saccadic movements of eyes jump within a range of motion (the field of view) and are said to be "mobile." Such movements of eyes form something like a mathematical group, although confined within limits. Jumpy movements are useful during exercises of freedom, while a person is considering multiple possibilities. As a practical matter, the person can look around and organize key features of the situation in his or her mind.

Jumpy performance is often riskier than continuous performance. Continuous performance is under continuous control but the performer loses control, at least in part, during jumpy performance. Some jumps end in landings that may not succeed. The concept of success/failure applies to jumpy action with more dramatic importance than with lower activations. Failure, when it occurs, is an interruption in the expectation of continuous performance; failure may be expected much of the time in some saccadic movements. If timings, directions and sizes of jumps are varied in a jumpy fashion, the resulting movements may be unpredictable and success or failure may turn into a matter of chance or luck.

Some saccadic movements, e.g., the cocking and kicking movement of the Dogtail, use a two-stage process. Activity in the first stage establishes and maintains a large difference in quasi-static activation between opposing body parts, which are held fixed and ready. Then the difference is quickly reversed to trigger or initiate sudden powerful action in the second stage. Such two-stage processes have a preparation or anticipation stage followed by an execution stage. Two-stage processes can take on a shimmering character, e.g., putting in golf or shooting baskets from the foul line. More highly developed four-stage processes handle situations that have continuous cycling, like a baseball player training his hitting skills with a pitching machine or a short-order cook. In device models, four-stage shimmering processes are used to carry out ***matching*** operations which perform logic-like switchings and selections.

[Two-stage and four-stage processes in Quad Net devices resemble those used in two-stroke and four-stroke internal combustion engines and in the math-like four-stroke Carnot cycle that models heat engines. Thermodynamics constructions that are based on Carnot cycles (see Truesdell & Bharatha) are different from those that are based on principles of mechanics. Energy is conserved in mechanical constructions while energy is always being dissipated in

Carnot cycles. The alternative view set forth herein is based on thermodynamics principles of dissipation and transformation instead of mechanical principles of conservation and invariance.]

The classes of Dogtail movements and activations have certain relations amongst themselves. Each class has a distinct definition but they share limit points and/or overlap each other. A tight fixed position can start to wiggle and wag with addition of a relatively small oscillatory motor signal. Alternating kick movements can be oscillatory if they start from and end in mirror-image fixed positions,. Positioning movements can be approximated by tiny little kicks.

Each level of activation generates distinct temporal forms of motor signal that produce distinct classes of muscle-like movements. Compare sitting and walking and jumping as representative of the three lower activations, especially if you imagine big jumps like a grasshopper. Activity controlled by shimmering activation is often based on pre-existing patterns that are held in memory, e.g., hitting a baseball with a bat, threading a needle, tuning a violin or performing a routine on a balancing beam in a gym. (The first three examples all involve ***focusing*** processes, which were investigated in An Eye for Sharp Contrast. ***Balancing processes*** incorporate both focusing processes and also ***following*** processes, which were investigated in *An Ear for Pythagorean Harmonics*. In balancing, the gravitational direction is maintained as a focus of action and a standard to follows.)

I suggest that the four classes of activations and movements (quasi-static, continuous, saccadic and shimmering) are parts of a larger repertoire of activations and movements which includes activations and movements that are additional to the specific classes previously discussed. ***Forms*** are within the larger repertoire and are used to control movements.

In specific constructions, ***balancing forms*** are used to control certain movements. Four kinds of balancing forms are: (1) ***static balancing forms*** that control positioning movements produced by static activation; (2) ***oscillatory balancing forms*** that control movements similar to wagging that are produced by continuous activation; (3) ***saccadic balancing forms*** that generate and control jumping and kicking movements that are produced by saccadic activation; and (4) ***shimmering balancing forms*** that are generated by shimmering activation and that are used to control or select from multiple possible movements.

The activity of swimming provides examples. For a person skilled in swimming, balancing in a watery environment is easy and the kind of balancing is easy to change. Static balancing can be maintained while floating on the back. While floating, limbs move only slightly and in a fashion that tends towards an immobile position. Then, a flutter kick with both feet adds an oscillatory balancing form that can be used to steer the body in different directions. Next, if the arms add a butterfly stroke, with sweeping motions in and out of the water, a saccadic character becomes predominant. Finally, suppose the person switches forms from butterfly to crawl and then to an underwater dive, employing the arts of shimmering activation.

Looking at specific activations, a biological parallel to the lowest or quasi-static level of activation occurs in the eye during focusing of the eye on an object. (See *An Eye for Sharp Contrast*.) Similarly, quasi-static muscular balancing maintains a momentarily fixed but adjustable opening in the pupil of the eye.

Oscillatory balancing is maintained by means of a cycling stream of actual movements that can be continually adjusted, e.g., during bicycling or stirring a pot of cooking food. In oscillatory balancing, the activity has a form where alternating and approximately equal movements on each side are subject to individual adjustments that maintain a symmetry through action.

Quasi-static and oscillatory balancing both incorporate continuity. Both approximate time-invariance; that is, activity from one period can be detached and superimposed, more or less, on activity of another period.

Saccadic balancing uses one jump to balance another jump. In contrast to static and oscillatory forms, both of which incorporate continuity and time-invariance, saccadic balancing can be abrupt, opportunistic and creative. Please recall discussion of the Hebrew word *regha*‘ in § 5.1.

Revenge or “getting even,” is a primal form of saccadic balancing. The *lex talionis*, “eye for eye, tooth for tooth” imposes symmetry on saccadic balancing to limit the violence and perhaps to interrupt the cycling back and forth. Saccadic balancing can occur in a single prescribed form or in multiple forms, e.g., through mediation and/or a lawsuit and/or vengeful acts.

Some saccadic forms of balancing are based on repeated abrupt reversals of action, e.g., in hockey, soccer or football, where first one side charges in one direction on the playing field and then the other side charges in the other direction. While charging, each side tries to balance and overbalance the charge of the other. Other forms of saccadic balancing occur in markets where money is balanced against goods and services. A downward jump in the buyer’s money supply is weighed against his calculated need or desire for the purchased goods or services. Diverse market transactions can be compared and balanced in terms of money. Adversarial and compensatory forms of saccadic balancing are combined when a jury awards a plaintiff money for pain and suffering, providing cash solace for an undeserved injury. The amount of the award will also depend on the personality and person of the defendant who caused the injury, e.g., attractive or obnoxious.

In the domain of brains, the vestibulo-ocular reflex or VOR observed in many animals is an example of saccadic balancing. If you gaze at a fixed object and jerk your neck muscles so as to jerk your head right or left (or up or down), your gaze will remain fixed on the object. This occurs even if you keep your eyes closed while you jerk your head. For example, if you close your eyes while gazing at the final word in this sentence, jerk your head and then open your eyes, your gaze will still be here. The VOR accomplishes this task by measuring the head jerk with sensory organs in the middle ear, the vestibular system, and generating signals that jerk the ocular muscles that control the gaze of the eye. The size and direction of eye muscle jerks compensate or balance for the head jerks so as to maintain the gaze fixed on the object. An invariance (the fixed gaze) is being maintained by balancing one kind of jump with another kind of jump. A gaze that stays fixed is very useful for a mobile wild animal. Maintenance of invariance is a development of previous discussions that started in Jaws for Cracking Nuts.

The VOR operates reflexively directly between head jerks and eye jerks: there is no need to interpret images or to calculate eye movements on the basis of images. Primary activity of the VOR operates when the eyes are closed or in the dark when there are no images. The VOR is foundational balancing activity that is based in muscular movements, not in images. I suggest that visual imagery stands on a mobile but balanced foundation of muscular activation.

The four kinds of activation thus lead to four kinds of control exemplified through balancing forms. Each kind of control uses distinct kinds of selection:

1. Static control — selections based on comparing sizes;
2. Continuous control — selections based on comparing rates;
3. Saccadic control — selections based on composing and comparing jumps;
4. Shimmering control — selections based on fitting to form.

I suggest that some control processes, especially saccadic processes and shimmering processes, generate ***imagery***, which identifies, indexes and encodes a person's experience, including experiences of sights, sounds, body movements and body positions. Such imagery may be recorded in ***memories***. My focus is on imagery that can be so remembered. ***Forms*** are a class of remembered images that are used in shimmering processes. Variable and adjustable forms lead to variable and adjustable muscular movements.

"Imagery" is my version of what others call "awareness" or "consciousness." Some questions about imagery are my versions of questions asked by others:

1. How do pulsating material bodies, whether in brains or in new device technologies, generate images that provides a basis for purposeful selections?

2. How do purposeful selections based on imagery lead to muscular movements in animals and persons; or, alternatively, to action-producing pulsations in devices?

3. How do purposeful selections based on imagery connect to a person's actual experience, e.g., to sights, sounds, bodily feelings and muscular movements?

4. What principles can help to develop constructions involving images for institutional use, e.g., in organizing materials for judicial management of lawsuits?

I propose answers to these questions. Some of my proposals are only sketches. An obvious shortcoming is that I lack actual operating devices that might demonstrate certain phenomena — or fail to demonstrate such phenomena as the facts should prove.

In my view, current questions of "consciousness" resemble those that led to the development of models of electromagnetism in the era of Hans Christian Ørsted (1777-1851), Michael Faraday (1791-1867) and James Clerk Maxwell (1831-1879). Ørsted moved magnetized needles by switching a nearby electrical circuit on and off, thus identifying phenomena that violated Newtonian mechanics and that first showed a connection between electrical currents and magnetic attractions and repulsions. (Popper & Eccles at 542.) Faraday invented electrical dynamos and motors (interconverting electrical, magnetic and mechanical energy) and imagined ***fields*** to model electrical and magnetic interactions. Maxwell imagined that a changing electrical field generated a changing magnetic field and that a changing magnetic field generated a changing electrical field: ***therefore***, let there be light, along with radio and TV broadcasts and Internet wireless. The metaphor is imperfect but suggestive for the questions stated above. What if streams of action pulses in devices and brains are like electrical currents and what if mental images are like magnetic attractions and repulsions? This would be a "dualistic" solution to the mind-body problem that has received but scant attention in the voluminous literature. (*Id*. at 182, n.3.)

In *Feelings, Forms and Freedom*, I suggest devices that generate images like the bodily feelings of a person and that produce muscle-like movements in coordination with the images, leading to production of movements according to forms held in memories. The path begins with a model for imagery of musical tones and harmonies as the simplest case. In musical instruments and physics labs, tuned and resonating devices go through repetitive movements that are suggestive of such imagery. Neuroscience suggests that tones are referable to a "mapping" in a brain. Different ways of moving between tones using musical instruments is suggestive of ways to move between locations in a brain map. I suggest similar models to locate pressure, itch and pain on maps of the body that are laid out in a brain. Feelings of hunger, thirst and sensations involved in other bodily functions can be projected onto appropriate places in such maps.

The first overlayer of development is directed at models of sensations of stretch in muscles. Coordination of stretches in different muscles to maintain a certain bodily position resembles coordination of different tones in music to maintain a chord. Models of both kinds of feelings use devices that generate ratios in the style of Pythagorean harmonics.

Development progresses towards larger organizations of images and wider repertoires of control. Different kinds of images must be accommodated. Further development would include multiple layers and specific models of bodily movements, purposeful acts or deeds and extensive courses of action.

I suggest that a person's imagery is not of a single kind nor is it based on a single set of principles. Rather, imagery is generated in disparate layers and with patches of different kinds. There are streams of imagery that may start and stop, that may remain steady or vary or that may be independent or coordinated. Images are blended under some circumstances and distinguished under other circumstances. Depending on situations, imagery may be or may not be subject to organization, to different and conflicting organizations and to re-organization. While a person may seek to unify or integrate his or her imagery — for ease of application, among other reasons, progress toward such integrity is an ongoing task that is imperfectly achieved.

I suggest that persons use imagery called "forms" to make selections, e.g., "stop on red, go on green." Such selections require a higher level of "awareness" than simply being alert, oriented and active. For example, a motorist waiting at a traffic light must consciously notice a change in the bright color in order to move his foot from the brake to the accelerator. If the motorist is not "paying attention," another driver may enlarge the range of his awareness by blowing a horn.

More generally, selection processes can be influenced in multiple, diverse ways. I suggest that, in memories, we have forms of selections we made in the past and that we use those forms to help make selections in the present. For example, I suggest that we use something like Shimmering Sensitivity to decide between forms of dinners, represented by words on a restaurant dinner menu. The first attempt to fit to form may be repetition or reconstruction of a memory. Such a repetition may succeed in the present situation. If not, maybe imagery can be modified by changing pieces according to other memories.

Development of models leads towards continuously cycling activities and saccadic moments of imagery flickering in multi-layered and patched neuronal mappings of body parts, tracking body positions and movements and also arising through body-imaged drives like sex and emotions. I suggest that we share with reptiles and other mammals the greater part of such continuous activities and saccadic imagery. Repetitive and familiar situations and accumulated memories of similar occurrences give a more solid constitution to such flickerings. We know what we are doing because we have done it before. Our imagery further develops through shimmering activation that operates by means of forms, such as forms of family, language, sports, music, mathematics, technology and institutions. Such forms control personal lives and the character of a community. The history of human civilization shows the power of spiritual imagery and of spiritually-inspired forms as controllers operating at the highest levels.

In sum, a flickering foundation of body-based continuous and saccadic imagery is given solidity by repetitive situations and resonant memories. The foundation is overlaid with more finely-detailed shimmering imagery that is attached to the foundation but that also responds to diverse influences, to forms and to detailed memories. In a larger perspective, all the imagery depends on the collective activities of human beings working together in a civilization. We depend on a global biological environment that sustains the repetitive situations needed for actual life.

I suggest that the solidity and self-knowledge that accompanies personal bodily experience is based on unifying resonances in multiple parts of multiple layers of brains and that such resonances arise in recurrent remembered situations that sustain repetitive activity. Organized operations can be partly static, partly continuous, partly saccadic and partly shimmering. It is through shimmering activity that we exercise freedom and it is through recurrent, fixed, continuous and saccadic bodily action that shimmering activity can influence actual life.

In my constructions, images are generated by a new physical principle, called Shimmering Sensitivity. Proposed devices, Toroidal Quad Nets (TQN's), go though repetitive, cycling "shimmering processes." Shimmering Sensitivity arises at critical moments in shimmering processes. Shimmering Sensitivity can be sustained, in a flickering fashion, through repetitive cycles and waves of critical moments in multiple TQN's that carry content from one critical moment to the next. I suggest that a piano or a symphony orchestra generates similar images in similar ways. Calvin used such metaphors in his book *Cerebral Symphony*.

The principle of Shimmering Sensitivity is based on physicists' studies of physical systems that pass through a ***critical point***. In such systems, as a hot body cools, there is a specific kind of transformation that occurs at a specific temperature called "the critical temperature." Such ***critical point transformations*** occur in a large class of physical and material systems and they have been successfully investigated both mathematically and in the laboratory. Cyril Domb was a pioneer in critical point physics and wrote an excellent technical review, *The Critical Point: A historical introduction to the modern theory of critical phenomena* (1996).

Materials that go through critical point transformations include water and other fluids, brass (an alloy) and iron magnets. Such a collection is ***disparate***; as a class, the materials have little in common besides critical point transformations. Critical point transformations are a special kind of phase transformation, which also include pearlite/martensite and snowflakes. Critical point transformations present features in common with the general class of phase transformations such as discontinuity and complete change of form. In addition, critical point transformations have special features. A critical point transformation occurs only at a specific temperature; e.g., the critical temperature or Curie Temperature for pure iron magnets is a single highly specific temperature near 770 °C. In contrast, for example, liquid water will transform to ice at any temperature below 0 °C.

At their respective critical points, disparate materials have important features in common. Away from the specific critical point, activities of disparate materials have essentially nothing in common. Common features in widely disparate critical point systems establish a principle called ***universality*** that appears in critical point physics. Universality in critical point physics is different from universality in platonic physics. Universality in critical point physics means that all the systems share certain properties when they are at the critical point. They do not share properties otherwise. Universal properties in critical point physics are highly local in space and time; they control only certain events rather than "everything," as in platonic physics.

Principles of nonlocal universality are important in my constructions. Based on such principles, I suggest that device modules with differing designs can go through shared critical moments when two or more selections are made together and in a unified way. I suggest that collective, nonlocal and synchronized critical moments are the answer to the binding problem discussed above. I suggest that the universality of critical moments is reflected in the nature of experiential imagery that has multiple forms co-existing in a person's imagination, e.g., in metaphors and analogies. Also many jokes, e.g., puns.

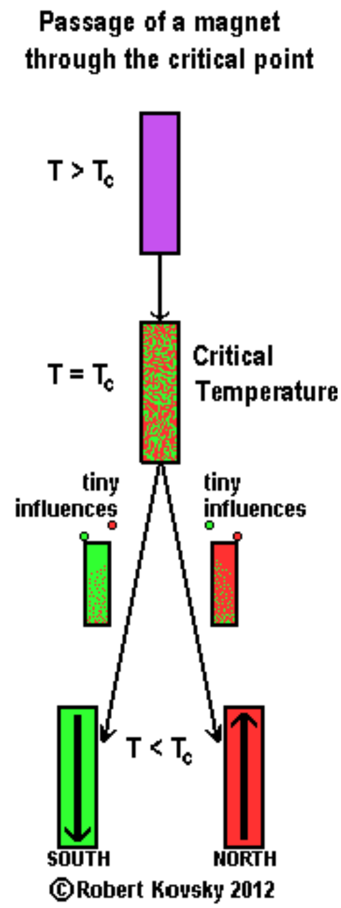
The principle of critical point universality develops collective principles previously introduced. Principles of device design suggest that: multiple action pulses add up to a unitary pulse bundle; multiple muscle fibers add up to a unitary muscle module; multiple saccadic jumps add up to a unitary course of action; and multiple selections in different devices and having different forms but sharing a single, interconnected critical moment of synchronous selection add up to integrated experiential imagery that can be indexed, stored and reconstructed though processes of memory.

Other aspects of critical point phenomena also contribute to my designs. The liquid water/steam system resembles an Ideal Gas at a limit point in a range of conditions; and the system passes through the critical point at another place in the range. A thermodynamic process that takes water from the critical point to Ideal Gas conditions resembles the passage of a device system that moves from delicate selections to strong muscular movements, such as a device system suggested above that might model "free will."

Critical point systems and the Ideal Gas each have a successful mathematical model. Critical point activity has been described by the mathematical ***Ising Model***. Lars Onsager, the previously-discussed winner of a Nobel Prize for his reciprocity relations, provided a closed-form mathematical solution for the Ising Model that led to "revolutionary" breakthroughs. (Domb.) The Ising Model is a quasi-static form that was a starting point for design of the Quad Net Model of brains, which uses an activated form.

As chief contrasting features, the Ideal Gas is fixed and conservational in its behavior but critical point systems are transformational. Within a system at the critical point, changes are always ongoing. A system at the critical point never relaxes, in contrast to equilibrium systems that are completely relaxed. Please see *A Patchwork Of Limits: Physics Viewed From an Indirect Approach* (2000), available on my website.

Academic institutions maintain online computerized demonstrations of the Ising Model. As shown in the models, phasic aggregates of particles are continually coalescing and dissolving. At the critical point, there is rough ongoing balancing between coalescence and dissolution.



The adjacent Figure shows the passage of a magnet through the critical point or temperature, T_c, also known as the Curie point or temperature.

A magnet with a temperature above the critical point has no intrinsic polarity. That is, it will not orient with respect to an external magnet. When the temperature of such a magnet falls below the critical point, it acquires a north polarity or a south polarity.

At the critical point, both polarities co-exist within the magnet in transient aggregates that are continually coalescing and dissolving.

Symmetries show that it is equally likely for the cooling magnet to turn into a north magnet or a south magnet. A ***tiny magnetic influence*** will select either north or south. As the cooling continues, the magnetic polarity becomes fixed.

At the critical point, $T=T_c$, it is very easy to shift the magnet's polarity back and forth from south to north. The magnet is very weak. When the temperature of the magnet falls to just a little bit below T_c, the polarity becomes fixed and the magnet is strong.

The foregoing critical point principles have been applied commercially in magneto-optical memory systems. Tiny magnetic elements on a disc store digital information. When appropriately directed, a laser heats up an element so that it is erased and re-set.

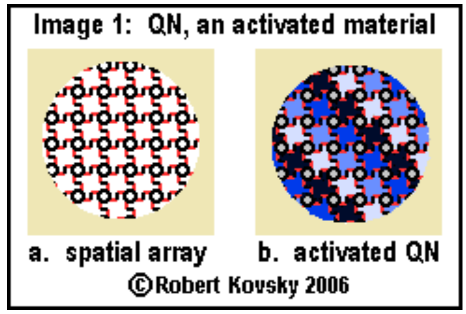
An important special feature of critical systems is that every spatial point within a system at the critical temperature affects every other spatial point regardless of distances between points. This is because activity is so highly activated and so congested that it quickly becomes ***nonlocal*** and a fluctuation at one point can connect with fluctuations at distant points to sweep over the entire interconnected region in a shimmering way. I suggest that nonlocal critical point activity is a basis for the binding principle discussed above.

My large-scale brain models are based on G. M. Edelman, *Neural Darwinism: The Theory of Neuronal Group Selection* (1987) as to important features. In the models, a brain includes a large number of smaller compact bodies that are themselves made of neurons. Such compact bodies, e,g,, bodies of neurons with names like nucleus and ganglion, are called ***neuronal groups***.

Edelman shows that there are thousands of neuronal groups in a human brain and that they are interconnected through nerve tracts that are like bundled cables of wires. Some neuronal groups receive signals from sensory organs and some neuronal groups send motor signals to muscles. A large functional unit inside a brain, e.g., the central thalamus, can be viewed as a clustered and layered structure of interconnected neuronal groups. The cerebal cortex is a larger structure that is similarly constituted of interconnected units. Neuronal groups apparently work together and scientists declare that there must be integrating principles. (Koch, Edelman & Tonini.)

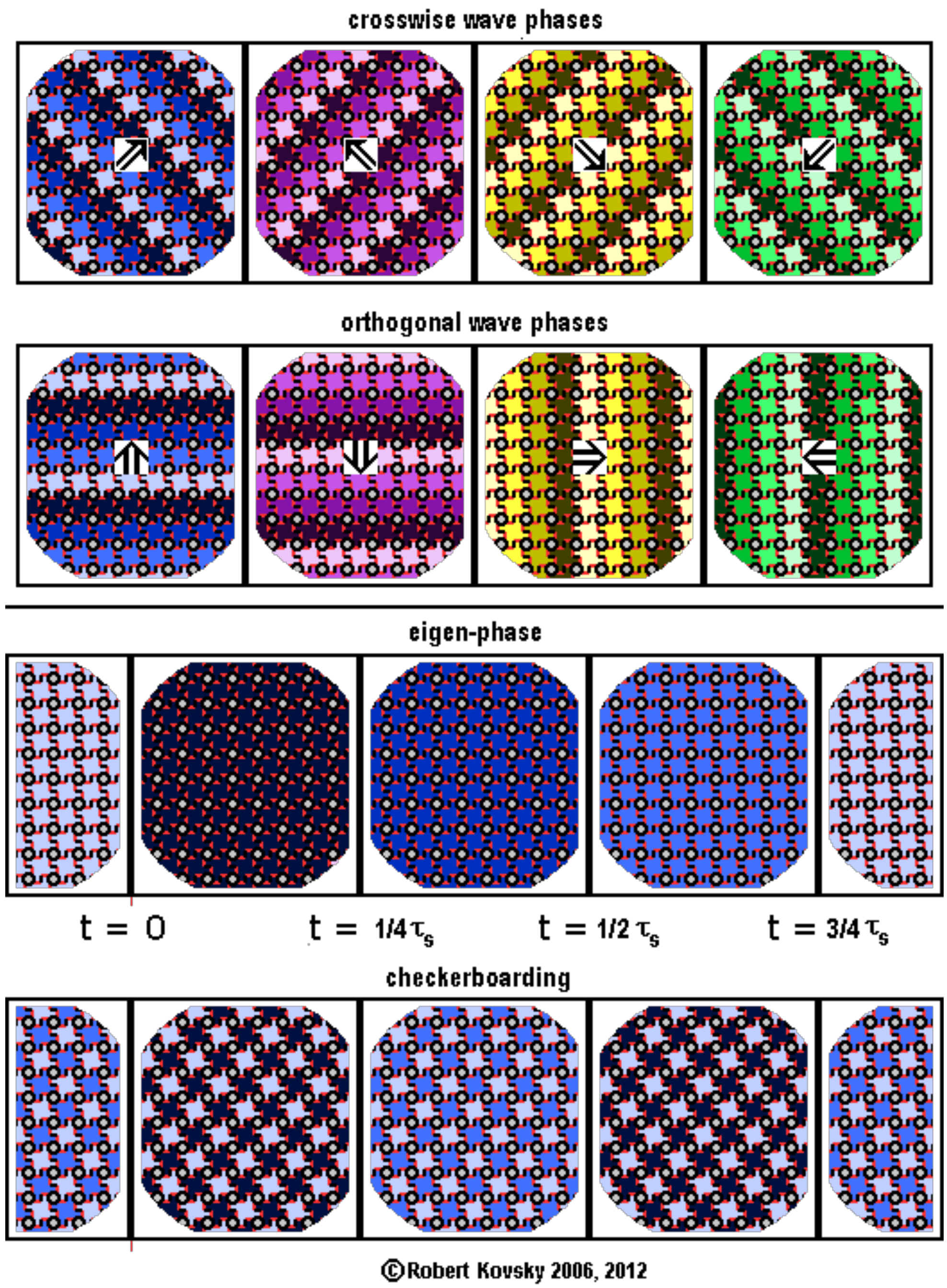
Activities of neuronal groups are studied using "functional Magnetic Resonance Imaging" or fMRI that monitors the distribution of sugar carried by blood and consumed by neuronal groups. Using such techniques, it is observed that, in a brain occupied with a specific task, some neuronal groups are highly activated and some neuronal groups have low activation. The set of highly activated neuronal groups is specific to the task; change the task and the set of activated neuronal groups changes. E.g., different sets are working when the person is engaged in sports, musical performance or committee meetings. Such a set of neuronal groups that are highly activated with respect to a specific task is called a ***coalition***.

The adjacent image shows Quad Net or "QN." A spatial array or field of "elemental devices" constitutes QN. Each device is connected to four neighboring devices. A pulse discharged by one device triggers neighbors that are ready. Pulsational activities generate waves of pulses within the material. Repetitive pulsational activity can be maintained in diverse forms, which are collectively called a ***repertoire of phases***.



Simple Quad Net operations can sustain a repertoire that has ten kinds of repetitive, cyclical phases. The repertoire of phases is shown in an image on the next page. There are eight wave phases (four crosswise phases and four orthogonal phases) and two collective phases (the eigen-phase and checkerboarding), Each of the eight wave phases includes a direction of travel. Operations discussed below are restricted to crosswise wave phases and the checkerboarding phase.

Image 11 (Revised): Repertoire of phases in Primal Quad Net



In checkerboarding, half of the devices in the field pulse together and then the other half of the devices in the field pulse together. The halves are like the red and black squares on a checkerboard. Pulses in each half-field are triggered by pulses in the other half-field. A relatively lengthy period of time passes between the triggering of a device and its pulsation ($\frac{1}{2}\tau_s$); during that period, the other half-field becomes ready. In checkerboarding, half the devices are responding at any given instant.

In wave activity, a first device does not become ready to receive a pulse produced by a second device that the first device has triggered. The first device becomes ready only after the second device has pulsed and the first device must wait for the cycle of pulsations to come around again. A device is in a responding condition for only a minor fraction of the wave period. If wavelengths become progressively longer, the fraction becomes progressively smaller.

In processes that generate Shimmering Sensitivity, shown on the next page, a device passes from the checkerboarding phase into wave activity. The passage may operate so as to carry out a selecton. The passage can be continuous and fully controlled or it can be carried out in a jumpy fashion. The actual result may depend on whether the passage is continuous or jumpy. I further suggest that, in addition to the function of making a selection, the passage can generate an image that encodes the selection. Similarly, I suggest that a person experiences the making of a selection in actual life and that the making of a selection is an event that is recorded in memory.

Quad Net is conceived of as an elastic, rather plastic material that can handled and shaped for specific purposes. Accordingly, Quad Net can be stretched and interconnected to form certain shapes, of which the most important here is the Toroidal Quad Net or TQN. Images from the *Quad Net* paper illustrate such construction methods. Construction methods are intended to be congruent with development of neuronal tissues of an animal in the uterus. (Edelman.)

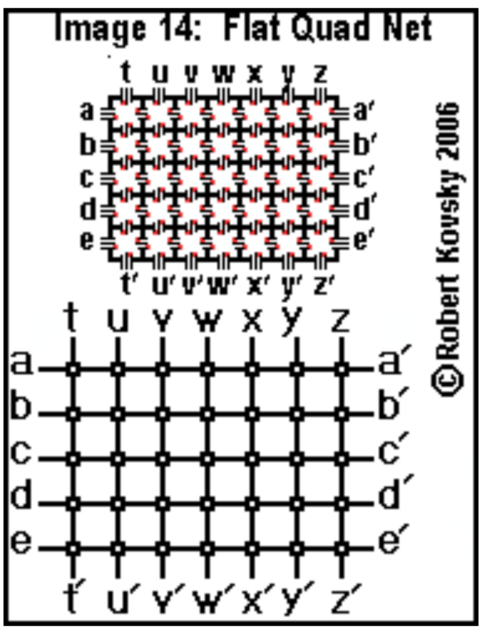


Image 14: Flat Quad Net

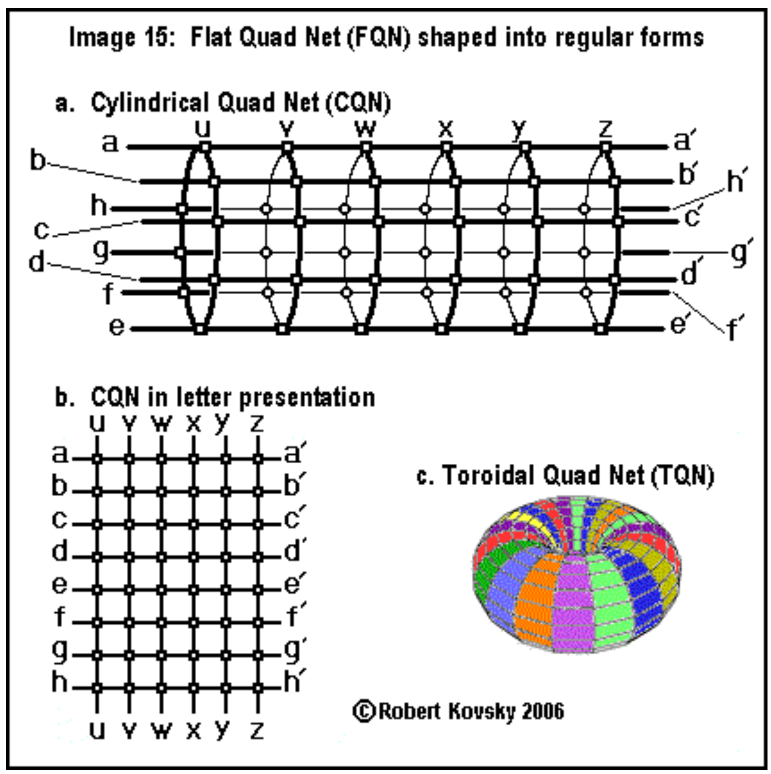
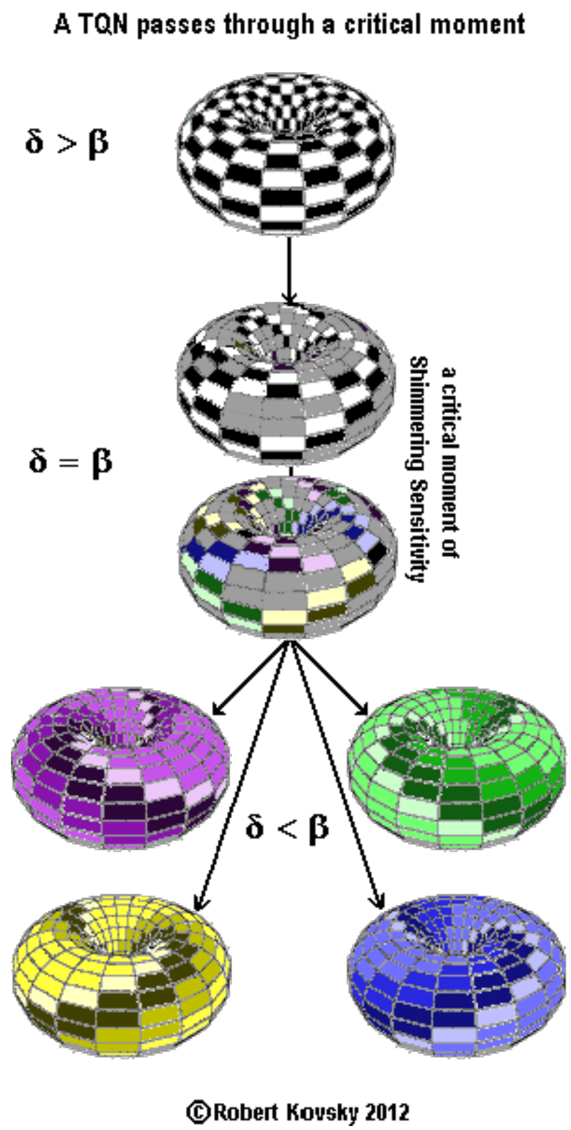


Image 15: Flat Quad Net (FQN) shaped into regular forms

Operations of a Toroidal Quad Net (TQN) shown in the adjacent image, depend on values of timing intervals δ and β. The timing interval δ is the period of time between the triggering of an elemental device and its discharge. The timing interval β is the period of time between the discharge of a device and its return to readiness. The timing interval δ is called "the responding period" and the timing interval β is called "the refractory period."



When $\delta > \beta$, an elemental device that discharges and triggers a neighbor will return to readiness before the neighbor discharges. The triggering device will get through β faster than the triggered device gets through δ . The resulting pattern is "checkerboarding" or alternating discharges.

When $\delta < \beta$, a device is still refractory when it receives a pulse from the neighbor it triggered; it does not respond. Activity takes the form of waves. Steady stable crosswise wave activity in the TQN occurs in exactly one of four directions. As with other collections of ticking clocks, ***entrainment*** unites devices into one pattern.

Critical point processes in TQN's resemble those seen in magnets. A shifting relationship between δ and β leads to a moment when $\delta = \beta$, the critical moment, when relatively weak signals from other devices generate and select the final wave pattern in the TQN, which is then maintained for the rest of the cycle.

In other words, passage of a TQN through the critical point generates a critical moment of Shimmering Sensitivity. At the commencement of the critical moment, activity in the TQN can appear as germinal "wavelets" moving in all directions. As in magnets at the critical point, aggregates coalesce and dissolve according to external influences. While coalescence and dissolution are occurring, there may be shimmering or jumping from pattern to pattern.

As the cycle continues, and as a result of unbalanced external signals, wavelets in one direction unite and take over the TQN, establishing simple waves. Because, at the outset, any of the patterns is equally possible, the selection is highly sensitive to external influences. All kinds of influences may affect the selection, including operational variations in the process.

I suggest that TQN's and other device parts can be organized in systems that maintain ongoing coalescence and dissolution of wave patterns. Advanced layered devices can circulate continually evolving patterns of coalescence and dissolution.

When activities of interconnected TQN's and other device parts are synchronized, they pass through critical moments together. Local activity within one TQN generates nonlocal activity in other interconnected TQN's and vice versa. Interconnected devices can generate a condition of shimmering in which resonating aggregates of activities in devices coalesce and dissolve.

An influence that reaches the coalition through one TQN may affect selections in all TQN's. One set of patterns may be steady while other patterns go through changes that are subject to the steady patterns.

Shimmering can extend over an entire synchronized coalition: then, as the critical moment passes, disparate selections occur simultaneously in different subsystems. Such selections can be organized through the collective power of entrainment. As the critical moment passes and activities in interconnected TQN's and devices are selected, they separate from each other and become independent, each confined to a specific domain. The coalition breaks apart into smaller coalitions and each smaller coalition takes on a selected character. Such critical moments may be repeated through cycling activity. In steady operations, a temporary or permanent hegemonic pattern may appear.

I further suggest that critical point and critical moment operations show how individualized experiential imagery and memories –a person's conscious experiences and memories of movements, feelings, positions, sights, sounds and forms – might be generated during phase changes in pulse patterns in neuronal groups in brains and have consequential power. The leap from phase changes in pulse patterns to experiential imagery is, obviously, highly speculative, but it seems clear to me that ***something*** is generating such imagery in my own brain – and phase changes and pulse patterns offer possibilities for development that are attractive to me. Such possibilities are worked out in constructions in *Feelings, Forms and Freedom*.

I suggest that such imagery — generated and sustained by synchronized and resonating coalitions of spatially-spread-out, interacting neuronal groups in a brain — has a precarious but compact existence with a complex, mobile interiority that can be identified with a person's self. Within such interiority, one kind of imagery, such as forms, can be invariant and in control of activities, while movements or other images are modified to conform thereto. It would appear that a course of action can be made subject to overall control, that is to controlling forms originating in childhood training, maintained by the self and sustained by a bodily and social environment. The controlling and maintained forms make up a personality. The person develops and maintains controlling forms of personality and self for the sake of doing it.

In other words, persons, or, at least, young persons, can be trained to generate and sustain mental imagery of specific forms of behavior and to exercise self-control through use of such forms in suitable environments. I suggest that in actual life, most persons exercise such self-control through personal choice and through selections of environments. Judgments of legal, social and moral responsibility are based on the capacity of a person to generate and sustain in mental imagery certain forms of behavior that are mandated by society and other influences (stop-on-red/go-on-green) and to follow those forms when changing possible bodily movements into actual movements. (Didn't Plato say something similar?)

A chief focus is on temporal forms of ***balancing***. Balancing activity is grounded in symmetry. More precisely, balancing activity establishes and maintains symmetry and, while successful, ***maintains a balance*** that can be stated in terms of symmetry. When balancing is elaborated into forms, it may also include a ***loss of balance***, which is a termination of symmetry that also terminates the activity of balancing. In processes that involve Shimmering Sensitivity, loss of balance is as important as maintenance of balance. In devices that shimmer like TQN's, balance can be lost in multiple possible directions but balance is actually lost in only one direction. Once balance is actually lost, it can be restored with minimal costs, under some circumstances, making continuous operations possible. Meanwhile, each actual loss of balance can be converted into selective muscular movements.

An idealized temporal form of balancing has a time prior to its existence, a point in time of its establishment, a period of existence or maintenance and a point in time of its termination. Such temporal forms in general (including forms of balancing) are called ***episodes***. A ***life*** is an episode. Each episode is separately produced and has distinct features, e.g., a unique lifetime that stretches from birth to death: only ***individual episodes*** are produced. It is not possible to produce the exact same episode twice and differences between any two episodes can always be detected, in addition to separate identities and different times of birth and death. Episodes do not fit easily into invariant, symmetric forms that disregard individual differences and that try to treat all individuals or all episodes "the same."

The individual episode form is, however, sometimes suitable for the important purpose of incorporation into a ***tiling*** temporal form, which can approximate invariance. Tiling forms are repetitive and cyclical and they also hook up end-to-end to generate ongoing activity that can be self-perpetuating. A tiled form is a sequence of episodes that approximate each other. Some tiled forms, e.g., an anniversary, are simply repetitive. In complex tilings, e.g., tournaments, a general form of activity is repeated cyclically but specific details are varied during the repetitions.

In larger constructions, individual episodes develop into courses of action that can grow and develop. A progression of episodes in a drama leads to a climax, which is a culminating and transformational episode. Individual law cases, each an individual episode, add up to a trend in jurisprudence. I suggest that, in ways that resemble generation and organization of action pulses in device constructions, individual instances of episodic balancing forms make up large scale activities in a civilization.

f. Sports contests and civil trials illustrate adaptations of strife to episodic forms of balancing. Such forms lead to transformational critical moments, e.g., moments of overtaking during footraces and moments of decision by judges and juries in courtroom proceedings.

In this subsection, principle previously developed are applied to large-scale events of actual life, namely, sepisodes of balancing in specific domains of racetracks and courtrooms. Discussion of a footrace focuses on a particular event. Discussion of courts reaches for a wider view.

The discussion begins with the element of ***strife***. Strife in actual life is difficult to bring under control of forms or laws, but considerable progress has been made. My approach starts with some general observations.

In many episodes of strife, animals fight for possession of a prize that may range from a carcass to a battleground highpoint to an Olympic medal to a court judgment. Each contestant seeks both to gain the prize and to prevent competing contestants from gaining the prize. Contestants anticipate each other's actions with respect to the prize and act to frustrate others' attempts to gain the prize. The Greek word for prize is *athlon* — hence our "athletics."

Episodic balancing forms are widely used in sports contests and civil trials. Such forms of balancing incorporate principles of symmetry and invariance that actually control and resolve strife in these domains. In actual life, I suggest, it is not music that quiets the savage beast, but prizes gained through controlled strife in contests that use episodic balancing forms.

According to de Santillana, Heraclitus (c. 500 B.C.) was "the philosopher of unresolved strife." Heraclitus wrote: "War is the father of all and king of all," "strife is justice" and "all things come into being and pass away through strife." De Santillana interprets: "There are great oppositions and polarities of nature, of which sex and war are only the too-visible symbols." (46.) Heraclitus' influence hung over Plato and other Greek philosophers who took very different approaches. Heraclitus "focused attention on how mysterious and ambiguous the objects of nature really are, however familiar and obvious they may appear to be." (49.)

Platonism is supposed to quell strife and to remove all causes for strife. Platonism assumes the existence of a single-minded and cosmological set of principles that can be declared by an institution of authoritative knowledge from which strife has been banished. Platonists often express an aversion to strife; and those with personal aversions to strife often adopt platonism.

Platonism breeds rebels. Among rebellious philosophers, Nietzsche is famous for his glorification of strife. E.g.: "*Out of life's school of war*: What does not destroy me, makes me stronger." (*Twilight of the Idols*, Maxim 8.)

Ancient texts also glorified strife. Major episodes of glorified strife in the Hebrew Bible include liberation from Egyptian bondage, the Conquest of the Homeland and wars involving Israel, Judah, Assyria and Babylon. Strife is central to family stories about Cain vs. Abel, Isaac vs. Ishmael, Jacob vs. Esau, Joseph vs. his brothers and King David's sons vs. David and each other. The Hindu epic, *Mahabharata*, is a massive, grand and glorious saga of peace and war and peace; one overall theme is that the heroic race of kings and warriors killed each other off, leaving priests and professors to run things.

Modern approaches to strife use various kinds of knowledge that do not fit together. Psychologist Alfred Adler (1870-1937) broke off his close association with mentor Sigmund Freud (1856-1939) and emphasized competition among siblings. (Kaufmann, Discovering the

Mind, v. III.) A 20th century strategist, Capt. B. H. Liddell-Hart, generalized wartime military decisions into metaphysical principles in *Strategy: The Indirect Approach*. Every county government in the United States, or nearly so, has a law library filled with materials used in resolving contested matters in court. Those involved with communal peacemaking often rely on principles and practices of non-violence originating with Mohandas Gandhi and Martin Luther King, Jr. See, e.g., Slattery et. al, *Engage: Exploring Nonviolent Living* (2005).

None of the approaches has provided solutions to problems of strife outside of a narrow domain. Given inherent difficulties of the topic and many diverse approaches, my approach is to narrow the focus of attention and to try to connect to actual life. Our need for new ways to deal with strife identifies important long-range goals for development of psychological principles. Constructions herein begin with principles of balancing. We use balancing principles in various ways, including resolution of cases of strife that are within the governance of institutions.

The principles are illustrated by a formal footrace in a sports arena. For particular features, imagine a mile race or a 1500 meter race that takes about 4 to 10 minutes.

Strife in a footrace is constrained by formal features that incorporate principles of symmetry and invariance. The geometry of the track gives every lane of travel closely-similar opportunities so that contestants are indifferent as to lane assignment. Contestants stand as equals before neutral officials and neutral rules. Rules are the same for all contests of a specific kind regardless of where or when the contest is held.

During a race, each contestant engages in action that has a similar course. The race starts according to a signal that is common for all runners and finishes at a common line. The competition is for "who runs the fastest," a contest of average speed. The only measure of speed that matters is the quantity of time required to run from the starting signal to the finish line. Because of the commonality of such features, comparison of contestants' speed can be made directly, according to the order they cross the finish line. The first to cross the finish line "wins" the race and winning is the purpose of each runner. Only one runner can win and runners try to exclude each other from winning. Each runner seeks to inflict defeat on each of the other runners. The conflicting purposes of the runners are the basis for strife in a footrace.

The foregoing symmetrical and invariant features provide a system of constraints for a footrace, or, in other words, a ***form*** for a footrace. The character of a race as a "fair race," depends on the occurrence of such formal features during the actual event. Formal features make a footrace suitable as an event in the life of an institution such as a college that hold sports competitions. The racetrack incorporates spatial forms of geometry that share in the universal acceptance of geometry. Rules incorporate the rigidity of invariant symmetry, always to be strictly applied the same to all persons. When races are run according to such forms and rules, runners accept the outcome and return for more races. Institutions, like babies and runners, do things for the sake of doing them. Helping to bring forms and rules into existence, adhering to them and organizing activities to conform to them are functions in the life of an institution.

The invariant, symmetrical track and rules only provide a container for the actual running of a footrace. In *The Crucible* (1992), available on my website, I compared institutional activity of a court to activity of a metallurgist inventing a new alloy. The metallurgist uses a fixed, stable material container – a crucible – inside of which various ingredients are mixed and melted together. The stable crucible provides a container for phase changes in metal alloys. I suggest that a court is like a crucible; it is a place for combining and mixing and modifying ingredients to arrive at a judgment. Likewise, I suggest that race tracks serve as crucibles for sports competitions that lead to a winner.

An actual footrace is controlled by temporal forms. To highlight episodic balancing forms, I consider a race with only two contestants, “he” and “she” and presume that he and she are roughly matched in training and speed. A few “special moments” divide the race into periods that are made up of “ordinary moments.” At “ordinary moments,” exactly one runner is in the lead. “Special moments” are moments of overtaking or challenge when no one is in the lead. From start to finish, the race is one extended period that fits the episodic balancing form.

The episode of a particular race contest is usually set in a context that includes other race contests; perhaps the context is called a “meet.” The meet may include 10 or 20 or so separate race contests. Each particular race episode has a starting time and a time when it has been completed. No actual racing occurs before the starting time or after the completion. The race is completely performed within a compact period of time that makes up the episode.

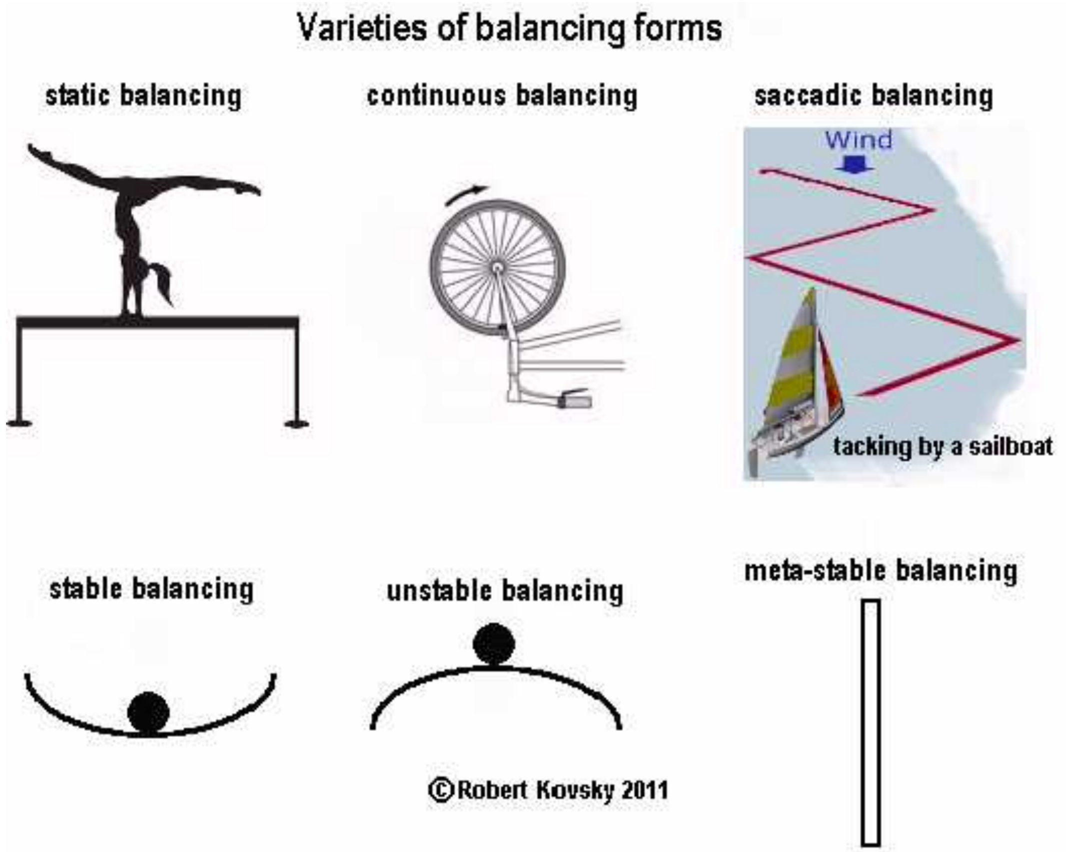
Although the underlying racetrack and rules are symmetrical, the focus of the race is asymmetry. There are two possible final asymmetries, one where he wins and one where she wins. Suppose asymmetry appears just after the starting signal and is followed by noting, at any particular moment, “who is in the lead.” Suppose that right after the starting signal, he takes the lead. (A symmetrical discussion applies if she takes the lead.)

There are three possible large-scale temporal forms for the race. First, during the course of the race, she passes him and wins the race. This temporal form of race is called “overtaking.” In the second temporal form, the “leads all the way” form, she does not pass him, even though she may challenge him, and he wins the race. In a third temporal form, the “see-saw” form, she passes him, then he passes her, then maybe she passes him and then maybe he wins and then maybe she wins. The forms and distinctions between forms are based on moments when one runner passes or overtakes the other runner. Such moments are like phase changes in materials, e.g., when water changes into ice. During such a moment of overtaking, the activity changes in a fundamental way.

During a moment of overtaking, the runners are in symmetrical positions, equally distant from the finish line. On the other hand, the speeds are unequal as one runner is moving faster than the other. The form of action combines symmetry and asymmetry. The form of action is an episode with overtaking at the central, critical moment.

Such balancing forms combine a spatial aspect with a temporal aspect. The spatial aspect is a symmetry between parts. The temporal aspect is the form of activity that can maintain the symmetry and that, more important, controls any loss of symmetry.

As shown in the Figure below, some temporal forms of balancing can be represented by an iconic or symbolic form and a name or verbal form. Such forms of balancing are named static, continuous, saccadic, stable, unstable and metastable.



An additional temporal form of balancing can occur during a footrace, a balancing form called “closing the gap.” Closing-the gap-balancing occurs in an episodic way around moments of challenge and/or passing. It is not represented by an iconic or symbolic form.

A description of closing-the-gap balancing starts with the goal of the runner, namely, to run faster than the other runner from the starting signal to the finish line. At any moment, the one who is running faster is ahead. Suppose that he is ahead; he needs only to maintain his lead to win. The way things are going, it is sufficient for him to maintain his speed. If he maintains his speed and she maintains her speed, his lead will increase. He will win by maintaining his average speed versus her average speed. She, in contrast, must increase her average speed to catch up and overtake him. This requires her to do things that he does not have to do. Chiefly she must close the ***gap*** that separates her moving position from his moving position.

The gap is based on her experience of his body and also on her experience of the visual space between the bodies. Although both bodies are moving, the gap between them remains more or less fixed – or perhaps it is increasing a bit because of the speed differential that puts him in the lead. It is the gap, I suggest, that signals and identifies the necessity of what she must do. And she does do it, if she summons up ***extra effort*** and increases her speed. The gap identifies, indexes and encodes the extra effort she needs to speed up, to overtake him and to win the race.

As modeled by An Eye for Sharp Contrast, the gap between her body and his body is measured by muscles that control the focus of the Lens of the Eye.   I suggest that she is looking at edges of his body and that there is a direct relationship between signals to her eye muscles that focus on edges and the distance to the object. I suggest that the extra muscular effort of her legs that is needed to close the gap is measured by muscles of her eye. Her feeling of the need for extra effort is based on signals from her eye muscles. There is muscle-to-muscle measurement and control that is shared with reptiles and that is foundational for extra effort summoned up by a conscious personality.

Suppose that she summons up extra effort and increases her speed sufficiently so that the gap between the runners is no longer growing, if it was growing, but is instead shrinking. At first, it shrinks only a little, but then the extra effort takes hold and it begins to shrink faster. As the gap shrinks, she enters into a moment when she is challenging him. But now she is moving faster than he is. She is behind in space but ahead in speed. The balance is shifting. Her challenge shifts to him the requirement to summon up extra effort. If he does not summon up extra effort, and if there is sufficient time before they reach the finish line, the challenge will succeed and she will overtake him. If he does summon up extra effort, he may withstand the challenge, or his extra effort may not be enough to maintain the lead, or the race may enter into a see-saw form. Runners' needs for extra effort and their summoning up of extra effort may continue to the end of the race, even possibly leading to a new personal record for the event.

Summing up and extending the foregoing, a footrace is based on balancing forms that are grounded in symmetries as to persons, space and time. The symmetries and balancing forms have the purpose and effect of bringing into existence, however transient and ill-defined that existence, an additional balancing form that is based in action and that decides the outcome of the race. The additional balancing form appears as a closing-the-gap challenge by a runner who is behind in space but who is moving faster than the one who is ahead. There is possible ***extra effort*** that controls the outcome.

Extra effort is additional episodic effort on top of a high degree of constant effort. Added speed from extra effort can balance or even over-balance a spatial lead.   Extra effort is a differential quantity of effort. It is identified, indexed and encoded by a visual gap between the leading runner and the challenger.

The episodic balancing form is characterized by a ***critical moment***, when the challenge either succeeds or fails or, perhaps, becomes the first of a series of critical moments. It is a critical moment of transformation that can occur as she who was behind becomes she who is ahead.

Similar reasoning applies to jury trials in courtrooms. Legal proceedings share many features with sports contests, chiefly resolution of strife by means of selections that are carried out through courses of action, supposed to be "fair," that lead to definite outcomes and that involve winning and prizes. A trial has a critical moment of decision by the jury, namely, the time when the jury is deliberating in the jury room. All activity of a trial is aimed at influencing that critical moment. A trial lawyer anticipates jury deliberations during the initial interview with a client.

Shifting attention from focal critical moments to the encompassing context, both domains, sports and courts, are constructed to further social values. Sports competitions appear in all societies and are self-perpetuating, being played and watched for their own sake by large fractions of the populace. In actual life, sports teams become civic institutions. Courts are established by all governments to enforce their mandates and prohibitions; to protect personal rights, property possessions and transactional integrity; and to resolve disputes involving governments, individuals and/or private organizations.

A contrasting feature of the two domains is that legal contests have consequences that are weightier than those of sports contests, often involving accusations of dishonesty or financial stakes of serious importance to the parties. Stakes in criminal proceedings include imprisonment or death of the defendant.

A "court" is a place where a judge presides; often the judge is called "the court." In the court, the judge is in absolute control and has an armed bailiff ready to arrest and imprison offenders on instructions from the judge. Another way the judge controls events is to send orders to the sheriff. The sheriff will obey a judge's order, e.g., the sheriff will use armed force, if necessary, to evict a tenant residing in an apartment when the owner has obtained a suitable court order based on the failure of the tenant to pay rent. Action by the sheriff is the court's equivalent of muscular movements of an organism. The territorial area in which the sheriff will perform such acts of enforcement according to the judge's orders defines the court's ***jurisdiction***. Typically, judges in one court will enforce orders written by judges in other courts, but questions can arise.

Both sports and courts employ symmetrical and invariant forms of contest to control and resolve strife. In proceedings, parties and/or attorneys — the competing "plaintiff" and "defendant" — have an equal status before the court. At least, such equality is practiced to the extent feasible under the circumstances. In a courtroom, an elevated judge's bench is the central focus. Space before the bench has two halves with equal furniture and furnishings provided to plaintiff and defendant and their lawyers. The witness chair and nearby jury box create an asymmetry which is usually resolved according to local tradition, e.g., plaintiff is closer to witness and jury box. Procedures apply the same to all parties and remain invariant for long periods; occasional changes are usually small, with infrequent major revisions.

Civil trials in courtrooms provide voluminous case studies of actual resolutions of strife through contests and outcomes that have winners and losers. (Other methods of resolution lead, e.g., to settlements.) Of importance in legal contests are ***written rules of law***, providing intellectual content that is absent in sports contests. Chief written rules of law are constitutions, statutes passed by legislatures and precedential case opinions of courts of appeal. When trial judges and appellate judges write about current cases, they do so in terms of written rules of law.

Written rules of law occupy an imaginary metaphysical domain that resembles the metaphysical domains of geometry, platonic Ideas and Laws of Physics discussed previously. I use the phrase "jurisprudential law" to denote the legal metaphysical domain. Principles of symmetry and invariance are of paramount importance in jurisprudential law, as in other such domains. Constructions put together in such metaphysical domains are supposed to control actual lives.

It is undeniable that judges do control actual lives through powers of the state. For example, if the court enters a money judgment in favor of plaintiff and against defendant and the court issues orders to the sheriff, the sheriff will deliver instructions to bank officers to transfer money from defendant's bank account to the sheriff's bank account and bank officers will comply with such instructions. Later, the sheriff will deliver the money to plaintiff. There, it's done and it's over.

A chief question (previously encountered in other guises in previous discussions) is the connection, if any, between metaphysical constructions of jurisprudential law and actual exercises of state power. One possibility is that decisions by courts are actually based on the domain of jurisprudential law where principles are invariant and symmetrical and that such principles are actually applied to the individual case through a process of reason. There are widespread beliefs that such "rational" operations and applications exist as part of the inherent nature of jurisprudential law. (See Frank, *Law and the Modern Mind* (1930, 2d. ed. 1935), "The Basic Myth," describing and disparaging such beliefs.) Another possible view is that claims about such rational operations are fabrications that try to camouflage the hegemony of a ruling class. According to this view, it is asymmetrical injustice that is invariant, if anything is. A third view is that court decisions are arbitrary, lacking symmetry or invariance despite illusions or pretenses to the contrary; rather, decisions are based on political positions and connections of judicial appointees or prejudices of jurors. Supposedly, the decider aims for a particular result that suits such positions, connections or prejudices and writes or says what appears to justify the desired result. Such possibilities, views and beliefs are topics of academic discourse.

My own views are rather different. Yes, many specific cases support each of the stated views. However, what actually happens often has a more practical character. Chiefly, satisfactory results are achieved when deciders ***follow the forms*** and ***the forms fit the task***. Often the forms authorize deciders to exercise freedom.

The task of a judge or jury in a courtroom is to answer questions that are implicit in a dispute. Which side is right? If plaintiff is right, how much must defendant pay to plaintiff to make things equal, more or less? American jurisprudence divides legal questions into classes according to the person who decides the questions. During a trial, certain questions, called ***questions of fact***, are decided by the jury. Other questions, called ***questions of law***, are decided by the trial court judge. After the trial, the losing party may appeal the judgment. A principle of appellate law is that the jury's decisions as to questions of fact will be taken as truth. Taking the jury's decisions as "true," the appeal court will try to make the jury's decisions justify the judgment. The appeal court will be more critical of the trial court judge's decisions on questions of law. Often, the appeal court will substitute its decision for that of the trial court judge. Another class of trial court decisions, called ***discretionary questions***, is treated more respectfully by appeal courts. As might be expected, some cases turn on the classification of questions. As exemplars: the amount of money compensation awarded by a jury is a question of fact within a broad range; whether a party has a right to have claim decided by a jury is a question of law; daily scheduling of the trial is a matter of trial court discretion.

In an actual jury trial, the jurors are the focus of attempts at persuasion. The jury's moment of decision occurs in the jury room close to the end of the trial. Most of the time during a trial is spent in obtaining formal testimony through lawyers' questioning of parties and witnesses and in dealing with physical evidence, e.g., documents, data sets and audio-visual presentations. After completion of evidence, the lawyers make ***closing arguments***, which are major efforts at persuasion. First the plaintiff's lawyer argues to the jury, then the defendant's lawyer argues to the jury, then the plaintiff's lawyer gets to make the last argument. After the arguments, the trial court judge ***instructs*** the jury, telling the jury the principles of jurisprudential law that should control their decisions. The instructions are set forth in formal ***jury instructions***. The jury instructions include ***jury verdict forms*** that set forth questions to the jury. When lawyers make closing arguments, they know the jury instructions and jury verdict forms that will be provided to the jury and they often quote from and argue from the text of the jury instructions and verdict forms. The focus here is on the decisional process of the jury that is influenced by jury instructions and verdict forms and by lawyer's arguments to the jury.

Forms used for actual decisions made by judges and jurors have shaping influences. In other words, such decisions have specific forms that have been shaped by needs to perform final and completing tasks, e.g., so that results can be turned into an unambiguous order or judgment that is enforceable by staff working in the sheriff's office, without need of legal interpretation. All the complexities must finally be reduced to simple acts. Either plaintiff wins an award of damages for a specific dollar amount or the case is dismissed. No other final result is possible, at least in a narrow view that sees only results. Whatever the result, the dispute reaches a stage of completion and resolution and neither party can question the result or return to the dispute, except through an appeal or other formal challenge that has explicit or implicit deadlines.

I suggest that certain legal forms provide intermediary functions. Such legal forms connect the metaphysical domain of jurisprudential law with the enforcement arm of the sheriff's office. At critical moments in proceedings, judges and jurors use legal forms to answer questions and reach results. Each such proceeding reduces the ambiguity and moves the case towards final resolution. A legal form provides a tool for judges and jurors to perform tasks assigned to them. When they do so, they ***follow the form***. The understanding is that if they follow the form, subsequent events will go smoothly and the matter can be closed and will stay closed. If judges or jurors want to reach a particular result, the form tells them whether they can do so in good conscience. Judges and jurors generally find that legal forms satisfy their desires and consciences. Legal forms are designed to provide satisfaction for deciders. What satisfies deciders, at last deciders in court, is actually reaching a decision and concluding the matter. Then, it's time to go home.

In order to achieve intermediary functions, some terms in legal forms are highly specific and other terms are quite vague. Vague or ***ambiguous*** terms in legal forms, e.g., "reasonable under the circumstances," authorize judges and juries to exercise freedom in turning metaphysical principles into the action forms of orders and judgments. The essay concludes with a discussion of legal ambiguity as an exemplar of freedom that is exercised by courts.

Often, courts use ambiguous forms at an earlier stage in proceedings and unambiguous forms at a later stage of proceedings. At the earlier stage of proceedings, a judge make decisions with sensitivity to multiple influences and multiple possible outcomes. At the later stage of proceedings, the sheriff carries out simple and clear instructions. This course of action resembles that suggested in earlier discussions of "free will."

Judges and jurors also follow forms that call on them to be personally indifferent to the outcome and to be insulated from unauthorized influences: these are forms based on symmetry. I suggest that judges and juries follow all such forms because following forms is the essence of institutional activity. This suggestion can be supported by examples from many domains of human activity, with examples from ancient and modern religious and community rituals. Institutions operate through forms; and institutions discipline or punish persons who fail to follow forms. Persons who follow forms are performing self-perpetuating behaviors that are called "duties" in institutional contexts. Persons involved with institutions often follow forms for their own sake ("rule of law"), often expressing their personalities while doing so.

Legal forms of various kinds are set forth in writings published by specialty business firms with venerable names. Published sets of legal forms have huge sizes and law libraries have racks of them. Law students learn how to find and use legal forms in law school courses on legal research. Attorneys have duties of lifelong education to keep up with changes in legal forms. Legal forms are to a lawyer what lumber and hardware are to a carpenter, providing ways to put together substantive facts and principles and make a functional object through the construction.

A chief legal form used during critical moments in trials is the ***jury instruction***, introduced above. After presentation of evidence and lawyers' arguments to the jury, the trial judge provides the jury with a statement of principles of law that the jury is to use in reaching a decision. Typically the judge reads aloud a set of such principles – the jury instructions – to the jury in a ritual session of proceedings in court. Then the jury retires to the jury room for private discussions and the moment of decision. Sometimes jury instructions and verdict forms are printed in a booklet that jurors take with them into the jury room.

Jury instructions and accompanying verdict forms are, in my view, pivotal forms in trial proceedings. They are actual means for turning evidence and argument into judgments. Often they are quoted in the climactic and all-important closing arguments. A lawyer begins preparing closing arguments in his or her mind the moment the case is first considered. Principles of law that can be turned into jury instructions are located and quoted in legal documents that are filed with the court. The lawyer acquires evidence before the trial and presents it during the trial for the purpose of being used in closing argument.

The judge's decisions concerning jury instructions are subject to conflicting and concurrent influences that are generated and cultivated by the lawyers for purposes of contest. Sometimes, a lawyer with a losing case will try to confuse proceedings and cause the judge or the other side to stumble and commit error that will persuade the court of appeal to reverse. The formulation of jury instructions is within the power of the trial judge and his or her decisions regarding jury instructions are given a permissive review by a court of appeal, with a standard of review that is between review of right to jury questions (strict) and review of scheduling questions (loose).

Jury instructions and verdict forms often include ***programs for decision*** for the jury. In 1995, for example, football star and entertainment celebrity O. J. Simpson was acquitted of criminal charges that he murdered his estranged wife, Nicole Brown Simpson, and her friend, Ron Goldman. Thereafter, Goldman's parents sued Simpson in civil court, seeking money as compensation for damages they claimed that Simpson had inflicted on them by killing their son. Their claims were not affected by Simpson's acquittal. Chiefly, the State of California had been required to prove Simpson's guilt "beyond a reasonable doubt" in criminal proceedings but, in civil proceedings, Goldman's parents only had to prove that it was "more likely than not" that Simpson had killed their son. This is the "preponderance of the evidence test," a ***balancing*** test.

In the jury room, the jury answered questions put to them on a verdict form:

"Question No. 1: Do you find by a preponderance of the evidence that defendant Simpson wilfully and wrongfully caused the death of Ronald Goldman? Yes. … Question No. 8: We award damages against defendant Simpson and in favor of plaintiffs: … $8.5 million."

The preponderance of the evidence test is stated in CACI 200. "CACI" refers to forms of Civil Jury Instructions published by an authoritative State agency, the Judicial Council of California.

> A party must persuade you, by the evidence presented in court, that what he or she is required to prove is more likely to be true than not true. This is referred to as "the burden of proof."
>
> After weighing all of the evidence, if you cannot decide that something is more likely to be true than not true, you must conclude that the party did not prove it. You should consider all the evidence, no matter which party produced the

evidence.

> In criminal trials, the prosecution must prove that the defendant is guilty beyond a reasonable doubt. But in civil trials, such as this one, the party who is required to prove something need prove only that it is more likely to be true than not true.

"More likely than not" implies a balancing between "likely" and "not likely," with a finding of greater weight on the "likely" side. It need be only a little bit weightier, like 51% to 49%, but it has to be more than 50-50.

Specific examples of express balancing are found in CACI (emphases added).

Where plaintiff claims having suffered harm from using a product manufactured by defendant, the jury may be instructed: "In determining whether defendant used reasonable care, you should ***balance*** what defendant knew or should have known about the likelihood and severity of potential harm from the product against the burden of taking safety measures to reduce or avoid the harm." (CACI 1221.)

If plaintiff claims harm from a dangerous condition on public property maintained by a governmental entity, the jury may be instructed: "In deciding whether defendant should have discovered the dangerous condition, you may consider whether it had a reasonable inspection system and whether a reasonable system would have revealed the dangerous condition. In determining whether an inspection system is reasonable, you may consider the practicality and cost of the system and ***balance*** those factors against the likelihood and seriousness of the potential danger if no such system existed." (CACI 1104.)

Where discharged plaintiff employee and defendant employer had an employment agreement that employee would not be discharged except for "good cause," a possible instruction states: "Good cause exists when an employer's decision to discharge an employee is made in good faith and based on a fair and honest reason. Good cause does not exist if the employer's reasons for the discharge are trivial, arbitrary, inconsistent with usual practices, or unrelated to business needs or goals or if the stated reasons conceal the employer's true reasons. In deciding whether defendant had good cause to discharge plaintiff, you must ***balance*** defendant's interest in operating the business efficiently and profitably against the interest of plaintiff in maintaining employment." (CACI 2404.)

As the foregoing instructions demonstrate, jurors may be called upon to balance different categories that have no clear basis for comparison, e.g., balancing "likelihood and severity of potential harm" from a dangerous product against "the burden of taking safety measures." Such ***disparate subject matters*** are supposed to be balanced according to lines of cases that trace back to United States v. Carroll Towing Co. 159 F.2d 169 (2d. Cir. 1947) where Judge Learned Hand stated a "calculus of negligence."

There are occasional cases where "risks of harms" and "ways to avoid harm" can be "balanced" using monetary estimates; but mostly, meanings are winked at, modified or distorted to suit the litigation goals of the parties or to justify a decision made by a court or a jury. Techniques include presentation of confusing or conflicting evidence from hired "scientific experts." Whatever decision the jury reaches will find support in the record of such evidence. It may happen, in actual life, that neither side is credible and that the decision is made for other reasons. Fitting the form may be crude, clumsy and forced. Imperfect fits are common in civil litigation. Such crudeness and clumsiness allow many cases to fit a form, even if imperfectly. Courts of appeal affirm the result regardless of defects so long as there is an appearance of justification. There, it's done and it's over.

Attempts to balance disparate matters do not fit the nature of a mathematical calculus, which deals with continuously variable quantities connected by equals signs. I suggest, rather, that legal balancing rules are statements of saccadic and shimmering balancing that require a wider perspective than mathematical formulations allow. Various kinds of influences have to be accommodated. Put into practice, such rules allow a manufacturer to sell a product like a chainsaw that is inherently dangerous if there are safety devices that frustrate children and warning labels. The defense is a practical one: there's nothing more that can be done to protect the public short of withdrawing the product from the market or making it prohibitively complicated or expensive. To support the defense, large bright red warning labels are advisable.

Balancing tests are generalized when the jury is called upon to ***weigh*** or balance a number of disparate subject matters. In a case claiming a defective design of a consumer product, for example, the jury may be instructed that if plaintiff proves that she was harmed because of the risky design of defendant's product, the jury should find in favor of the plaintiff:

"unless defendant proves that the benefits of the design outweigh the risks of the design. In deciding whether the benefits outweigh the risks, you should consider the following:

(a) The gravity of the potential harm resulting from the use of the product;

(b) The likelihood that this harm would occur;

(c) The feasibility of an alternative safer design at the time of manufacture;

(d) The cost of an alternative design; and

(e) The disadvantages of an alternative design."

Such a weighing does not merely balance one disparate subject matter against a second such matter. Rather, many subject matters are thrown onto the scales.

Important features of balancing forms are shown by reference to device models. Balancing forms used in footraces can be modeled using a continuous activation; models of balancing forms used in civil trials require saccadic and shimmering activations. The gap in a footrace, a spatial quantity, becomes a formal ***distinction*** (or a structure of distinctions) in jurisprudential law. That is, a gap in a footrace is a difference in a spatial quantity that identifies, indexes and encodes the need for extra effort to change an outcome. A distinction, in contrast, states a difference in kind that identifies, indexes and encodes the content that is needed for different outcomes in two comparable civil cases. Plaintiff wins in case 1 but defendant wins in similar case 2: a distinction between the two cases justifies the different outcomes. I suggest that temporal muscular forms of balancing in a footrace have counterparts in legal forms that are chiefly conceptual.

The gap in a footrace defines a focal space that separates two runners in an athletic domain; a distinction in a courtroom defines a focal fact that separates two cases in a judicial domain. Such a space and such a fact may have similar decisive importance in corresponding critical moments.

Use of ambiguities and distinctions in legal forms is illustrated by the development of protections for workers injured during the course of employment. Such injuries are frequent. Changing social and political attitudes have led to development of laws that make employers responsible for injured workers.

According to scholars, the ancient Babylonian Code of Hammurabi declared that employers were liable for any injury that might befall a worker in the course of his labor. Apparently, slavery was rare in ancient Babylonia and employment was mostly contractual. Subsequent civilizations were based on slavery, feudalism, indenture and paternalism; whatever their defects, such employment relationships established a basis for employer responsibility for care of injured workers. The Industrial Revolution changed employment relations. (Herlick, § 1.01.) It also led to enormous increases in worker injuries.

As stated in Friedman, *A History of American Law* (1973) at 262-263:

> The explosion of tort law, and negligence in particular, must be entirely attributed to the age of engines and machines. … The machines and tools of modern man…blindly cripple and maim their servants. From about 1840 on, one specific machine, the railroad locomotive, generated, on its own steam (so to speak), more tort law than any other in the 19th century. The railroad engine swept like a great roaring bull through the countryside, carrying out an economic and social revolution; but it exacted a toll of thousands, injured and dead.
>
> The existing law of tort was not prepared to bear the burden of these accidents. … The law developed in a way which the power-holders of the day considered socially desirable. This way, in brief, was to frame rules friendly to the growth of young businesses; or at least rules the judges thought would foster such growth. … The most famous (or infamous) new doctrine was the fellow-servant rule. This was the rule that one servant (employee) could not sue his master (employer) for injuries caused by the negligence of another employee. … Chief Justice Lemuel Shaw of Massachusetts wrote … that the workman who takes on a dangerous job must be held to have assumed the ordinary risks of that job. In theory, the wage rate included an adjustment for the added danger. Since that was so, the risk must be left on the person who had, for a price, voluntarily assumed it. The injured workman was thus thrown back on his own resources or, if he had none, to the tender mercies of the poor laws.

The fellow-servant rule introduced a distinction into the developing law of negligence and also into the law of agency. "In the law of agency, the principal [employer] is generally liable for negligent acts of his agent [fellow-servant]. … But this general rule was never extended to the factory and to railroad yard workers." (263, emendations added.)

"To keep the workers reasonably content, European legislatures enacted workers' compensation laws in the late 1880's. It took about a generation for the idea to span the Atlantic. California was one of the first states to enact a workers' compensation law." (Herlick, § 1.01.)

Workers' compensation systems amount to a re-balancing of the legal system for injured workers. Through legislative enactments, mandates are imposed on all employers and on their employees. Employers are required to contribute money to a fund in amounts proportional to their payrolls and rate of injuries and the fund pays for treatment of injured workers. The fund is managed like an insurance company. Workers are entitled to treatment for injuries sustained during the course of employment regardless of fault, whether the employer's fault, a fellow-worker's fault or their own fault. It is a no-fault system unlike the traditional negligence system where a person could not recover for injuries sustained through his or her own fault. As part of the re-balancing, workers lose claims and rights they would have in court proceedings, such as claims for pain and suffering and the right to a jury trial. Injured workers' claims are excluded from regular courts. Workers' compensation proceedings are quicker than court proceedings and are conducted by special tribunals that may be accused of institutional biases. Workers may lose some or all control over their medical care and rehabilitation. Such re-balancing amounts to an enforced bargain, where each side gives something and gets something.

To sum up previous constructions, I suggest that balancing forms are used throughout legal proceedings, even appearing in symbols of justice and of the legal profession. Legal balancing forms have common roots in actual life with balancing forms of sports competitions. There is a foundation of muscular movements and bodily feelings of actual life. Forms incorporate symmetry and invariance; also, shifting asymmetries are of focal importance. Balancing forms combine a symmetrized spatial character with an episodic temporal character.

The final construction develops previously-discussed principles into a view of jurisprudential law. Jurisprudential law is stated in constitutions, statutes and court decisions. Jurisprudential law states fixed principles that are supposed to control legal proceedings in courtrooms. Of perhaps even greater consequence, jurisprudential law states fixed principles that are supposed to control actual lives of persons in society.

Jurisprudential law can both be assimilated to and also distinguished from scientific law.

In my view, all law – whether scientific, jurisprudential or moral – has a primal form that states what a body must do and/or what a body must not do. "Thou shalt" and "thou shalt not" are formalizations of parental instructions. As discussed below, Jerome Frank stated something similar in *Law and the Modern Mind*. Scientific law applies "shalt" and "shalt not" to material bodies. In jurisprudential law, the body is called a person. To use such words in parallel statements: the law of gravity states that a material body that is dropped from a height must fall; and the Vehicle Code states that a person must not drive a car through a red traffic light.

In other words, the primal form of a law is a mandatory or prohibitory action statement applicable to a class of activities of a class of bodies. Pursuant to the form, the law applies to all designated activities of all bodies within the class in a rigid, symmetrical and invariant way. Such a form is often useful but there are many situations where the actual case does not fit easily into the form. Jurisprudential law has developed flexible forms to deal with such situations.

Investigation into jurisprudential law starts with three basic forms of legal reasoning that have been followed in Western Civilization since days of the Roman Empire, all based on notions about the origin of law, namely: (1) jurisprudential law is inherent in things and eternal, as declared by a deity or discovered scientifically — called the ***natural law*** theory;
(2) jurisprudential law is the will of the ruling Sovereign, declared and enforced for His, Her or Its purposes, however transient — called the ***positive law*** theory; and (3) jurisprudential law is a formalized expression of traditions established in a community and/or from a course of dealings between parties — called the ***customary law*** theory.

See D. J. Boorstin, *The Mysterious Science of the Law: an Essay on Blackstone's Commentaries* (1941, 1996) as to natural law; H. L. A. Hart, *The Concept of Law* (1961), chiefly propounding positive law; and Lon L. Fuller, *Anatomy of the Law* (1968), which discusses customary law.

The most powerful statement of natural law was written by Thomas Jefferson in the American

Declaration of Independence: "We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness." Jefferson (1743-1826) got many of his ideas from Blackstone (1723-1780). (Boorstin.) In recent times, natural law theory has been used to expand concepts of human and civil rights.

A simple example of positive law is the law of taxes. Whether imposed by a tyrant or by a popular Congress of the United States, taxes are painful and many persons would not pay them but for even greater pain that is threatened for failure to pay. A Sovereign can impose taxes in one form or another or in a range of rates according to His, Her or Its financial needs and political considerations: the instrumentalities of taxation are highly adaptable to practicalities of situations. Neither eternal principles nor community traditions are much of an impediment to a Sovereign's determination to tax. A threat of insurrection or mass refusal is probably the most potent curb.

Major examples of customary law start with the ***law merchant*** that enabled traders in far-flung ports to deal with one another. Chiefly, sailing ships are risky vehicles for precious metals or money. It is much safer and easier to take a piece of paper that entitles the identified bearer to get or deposit money, so long as counterparts in such transactions are reliable. In medieval times, especially in ports around the Mediterranean Sea and the cold but cozy Baltic Sea, customary forms of dealing arose to make such documentary transactions easy and convenient, with appropriate charges for services. Handling such transactions for customers became activity of trading companies, moneylenders, moneychangers and operators of markets and exchanges. Respected neutral members of the community resolved disputes.

With the advent of railroads in the nineteenth century, development of forms of the law merchant in the United States blossomed to deal with the enlarged geographic reach of trading, e.g., forms used in freight forwarding and credit arrangements. The need for approved and mandatory forms led to legislative enactment of codes of laws regulating Sales. Private organizations sponsored new developments, of which perhaps the most successful is the Uniform Commercial Code that facilitates interstate commerce and that has been adopted, with variations, by all the States of the United States. (Gilmore.) Customary laws became strict rules, along with new standards, e.g., those stated in warranties that accompany consumer products.

In addition to the three traditional theories of jurisprudence based on the supposed origin of law (natural, positive and customary theories), there is a fourth approach that has, as a practical matter, superseded them all, borrowing authority from such traditional theories to support its utilitarian purposes. The fourth approach has no simple name but one label is the ***social interests approach***. According to a social interests formulation, the law is an instrument that is applied to achieve certain social interests, goals or purposes. The social interests approach focuses on goals and purposes rather than on origins. For example, the purposes of the Uniform Commercial Code are stated as part of the Code: "(a) to simplify, clarify and modernize the law governing commercial transactions; (b) to permit the continued expansion of commercial practices through custom, usage and agreement of the parties; (c) to make uniform the law among the various jurisdictions." (UCC § 1-102.) Accordingly, a State court faced with a novel kind of problem will review and tend to apply rules that have been adopted by a consensus of other States. Courts enforce a social and commercial interest in having uniform rules across the nation.

The social interests approach developed during the late 19th and early 20th centuries. It is best identified with Oliver Wendell Holmes, Jr. (1841-1935). Holmes fought as a junior officer in the American Civil War, wrote major Supreme Court opinions and welcomed newly-elected President Franklin D. Roosevelt to Washington in 1933. He famously announced the advent of the new era: "The life of the law has not been logic; it has been experience." (*The Common Law* (1881) at 1.)

In *The Path of the Law* (1897), Holmes wrote:

> Take the fundamental question, What constitutes the law? You will find some text writers telling you that it is something different from what is decided by the courts of Massachusetts or England, that it is a system of reason, that it is a deduction from principles of ethics or admitted axioms or what not, which may or may not coincide with the decisions. But if we take the view of our friend the bad man we shall find that he does not care two straws for the axioms or deductions, but that he does want to know what the Massachusetts or English courts are likely to do in fact. I am much of this mind. ***The prophecies of what the courts will do in fact, and nothing more pretentious, are what I mean by the law***.
> (Emphasis added.)

From my perspective, Holmes was declaring an ***actual jurisprudence*** that takes as its chief subject matter the actual decisions, practices and procedures of courts and other institutional deciders. When social interests jurisprudence was overcoming prior jurisprudential approaches in the 1930's, it was called ***Legal Realism***. A leading legal realist was Jerome Frank (1889-1957), who served as Chairman of the Securities and Exchange Commission and as a Judge on the Second Circuit Court of Appeals; he also wrote *Law and the Modern Mind* introduced above, which extolled the practical reasoning of Holmes. Frank challenged the hegemony of traditional legal theories, using labels like "the basic myth," "legal fundamentalism" and "mechanical jurisprudence." Please compare to "platonic science" herein.

The focus of actual jurisprudence is on exercises of freedom by judges and juries. However, written laws are often stated in traditional formulations of mandates or prohibitions that apply to classes in invariant and symmetrical ways. Such formulations are not always suitable for the personalized decisions that actual disputes require. To accommodate and allow for personalized decisions, judges and legislators introduced ***methods of ambiguity***. An ambiguous term must be interpreted and an interpretation can take into account various considerations that can lead to various results. Using methods of ambiguity, judges can exercise freedom in deciding disputes. Modern formulations of laws often incorporate such exercises of freedom expressly, especially in connection with discretionary procedures such as those involving preliminary injunctions.

Such freedom was described by Gilmore & Black in *The Law of Admiralty* (2d ed. 1975), § 10-20 in connection with a particular legal question that is somewhat complex. Some background provides context. United States Congresses enacted and Presidents signed bills dealing with commercial shipping that, in the aggregate, are called the ***Limitation Act***. Included in the Limitation Act are two key phrases that illustrate ambiguity, namely, "privity or knowledge" and "design or neglect." Under the Act (and ignoring everything but this issue), a shipowner whose vessel is involved in a catastrophe can ***limit his liability*** to the value of the vessel and be exonerated from further liability, e.g., as to claims from owners of lost cargo. (Claims by injured seamen are more complex.) In effect, the shipowner can legally say: "take the wreck, I'm through" – ***unless*** his role in the catastrophe is characterized by "privity or knowledge" or if there was "design or neglect" on his part; and, if so, then there is ***no*** limitation and ***no*** exoneration. Such rules were first established when seafaring was routinely hazardous and were meant to free a shipowner from claims arising from catastrophic loss if he attended to matters involving the ship in the ordinary course of business. The ambiguities in enforcement of the enacted laws ("statutes") are clearly identified in the following passage by Yale Law School professors with expertise in legal history and jurisprudence (emphases added, reference omitted).

> "Privity or knowledge" and "design or neglect" are phrases devoid of meaning. They are ***empty containers into which the courts are free to pour whatever content they will***. The statutes might quite as well say that the owner is entitled to exoneration from liability or to limitation of liability if, on all the equities of the case, the court feels that the result is desirable; otherwise not. Since, in the infinite range of factual situations no two cases will ever precisely duplicate each other, no judge with the slightest flair for the lawyer's craft of distinguishing cases need ever be bound by precedent: "privity like knowledge," the Supreme Court has remarked, "turns on the facts of particular cases."
>
> Judicial attitudes shape the meaning of such catch-word phrases for successive generations. In the heyday of the Limitation Act it seemed as hard to pin "privity or knowledge" on the petitioning shipowner as it is thought to be for the camel to pass through the needle's eye. To the extent that in our own or a subsequent generation the philosophy of the Limitation Act is found less appealing, that attitude will be implemented by a relaxed attitude towards what constitutes "privity or knowledge" or "design or neglect." ***The Act, like an accordion, can be stretched or narrowed at will***.

According to the authors, "the courts" are able to play with laws in the style of a musician, re-writing tunes that control procedures and outcomes. Such exercises by courts are stated in terms of targets that were "hard to pin" until a "relaxed attitude" appeared and in terms of "empty containers" into which courts "are free to pour whatever content they will" and muscle-like movements that can "stretch and narrow at will" legal liabilities and exonerations.

Here at last we have found a "free will" that connects to actual life. The "will" of the courts clearly denotes the freedom that judges exercise, along with the power that they obtain through the legal system. Similar kinds of freedom are given to juries, with narrower decisions and indirect powers. Such kinds of freedom appear to be subject to analysis based on episodic forms of balancing that can be modeled and mimicked using new technologies. Previously-presented kits of parts are suggestive of further development. However, anticipated projects reach too far beyond limitations of platonic science for purposes of this essay; they are, therefore, left for subsequent constructions.

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